Final Draft Report

Stormwater Master Plan

Prepared for

City of Dallas

April 2016

CH2MHILL®

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3rd Floor
Portland, Oregon 97201

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Acronyms and Abbreviations

ACWA	Association of Clean Water Agencies
APWA	American Public Works Association
BMP	best management practice
cfs	cubic feet per second
CIP	capital improvements plan
City	City of Dallas
DEQ	Oregon Department of Environmental Quality
DMA	Designated Management Agency
EIA	effective impervious area
EPA	U.S. Environmental Protection Agency
ERU	equivalent residential units
°F	Fahrenheit
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FTE	full time equivalent
GIS	geographic information system
HDPE	high-density polyethylene
HBRR	Highway Bridge Replacement and Rehabilitation
IDF	intensity-duration-frequency
lf	linear feet
Lt	lag time
MRLC	Multi-Resolution Land Characteristics
MS4	Municipal Separate Storm Sewer System
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service (formerly SCS)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
ODOT	Oregon Department of Transportation
SDC	system development charge

SCS	Soil Conservation Service: former name for NRCS
SSURGO	Soil Survey Geographic Database
SWM	stormwater management
SWMP	Stormwater Master Plan
TMDL	total maximum daily load
TOC	Time of Concentration
URAC	Utility Rate Advisory Committee
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UGB	Urban Growth Boundary

Executive Summary

Purpose

This master plan identifies and prioritizes necessary or desirable capital improvements and stormwater operational staffing needs of the City of Dallas and establishes a schedule and financing plan to implement the recommended necessary improvements.

More specifically, this plan presents the results of the analysis of the existing stormwater collection and conveyance system, focusing on existing problem areas to identify modifications and additions to correct current deficiencies and address predicted future needs.

As part of this master planning project, data about the storm drainage system were converted from computer-aided drafting (CAD) files to a database that can be used with geographical information system (GIS) to facilitate future system analysis and asset management. The available data from the CAD files are limited and will be supplemented with additional information in the future.

Watershed Characteristics

The study area for this plan is defined by the current (2014) City of Dallas boundary, and the La Creole and Barberry growth nodes. These growth nodes are identified as Master Plan Overlay Zones on the City of Dallas Zoning Map dated January 2014; they are outside of the City boundary but within the Urban Growth Boundary (UGB).

The City is bisected by Rickreall Creek, which runs from west to east. The City collects water from the Rickreall Creek watershed for municipal use, and discharges treated water from a wastewater treatment facility downstream of the City. Two additional waterways drain the City of Dallas: Harland Slough (tributary to Baskett Slough) and the North Fork Ash Creek. The west side of the City of Dallas lies along the eastern foothills of the Coastal Mountain Range, but the majority of the City's topography is relatively flat.

Stormwater runoff is drained by pipe and open channel systems throughout the watershed. Most of the runoff from the urbanized areas, especially the central business district, is piped. Runoff is transported through these pipes and discharged into the creeks and streams flowing through the City.

Within the study area, nearly 99 percent of the area is covered with soils of moderate or poor permeability. The predominant soils within the Dallas UGB have low infiltrative capacity during large events. Except in localized areas, disposal of stormwater through surface infiltration is not considered to be an effective strategy. Also for this reason, groundwater and stormwater interactions are assumed to be minimal. The study area is currently zoned for residential (77.5 percent), commercial (5.9 percent), industrial (12.6 percent), parks (2.4 percent), and agricultural and forest uses (1.6 percent).

Analysis Approach and Methodology

Analysis Approach

The primary objective of the analysis was to evaluate the adequacy of the existing drainage systems at sites known to experience flooding and to develop a phased capital improvements plan to upgrade inadequate facilities. The following sites with known flooding problems were identified by the City:

- Douglas Street at the inlet to the piped system
- Fairhaven Street culvert
- Murphy's Grill parking lot at the inlet to the piped system
- Culverts under Kings Valley Highway/Highway 223 near the cemetery
- Kings Valley Highway/Highway 223 crossing of North Fork Ash Creek at the Bridlewood subdivision

- Former Weyerhaeuser property
- Uglow Street
- Monmouth Cutoff crossing of the North Fork Ash Creek
- Monmouth Cutoff crossing of the tributary
- Godsey Road

This study identified improvement alternatives and selected conceptual system improvements for each of the identified problems. The system improvements were selected to enable the system to convey the peak 100-year flow[1] at buildout without causing surface flooding.

In order to evaluate hydraulic deficiencies and potential solutions, hydrologic analysis was first conducted to determine peak flow for multiple recurrence intervals. The results of the hydrologic analysis also provided a planning basis for future infrastructure needs in the Wyatt, La Creole and Barberry growth nodes.

Methodology

Hydrologic Analysis

Two methods were used to estimate peak flows from drainage areas within the study area. The first was the hydrologic modelling software HEC-HMS (v3.1.0) by U.S. Army Corps of Engineers (USACE) using Soil Conservation Service (SCS) methodology, and the second consisted of prediction equations published by the U.S. Geological Survey (USGS). In general, HEC-HMS was used to estimate peak flows from subbasins with the UGB or tributary to Rickreall Creek, while the USGS regression equations were used for the large rural basins tributary to the North Fork Ash Creek.

Hydraulic Analysis

Hydraulic analysis was focused on the areas of known flooding problems. A systems approach was used to group sites that are hydraulically linked. These groups were then analyzed as functional systems rather than isolated problems.

XPSWMM by XP Solutions was used to model existing and proposed infrastructure to alleviate flooding at several of the identified problem sites with pipe network elements. Bentley FlowMaster was used in conjunction with the Federal Highway Administration's culvert hydraulic analysis program HY-8 to evaluate channel and culvert requirements.

Basin Delineation and Model Parameters

Major drainage basins were defined according to existing drainage routings within the City and topography. The major basins (shown in Figure ES-1) include Ash Creek Bridlewood, Ash Creek Industrial, Ash Creek Residential, Baskett Slough, Douglas, Rickreall Barberry, Rickreall Central Business District (CBD), Rickreall North Central (NC), Rickreall Northeast (NE), Rickreall Northwest (NW), Rickreall Southeast (SE), Rickreall Southwest (SW), and Rickreall Uglow-Orchard (UO).

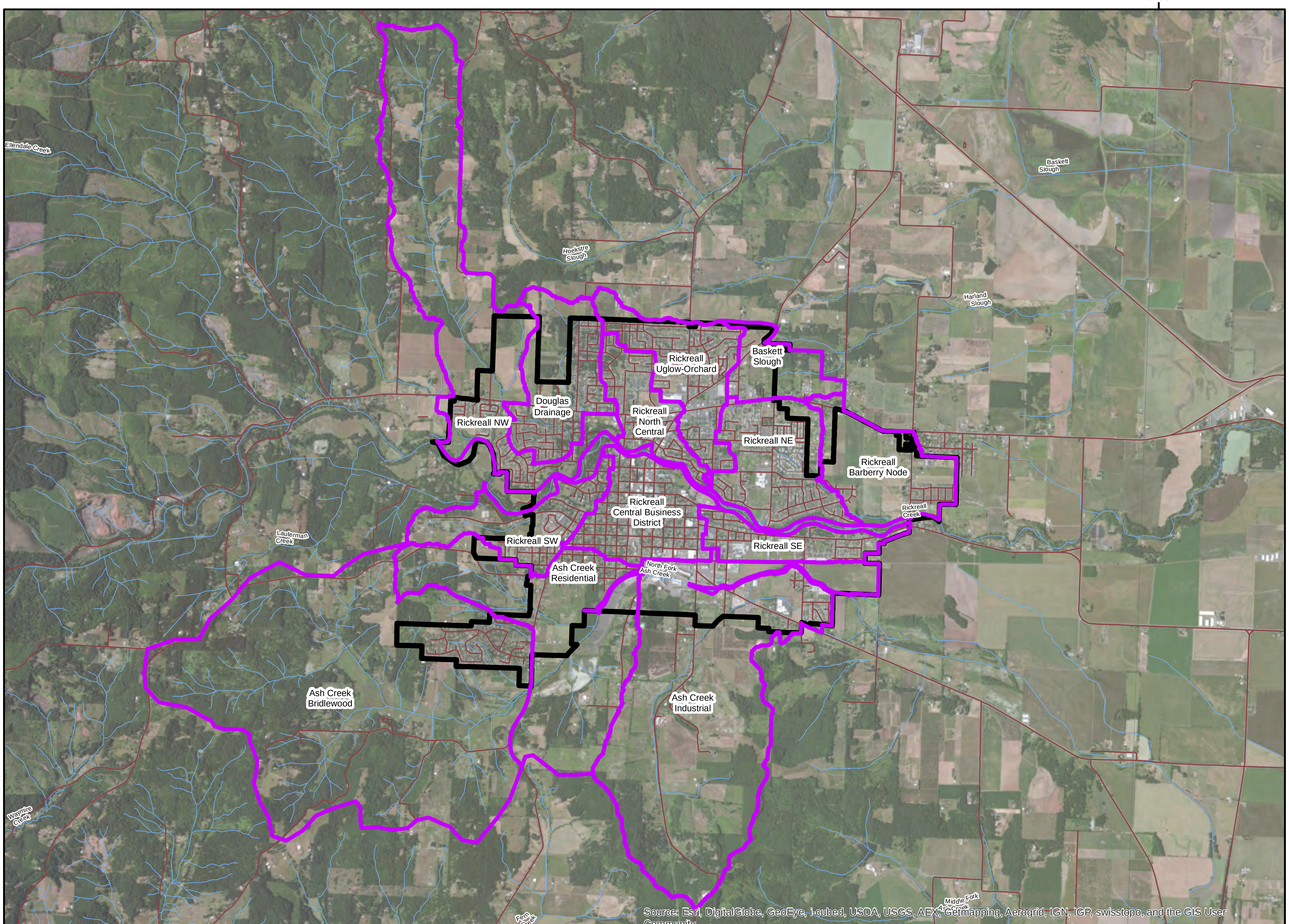
National Land Cover Database data were analyzed to determine the currently mapped percent impervious areas. Soils in the area were characterized using the hydrologic soil classification system developed by the SCS (now called Natural Resources Conservation Service [NRCS]). Soil parameters were derived from the Soil Survey Geographic Database, which was published by the NRCS in 2003.

Basin Runoff Analysis and Results

Runoff from each subbasin was determined using the SCS methodology in the USACE HEC-HMS hydrologic computer model, except for the three large rural basins outside the UGB that are tributary to North Fork Ash Creek, which were calculated using USGS regression equations. Results are summarized in Table ES-1.

[1] A flooding event that has a 1 percent chance of occurring during any year.

123°15'0"W



123°15'0"W

FIGURE ES-1

Major Basins

City of Dallas
Stormwater Master Plan

Legend

- Major Basins
- City Boundary
- Roads
- Streams

N

1 inch equals 3,200 feet

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TABLE ES-1
Peak Major Basin Flows
City of Dallas Stormwater Master Plan

Routed Flow	Total Basin Area (acres)	Current Condition Flows (cfs)				Buildout Flows (cfs)			
		10 yr	25 yr	50 yr	100 yr	10 yr	25 yr	50 yr	100 yr
Ash Creek Bridlewood	2,056	329	402	465	542	329	405	465	544
Ash Creek Industrial	1,379	331	395	449	516	383	450	507	578
Ash Creek Residential	783	263	318	364	421	305	365	413	473
Baskett Slough	160	100	120	137	158	122	145	164	188
Douglas	334	202	240	273	313	224	266	300	342
Rickreall Barberry	315	147	179	205	238	207	246	279	318
Rickreall CBD	302	266	305	338	377	265	305	337	376
Rickreall NE	349	233	273	308	348	269	314	352	397
Rickreall NC	190	161	188	210	237	174	201	224	251
Rickreall NW	986	357	440	511	598	367	449	519	604
Rickreall SE	174	136	159	179	202	146	170	190	214
Rickreall SW	254	169	202	229	263	173	206	233	267
Rickreall UO	311	250	292	327	370	260	300	339	382

cfs = cubic feet per second.
yr = year.

Water Quality

The City of Dallas is a Designated Management Agency under the Willamette total maximum daily load (TMDL). As such, the City has developed a comprehensive Willamette TMDL Implementation Plan (Dallas TMDL Plan) to improve the quality stormwater runoff from the City (City of Dallas, 2008a). Several action items have already been implemented. The following recommendations are based on review of the Dallas TMDL Plan, relevant topographical and climatic information, types of source contamination, frequently cited sources of those contaminants, observed levels of contamination, methods of removal, and the overall regulatory climate. Recommendations are as follows:

- Continue implementation of the action items contained in the Dallas TMDL Plan.
- Consider adoption of the sumped style of catch basins for public facilities and either sumped or siphoned private facilities within the City and use this style as new catch basins are built or as old catch basins are replaced within the normal schedule of maintenance and improvements.
- Retain natural existing open channel waterways as such to the extent possible, rather than allow their replacement with piped systems. Exceptions to this policy should include situations where the waterway cannot be maintained free from encroaching vegetation or human activities to prevent flooding of adjacent lands due to such encroachment.
- Consider increased detention requirements to manage hydrologic impacts (e.g., channel down-cutting) or if significant growth is expected in a specific stream basin.
- Establish treatment requirements for developments by setting a treatment threshold for increased impervious area; for example, 5,000 to 10,000 square feet. More discussion of allowable treatment facilities and the interaction with water quantity management techniques, would be appropriate additions to design standards.
- Incorporate measures to ensure adequate long-term operation and maintenance of post-construction best management practices (BMPs) to the overall stormwater management program and policies.

- Develop additional action items related to construction sites, including:
  - Requirements to control other (non-sediment) waste at the construction site
  - Procedures to receive and consider information/complaints submitted by the public
  - Procedures for inspections and enforcement of stormwater requirements at construction sites
  - Removal of sediment control measures following construction

Analysis Results and Recommended Improvements

As noted above, a systems approach was taken to group and analyze hydraulically linked problem areas together. As a result, there are fewer analysis areas than identified problem areas. Though not listed as a flooding site, Hunter Street was identified as an additional location for needed drainage improvements because of the construction of a house directly on top of a concrete culvert. In total, there were six areas of analysis:

- West Ellendale at Wyatt
- Douglas Drainage
- Rickreall Uglow/Orchard
- Kings Valley Highway/Highway 223 at the Cemetery
- North Fork Ash Creek
- Hunter Street

The analysis areas are shown in Figure ES-2. The problems and recommended improvements for these areas are described separately below. In each case, the hydrologic and hydraulic analysis and resulting recommended capital improvement projects are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects.

West Ellendale at Wyatt

Historically, floodwaters overtop West Ellendale and run down Wyatt Street.

Proposed capital improvement projects include:

- Regrade the channel
- Clean and replant channel: replace existing brushy weeds with short grass to achieve greater flow capacity
- Replace circular culvert with larger box culvert

These improvements are recommended assuming that the earthen berm on the north side of Ellendale was not designed as a permanent improvement and will eventually be removed as development occurs.

The following next steps are recommended as part of the design process:

- Add detail about the Kingsborough Park detention pond and the connection to the hydraulic model to better understand interactions between the two and potential impacts to recommended improvements
- Determine cause of existing reverse grade at existing culvert outlet and conduct scour analysis to mitigate the cause and prevent reoccurrence
- Confirm channel dimensions and grade; adjust length of channel that must be regraded if necessary to provide hydraulic capacity
- Confirm fish passage requirements and adapt culvert design concept accordingly

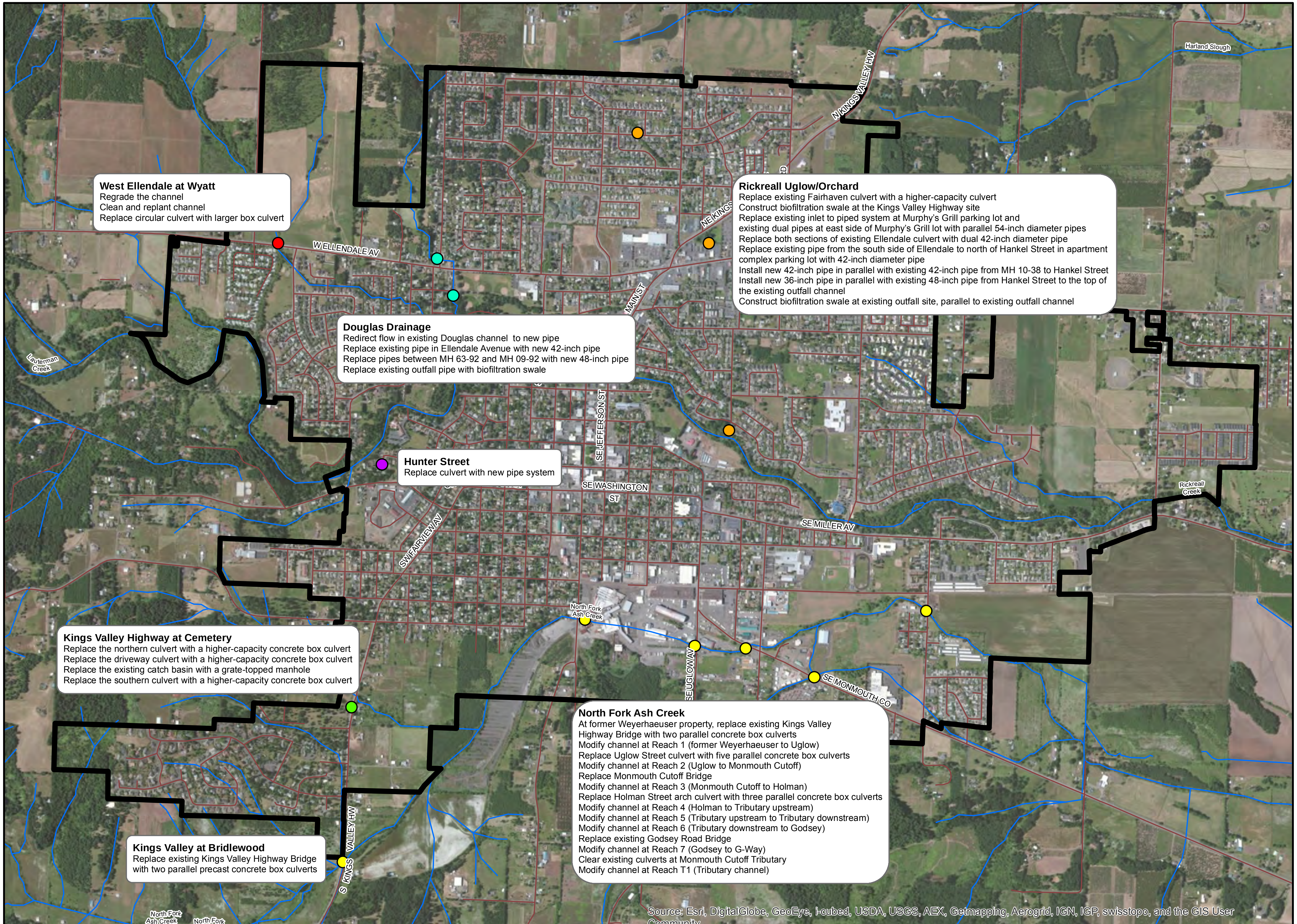

FIGURE ES-2

Recommended Capital Improvements

City of Dallas Stormwater Master Plan

Legend

AnalysisArea
- Douglas Drainage
- Hunter Street
- Kings Valley Highway at the Cemetery
- North Fork Ash Creek
- Rickreall Uglow/Orchard
- West Ellendale at Wyatt
- City Boundary
- Roads
- Streams

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1 inch equals 1,500 feet

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Douglas Drainage

Water rises to the surface at the upstream end of the system on Douglas Avenue, where flow from a straightened natural channel enters the piped system.

Proposed capital improvement projects include:

- Redirect flow in existing Douglas channel to new pipe
- Replace existing pipe in Ellendale Avenue with new 42-inch pipe
- Replace pipes between MH 63-92 and MH 09-92 with new 48-inch pipe
- Replace existing outfall pipe with biofiltration swale

The following next steps are recommended as part of the design process:

- Establish groundwater levels and evaluate potential impacts to proposed outfall biofiltration facility
- Check buoyancy conditions for new large manholes

Rickreall Uglow/Orchard

Flooding has been observed in the parking lot of Murphy's Grill; floodwaters cross the parking lot and flow south over Ellendale Avenue to flood the parking areas of the businesses to the south.

Proposed capital improvement projects include:

- Replace existing Fairhaven culvert with a higher-capacity culvert
- Construct biofiltration swale at the Kings Valley Highway/Highway 223 site
- Replace existing inlet to piped system at Murphy's Grill parking lot and existing dual pipes at east side of Murphy's Grill lot with parallel 54-inch diameter pipe
- Replace both sections of existing Ellendale culvert with dual 42-inch diameter pipes
- Replace existing pipe from the south side of Ellendale to north of Hankel Street in apartment complex parking lot with 42-inch diameter pipe
- Install new 42-inch pipe in parallel with existing 42-inch pipe from MH 10-38 to Hankel Street
- Install new 36-inch pipe in parallel with existing 48-inch pipe from Hankel Street to the top of the existing outfall channel
- Construct biofiltration swale at existing outfall site, parallel to existing outfall channel
- The following next steps are recommended as part of the design process:
- Establish groundwater levels and evaluate potential impacts to proposed biofiltration facilities
- Additional survey

Kings Valley Highway/Highway 223 at the Cemetery

Floodwaters overtop Kings Valley Highway/Highway 223 at the entrance to the cemetery.

Proposed capital improvement projects include:

- Replace the northern culvert with a higher-capacity concrete box culvert
- Replace the driveway culvert with a higher-capacity concrete box culvert
- Replace the existing catch basin with a grate-topped manhole
- Replace the southern culvert with a higher-capacity concrete box culvert
- Replace existing Kings Valley Highway/Highway 223 Bridge with two parallel precast concrete box culverts

The following next steps are recommended as part of the design process:

- Determine downstream capacity and backwater effects on proposed culvert improvements
- Assess upstream detention storage to mitigate potential effects on downstream system
- Perform additional survey

North Fork Ash Creek

Flooding has been observed at multiple locations in the upper portions of the North Fork Ash Creek watershed, including five road crossings and the former Weyerhaeuser property between Main Street and Uglow Street.

The proposed capital improvement project is to construct in-line detention storage of the North Fork Ash Creek. Detention of peak flows could reduce the size of downstream conveyance infrastructure. High-level conceptual analysis of this proposed project indicates that a 6-foot deep pond approximately 20 acres in size would be required.

If this capital improvement project proves infeasible, an alternative approach would be to increase conveyance through and immediately upstream of the Weyerhaeuser property. The capital improvement projects for this alternative approach would include:

- Replace existing Kings Valley Highway/Highway 223 Bridge with two parallel concrete box culverts
- At former Weyerhaeuser property, replace existing culverts with two parallel concrete box culverts or alternate detention area
- Modify channel at Reach 1 (former Weyerhaeuser to Uglow)
- Replace Uglow Street culvert with five parallel concrete box culverts
- Modify channel at Reach 2 (Uglow to Monmouth Cutoff)
- Replace Monmouth Cutoff Bridge
- Modify channel at Reach 3 (Monmouth Cutoff to Holman)
- Replace Holman Street arch culvert with three parallel concrete box culverts
- Modify channel at Reach 4 (Holman to Tributary upstream)
- Modify channel at Reach 5 (Tributary upstream to Tributary downstream)
- Modify channel at Reach 6 (Tributary downstream to Godsey)
- Replace existing Godsey Road Bridge
- Modify channel at Reach 7 (Godsey to G-Way)
- Clear existing culverts at Monmouth Cutoff Tributary
- Modify channel at Reach T1 (Tributary channel)

Channel modifications mostly consist of widening the channel to increase conveyance capacity. In some locations, a levee is required to contain the water within the design channel and prevent flooding of low-lying areas on either or both sides.

The proposed capital improvement projects are based on hydraulic capacity requirements only, with very limited consideration of fish passage or other ecological and permitting challenges. The proposed channel modifications (including levees) and culvert replacements are all located within a regulatory floodplain. The analysis, and resulting proposed capital improvements, did not consider alternatives for overbank flow outside of the proposed channels, nor did it account for potential floodplain storage effects. Wetland mapping was not conducted as part of this project, but it is presumed that this project will have some wetland impacts.

In addition to compliance with City of Dallas and Polk County development code and floodplain ordinances and local permits, the following federal and state permits may be required:

- Clean Water Act Section 404 Permit (USACE)
- National Environmental Policy Act assessment
- Clean Water Act Section 401 Water Quality Certification (DEQ)
- Removal-fill Permit (Oregon Department of State Lands)
- Fish Passage Approval (Oregon Department of Fish and Wildlife)
- Oregon State Historic Preservation Office Concurrence

The following next steps are recommended as part of the design process:

- Comprehensive project feasibility study. The hydraulic interactions between the floodwaters from the former Weyerhaeuser property, the tributary, and the mainstem of the North Fork Ash Creek are complex and are not currently represented by an accurate, interlinked dynamic model. A detailed hydraulic study of this system, including collection of flow monitoring data for model calibration, is recommended before further development of the proposed capital improvements. A full analysis of the conceptual detention storage should be incorporated into this study.

- This study should include early coordination between the City, the Ash Creek Water Control District, and state and federal agencies including Federal Emergency Management Agency, USACE, DEQ, Oregon Department of State Lands, and Oregon Department of Fish and Wildlife.

- Thorough evaluation of permitting requirements should be undertaken as part of the recommended further study in order to understand potential regulatory constraints on the proposed projects. Investment in such a study may result in significant overall capital cost saving.

It is anticipated that project coordination with other vested parties and other planned city activities such as roadway maintenance, permitting, and coordination of funding resources will result in a long lead time before design and construction of the various projects can begin. Implementation and phasing of the projects will depend on these factors.

Hunter Street

A house was built over the top of a 48-inch culvert; the culvert is presumed to be nearing the end of its lifecycle and may start to cause problems for the property owner if not re-aligned.

A new 48-inch diameter pipe system is proposed. The existing culvert can be capped and abandoned in place.

Additional Recommendations

Private Development Drainage Facilities

Other drainage facilities will be needed within developments that occur on the fringes of existing development. These additional facilities are typically provided by the developer as part of the development's infrastructure and are either kept as private drainage facilities or are constructed to City standards and turned over to the City upon acceptance of the construction by the City. It is not the intent of this plan to place restrictions on the alignment of drainage facilities within these currently undeveloped lands, except as specifically provided for in this plan.

Drainage facilities will be planned for these outlying areas as part of the City's normal site design review process. These facilities should have the capacities necessary to handle the flows estimated by this master plan and should provide for continuity of existing drainageways.

Stormwater Detention Considerations

Stormwater detention is an effective tool for limiting the increase in peak runoff resulting from continued urbanization. The location of these facilities within a watershed has a significant impact on their effectiveness at reducing peak flows in the receiving waters. The impact of detention facilities within a system is dependent on the timing of peak flows in relation to the timing of adjacent and downstream systems. A more detailed look at timing effects is recommended before pursuing detention storage as a strategy to reduce capital improvement cost.

For the purpose of the master planning analysis, the effects of future stormwater detention were ignored in the hydrologic and hydraulic analysis.

Future Service for Growth Nodes

There are three growth nodes within the study area: Wyatt, La Creole, and Barberry.

Wyatt

Flow from the Wyatt growth node was included in the analysis of the West Ellendale at Wyatt and Douglas Drainage capital improvement areas. A new stormwater drainage system will need to be constructed to provide service for future development in the growth node.

La Creole

Based on existing topography, it is most likely that future development in the La Creole growth node will drain to Harland Slough (a tributary to Baskett Slough). New stormwater drainage facilities will need to be installed to convey flow to this drainage.

Barberry

The Barberry growth node lies mostly within the Rickreall Barberry Node major basin, though a small portion in the southwest corner of the growth node and the area west of Hawthorne Avenue are included in the Rickreall SE basin. The southwest corner area within the Rickreall SE basin is currently developed and served by a local drainage system.

The area west of Hawthorne Avenue could be served either by a new system in Hawthorne Avenue, or conveyed to the ditch to the east where there are two stormwater outfalls.

Stormwater runoff from subbasin R-B-C1 can be routed through the existing storm drainage line in Fir Villa Road. Subbasin R-B-D2 is partially developed, with a local storm drainage system in the southern portion of the subbasin. Runoff from future development in this subbasin could be routed to Fir Villa Road or to the existing subdivision drainage system. Runoff from subbasin R-B-D3 drains generally southwest toward Fir Villa Road and subbasin R-B-D2. The existing stormwater drainage systems in those locations could be used to convey runoff from R-B-D3.

Subbasin R-B-D1 drains toward Rickreall Creek. Runoff from future development in this subbasin could be routed to the outfall pipe of the subdivision drainage system in R-B-B2. Additional outfalls could also be constructed, depending on the layout of future developments.

Capacity analysis of the existing systems to convey runoff from future development was not conducted as part of this project.

Subbasins R-B-B2 and R-B-B3 are currently undeveloped and have no existing stormwater infrastructure. A new drainage system will need to be constructed to provide service for future development in these areas.

Data Collection

As part of this project, the City has developed a stormwater system database that includes all information about the existing stormwater pipe network. There are several gaps in the data that prevented a more detailed capacity analysis from being conducted as part of this project, and necessitated use of reasonable assumptions in order to develop recommendations for some of the capital improvement analysis areas. Collection of data to complete this database is recommended. A more complete database will provide the information required for future capacity and repair/rehabilitation analyses.

Condition Assessment

Assessment of the existing condition of the stormwater system is recommended to facilitate prioritization of a proactive pipe rehabilitation and replacement program.

Pipe Rehabilitation and Replacement

The precise age and condition of much of the City's existing stormwater network is not known, but it is acknowledged that much of the system is aging. Development of a prioritized pipe rehabilitation and replacement program is recommended to minimize the risk of failure of the existing infrastructure. Results of the condition assessment should be used to inform rehabilitation and replacement priorities.

Periodic Rate Model and System Development Charge Methodology Updates

It is recommended that the City update the rate model and system development charge methodology every 3 to 5 years.

Capital Cost Estimate

Costs developed for the Dallas Stormwater Master Plan are Class 4 project definition estimates as defined by the Association for the Advancement of Cost Engineering (AACE) International and adopted by the American National Standards Institute in *Cost Estimate Classification System* (AACE International, 2011) and *Cost Estimating Classification System as Applied in Engineering, Procurement, and Construction for the Process Industries* (AACE International, 2011).

A Class 4 cost estimate corresponds to a level of engineering design detail between project definition and schematic design and is appropriate for this level of capital planning. A Class 4 cost estimate is normally expected to be within +50 percent or -30 percent of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. As a result, the final project costs will vary from the estimates presented in this report.

Additionally, the presented costs include an allowance for fees associated with administration, engineering, and permitting. Given the potential difficulty and complexity associated with permitting the proposed capital improvements for the North Fork Ash Creek between the former Weyerhaeuser property and G-Way Ranch, the allowance was increased to 45 percent of the construction cost. All other project sites addressed in the stormwater master plan include a 30 percent allowance.

Capital cost estimates for recommended capital improvements are summarized in Table ES-2 for the analysis areas. Installed costs have been rounded to the nearest $1,000.

Capital Plan

Schedule

The capital plan schedule is shown in Table ES-3.

Cost Sharing and Grant Funding

The potential for cost sharing has been identified for several of the proposed projects. Potential cost sharing partners include:

- Ash Creek Water Control District
- Polk County

- ODOT
- Private developers

Bridge replacement projects may be eligible for grant funding through the Federal Highway Administration's Highway Bridge Replacement and Rehabilitation (HBRR) program.

TABLE ES-2
Capital Cost Estimates for Recommended Capital Improvements
City of Dallas Stormwater Master Plan

		Funding Sources	
Analysis Area	**Installed Cost[a]**	**Current and Future Rate Payers**	**Other**
Site-specific Projects			
West Ellendale at Wyatt	$495,000	$495,000	$0
Douglas Drainage	$755,000	$755,000	$0
Rickreall Uglow/Orchard	$2,348,000	$2,348,000	$0
Kings Valley Highway/Highway 223 at the Cemetery	$131,000	$131,000	$0
Kings Valley Highway/Highway 223 at Bridlewood	$170,000	$0	$170,000[c]
North Fork Ash Creek Weyerhaeuser to G-Way Ranch	$10,000,000	$4,000,000	$6,000000
Hunter Street	$209,000	$209,000	$0
Subtotal for Site-specific Projects	$14,108,000	$7,938,000	$6,170,000
Growth Node Projects			
Wyatt	$896,000	$81,000	$815,000[e]
La Creole	$1,112,000	$100,000	$1,012,000[e]
Barberry	$1,308,000	$118,000	$1,190,000[e]
Subtotal for Growth Node Projects	$3,316,000	$299,000[b]	$3,017,000
Non-site-specific Projects			
Data Collection	$250,000	$250,000	$0
Condition Assessment	$250,000	$250,000	$0
Pipe Rehabilitation and Replacement	$2,947,000	$2,947,000	$0
Subtotal for Non-site-specific Projects	$3,447,000	$3,447,000	$0
Total	$20,871,000	$11,184,000	$9,187,000

[a]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

[c]ODOT or Polk County.

[d]Developer contributions and LIDs, flood control district, and Federal Highway Administration's Highway Bridge Replacement and Rehabilitation program.

[e]Developer paid.

TABLE ES-3

Capital Improvement Plan Schedule

City of Dallas Stormwater Master Plan

Project Name	Amount to be financed*	Fiscal Year																				
		2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36
Douglas/Softball Field	$755,000													$ 249,000	$ 506,000							
Cemetery[a]	$166,000														$ 35,000	$ 55,000	$ 76,000					
Rickreall Uglow/Orchard	$2,348,000													$ 704,000	$ 822,000	$ 822,000						
West Ellendale at Wyatt	$496,000			$ 159,000	$ 337,000																	
5' x 6' concrete box culvert	$337,000				$ 337,000																	
Clear & replant channel	$152,000			$ 152,000																		
Regrade channel	$7,000			$ 7,000																		
Kings Valley Highway at Bridlewood[b]	$0																					
North Fork Ash Creek Weyerhaeuser to G-Way Ranch[c]	$8,121,000	$ 75,000	$ 225,000	$ 550,000	$ 743,000	$ 411,667	$ 672,667	$ 863,667	$ 1,380,000	$ 800,000	$ 800,000	$ 800,000	$ 800,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Feasibility Study	$300,000	$ 75,000	$ 225,000																			
Restoration, Mitigation, ROW acquisition	$4,000,000								$ 800,000	$ 800,000	$ 800,000	$ 800,000	$ 800,000									
Former Weyerhaeuser property - 2 parallel 6' x 10' concrete box culverts	$0																					
Uglow Street - 5 parallel 6' x 5' concrete box culverts	$618,000			$ 124,000	$ 185,000	$ 103,000	$ 103,000	$ 103,000														
Monmouth Cutoff west of Holman - new bridge	$0			$ -	$ -	$ -	$ -	$ -														
Holman Street - 3 parallel 8' x 11' concrete box culverts	$1,085,000			$ 217,000	$ 326,000	$ 180,667	$ 180,667	$ 180,667														
Godsey Road- new bridge	$0			$ -	$ -	$ -	$ -	$ -														
Monmouth Cutoff Tributary - clear existing culverts	$28,000			$ 28,000																		
Channel modifications - Reach 1 (Former Weyerhaeuser to Uglow)	$122,000			$ 8,000	$ 8,000	$ 8,000	$ 25,000	$ 37,000	$ 36,000													
Channel modifications - Reach 2 (Uglow to Monmouth Cutoff)	$262,000			$ 17,000	$ 17,000	$ 17,000	$ 53,000	$ 79,000	$ 79,000													
Channel modifications - Reach 3 (Monmouth Cutoff to Holman)	$119,000			$ 8,000	$ 8,000	$ 8,000	$ 24,000	$ 35,000	$ 36,000													
Channel modifications - Reach 4 (Holman to Tributary upstream)	$181,000			$ 12,000	$ 12,000	$ 12,000	$ 37,000	$ 54,000	$ 54,000													
Channel modifications - Reach 5 (Tributary upstream to Tributary downstream)	$270,000			$ 18,000	$ 18,000	$ 18,000	$ 54,000	$ 81,000	$ 81,000													
Channel modifcations - Reach 6 (Tributary downstream to Godsey)	$319,000			$ 21,000	$ 21,000	$ 21,000	$ 64,000	$ 96,000	$ 96,000													
Channel modifications - Reach 7 (Godsey to G-Way)	$660,000			$ 44,000	$ 44,000	$ 44,000	$ 132,000	$ 198,000	$ 198,000													
Channel modifications - Reach T1 (Tributary channel)	$157,000			$ 53,000	$ 104,000																	
Hunter Street	$209,000																		$ 69,000	$ 140,000		
Subtotal for Site Specific Projects per Fiscal Year		**$ 75,000**	**$ 225,000**	**$ 709,000**	**$ 1,080,000**	**$ 411,667**	**$ 672,667**	**$ 863,667**	**$ 1,380,000**	**$ 800,000**	**$ 800,000**	**$ 800,000**	**$ 800,000**	**$ 953,000**	**$ 1,363,000**	**$ 877,000**	**$ 76,000**	**$ -**	**$ 69,000**	**$ 140,000**	**$ -**	**$ -**
Non-Site Specific Projects		$250,000	$ -	$ 250,000	$ -	$ -	$ 100,000	$ 110,000	$ 120,000	$ 130,000	$ 140,000	$ 150,000	$ 160,000	$ 170,000	$ 180,000	$ 190,000	$ 200,000	$ 220,000	$ 240,000	$ 259,000	$ 279,000	$ 299,000
Data Collection	$250,000	$250,000																				
Condition Assessment	$250,000			$250,000																		
Pipe Rehabilitation and Replacement[d]	$2,947,000						$100,000	$110,000	$120,000	$130,000	$140,000	$150,000	$160,000	$170,000	$180,000	$190,000	$200,000	$220,000	$240,000	$259,000	$279,000	$299,000
TOTAL PER FISCAL YEAR		**$325,000**	**$225,000**	**$959,000**	**$1,080,000**	**$411,667**	**$772,667**	**$973,667**	**$1,500,000**	**$930,000**	**$940,000**	**$950,000**	**$960,000**	**$1,123,000**	**$1,543,000**	**$1,067,000**	**$276,000**	**$220,000**	**$309,000**	**$399,000**	**$279,000**	**$299,000**

Notes

[a] Amount to be financed includes $35,000 for recommended downstream capacity analysis

[b] Kings Valley Highway at Bridlewood will be 100% paid for by others (Polk County or other).

[c] Weyerhaeuser project will be 100% developer financed;

Monmouth Cutoff west of Holman and Godsey Road will be paid by HBRR grant program;

Reach 6 modifications will be paid 50% by ACWCD;

Growth node projects are 100% developer paid.

[d] Rehabilitiation and repair cost assumed to be $120/foot; costs ramp up from 0.25 percent in 2020 to 0.5 percent in 2030 and leveling off at 1 percent by 2040.

Staffing Analysis

Recommended staffing for all stormwater operations and maintenance (O&M) activities, including administration, are summarized in Table ES-4.

TABLE ES-4
Recommended Staffing Need Summary
City of Dallas Stormwater Master Plan

Role	FTE for CIP and Regular O&M Activities	FTE for Full Implementation of Dallas TMDL Plan*	FTE for NPDES MS4 Permit	Total
Administration	1.0	0.25	0.5	**1.75**
O&M	3.3	1.2	0.5	**5**
Total FTEs	**4.3**	**1.45**	**1.0**	**6.75**

**City of Dallas Willamette TMDL Implementation Plan* (City of Dallas, 2008a).

CIP = capital improvement plan.
FTE = full time equivalent.
MS4 = Municipal Separate Storm Sewer System.

The stormwater system rehabilitation and replacement activities will be gradually increased over the course of the master planning period. O&M staffing levels should be similarly increased to keep pace with increased demands, starting with 0.25 full time equivalent (FTE) in the first 2 years for the data collection and condition assessment tasks and increasing to a total of 3.3 FTEs at the end of the master planning period. The 1 FTE administrative role should be filled in the first year of the capital improvement plan (CIP).

Implementation of the Dallas TMDL Plan is behind schedule. The 1.2 FTEs for O&M and 0.25 FTE for administration should be added in the first year of the master planning period.

In summary, a total of 1.45 FTEs for O&M and 1.25 FTEs for administration are recommended to be added in the first year of the capital plan. Maintenance staffing will increase to a total of 3.3 by the end of the master planning period *if an MS4 permit is not required*, and administration will remain at 1. 25 FTEs through the planning period *if an MS4 permit is not required*.

Staffing needs of 0.5 FTE for O&M and 0.5 FTE for administration should be added if and when an MS4 permit becomes required.

SECTION 1

Introduction

1.1 Purpose and Need

This master plan identifies and prioritizes necessary or desirable capital improvements and stormwater operational staffing needs of the City of Dallas and establishes a schedule and financing plan to implement the recommended necessary improvements.

More specifically, this plan presents the results of the analysis of the existing stormwater collection and conveyance system, focusing on existing problem areas to identify modifications and additions to correct current deficiencies and address predicted future needs.

1.2 Goals and Objectives

The goals and objectives of the master plan are as follows:

- Provide for the orderly provision of drainage services and provide for adequate flood protection within the City through the following actions:
  - Describe and analyze known stormwater system deficiencies
  - Identify and prioritize capital improvements to alleviate deficiencies
  - Develop geographical information system (GIS) database
- Provide financial planning for provision of drainage services through the following actions:
  - Develop capital cost estimates for identified capital improvements
  - Evaluate staffing needs for improved stormwater system
  - Develop appropriate system development charge and rate structure

1.3 Risks of Inaction

The risks of inaction are as follows:

- Loss of life
- Significant property damage
- Disruption of commerce
- Displacement of people
- Declining property values
- Increased nuisances
- Decreased community livability

1.4 Project Selection and Prioritization Criteria

The project selection and prioritization criteria are as follows with designated scores (100 maximum score):

- Relative hazard—consequences of failure or inaction (40):
  - Failure or inaction likely to result in loss of life (40)
  - Failure likely to result in significant (> $100,000) property damage and disruption of commerce/displacement of people (30)
  - Inaction likely to result in some disruption of commerce or displacement of people (25)
  - Inaction results in continuation of nuisance flooding occurring more than once every 5 years (10)

  - Inaction results in continuation of nuisance flooding occurring on average fewer than once every 5 years (5)
- Cost/benefit of project (30)
- One-time opportunity (20)
- Other benefits (20)
  - Water quality improvements
  - Educational opportunities
  - Recreational opportunities
  - Combined project opportunity

1.5 Intended Readers

This master plan was written for the following target audience:

- Managers and staff of City of Dallas to document the overall plan, continue providing reliable service, meet regulatory requirements, protect the public, protect the environment, and support the long-term goals of the community
- Members of the public to provide a better understanding of City of Dallas services and responsibilities, ongoing operations and maintenance activities, facility condition, and recommended concepts to meet current and future needs and requirements
- Subsequent engineering study and design teams for successful project implementation

SECTION 2

Watershed Characteristics

This section describes drainage characteristics unique to the City of Dallas and the watersheds that drain through the City. The following drainage characteristics are summarized: location, study area parameters, climate, soil conditions, land cover, topography, existing drainage facilities, and existing and future land use conditions. This information will be used in the master plan to evaluate the performance of the existing drainage facilities and to identify improvements to alleviate deficiencies.

2.1 Location and Waterways

The City of Dallas is located in Polk County, situated in the northern Willamette Valley between the Coastal and Cascade Mountain ranges. It is approximately 60 miles southwest of Portland and 15 miles west of Salem, Oregon.

Major waterways in the City include Rickreall Creek, Harland Slough (tributary to Baskett Slough), and the North Fork Ash Creek. Figure 2-1, Topography Map, shows the locations of these major waterways.

Rickreall Creek bisects the City, running from west to east for approximately 4.5 miles within the urban growth boundary. Rickreall Creek drains an area of 98 square miles, with a total length of 25 miles from the crest of the Coast Range to the Willamette Valley.

Significant tributaries to Rickreall Creek in the vicinity of the City include Ellendale Creek, Forestry Creek, and Baskett Slough. Ellendale Creek drains an area of approximately 3.75 square miles, and joins Rickreall Creek near the intersection of Martin Road and Ellendale Avenue, approximately 1 mile west of the City boundary. Forestry Creek drains approximately 740 acres, and enters the City at north of Ellendale Avenue, crossing under Ellendale at the northwest corner of Kingsborough Park. Forestry Creek is discussed in further detail in Section 7.1. Baskett Slough drains the rural area to the northeast of the City, entering Rickreall Creek approximately 4.25 miles downstream of City limits.

Additional detail about the North Fork Ash Creek is provided in Section 7.5.

2.2 Study Area Delineation

While this master plan considers runoff impacts from watersheds that contribute flow to critical analysis areas, the study area for this plan is defined by the current (2014) City boundary, and the La Creole and Barberry growth nodes. These growth nodes are identified as Master Plan Overlay Zones on the City of Dallas Zoning Map dated January 2014; they are outside of the City boundary but within the Urban Growth Boundary (UGB).

Figure 2-2, Study Area, shows the boundaries of the study area and the approximate extent of development as of July 2011. This map provides a visual indication of the limits of existing development and portions of the study area that are generally not yet developed.

Four major streets within the study area serve as references for describing locations in this plan: East Ellendale Avenue, West Ellendale Avenue, Kings Valley Highway/Highway 223, and Monmouth Cutoff.

Highway 223 runs through the City of Dallas, connecting the City to the City of Salem in the east and to Highways 194 and 20 to the south. Highway 223 turns from east-west to north-south at the intersection of Ellendale Avenue and the Kings Valley Highway. Within the City, Highway 223 is named East Ellendale Avenue for the east-west portion, and Kings Valley Highway for the north-south portion. For clarity in this report, Highway 223 will be referred to as either East Ellendale Avenue or Kings Valley Highway/Highway 223. The portion of Ellendale Avenue west of Highway 223 is referred to as West Ellendale Avenue.

2.3 Climate

The climate of the City of Dallas is similar to the other areas of the upper Willamette Valley. It is generally mild and marked by long wet winters and short dry summers. Its climate results from moist maritime air masses moving from the Pacific Ocean (approximately 30 miles away) inland over the Coastal Mountain Range.

2.3.1 Precipitation and Temperature

The entire Willamette Valley is characterized by cool, wet winters and warm, dry summers. On the average, 74 percent of the precipitation occurs during the winter months from November through March, while only 5 percent normally occurs during the three summer months. The average annual rainfall in Dallas is approximately 47 inches. Winter days are generally cloudy, and rainfall on a daily basis is not uncommon. The months with the greatest amounts of precipitation are November, December, and January. The maximum average monthly precipitation is approximately 9 inches and usually occurs in December. Local peak runoff events are, therefore, most likely to occur during the winter months from November through March.

There are typically only several days with any measurable snowfall. Snowfall depths rarely exceed 1 to 2 inches and will usually melt in a day or two. Snowmelt is not considered to have a significant impact on the local watershed.

Only a fraction of the annual rainfall takes place between July and September. The lack of precipitation and increased irrigation during the summer months significantly reduces the flow in the major waterways. Average monthly temperatures range 50 degrees Fahrenheit (°F) between the coldest temperatures in January to the warmest temperature in July. The average maximum and minimum temperatures are 47°F and 35°F in January and 83°F and 51°F in August. Winter low temperatures generally average in the middle to upper 30s, while average daily summer temperatures are in the middle 70s to low 80s. Therefore, during the infrequent summer storm, potential runoff is often largely evaporated by hot temperatures and/or absorbed by dry soils.

2.3.2 Precipitation Depth

The amount of stormwater runoff generated by a storm depends on the amount of rain that falls as well as the moisture conditions of the soil. If the soil is wet from previous rain events, it will have less capacity to absorb the rainfall and, as a result, more of the rain will become runoff.

For analytical purposes, storms are characterized by their probability of occurrence in a given year; this probability is expressed as a recurrence interval in terms of years. A storm that has a 1 in 100 chance of occurring in any given year is referred to as the 100-year storm (100 divided by 1 is 100), while a storm that has 20 out of 100 chance of occurring in a given year is referred to as the 5-year storm (100 divided by 20 is 5). The depth of rainfall associated with storms of various recurrence intervals is provided in Table 2-1. These depths represent the cumulative rainfall over a 24-hour period; the intensity of the rainfall will vary over the course of the 24 hours.

TABLE 2-1
Precipitation Associated with Storm Recurrence Interval

Recurrence Interval	24-hour Precipitation (inches)
2-year	3.1
5-year	3.9
10-year	4.6
25-year	5.2
50-year	5.7
100-year	6.3

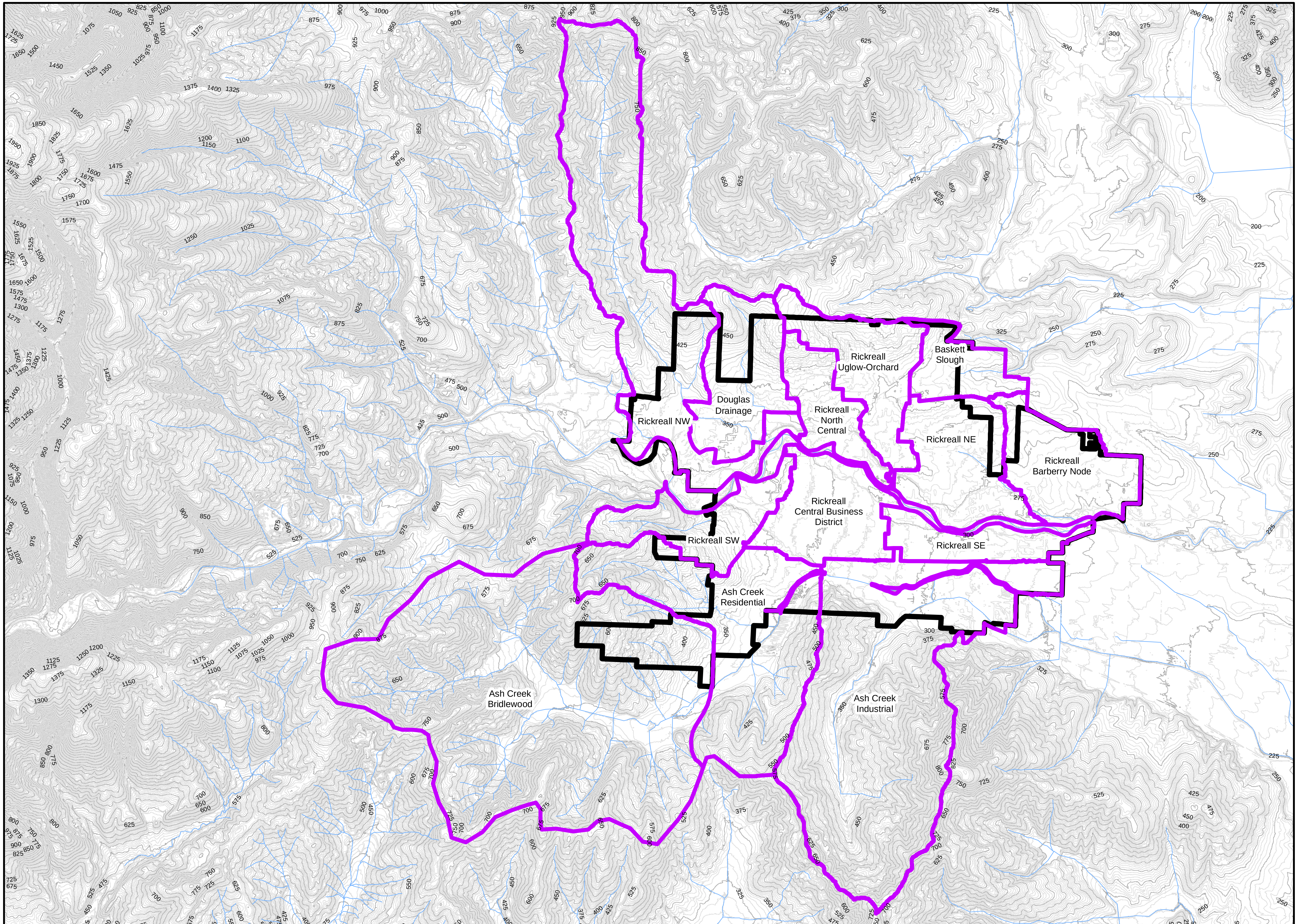

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FIGURE 2-1

Topography

City of Dallas Stormwater Master Plan

Legend

Major Basins

City Boundary

Streams

Contour Interval

25 ft (NGVD29)

5 ft (NGVD29)

N

1 inch equals 3,200 feet

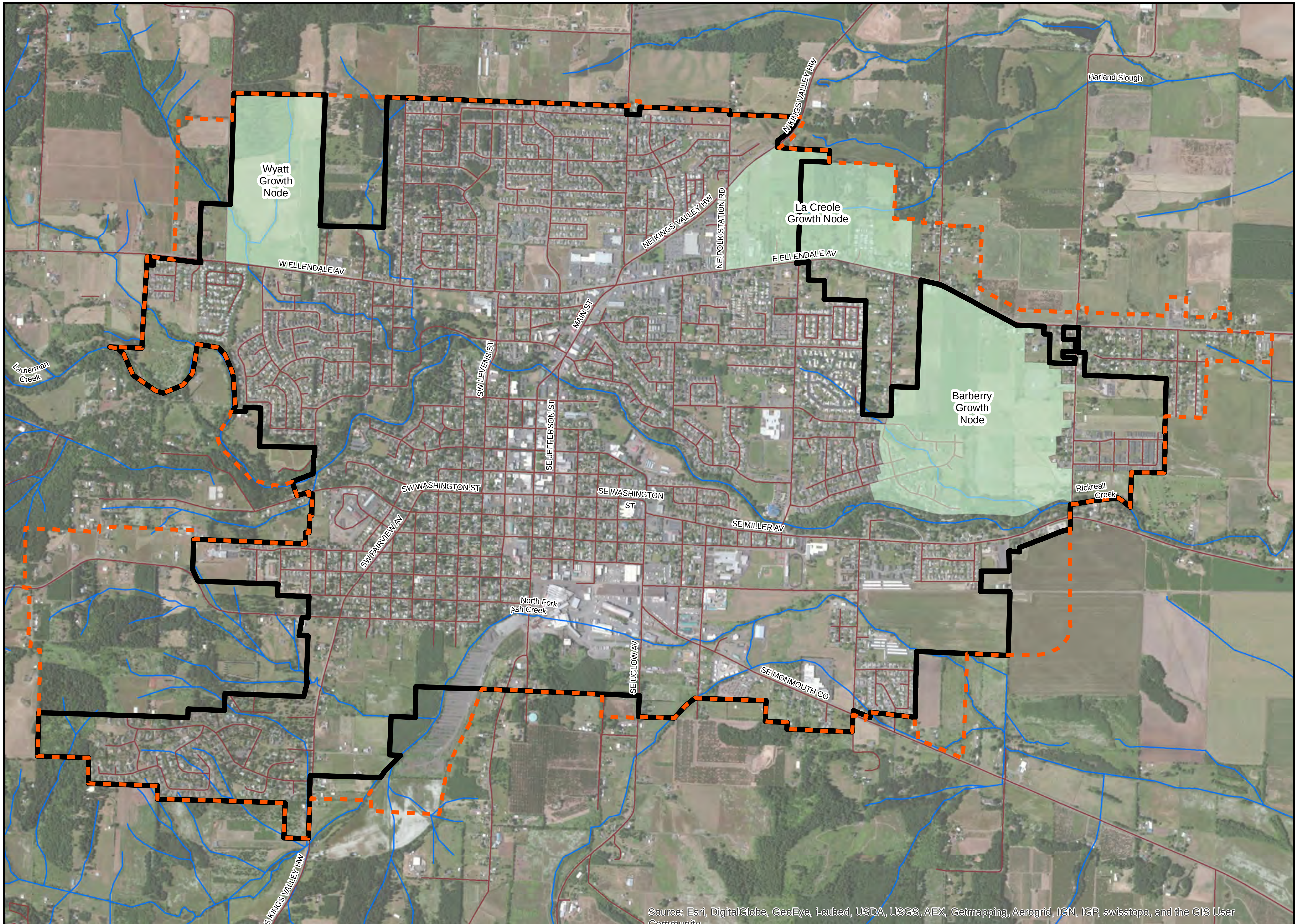
CH2MHILL

Date: 12/18/2014

FIGURE 2-2

Study Area

City of Dallas Stormwater Master Plan



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Legend

- UGB
- City Boundary
- Growth Nodes
- Roads
- Streams

N

1 inch equals 1,600 feet

CH2MHILL

Date: 12/18/2014

2.4 Soils

Knowledge of local soil conditions and response to precipitation is essential for evaluating a drainage system. There are various disposal paths possible for precipitation. Besides creating runoff, precipitation may evaporate, collect in depressions, be intercepted by plants, or infiltrate into the soil. When precipitation exceeds the capacity of these loss paths, surface water runoff is generated.

Runoff rates and total runoff volumes are increased by the amount of impervious ground cover such as rooftops and pavements. Runoff rates are also increased by the existing degree of soil saturation and by the slope of the watershed. Runoff potential is based on the soil's capacity to absorb precipitation. The lower the soil's infiltration capacity, the higher will be its runoff potential. Sandy soils generally have higher infiltration capacity and lower runoff potential, while impervious surfaces have limited infiltration capacity and very high runoff potential.

Based on runoff potential, soils are grouped into SCS (now called NRCS) hydrologic groups A, B, C, or D. Soils in hydrological group A have good infiltration and low runoff potentials, while those in group D have poor infiltration and high runoff potentials. Classifications of the soils in the study area are presented in Table 2-2. The locations of these hydrologic soil groups within the study area are shown in Figure 2-3. Within the study area, nearly 99 percent of the area is covered with soils of moderate or poor permeability (hydrologic group C, C/D, or D).

TABLE 2-2
Hydrological Classification of Soils
City of Dallas Stormwater Master Plan

Soil Classification*	Hydrological Group
Abiqua silty clay loam, occasionally flooded	C
Amity silt loam	C/D
Camas gravelly sandy loam	A
Chehalis silty clay loam, occasionally flooded	B
Cloquato silt loam	B
Coburg silty clay loam	C
Cove silty clay loam	D
Dayton silt loam	D
Holcomb silt loam	D
Malabon silty clay loam, occasionally flooded	C
Waldo silty clay loam	C/D
Xerochrepts and Haploxerolls, steep	B
Xerofluvents, loamy	A
Briedwell silt loam	B
Abiqua silty clay loam	C
Dupee silt loam	C
Hazelair silt loam	D
Jory silty clay loam	C
McAlpin silty clay loam	C
Nekia silty clay loam	C
Rickreall silty clay loam	D
Salkum silty clay loam	C
Steiwer silt loam	C
Suver silty clay loam	D
Bashaw silty clay	D
Willakenzie silty clay loam	C
Willamette silt loam	B
Bellpine silty clay loam	C

*Listed in order of most to least prevalent.

2.5 Topographical Features

Although the City of Dallas' west side lies along the eastern foothills of the Coastal Mountain Range, the majority of the City's topography is relatively flat. Figure 2-1, Topography Map, shows the Dallas watershed boundaries and its topography.

Both the Rickreall Creek and North Fork Ash Creek waterways drain a portion of the study area. These waterways, with their tributaries, meander through the area's flat terrain; Rickreall Creek flows through the central part of the study area and Ash Creek is to the south. The developed lands of Dallas adjacent to Rickreall Creek are situated above high water and are provided with sufficient slope for storm drainage systems.

The Rickreall Creek basin on the south side of Rickreall Creek, and the North Fork Ash Creek basin are both very flat with little topographic relief. Flood water may cross basin boundaries in a peak flow event.

The 100-year floodplain within the study area was established as part of the Federal Emergency Management Agency (FEMA) *Flood Insurance Study for the City of Dallas* (2006a). The floodplain for the North Fork Ash Creek does not account for redirection of the tributary that enters the mainstem from the south approximately 1,000 feet east of Holman Road. Before the redirection, the tributary ran west to east on the north side of the Monmouth Cutoff highway, joining the mainstem east of Godsey Road near G-Way Ranch. The regulatory floodway is designated with cross hatches on the City of Dallas zoning map shown in Figure 2-4.

2.6 Groundwater

Soils within the Dallas UGB are predominantly of hydrologic type C or D. These soils have low infiltrative capacity during large events. Except in localized areas, disposal of stormwater through surface infiltration is not considered to be an effective strategy. Also for this reason, groundwater and stormwater interactions are assumed to be minimal.

2.7 Existing Drainage System

Stormwater runoff is drained by pipe and open channel systems throughout the watershed. Most of the runoff from the urbanized areas, especially the central business district, is piped. Runoff is transported through these pipes and discharged into the creeks and streams flowing through the City. The existing municipal stormwater system configuration is shown in Figure 2-5. As part of this master plan, data about the storm drainage system were converted from computer-aided drafting (CAD) files to a database that can be used with GIS to facilitate future system analysis and asset management. The available data are limited and will be supplemented with additional information in the future.

2.8 Land Use

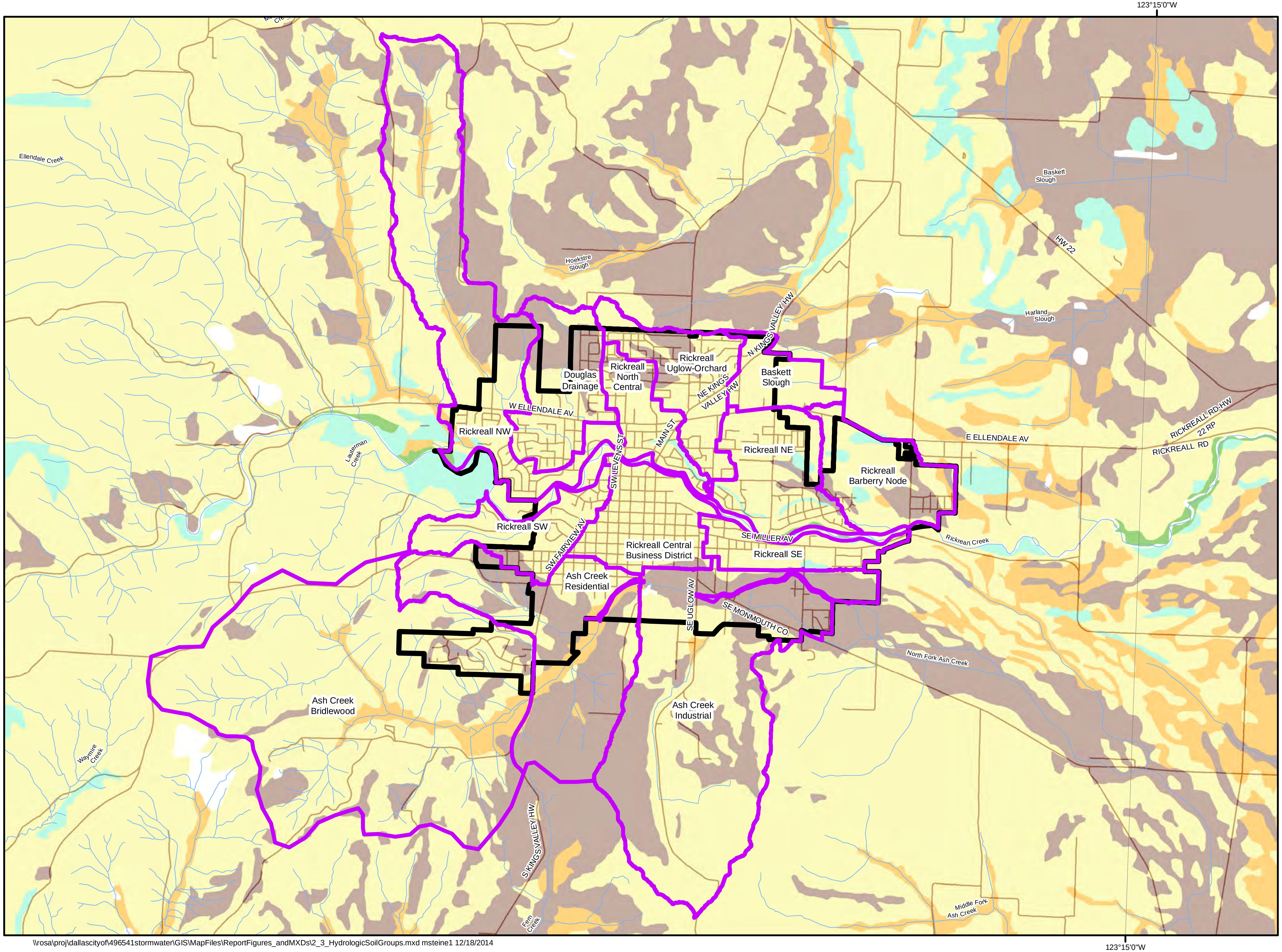
Knowledge of local land use practices is essential for developing a successful stormwater master plan because as a watershed urbanizes, impervious areas within the drainage basin typically increase. This increase in impervious area can often dramatically increase the amount and rate of runoff within the watershed. Increases in impervious area also decrease the time of concentration within the watershed. Time of concentration refers to the time it takes for runoff from the most hydraulically distant point in the basin to reach the outlet point of interest. These parameters are explained in more detail in Section 4.8.

To minimize the risk of flooding and to protect against the loss of property, a drainage system is typically designed to accommodate both existing flows and anticipated future flows for some frequency of occurrence that is commensurate with the potential for loss. The basis for existing and future impervious areas is discussed below.

FIGURE 2-3

Hydrologic Soil Groups

City of Dallas
Stormwater Master Plan



Legend

- Major Basins
- City Boundary
- Streams

Hydrologic Soil Class

- A
- B
- C
- C/D
- D
- Roads

N

1 inch equals 3,200 feet

CH2MHILL

Date: 12/18/2014

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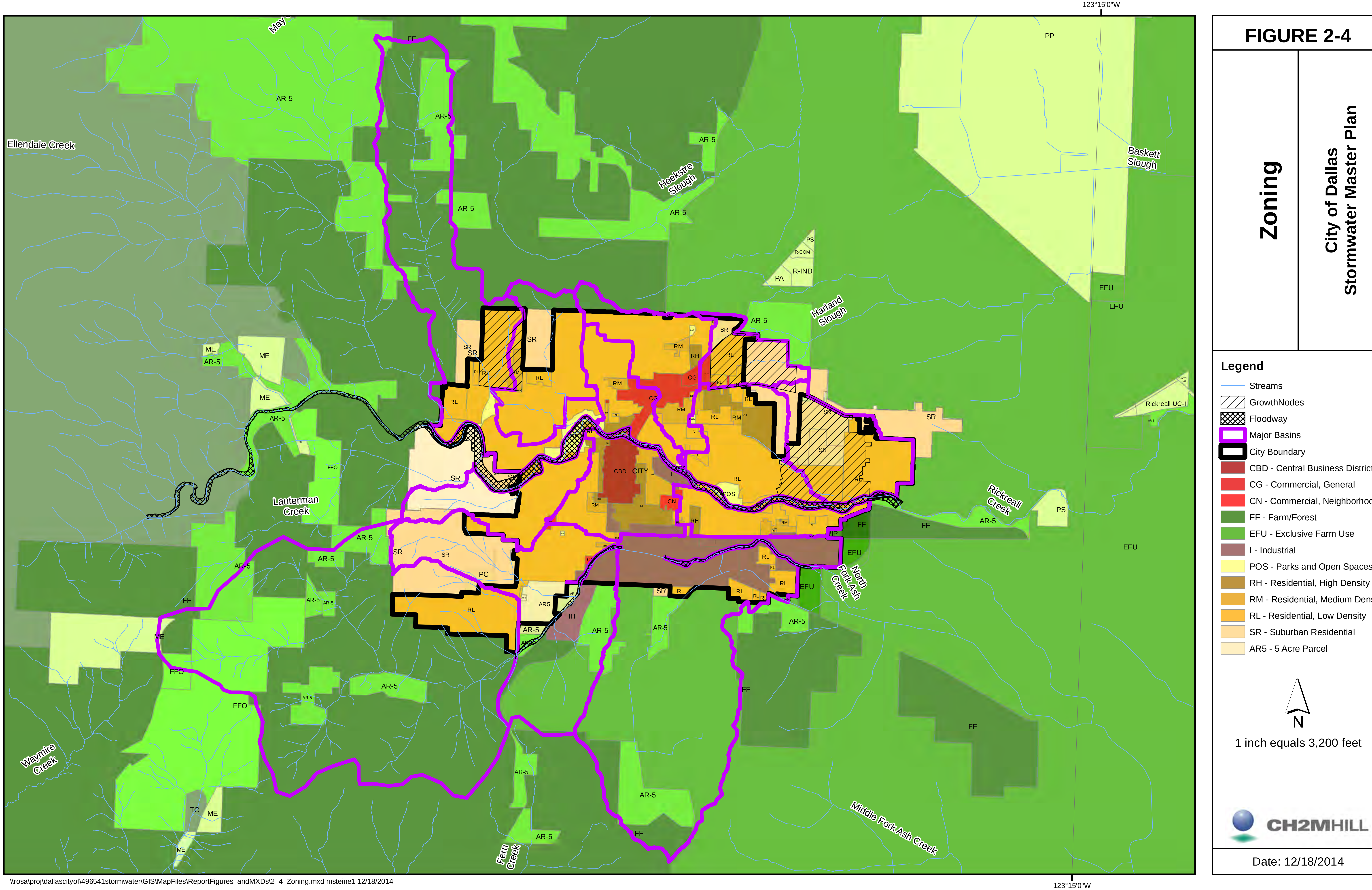

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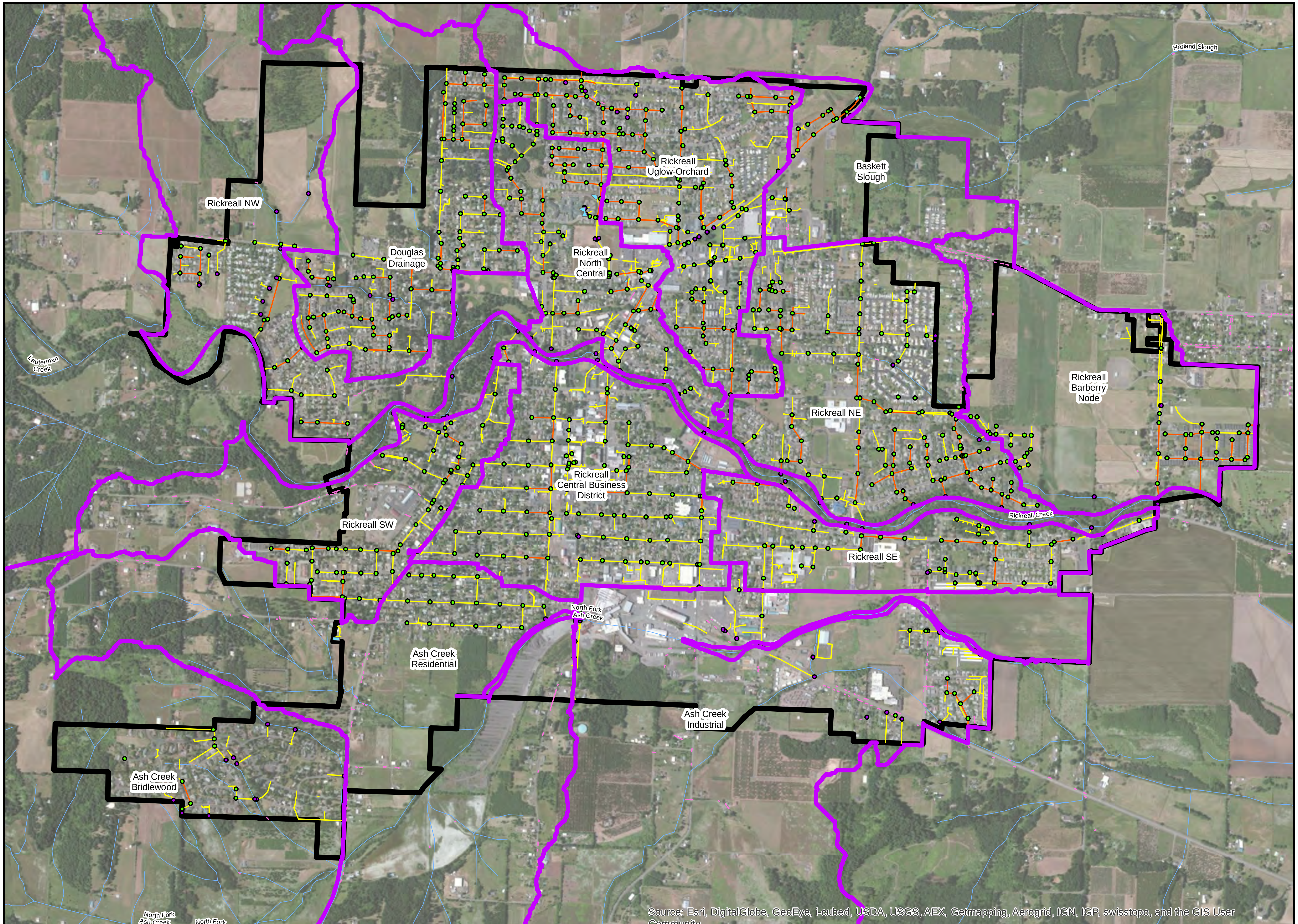
FIGURE 2-5

Existing Stormwater System

City of Dallas
Stormwater Master Plan



Legend

- Major Basins
- Storm Detention
- Manhole
- Outfall
- Storm Pipe (complete data)
- Storm Pipe (incomplete data)
- Storm Culvert
- City Boundary
- Streams

N

1 inch equals 1,500 feet

CH2MHILL

Date: 12/18/2014

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The City of Dallas Stormwater Master Plan study area is delineated by the current (2014) City boundary, and the La Creole and Barberry growth nodes. The study area is currently zoned for residential, commercial, industrial, parks, and agricultural and forest uses. Figure 2-4 shows a map of each zoned region in the study area. Figure 2-6 provides a breakdown of each land use by percentage of total area in the study area.

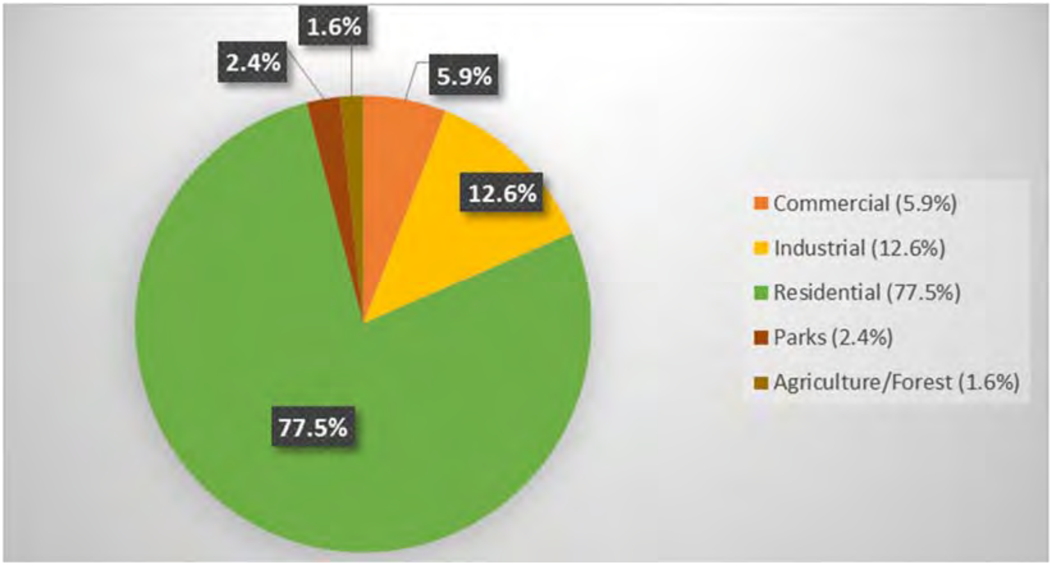

FIGURE 2-6
Percentage of Total Study Area by Land Use
City of Dallas Stormwater Master Plan

2.8.1 Residential

There are approximately 2,404 acres within the City limits zoned for residential use—comprising approximately 77.5 percent of the total area. Single-family homes are the predominant residential type in the City. Over 85 percent of the residential land area within the City limits is zoned as single-family use, with the remaining 15 percent zoned for duplex or multi-family residential.

2.8.2 Industrial

There are two major industrial areas in Dallas. The larger of the two is at the southern limits of the City, with drainage to the North Fork of Ash Creek. Most of the industrial area is currently developed, though some areas of the North Fork Ash Creek industrial lands are not. The other, smaller industrial area is east of the downtown area on the south side of Rickreall Creek.

2.8.3 Commercial

Existing, zoned, and ultimate commercial development is concentrated along NE Kings Valley Highway/Highway 223, portions of East and West Ellendale Avenue, and the central business district. Shopping centers, big box retailers, fueling stations, and warehouse sales operations are generally located to the northeast of City Center along NE Kings Valley Highway/Highway 223 and Ellendale Avenue. These areas are characterized for drainage purposes by large expanses of parking areas. The downtown area generally tends towards shops, office space, and institutional centers with smaller parking areas and a higher density of structures.

2.8.4 Parks

Parks and open spaces are zoned throughout the study area. Three of the parks are significant in size. All areas zoned as parks are located outside of the central business district, commercial, and industrial zones and are instead surrounded by residential spaces.

2.8.5 Agricultural/Forest

Very little of the study area is designated for agricultural or forest use. The largest zone is located in the southwest corner of the study area.

2.8.6 Floodplain

In 2006, FEMA updated its Flood Insurance Study for Polk County and incorporated areas—study number 41053CV000A (FEMA, 2006b). This study is required as part of the National Flood Insurance Act of 1968 and Flood Disaster Protection Act of 1973. The City of Dallas has adopted regulation to restrict floodplain development.

Floodplain areas are shown on the City's comprehensive plan land use map (2008b) and are illustrated in Figure 2-4. These floodplain areas serve as high flow storage areas and over-sized conveyances for peak storm events. Most of these zones are located along major waterways, such as the North Fork of Ash Creek and Rickreall Creek. The North Fork Ash Creek floodplain does not reflect the redirection of the tributary flow, which now enters the mainstem North Fork east of Holman Road.

2.9 Land Cover

The Multi-Resolution Land Characteristics (MRLC) consortium is a group of federal agencies that have generated information on the Nation's land cover called the National Land Cover Database (NLCD).

The NLCD is based primarily on 2011 Landsat satellite data and provides a percent impervious in a 30-meter resolution for the City of Dallas. To simulate buildout conditions, percent impervious values were modified by zoning classification to reflect the change in land cover from current conditions to buildout—see Section 3.2 for a more detailed explanation. Figure 2-7 shows the percent impervious for all the major basins in the study area.

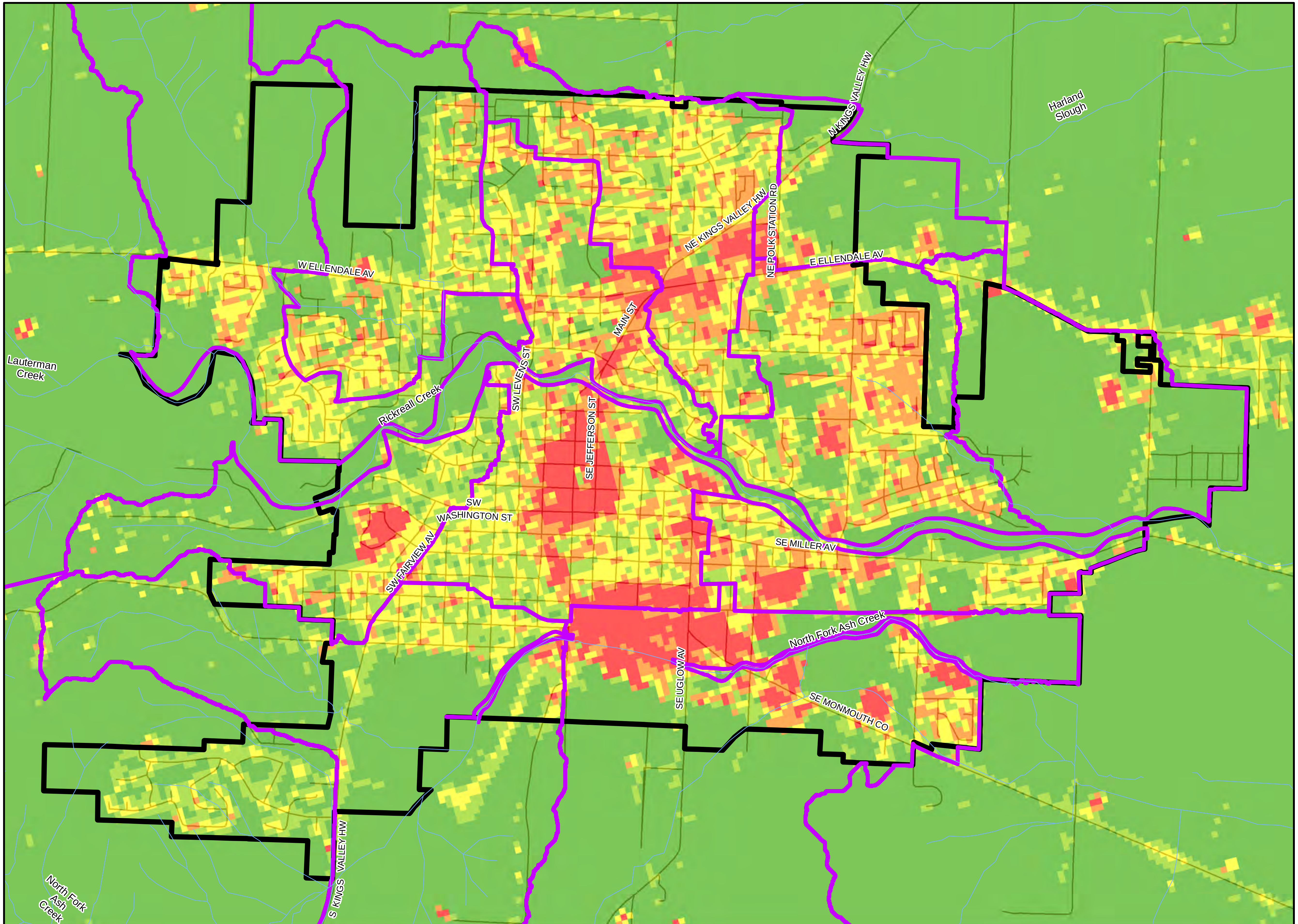

FIGURE 2-7

Land Cover (Impervious Area)

City of Dallas
Stormwater Master Plan

Legend

- Streams
- Major Basins
- City Boundary

Impervious Area (Percent)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- Roads

N

1 inch equals 1,500 feet

CH2MHILL

Date: 1/29/2015

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SECTION 3

Analysis Approach and Methodology

This section describes the analysis approach and methodology taken to evaluate drainage needs to accommodate future peak flows. First, the overall analysis approach is described. Then, several basic assumptions are presented, followed by a description of the methods used for the hydrologic and hydraulic analyses.

3.1 Analysis Approach

The primary objective of the analysis was to evaluate the adequacy of the existing drainage systems at sites known to experience flooding and to develop a phased capital improvements plan to upgrade inadequate facilities. The City identified several sites of that have experienced roadway overtopping surface flooding during rain events in the past. These sites are shown in Figure 3-1 and include:

- Douglas Street at the inlet to the piped system
- Fairhaven Street culvert
- Murphy's Grill parking lot at the inlet to the piped system
- Culverts under Kings Valley Highway/Highway 223 near the cemetery
- Kings Valley Highway/Highway 223 crossing of North Fork Ash Creek at the Bridlewood subdivision
- The former Weyerhaeuser property
- Uglow Street
- Monmouth Cutoff crossing of the North Fork Ash Creek
- Monmouth Cutoff crossing of the tributary
- Godsey Road

This study identifies improvement alternatives and selects conceptual system improvements for each of the identified problems.

This approach was used first to analyze the drainage system's response to existing peak flows, and then its response to future peak flows. The system improvements were selected to enable the system to convey the peak future 100-year flow without causing surface flooding.

In order to evaluate hydraulic deficiencies and potential solutions, hydrologic analysis was first conducted to determine peak flow for multiple recurrence intervals. Results of the hydrologic analysis also provide a planning basis for future infrastructure needs in the La Creole and Barberry growth nodes.

3.2 Basic Assumptions

The following basic assumptions for the hydrologic analysis were made:

- Hydrologic flows will be assessed at three points in time:
  - The present (current condition)
  - 20-year planning horizon
  - Full buildout
- Assumptions for determining the runoff curve number and impervious area for each subbasin at each of these points in time are as follows:
  - Current Condition

    Land use and percent impervious based on City zoning map and NLCD 2006 data, verified with visual inspection and comparison to Dallas development code
  - 20-year planning horizon

  - o Land use for growth areas identified by City (La Creole and Barberry nodes) will be based on full buildout to City zoning map. Percent impervious will be based on areas of same zoning class that are currently fully built out.
  - o Land use for non-growth areas will be assumed to be same as current condition.
- – Full Buildout

  Land use for entire planning area will be based on full build out to City zoning map. Percent impervious will be based on areas of same zoning class that are currently fully built out.

- Hydraulic improvements will be sized for conveyance of the peak runoff from the future 100-year storm.
- Surcharge within hydraulic structures is acceptable but surface flooding is to be prevented.
- Rainfall is assumed to be uniform throughout the watershed during a design storm event. That is, the design rain event occurs at the same time and uniformly across the entire City.
- Parameters, such as hydrologic soil types, will be estimated for drainage subbasins using parameter values weighted by area within each subbasin.
- The SCS 100-year 24-hour Type 1A storm is assumed to be the design storm. The National Oceanic and Atmospheric Administration's (NOAA) *Precipitation-Frequency Atlas of the Western United states, Volume X—Oregon*, 1973, was used to determine precipitation depth for various return intervals.

3.3 Hydrologic Analysis

Two methods were used to estimate peak flows from drainage areas within the study area. The first was the SCS method using hydrologic modelling software HEC-HMS (v3.1.0) by U.S. Army Corps of Engineers (USACE), and the second consisted of prediction equations published by the U.S. Geological Survey (USGS). In general, HEC-HMS was used to estimate peak flows from subbasins within the UGB or tributary to Rickreall Creek, while the USGS regression equations were used for the large rural basins tributary to the North Fork Ash Creek. A brief description of each of these analytic methods is provided in the following subsections.

3.3.1 HEC-HMS

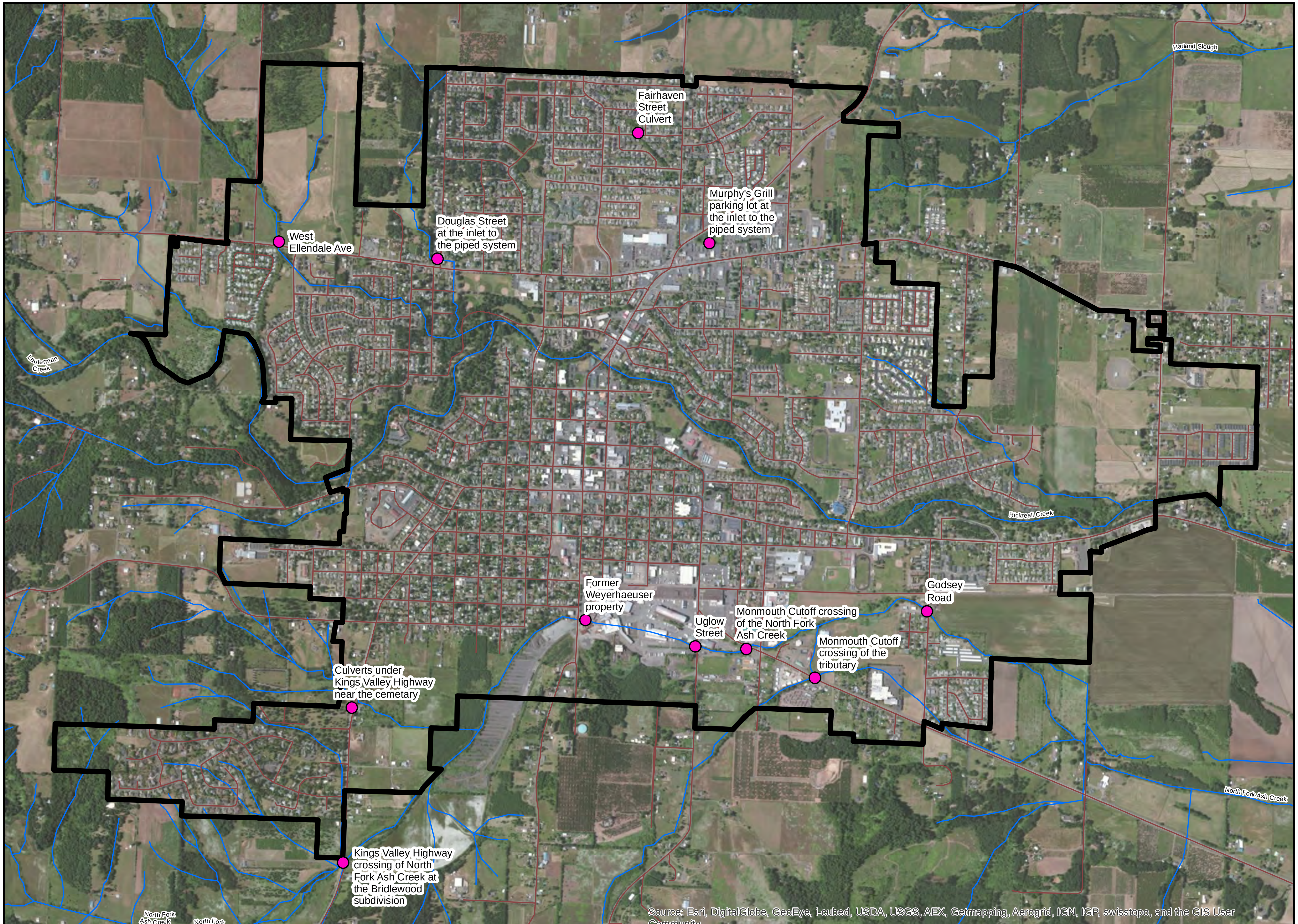
The HEC-HMS model is designed to simulate the stormwater runoff response in a basin for a given precipitation event. The rainfall hyetograph is translated into a runoff hydrograph and the hydrograph from each subbasin is routed by the model to the point of confluence with other subbasins. When combined with the hydrograph from another subbasin, a composite hydrograph is computed by the model that accounts for any differences in time of concentration between the two hydrographs. The Muskingum-Cunge method was used for routing the runoff hydrographs through the subbasins and major drainageways. The runoff hydrograph was determined by using the SCS unit hydrograph method[2]. This method uses lag time as the single parameter in a set of empirical equations to determine the shape of the runoff hydrograph for each subbasin. The HEC-HMS model requires five input parameters for calculating the runoff hydrograph in each subbasin: total subbasin area, curve number, impervious area, lag time, and precipitation.

[2] The Soil Conservation Service (SCS) was renamed the National Resources Conservation Service (NRCS) in 1994. However, HEC-HMS uses the old nomenclature.

FIGURE 3-1

Identified Problem Areas

City of Dallas
Stormwater Master Plan



Legend

- Identified Problem Areas
- City Boundary
- Roads
- Streams

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1 inch equals 1,500 feet

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3.3.1.1 Total Subbasin Area

Subbasin area is the watershed within which runoff can be assumed to flow to a single discharge point.

3.3.1.2 Composite Soil Conservation Service Soil Curve Number

The soil curve number is used to determine the initial abstraction and runoff potential based on the composite hydrologic group of the soils, land use, and percent impervious area within each subbasin. The greater the soil curve number, the more impervious the soil is to infiltration and the greater the percentage runoff.

3.3.1.3 Percent Impervious Area

The percent of impervious area was calculated based on NLCD data and used to calculate a composite curve number. Because impervious area was considered in the calculation of the composite soil curve number, no impervious area was specified separately from the composite curve number. High percent impervious area results in larger composite curve number.

3.3.1.4 Lag Time

Lag time (in hours) is a function of time of concentration and is the time difference between the peak precipitation intensity and the peak runoff rate from the subbasin in question.

The result of the HEC-HMS modeling process is the computation of subbasin runoff hydrographs (runoff from each individual subbasin versus time) and stream flow hydrographs (stream flow rates from all upstream subbasins versus time). The free flowing peak flows at desired locations in the drainageways were estimated for both existing and ultimate (full buildout) development conditions. Peak flows from individual subbasins (SubBasin Flows) for the full buildout condition for the 10- and 100- year recurrence intervals are described in Section 5, Basin Runoff Analysis and Results.

3.3.1.5 HEC-HMS Model Calibration

Flow data were not available to calibrate the HEC-HMS model.

3.3.2 USGS Prediction Equations

For three large rural subbasins draining to the North Fork Ash Creek, results of the HEC-HMS model were considered to overestimate peak flows. Flows for these large rural basins were instead calculated using prediction equations developed by the USGS, in coordination with the Oregon Water Resources Department, for estimating peak discharges for rural, unregulated streams in western Oregon. Western Oregon was divided into three flood regions and prediction equations were developed for estimating peak discharges at ungaged sites for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals. The City of Dallas lies in flood region 2B.

The equations relate peak discharge to physical and climatological watershed characteristics including drainage area, slope, and precipitation intensity. Data from 376 gaged watersheds were used in generalized least-squares regression analysis to determine the prediction equations for ungaged watersheds. The average standard error of prediction for the equations ranges from 31.9 percent for the 2-year recurrence interval to 37.7 percent for the 500-year recurrence interval. The standard error for the 100-year recurrence interval is 35 percent. The equations for each recurrence interval are as follows:

$$Q(2) = 9.136 Area^{0.9004} Slope^{0.4695} I24-2^{0.8481}$$
$$Q(5) = 14.54 Area^{0.9042} Slope^{0.4735} I24-2^{0.7355}$$
$$Q(10) = 18.49 Area^{0.9064} Slope^{0.4688} I24-2^{0.6937}$$
$$Q(25) = 23.72 Area^{0.9086} Slope^{0.4615} I24-2^{0.6578}$$
$$Q(50) = 27.75 Area^{0.9101} Slope^{0.4559} I24-2^{0.6390}$$
$$Q(100) = 31.85 Area^{0.9114} Slope^{0.4501} I24-2^{0.6252}$$
$$Q(500) = 41.72 Area^{0.9141} Slope^{0.4365} I24-2^{0.6059}$$

Estimated peak flows are input to the hydraulic models described below. The HEC-HMS hydrologic model estimates “how much” flow is occurring and the hydraulic models estimate “how deep” the flow will get in the various types of conveyance structures.

3.4 Hydraulic Analysis

Hydraulic analysis was focused on the areas of known flooding problems shown in Figure 3-1. A systems approach was used to group sites that are hydraulically linked. These groups were then analyzed as functional systems rather than isolated problems. Further discussion of these groupings is provided in Section 7, Analysis Results and Recommended Improvements.

The sections below describe the computational tools used to evaluate the hydraulic performance of various components of the stormwater system at each of the identified problem areas under existing and future conditions. Specific information about the application of these hydraulic analysis tools is provided in Section 7.

3.4.1 XPSWMM

XPSWMM by XP Solutions was used to model existing and proposed infrastructure to alleviate flooding at several of the identified problem sites. XPSWMM is a comprehensive hydrologic and hydraulic modeling environment that calculates conveyance capacity and water surface elevations for all hydraulic structures. XPSWMM was used to determine appropriate pipe and culvert sizes and channel dimensions for the Douglas, Uglow/Orchard, and Cemetery systems. Appendix A contains the XPSWMM analysis reports.

3.4.2 FlowMaster

Bentley FlowMaster is a hydraulic analysis and design software for open channels, pipes, weirs, and orifices. It was used in this plan to size trapezoidal channels to convey the peak 100-year storm flow between road crossings of the North Fork Ash Creek, as described in further detail in Section 7. The software was used to determine the required bottom width to convey a given flow with specified normal water depth, longitudinal slope, and side slope. Gradually varied flow analysis was then performed to generate a water depth profile in each reach, given a downstream water surface elevation. FlowMaster was used in conjunction with HY-8 to evaluate channel and culvert requirements. Appendix B contains the FlowMaster and HY-8 analysis reports.

3.4.3 HY-8

The Federal Highway Administration’s (FHWA) culvert hydraulic analysis program HY-8 (Version 7) was used to determine the size of culverts required to pass the 100-year peak flow under the existing crossings on the North Fork Ash Creek. The HY-8 model incorporates analytical methods described in FHWA’s Hydraulic Design Series Number 5 (FHWA, 2012). The program essentially computes hydraulic conditions at the inlet and outlet of the culvert over a range of flows and produces rating curves for inlet and outlet control conditions. The capacity of a culvert is typically evaluated based on the lower performance of those two curves. This ensures adequate performance under the least favorable hydraulic conditions. HY-8 was used in conjunction with FlowMaster to evaluate channel and culvert requirements. Appendix B contains the FlowMaster and HY-8 analysis reports.

3.4.4 HEC-RAS

The existing HEC-RAS hydraulic model developed by the Ash Creek Water Control District for the *Ash Creek Flood Study* was reviewed and considered for use in the current hydraulic analysis. The existing model includes the North Fork, Middle Fork, and the main stem of Ash Creek, but does not include the North Fork tributary associated with flooding of the Monmouth Cutoff highway in Dallas. Additionally, the Monmouth Cutoff crossing west of Holman Street, was not included in the model, nor was the culvert at the former Weyerhaeuser property.

None of the road crossings identified as problem areas for this stormwater master plan were shown to be inundated by the flows included in the existing model. Updating the steady flow data with results of the hydrologic analysis conducted for this project did result in inundation at the expected locations.

However, because the model did not include all of the structures on the main stem channel of the North Fork and did not model the interaction between the tributary and the North Fork, it cannot be used as an accurate tool for evaluating either existing conditions or potential improvements. Additional field data including channel and structure geometry and flow data are required to update and calibrate the existing HEC-RAS model so that it can be used to accurately evaluate existing conditions and potential improvements.

SECTION 4

Basin Delineation and Model Parameters

This section describes the process used to delineate the major drainage basins and subbasins within those major basins. It also explains the conventions used for referencing the subbasins and briefly describes each major drainage basin within the Dallas watershed including a summary of acreages. The following sections describe and then quantify the other input parameters for the computer runoff model: percent impervious area, soil loss parameter, initial abstraction and soil retention, and lag time.

4.1 Major Drainage Basins

The major drainage basins are shown in Figure 4-1. Major drainage basins were defined according to existing drainage routings within the City and topography. The major basins include Ash Creek Bridlewood, Ash Creek Industrial, Ash Creek Residential, Baskett Slough, Douglas, Rickreall Barberry, Rickreall Central Business District (CBD), Rickreall North Central (NC), Rickreall Northeast (NE), Rickreall Northwest (NW), Rickreall Southeast (SE), Rickreall Southwest (SW), and Rickreall Uglow-Orchard (UO).

The names, abbreviations, and areas of the major basins are summarized in Table 4-1.

TABLE 4-1
Major Drainage Basin Abbreviations and Drainage Area Acreages
City of Dallas Stormwater Master Plan

Major Basin Name	Basin Prefix	Drainage Area (acres)
Ash Creek Bridlewood	A-BW	2,056
Ash Creek Industrial	A-I	1,379
Ash Creek Residential	A-R	783
Baskett Slough	BS	160
Douglas	R-D	334
Rickreall Barberry	R-B	315
Rickreall CBD	R-CBD	302
Rickreall NC	R-NC	190
Rickreall NE	R-NE	349
Rickreall NW	R-NW	986
Rickreall SE	R-SE	174
Rickreall SW	R-SW	254
Rickreall UO	R-UO	311
Total		7,593

4.2 Subbasin Delineation Methodology

To refine the modeling analysis and facilitate evaluation of known drainage improvements, each major basin was further delineated into subbasins. The factors used to delineate the subbasins are as follows:

- **Size roughly between 30 and 60 acres**—Subbasin areas within this range increase the modeling accuracy of peak flow analysis and are typically used in stormwater master planning. Some subbasins are smaller than 30 acres, particularly near the commercial or downtown areas, due to presence of extensive piped networks. Subbasins larger than 150 acres are located outside of the Dallas study area.

- **Similar zoning or land uses within subbasin**—Since runoff rates and amounts are significantly impacted by impervious surface areas and since the amount of impervious surfaces is largely a function of zoning intensity, delineating subbasins with relatively uniform land uses allows more meaningful runoff parameters to be estimated.
- **Consistent topography**—Since the time for runoff to reach the outfall of a subbasin from the furthest reaches of the subbasin is an important factor in the determination of peak flows and since flow time is related directly to slope, accuracy is improved if the subbasin is drawn to include areas of relatively uniform slope.
- **Consistent soil type**—Since runoff is that portion of precipitation that is not absorbed by the soil or otherwise retained, and since the type of soil is directly related to how much water infiltrates through the soil, the estimation of subbasin flows is more realistic if the subbasins are drawn to include areas of relatively uniform soils.
- **Common outfall**—Generally, the subbasin should be drawn so that all flow from the subbasin discharges at one point, i.e., one storm drain outfall or a creek. For those subbasins which lie along major waterways, discharges into the waterway are often numerous and sometimes indistinct. However, these subbasins, which discharge along drainageways, can generally be considered as if they discharged at a single outfall into the waterway.

Using the above factors, this delineation process resulted in 118 subbasins with areas generally ranging in size from 20 to 120 acres within the study area. The locations of these subbasins are identified in Section 6, Basin Runoff Analysis and Results. The coding and drainage parameters of these subbasins are described below.

4.3 Subbasin Coding Convention

Subbasin coding is required as input into the stormwater computer models and is useful to reference drainage subbasin areas. Each of the thirteen major drainage basins was assigned a prefix to facilitate subbasin coding. The major drainage basins and their subbasin code prefixes are listed in Table 4-1.

To describe the subbasin coding convention used in this stormwater master plan, a portion of the Douglas basin, shown in Figure 4-2, is used as an example. The subbasins within the Douglas Basin are coded with the prefix “R-D.” The first letter represents the basin’s receiving water body—in this case, it is “R” for “Rickreall Creek.” Because Ash Creek and Rickreall Creek have multiple basins discharging to them, the second letter(s) represent the major basin. In the Douglas basin, “D” is used.

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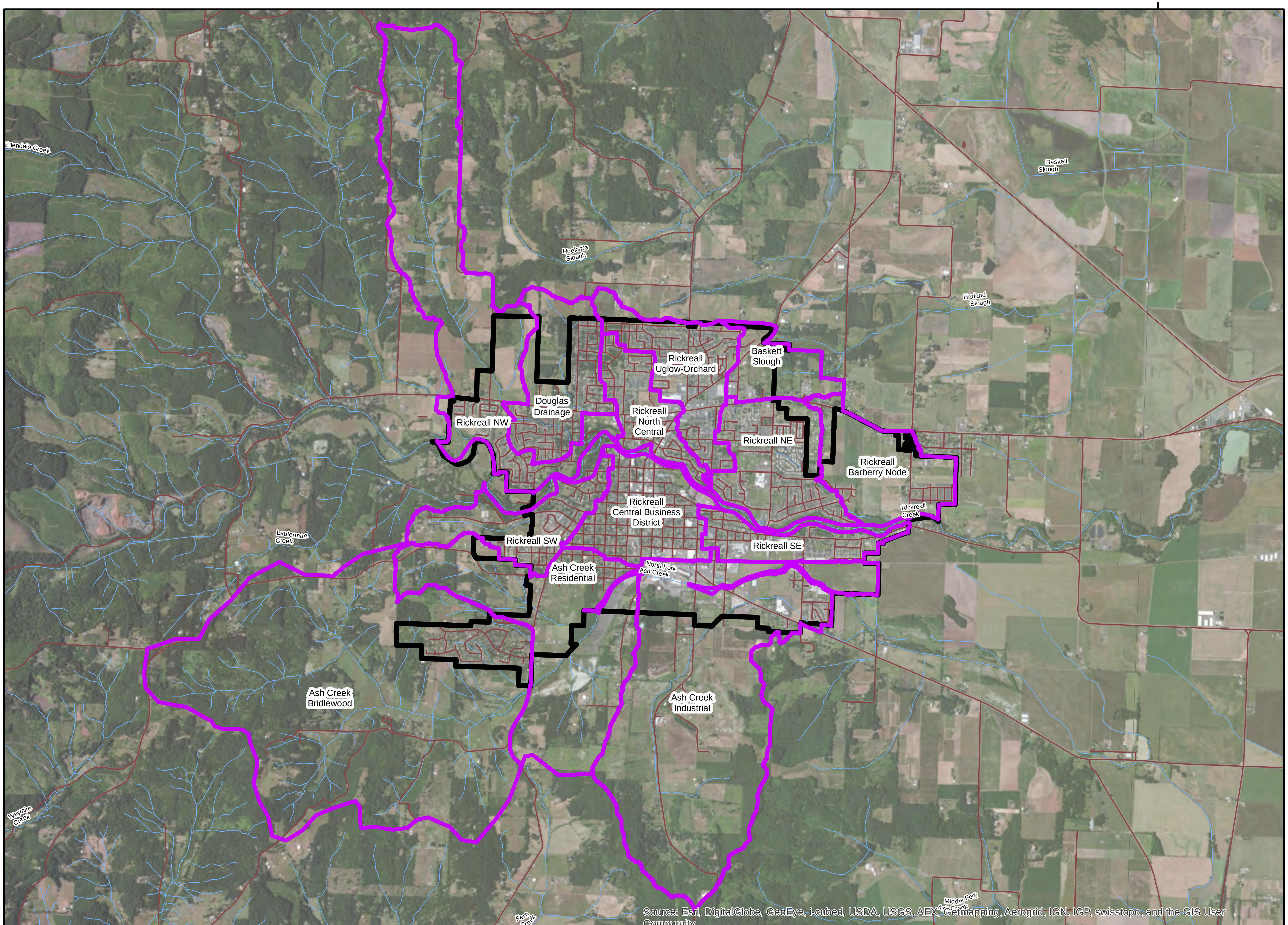

123°15'0"W

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FIGURE 4-1

Major Basins

City of Dallas
Stormwater Master Plan

Legend

- Major Basins
- City Boundary
- Roads
- Streams

N

1 inch equals 3,200 feet

CH2MHILL

Date: 12/18/2014

FIGURE 4-2
Douglas Basin Example of Subbasin Coding Convention

Each subbasin has only one node where the runoff collected within the subbasin is discharged either into a tributary of Rickreall Creek or the next downstream subbasin. The downstream node number and the subbasin designation are the same. The node at the most downstream point within the Douglas basin is labeled with a letter and numbered “1.” The letter indicates a discharge location. For example, R-D-A1 and R-D-B1 discharge independently and in different locations to Rickreall Creek, but both subbasins are the most downstream points in the Douglas basin. The number in the subbasin’s name is also changed based on its relation upstream of the discharge point. Moving upstream along the basin’s stormwater path, each node is numbered sequentially and the same letter is used. In Douglas, R-D-A4 drains to R-D-A3 and so on until the reaching the most downstream point, R-D-A1.

In some instances, more than one basin drains into the same basin. When that happens, each basin is labeled with a cardinal direction at the end of the basin name. For example, subbasin R-D-A1 is downstream of both R-D-2E and R-D-2W. R-D-2E is the east-most subbasin and thus noted by the “E,” and R-D-2W is noted for being the west-most subbasin by the “W.”

This coding convention gives some physical meaning to the subbasin naming, which allows the flows within the system to be easily traced from one node to the next, facilitating analysis of the drainage system. Figure 4-3 shows a summary of the naming strategy.

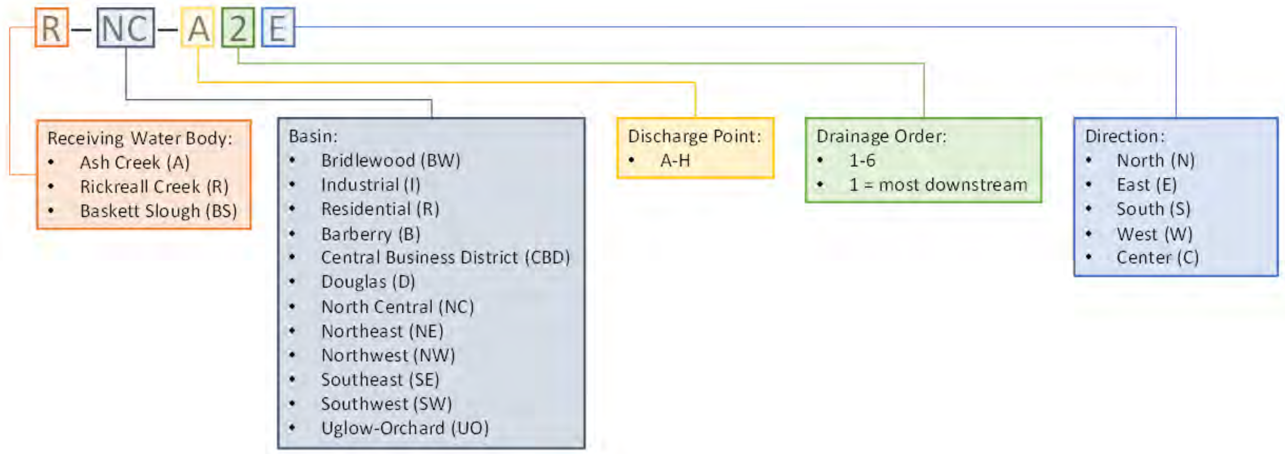

FIGURE 4-3
Summary of Naming Strategy

4.4 Description of Drainage Basins

The major drainage basins are shown in Figure 4-1 and the characteristics of these basins are described below. The basin characteristics described below are summarized in Appendix C. The subbasins are show in Figure 4-4.

4.5 Impervious Area

The amount of runoff is increased substantially by increased impervious areas within the subbasins. Impervious areas such as streets, parking lots, rooftops, sidewalks, and loading areas, increase the volume by preventing infiltration. Further, these impervious areas tend to concentrate the runoff into storm drains or ditches, which more rapidly convey the runoff to the receiving stream. This decreased time of conveyance decreases the time of concentration and generally increases peak rates of runoff downstream. Transformation of agricultural lands to highly urbanized lands can increase the rates and volumes of storm runoff by a factor of 2 to 4 times. Impervious area is a very significant factor in the analysis of storm drainage systems.

NLCD data were analyzed to determine the currently mapped percent impervious area in each zone.

The future buildout condition scenario assumes full buildout to the study area at maximum density. The future impervious area was determined through inspection and analysis of the current impervious area using the following methodology:

- The current mapped impervious area of fully built out areas was used to select a typical buildout impervious area percentage.
- Areas of a given zoning designation whose current mapped impervious areas were higher than the selected typical future value were left unchanged.
- Where the current mapped impervious area was lower than the selected typical future value, the typical future value was used in the future runoff calculations.

For the 20-year planning horizon, subbasins in the La Creole and Barberry growth nodes were assumed to have reached full buildout conditions. All other subbasins were assumed to remain at the current condition.

Rural basins outside of the study area were considered to remain at the current condition for both the 20-year and buildout conditions.

The current mapped impervious area and the typical future impervious area for each zoning designation are compared in Table 4-2.

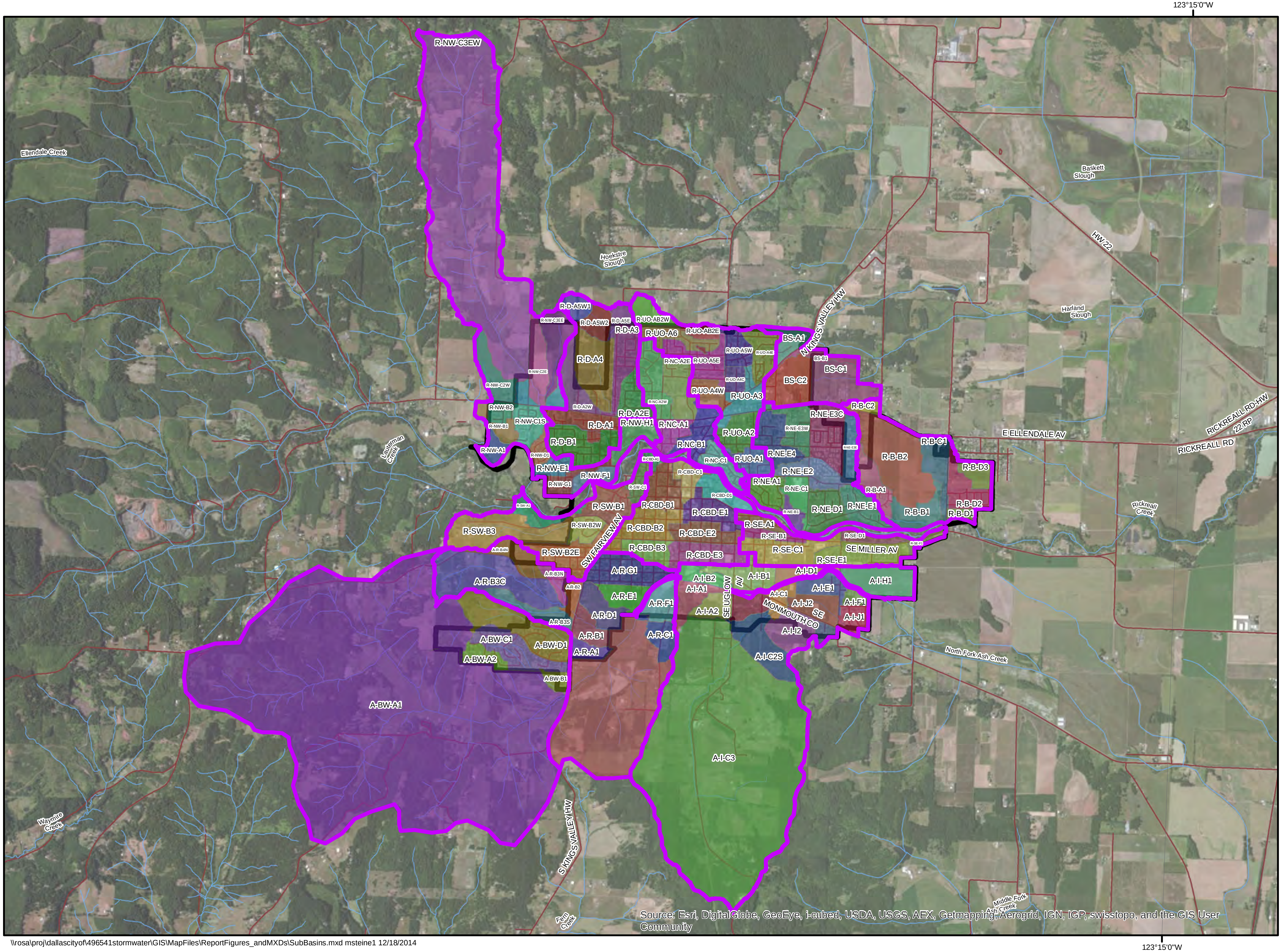

FIGURE 4-4

Subbasins

City of Dallas Stormwater Master Plan

Legend

- Major Basins
- City Boundary
- Streams
- Roads

N

1 inch equals 3,200 feet

Source:

CH2MHILL

Date: 12/18/2014

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TABLE 4-2
Estimated Mapped Impervious Area by City Zoning Designation
City of Dallas Stormwater Master Plan

Zoning Designation	Current Mapped Impervious Area (percent)	Typical Future Impervious Area (percent)
Residential		
High Density	50.2%	55%
Medium Density	32.0%	50%
Low Density	31.2%	40%
Suburban Residential	8.9%	20%
Commercial		
Commercial General	70.3%	70%
Commercial Neighborhood	54.5%	68%
Central Business District	76.9%	77%
Industrial	45.6%	90%
Park and Open Spaces	24.1%	25%
Agricultural/Forest*		
AR-5	15.1%	26%

*GIS data analysis included <0.1 acre of area within the City zoned either Farm/Forest or Exclusive Farm Use. These areas are considered to be an artifact of using GIS data from multiple sources. The effect of these small areas on the overall impervious area of a basin, and the resulting stormwater runoff, is negligible.

4.6 Soil Loss Parameter

Soils in the area were characterized using the hydrologic soil classification system developed by the SCS. Soils mapping and parameters were derived from the Soil Survey Geographic Database (SSURGO), which was published by the Natural Resources Conservation Service (NRCS) in 2003. For drainage purposes, each soil type in the SSURGO is given a hydrologic group designation (A, B, C, or D) which represents relative infiltration and runoff characteristics.

A hydrologic soil classification of *A* is typical of highly pervious soils with low potential for runoff, such as sands. A hydrologic soil classification of *D* would be typical of fine-grained impervious soils with high runoff potential such as clays. A listing of soil types found in the study area with their hydrologic soil classification is presented in Table 2-2.

This alphabetic classification can be transformed into a numeric value using “runoff curve numbers.” The NRCS runoff curve number procedure provides information that relates hydrologic soil group to runoff potential as a function of soil cover and antecedent soil moisture conditions. The curve numbers assigned to each of the hydrologic soil groups based on zoning throughout the Dallas area are listed in Table 4-3. These curve numbers were based on the NRCS Technical Release (TR-55), *Urban Hydrology for Small Watersheds* (NRCS, 1986), and adjusted for knowledge of local conditions.

TABLE 4-3
Curve Numbers by Hydrologic Soil Group
City of Dallas Stormwater Master Plan

	Hydrologic Soil Group				
Zoning Designation	**A**	**B**	**C**	**C/D**	**D**
Residential Low Density	61	75	83	85	87
Residential Medium Density	69	80	86.5	88	89.5
Residential High Density	77	85	90	91	92
Parks and Open Spaces	49	69	79	81.5	84
Commercial Neighborhood	83	88.5	92	92.75	93.5
Commercial General	89	92	94	94.5	95
Central Business District	89	92	94	94.5	95
Industrial	81	88	91	92	93
Exclusive Farm Use	30	58	71	74.5	78
Farm/Forest	43	65	76	79	82
Suburban Residential	51	68	79	81.5	84

A composite area-weighted average curve number based on soil type, zoning, and percent impervious within each subbasin was developed and used in the HEC-HMS hydrologic analysis. A curve number of 98 was used for all impervious surfaces in the composite curve number classification.

4.7 Initial Abstraction and Soil Retention

The initial abstraction (Ia) refers to rainfall that is intercepted, infiltrated, or stored on the surface (depression storage), before surface runoff occurs. This component of rainfall is often estimated as a function of the maximum soil retention (S), which is the limiting value of infiltration rate at the surface, transmission through the soil profile, or water-storage capacity. The following empirical relationship is used to relate maximum soil retention to the curve number for any given soil type:

S = [1,000/Curve Number] – 10

Empirical studies conducted by NRCS have shown that the initial abstraction can be approximated as a linear function of the maximum soil retention. NRCS reports suggest using the following relationship:

$I_a = 0.2 \times S$

4.8 Time of Concentration and Lag Time

Lag time is the delay in time, after a period of rain, before runoff reaches its maximum rate. This is a critical parameter that affects the shape and magnitude of the runoff hydrograph. However, it is also one of the most difficult to accurately quantify. One of the most common methods is to estimate lag time as a function of time of concentration (T_c). The following empirical relationship was used for this study:

LAG TIME = $0.6 \times T_c$

The time of concentration is the time it takes for runoff to travel from the hydraulically most distant part of the basin to the point of interest, typically the basin outlet. The time of concentration is most commonly estimated by calculating and summing the travel times for a theoretical drop of water as it flows through various elements of the system.

Travel times were estimated according to the specific type of flow for that subbasin, specifically overland flow, shallow concentrated flow, gutter flow, channel flow, or pipe flow.

4.8.1 Sheet Flow

Sheet flow is shallow (less than 1 inch) and unchannelized. The velocity of sheet flow is estimated using Manning's equation. Table 4-4 shows the Manning's roughness coefficients for various surface types. These values are consistent with the Oregon Department of Transportation (ODOT) *Hydraulics Manual* (2014).

TABLE 4-4
Manning's Roughness Coefficients for Sheet Flow Analysis over Various Surfaces
City of Dallas Stormwater Master Plan

Description of Surface Type	Manning's Roughness Coefficient, *n**
Pavement and Roofs	0.014
City Business Area	0.014
Gravel	0.020
Apartment Dwellings	0.050
Industrial Area	0.050
Urban Residential	0.080
Meadow, Pasture, Range Land	0.150
Rural Residential	0.240
Light Turf	0.240
Heavy Turf (Parks)	0.400
Forest	0.400

*ODOT, 2014.

The overland flow time of concentration equation used from NRCS TR-55 is as follows:

$$T_c = [0.007(n \times L)^{0.8}] / [P_2^{\,0.5} \times S^{\,0.4}]$$

where:

T_c = time of concentration (hours)

n = Manning's roughness coefficient (dimensionless)

L = length of flow (feet)

S = slope (dimensionless)

P_2 = precipitation (inches/hour), which for this case = 3.1 inches/hour

4.8.2 Shallow Concentrated Flow

After a maximum distance of 300 feet, sheet flow typically becomes shallow concentrated flow, which is deeper and generally flows faster than sheet flow. The velocity of sheet flow is a function of surface type and slope. NRCS TR-55 provides a figure that relates slope to average velocity for both paved and unpaved surfaces. Two log-functions were developed from these curves, one for paved surfaces, and the other for unpaved surfaces. These velocity functions are:

Average flow velocity over **paved** surfaces: $V_{paved} = [S/0.00245]^{\wedge}(1/1.991)$

Average flow velocity over **unpaved** surfaces: $V_{unpaved} = [S/0.00393]^{\wedge}(1/1.985)$

where:

S = slope (dimensionless)

4.8.3 Gutter, Pipe, and Channel Flow

Once the flow intersects a gutter, pipe, or channel, the average velocity increases dramatically and it takes little time from there to reach the outlet. A constant average velocity was used to estimate travel times for this segment of the flow path. In pipes and channels, the average velocity was assumed to be 3 feet per second. For gutters, it was assumed to be 1.5 feet per second (fps).

The time of concentration equation used for gutter, pipe, and channel flow is as follows:

$$T_c = L/3600 \times V$$

where:

T_c = time of concentration (hours)

L = length of flow (feet)

V = velocity (fps): gutter V = 1.5 fps; pipe V = 3.0 fps; channel V = 3.0 fps

SECTION 5

Basin Runoff Analysis and Results

Runoff from each subbasin was determined using the USACE HEC-HMS hydrologic computer model, except for the three large rural basins outside the UGB that are tributary to North Fork Ash Creek. The HEC-HMS model uses the input parameters presented in Section 4, Basin Delineation and Model Parameters, to compute estimated peak flows from each subbasin. Detailed hydrologic analysis data, calculations, and results are provided in Appendix C.

5.1 Design Storm Precipitation Depths

The NOAA isopluvial maps are a readily available source for 24-hour precipitation depths. The 24-hour Type 1A storm was used as the design storm. The total 24-hour precipitation depth estimates for various frequency events are shown in Table 5-1.

TABLE 5-1
Total 24-Hour Precipitation for Select Recurrence Intervals
City of Dallas Stormwater Master Plan

Recurrence Interval	24-hour Precipitation (inches)
2-Year	3.1
5-Year	3.9
10-Year	4.6
25-Year	5.2
50-Year	5.7
100-Year	6.3

* Source: NOAA Isopluvial Maps.

5.2 Peak Subbasin Flows

Peak flows from each subbasin were computed for the 2-, 5-, 10-, 25-, 50-, and 100-year frequency events for the current, 20-year, and buildout conditions. The results of this analysis for the 10-year and 100-year events from each individual subbasin buildout condition are presented in Figures 5-1 through 5-12. These flows should be used when estimating local flows generated from part of an individual subbasin.

5.3 Peak Major Basin Cumulative Flows

Flow routing from each subbasin is shown on the major basin hydrologic summary figures (Figures 5-1 through 5-13). Each figure shows a major basin with its subbasins, subbasin code names, the buildout peak flows for the 10-year and 100-year recurrence interval, and point of discharge for each basin that discharges to Rickreall Creek or North Fork Ash Creek. Cumulative routed flow at the point of discharge for the 100-year storm is reported at the point of discharge only for those subbasins that have one or more subbasins upstream. For basins that do not have any upstream subbasins, the flow at the point of discharge is the same as the flow reported in the label for that subbasin.

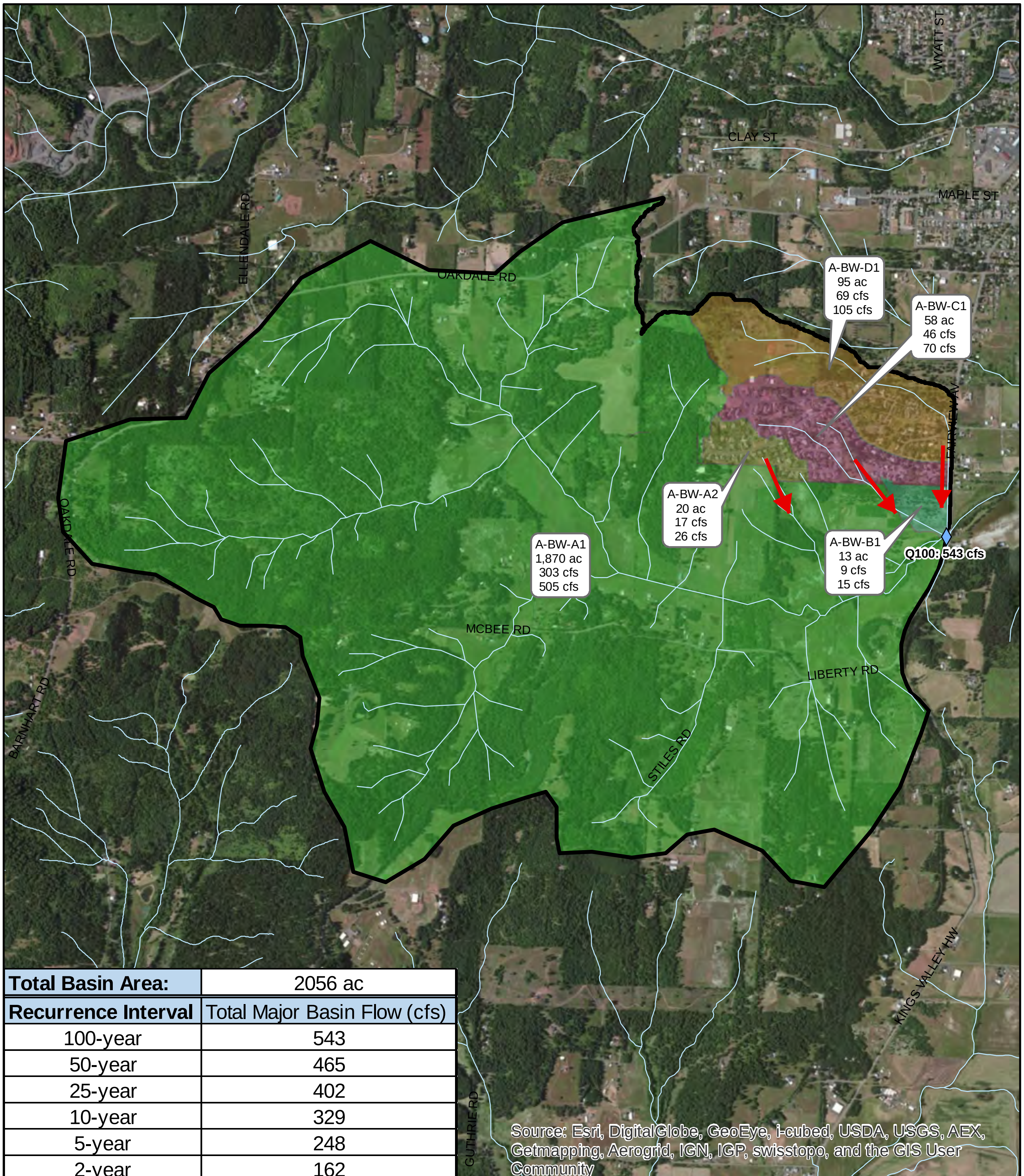
Cumulative routed flow is also shown at key points of analysis in some basins. Cumulative routed flows in the Douglas and Rickreall Uglow/Orchard major basins were hydraulically routed using XPSWMM. All other reported cumulative flows were hydrologically routed using HEC-HMS.

Results for the current and buildout conditions are presented in Table 5-2. Flows for individual subbasins at the current, 20-year, and buildout planning horizons are provided in Appendix C.

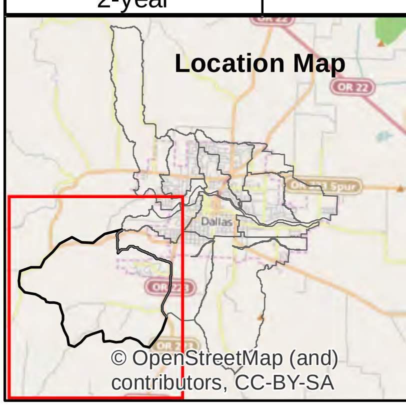
TABLE 5-2
Peak Major Basin Flows
City of Dallas Stormwater Master Plan

Routed Flow	Total Basin Area (acres)	Current Condition Flows (cfs)				Buildout Flows (cfs)			
		10 yr	25 yr	50 yr	100 yr	10 yr	25 yr	50 yr	100 yr
Ash Creek Bridlewood	2,056	329	402	465	542	329	405	465	544
Ash Creek Industrial	1,379	331	395	449	516	383	450	507	578
Ash Creek Residential	783	263	318	364	421	305	365	413	473
Baskett Slough	160	100	120	137	158	122	145	164	188
Douglas	334	202	240	273	313	224	266	300	342
Rickreall Barberry	315	147	179	205	238	207	246	279	318
Rickreall CBD	302	266	305	338	377	265	305	337	376
Rickreall NE	349	233	273	308	348	269	314	352	397
Rickreall NC	190	161	188	210	237	174	201	224	251
Rickreall NW	986	357	440	511	598	367	449	519	604
Rickreall SE	174	136	159	179	202	146	170	190	214
Rickreall SW	254	169	202	229	263	173	206	233	267
Rickreall UO	311	250	292	327	370	260	300	339	382

cfs = cubic feet per second.
yr = year.



Total Basin Area:	2056 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	543
50-year	465
25-year	402
10-year	329
5-year	248
2-year	162



Legend

- Cumulative Routed Flow
- Direction of Stormwater Flow
- Streams

Basin Boundary

- Ash Creek Bridlewood

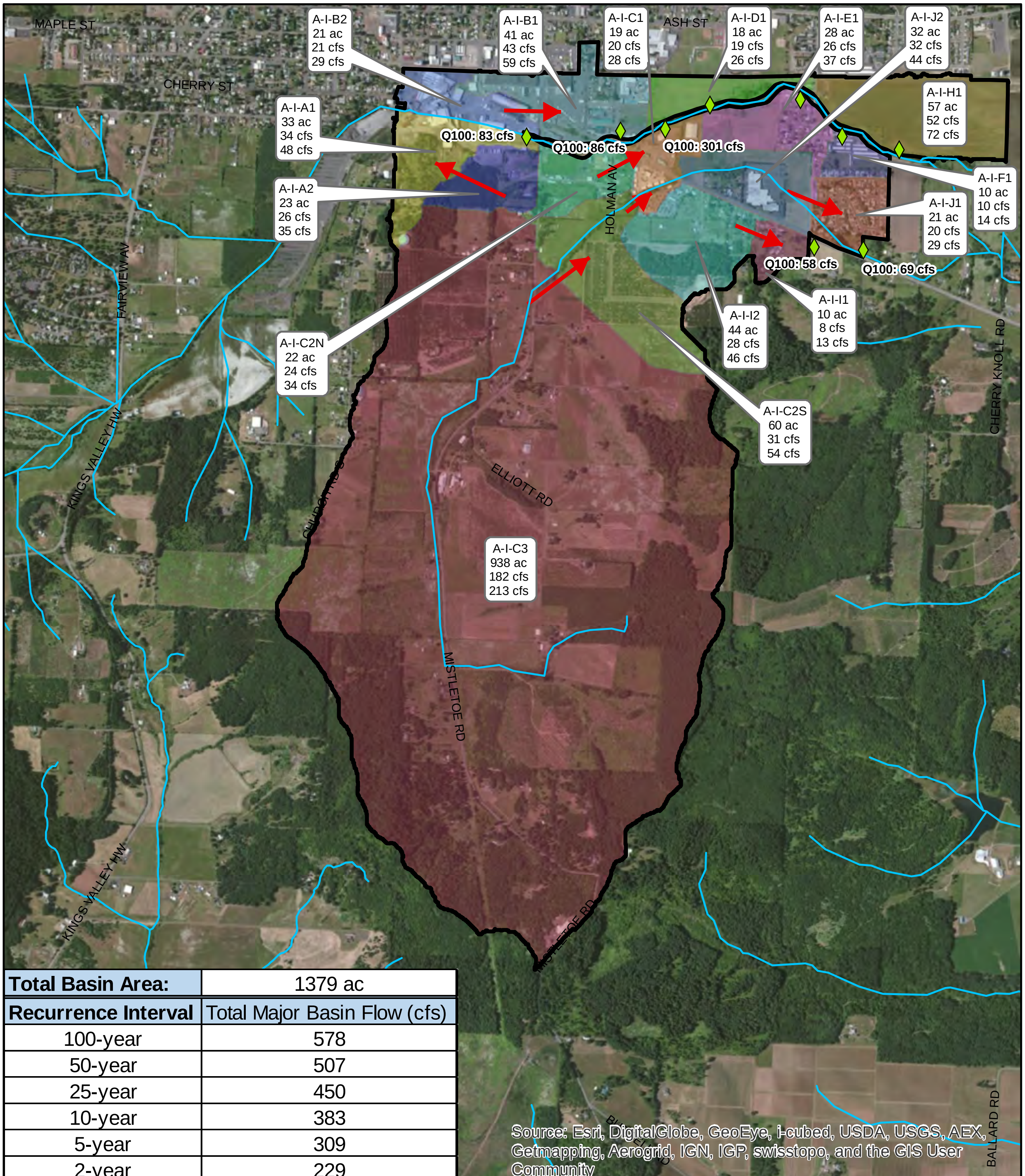
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

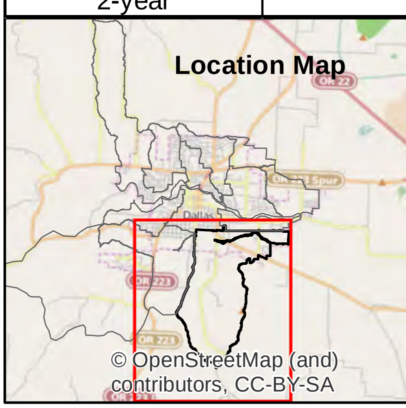
0 1,125 2,250 4,500 ft

FIGURE 5-1
Hydrologic Summary
Ash Creek Bridlewood Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	1379 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	578
50-year	507
25-year	450
10-year	383
5-year	309
2-year	229



Legend

Streams

Direction of Stormwater Flow

Basin Boundary

Ash Creek Industrial

Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

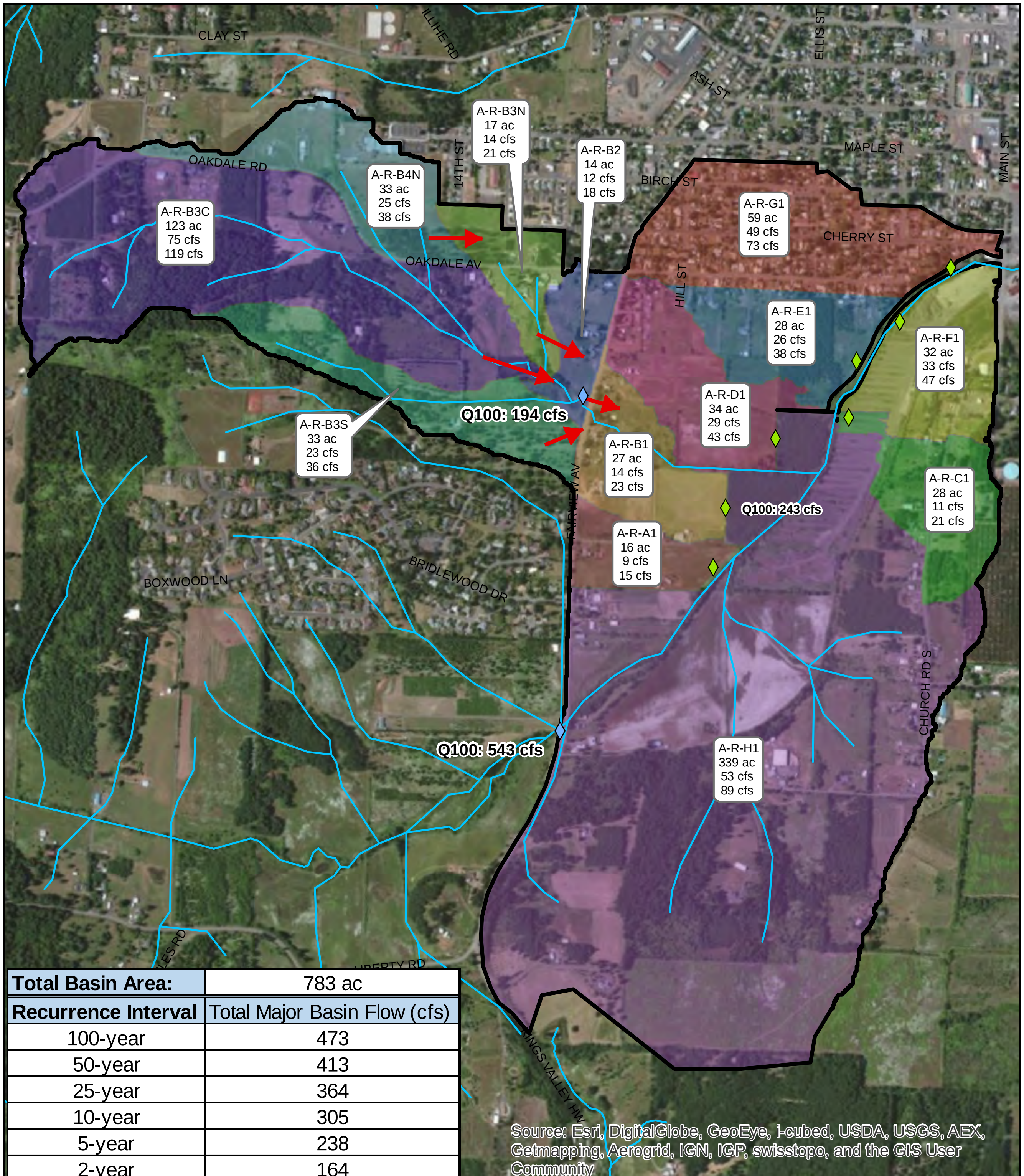
XX	Sub-basin ID
XX ac	Sub-basin Size (ac)
XX cfs	Buildout 10-year Flow (cfs)
XX cfs	Buildout 100-year Flow (cfs)

N

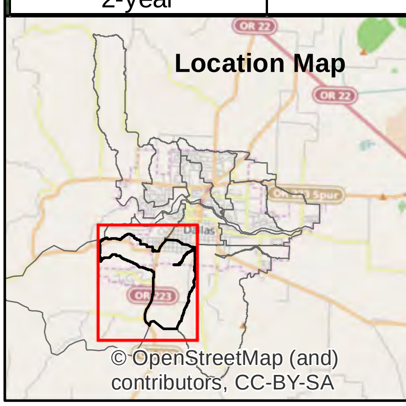
0 1,000 2,000 4,000 ft

FIGURE 5-2
Hydrologic Summary
Ash Creek Industrial Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	783 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	473
50-year	413
25-year	364
10-year	305
5-year	238
2-year	164



Legend

- Cumulative Routed Flow
- Direction of Stormwater Flow
- Streams

Basin Boundary

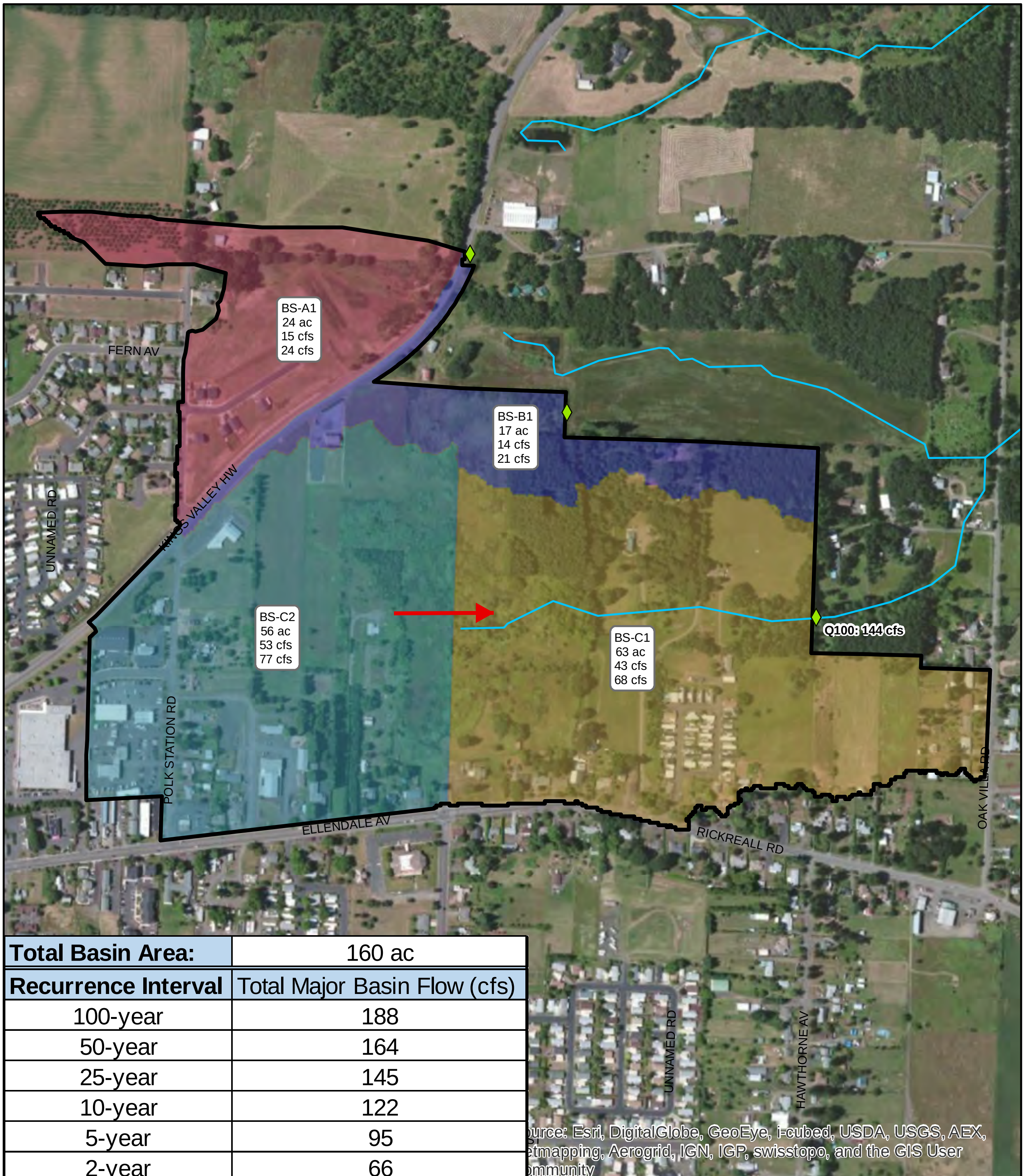
- Ash Creek Residential
- Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

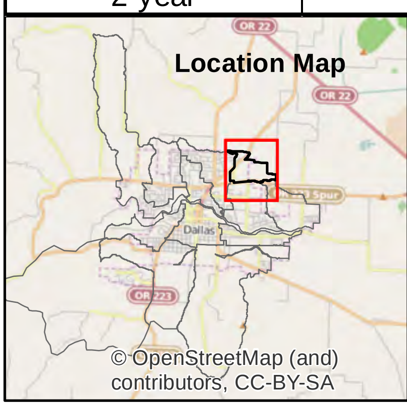
N

0 625 1,250 2,500 ft

FIGURE 5-3
Hydrologic Summary
Ash Creek Residential Basin
City of Dallas Stormwater Master Plan



Total Basin Area:	160 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	188
50-year	164
25-year	145
10-year	122
5-year	95
2-year	66



Legend

Streams

Direction of Stormwater Flow

Basin Boundary

Baskett Slough

Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

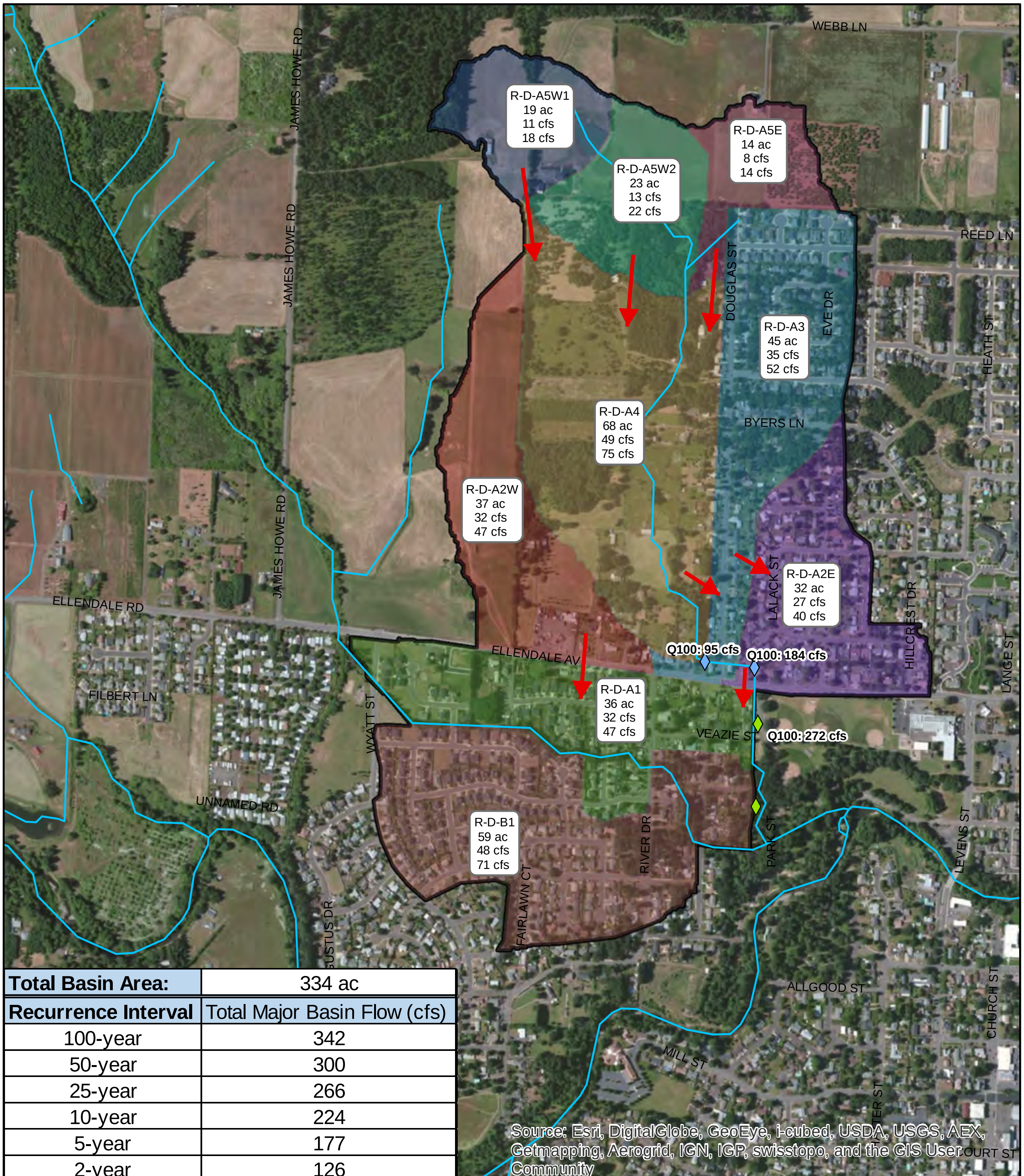
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

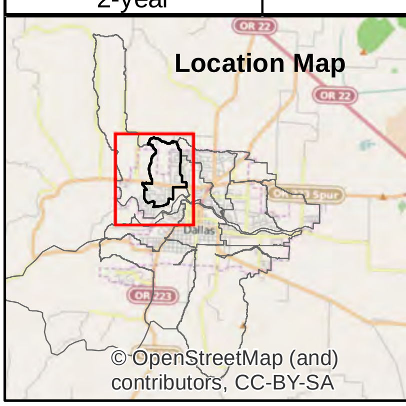
0 335 670 1,340 ft

FIGURE 5-4
Hydrologic Summary
Baskett Slough Basin
City of Dallas Stormwater Master Plan

CH2MHILL



Total Basin Area:	334 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	342
50-year	300
25-year	266
10-year	224
5-year	177
2-year	126



Legend

- Cumulative Routed Flow
- Streams
- Direction of Stormwater Flow

Basin Boundary

- Douglas Drainage
- Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

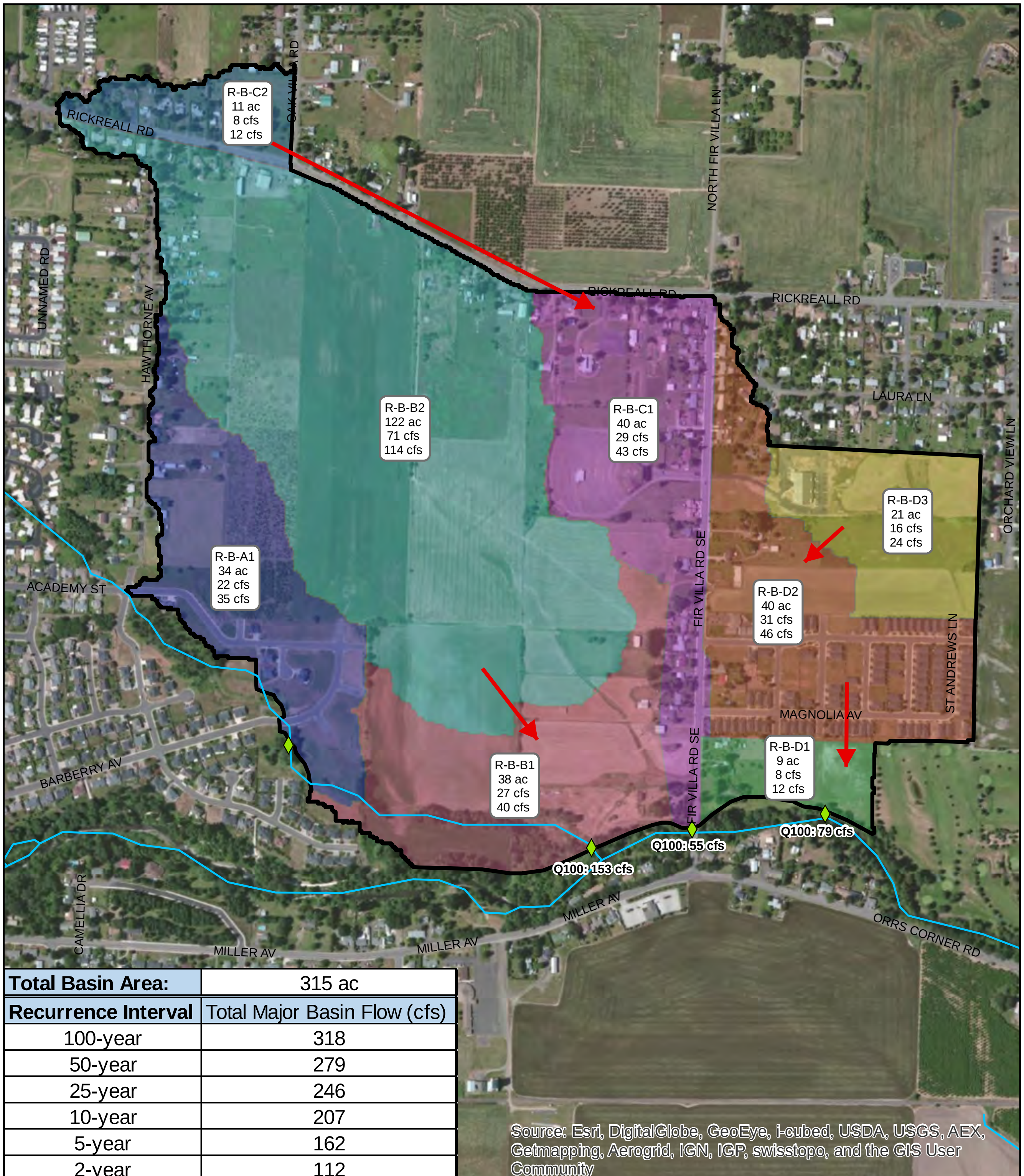
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

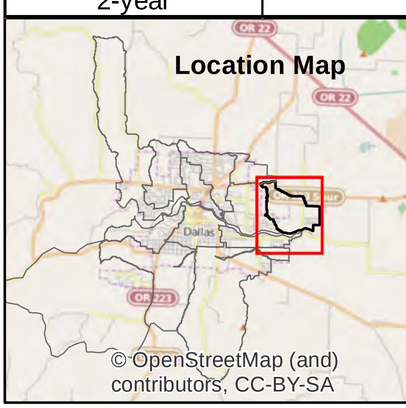
0 500 1,000 2,000 ft

FIGURE 5-5
Hydrologic Summary
Douglas Drainage Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	315 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	318
50-year	279
25-year	246
10-year	207
5-year	162
2-year	112



Legend

Streams

Direction of Stormwater Flow

Basin Boundary

Rickreall Barberry Node

Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

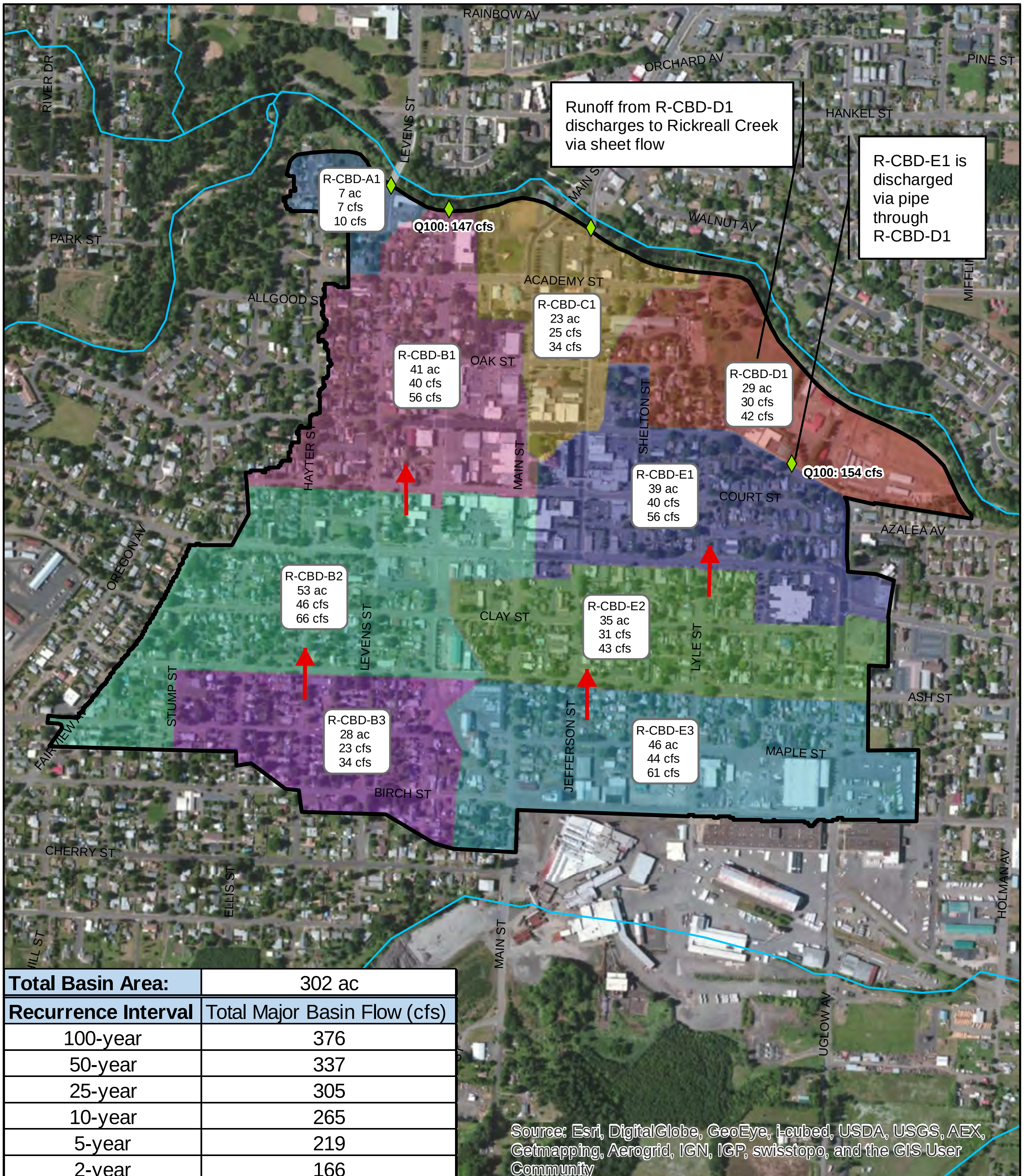
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

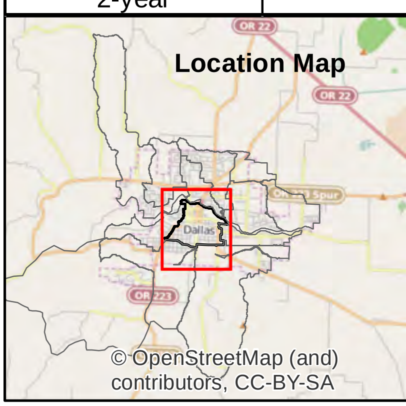
0 420 840 1,680 ft

FIGURE 5-6
Hydrologic Summary
Rickreall Barberry Node Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	302 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	376
50-year	337
25-year	305
10-year	265
5-year	219
2-year	166



Legend

Streams

Direction of Stormwater Flow

Basin Boundary

Rickreall Central Business District

Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

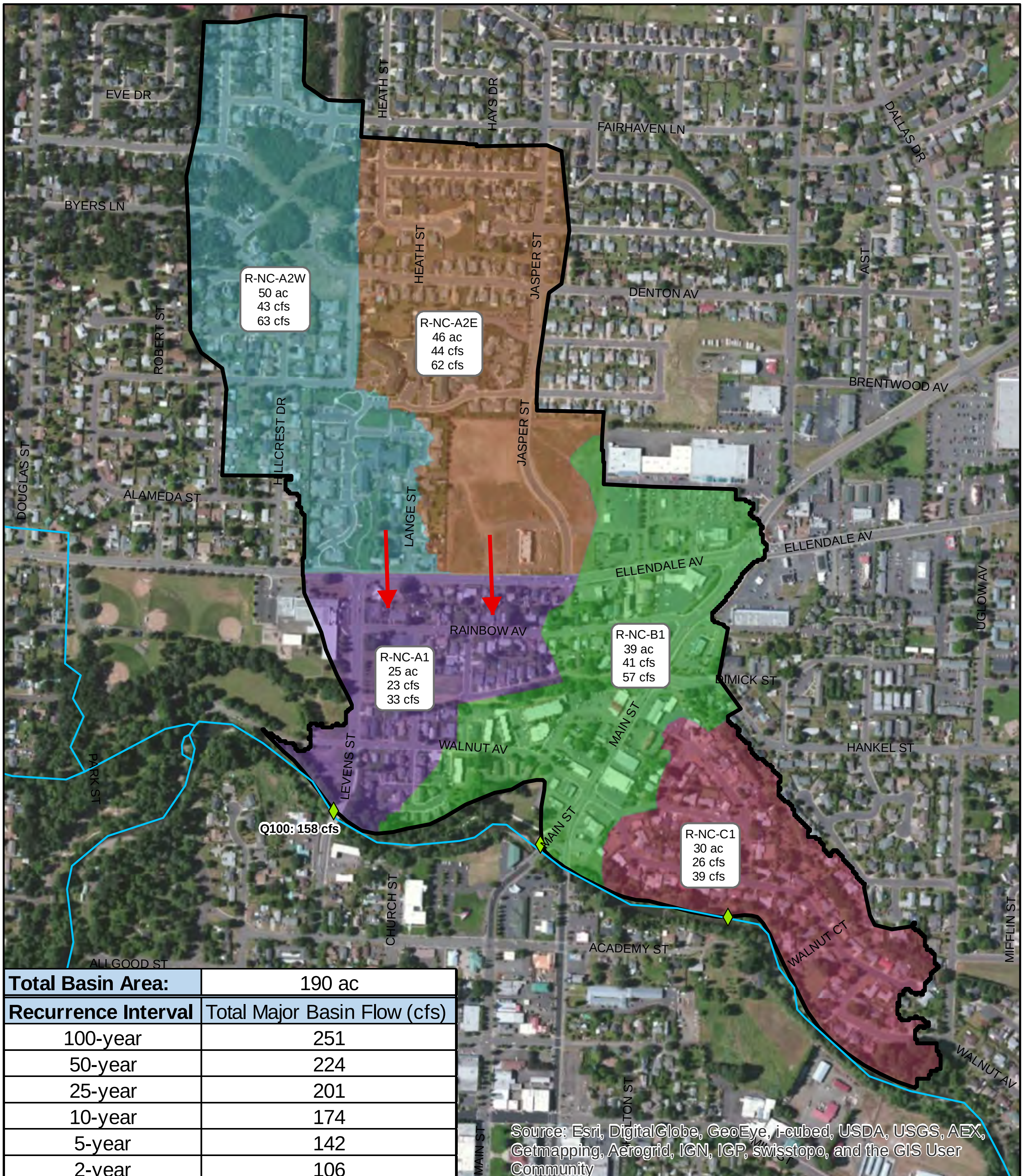
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

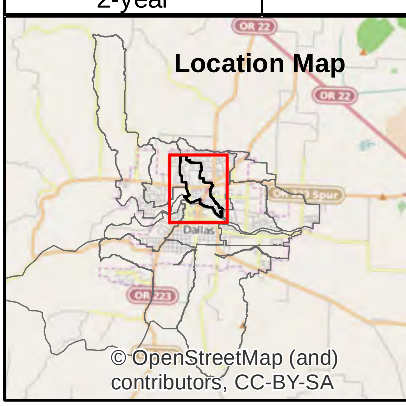
0 440 880 1,760 ft

FIGURE 5-7
Hydrologic Summary
Rickreall Central Business District Basin
City of Dallas Stormwater Master Plan

CH2MHILL



Total Basin Area:	190 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	251
50-year	224
25-year	201
10-year	174
5-year	142
2-year	106



Legend

Steams

Direction of Stormwater Flow

N

Basin Boundary

Rickreall North Central

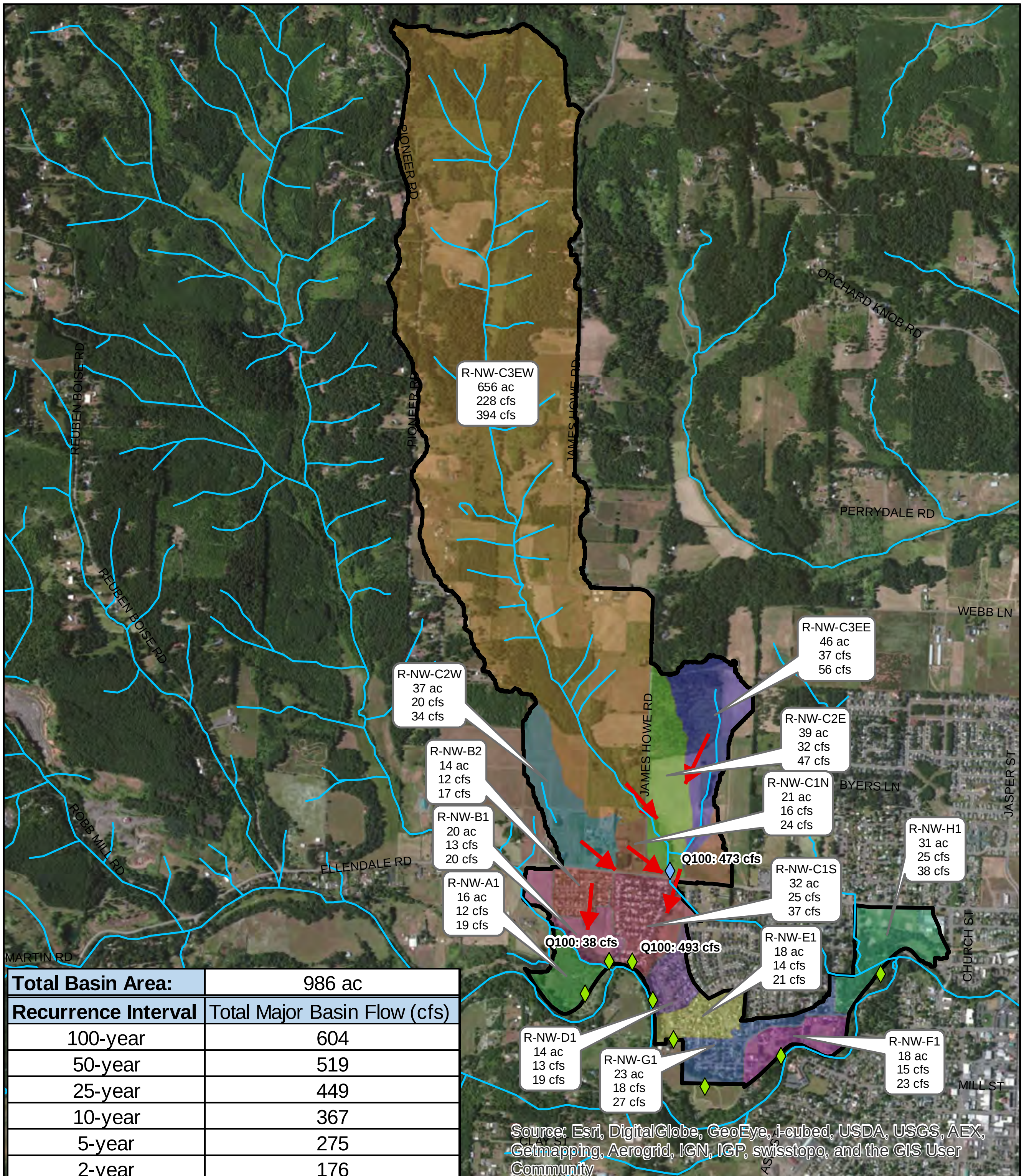
Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

XX	Sub-basin ID
XX ac	Sub-basin Size (ac)
XX cfs	Buildout 10-year Flow (cfs)
XX cfs	Buildout 100-year Flow (cfs)

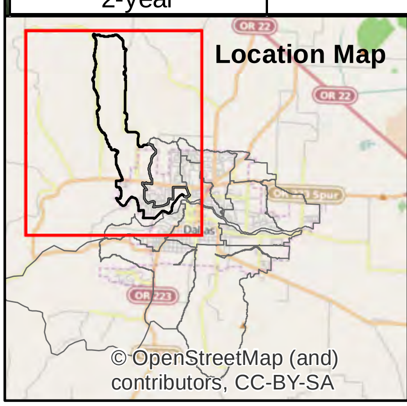
0 375 750 1,500 ft

FIGURE 5-8
Hydrologic Summary
Rickreall North Central Basin
City of Dallas Stormwater Master Plan

CH2MHILL



Total Basin Area:	986 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	604
50-year	519
25-year	449
10-year	367
5-year	275
2-year	176



Legend

- Cumulative Routed Flow
- Streams
- Direction of Stormwater Flow

Basin Boundary

- Rickreall NW
- Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

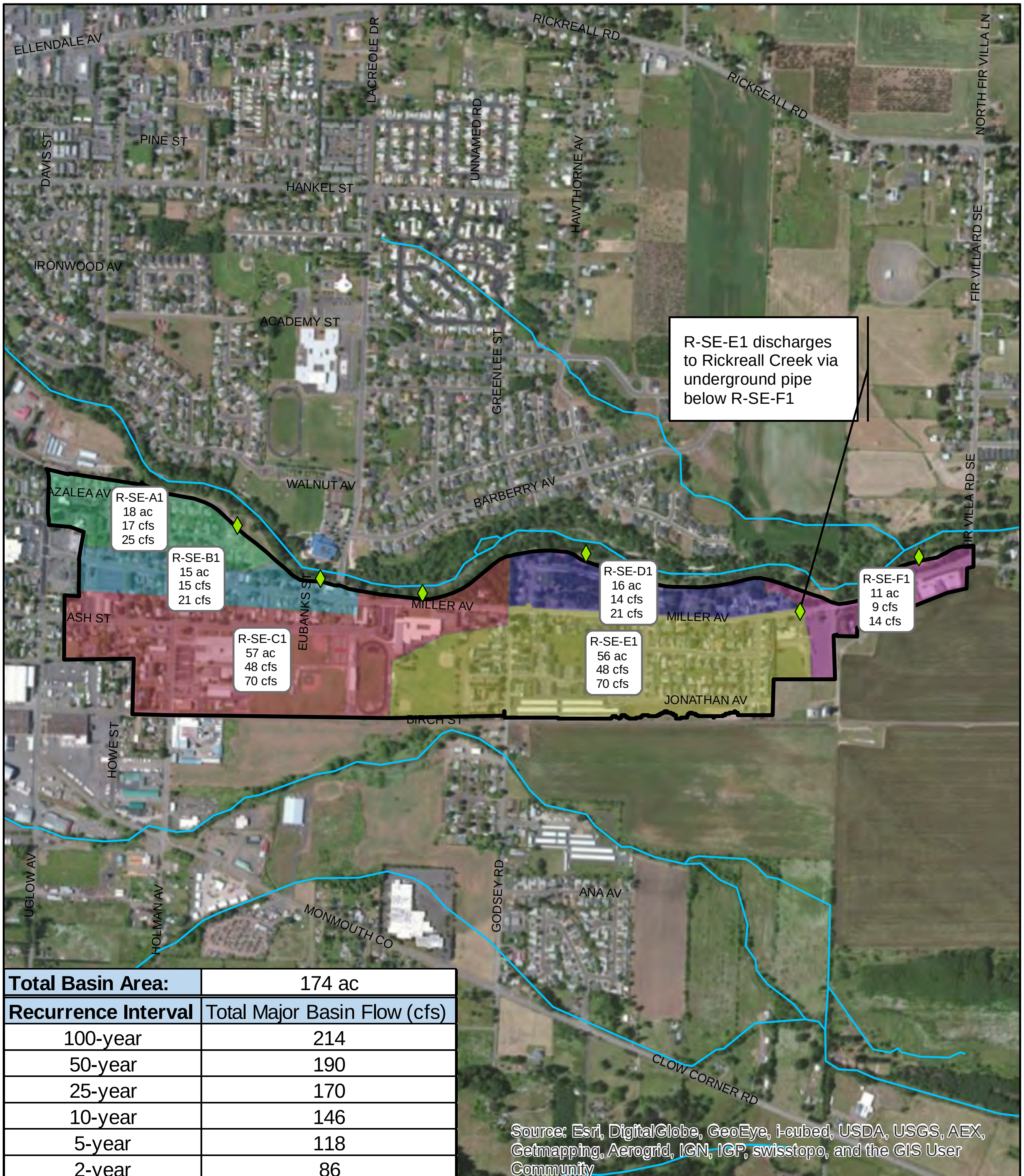
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

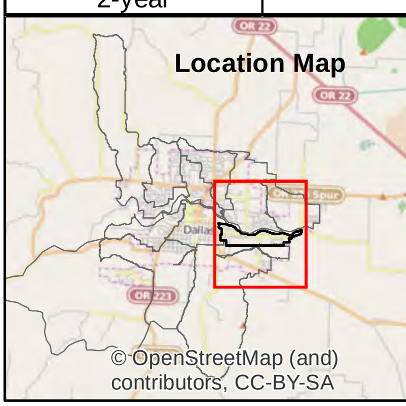
0 1,125 2,250 4,500 ft

FIGURE 5-9
Hydrologic Summary
Rickreall NW Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	174 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	214
50-year	190
25-year	170
10-year	146
5-year	118
2-year	86



Legend

Streams

Basin Boundary

Rickreall SE

Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

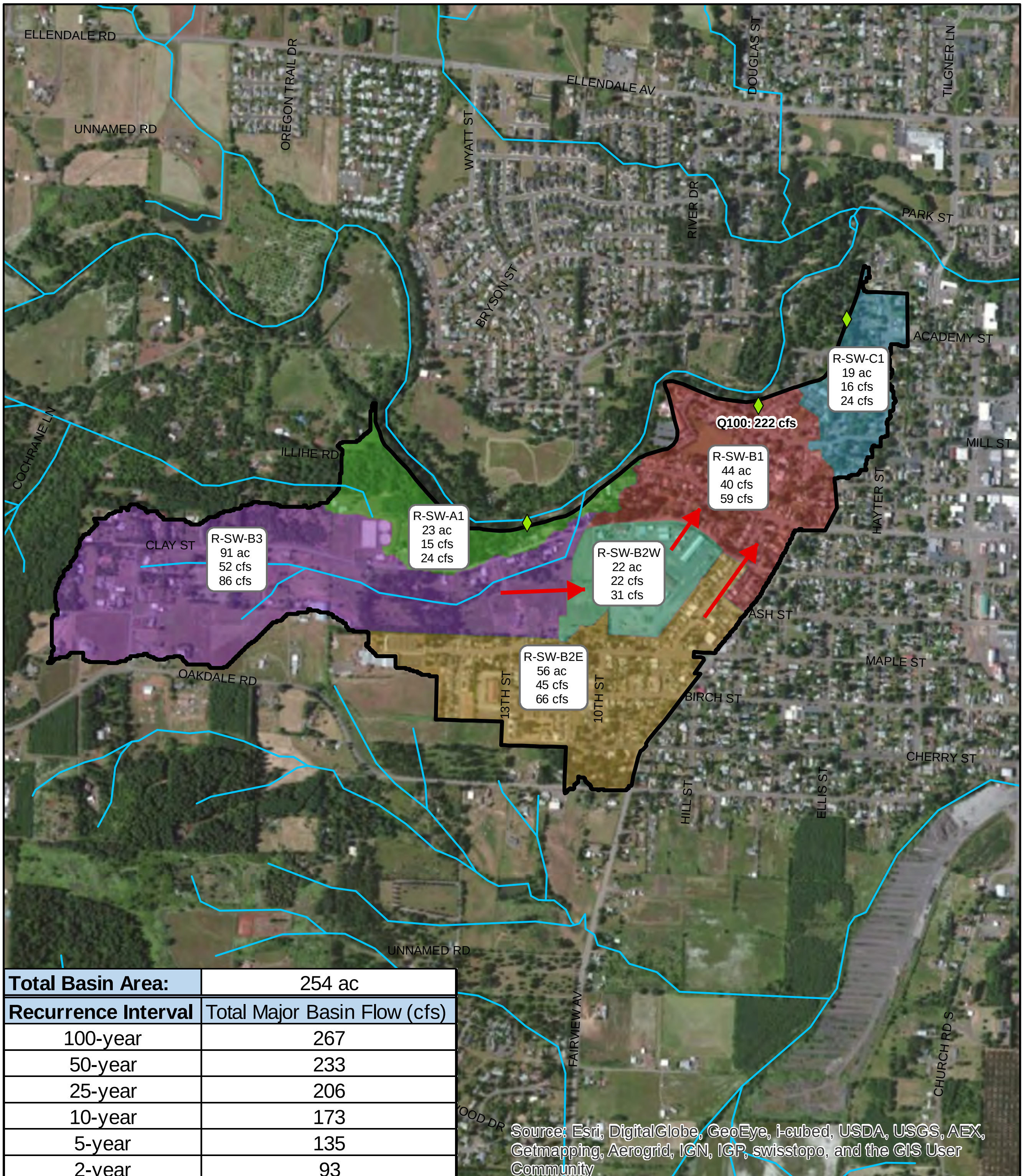
XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

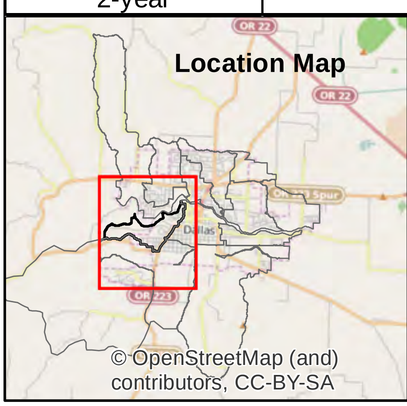
0 550 1,100 2,200 ft

FIGURE 5-10
Hydrologic Summary
Rickreall SE Basin
City of Dallas Stormwater Master Plan

CH2MHILL



Total Basin Area:	254 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	267
50-year	233
25-year	206
10-year	173
5-year	135
2-year	93



Legend

Streams

Direction of Stormwater Flow

N

Basin Boundary

Rickreall SW

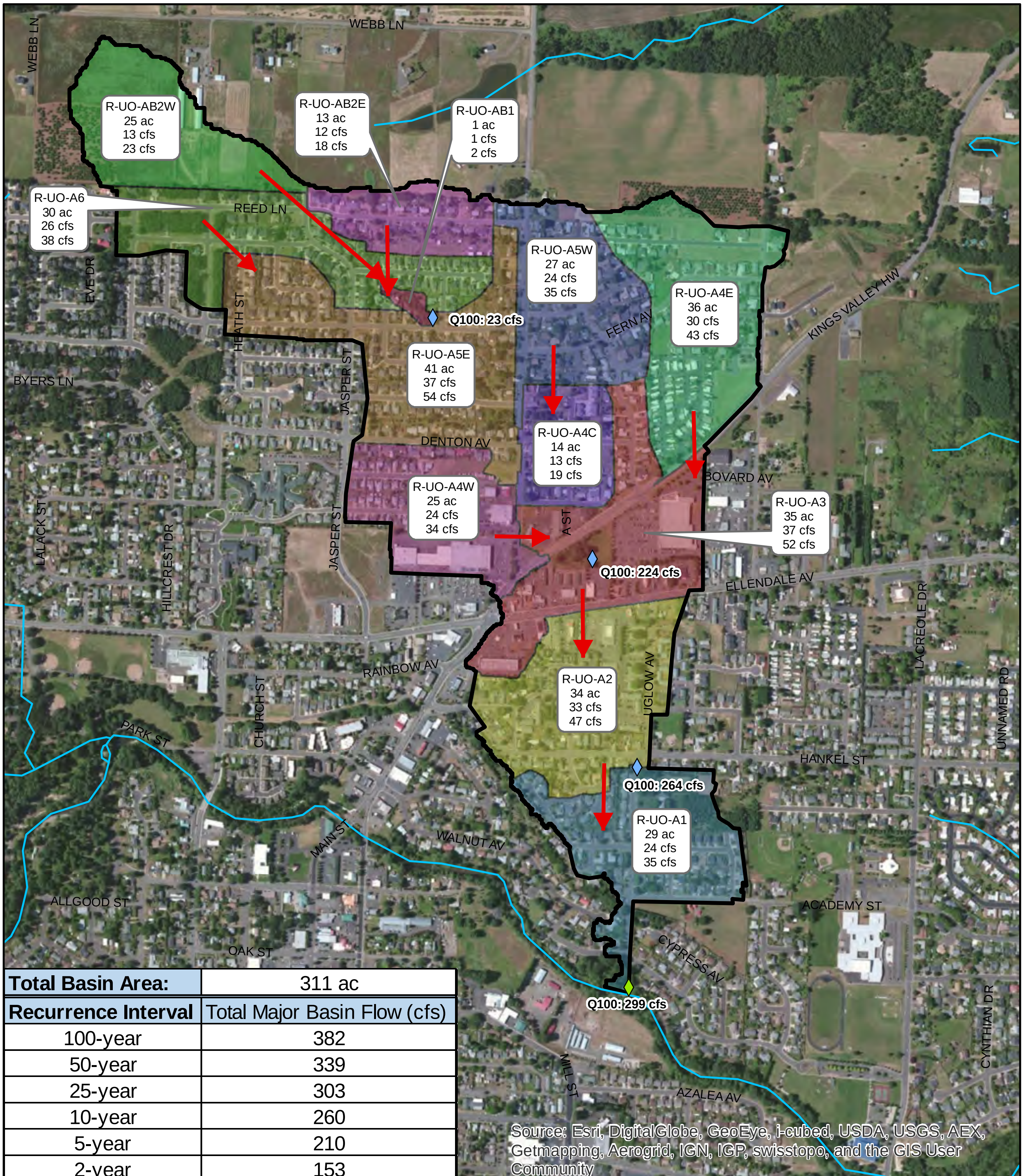
Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

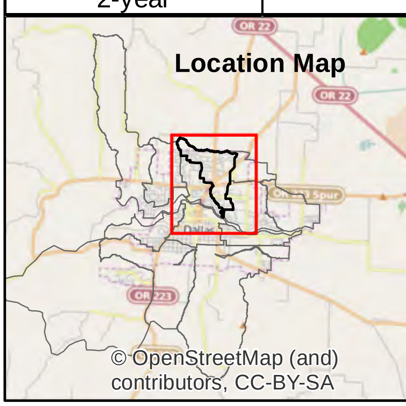
0 600 1,200 2,400 ft

FIGURE 5-11
Hydrologic Summary
Rickreall SW Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	311 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	382
50-year	339
25-year	303
10-year	260
5-year	210
2-year	153



Legend

- Discharge Points
- Cumulative Routed Flow
- Streams
- Direction of Stormwater Flow

Basin Boundary

- Rickreall Uglow-Orchard

XX
XX ac
XX cfs
XX cfs

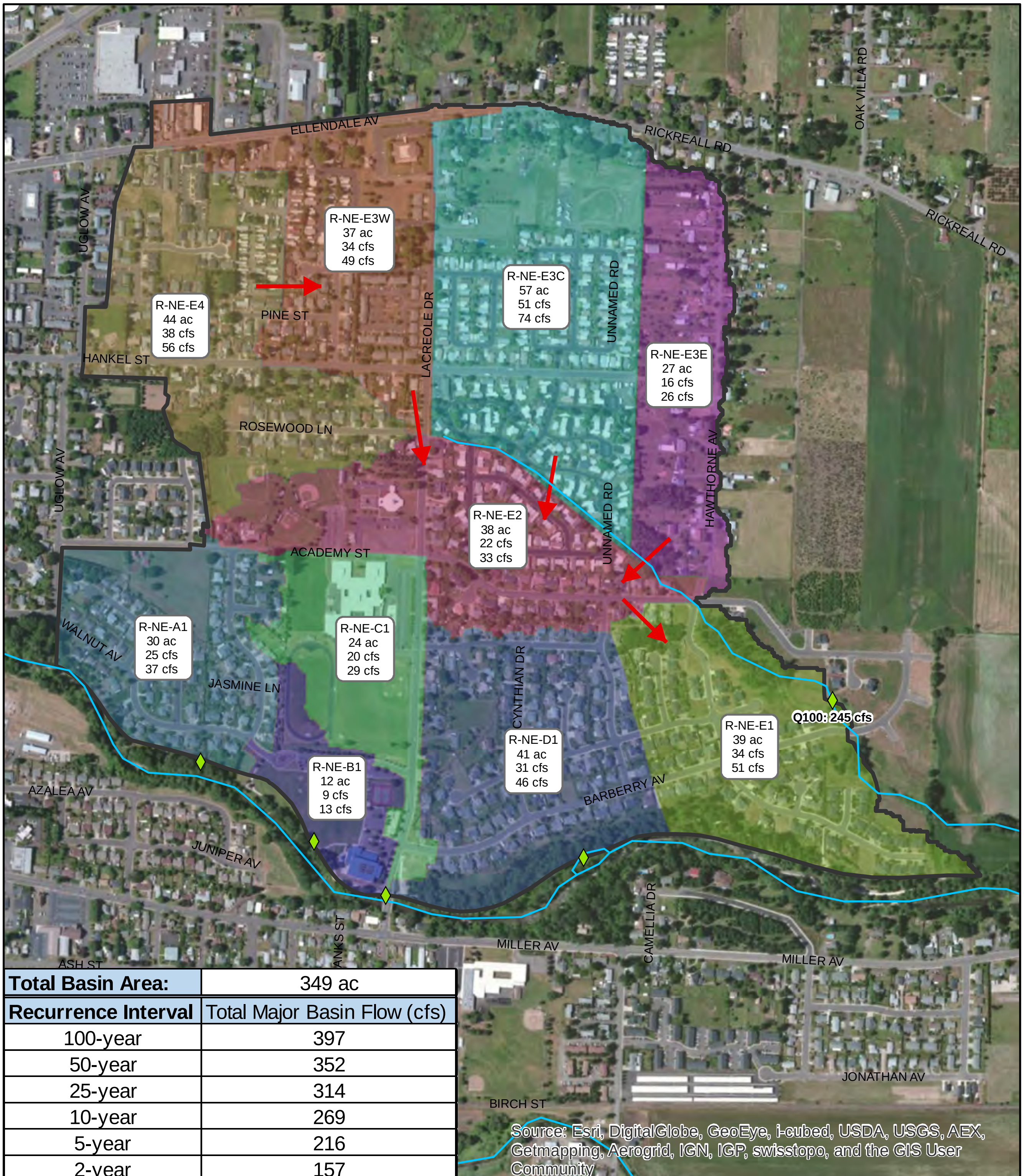
Sub-basin ID
Sub-basin Size (ac)
Buildout 10-year Flow (cfs)
Buildout 100-year Flow (cfs)

N

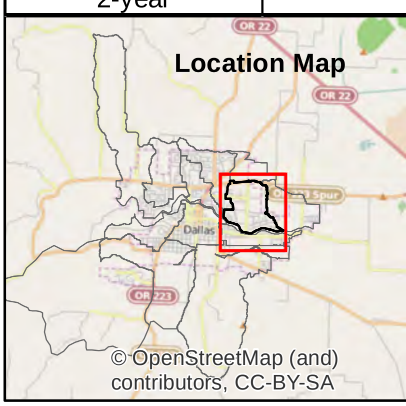
0 500 1,000 2,000 ft

FIGURE 5-12
Hydrologic Summary
Rickreall Uglow-Orchard Basin
City of Dallas Stormwater Master Plan

CH2MHILL.



Total Basin Area:	349 ac
Recurrence Interval	Total Major Basin Flow (cfs)
100-year	397
50-year	352
25-year	314
10-year	269
5-year	216
2-year	157



Legend

- Cumulative Routed Flow
- Streams
- Direction of Stormwater Flow

Basin Boundary

- Rickreall NE
- Discharge Points Q100 provided on map for points with more than 1 upstream sub-basin

XX XX ac XX cfs XX cfs	Sub-basin ID Sub-basin Size (ac) Buildout 10-year Flow (cfs) Buildout 100-year Flow (cfs)

N

0 425 850 1,700 ft

FIGURE 5-13
Hydrologic Summary
Rickreall NE Basin
City of Dallas Stormwater Master Plan

CH2MHILL

SECTION 6

Water Quality

The City has taken a proactive approach to improving the quality of stormwater runoff in the downtown area by developing and implementing several action items from the *City of Dallas Willamette TMDL Implementation Plan* (Dallas Total Maximum Daily Load [TMDL[3]] Plan) (City of Dallas, 2008a). The City has also installed bioretention facilities on SE Jefferson Street in the downtown area. Bioretention facilities are effective mechanisms for reducing the contaminant load from stormwater, generally considered a "non-point source" of pollution.

"Non-point source" loads are naturally occurring or manmade contaminants that are dissolved or suspended by storm runoff and transported by that runoff to waterways of interest. These are distinguished from the "point source" loads, such as those that are intentionally discharged at sewage treatment plants. Strategies for control of point- and non-point sources can vary dramatically, but from a regulatory perspective, there is no difference between the types for a municipal agency like the City. For that reason, this section will describe source loads without differentiating the type.

This section discusses relevant topographical and climatic information, types of source contamination, frequently cited sources of those contaminants, observed levels of contamination, methods of removal, regulatory climate, and recommendations.

6.1 Regulatory Climate

The Oregon Department of Environmental Quality (DEQ) administers the National Pollutant Discharge Elimination System (NPDES) for Oregon on behalf of the U.S. Environmental Protection Agency (EPA). In general terms, this means the agency regulates the terms and conditions of permits that allow discharge of pollutants into regulated receiving waters.

In 1990, rules were adopted for permitting of Municipal Separate Storm Sewer Systems (MS4s). This approach treats a City's system as under a single permit, instead of permitting each individual storm sewer outfall. At this time, the program does not include end-of-pipe monitoring, but focuses instead on program-level performance and in-stream monitoring of the receiving waters. Phase I MS4 regulations were applied to communities with populations greater than 100,000. Initially, Phase II regulations were applied to cities of greater than 50,000, but they are in the process of being expanded to reach smaller communities in Oregon. At this time, Dallas is not classified as a Phase II community. However, the City is a Designated Management Agency (DMA) under the Willamette TMDL. As such, the City was required to develop the Dallas TMDL Plan to address the same six control measures required in the Stormwater Management Plan (SWMP) of MS4 permittees:

1. Public education and outreach
2. Public participation/involvement
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post-construction runoff control
6. Pollution prevention/good housekeeping

For purposes of the TMDL, Ash Creek is considered part of the Rickreall Creek Watershed, which is tributary to the Willamette River. As such, both creeks are subject to the Willamette TMDL.

Rickreall Creek was given an explicit waste load allocation for ammonia and biochemical oxygen demand. Rickreall Creek was also cited for temperatures above the criterion for salmon migration and rearing but a

[3] Regulatory measure of acceptable loading of pollutants into a receiving stream.

temperature TMDL has been delayed. While there is no temperature TMDL established for Rickreall Creek, steps have been taken to improve riparian areas and riverbanks to address temperatures in the Middle Willamette Subbasin.

The Middle Willamette Subbasin and its tributaries were also included in the 2006 Willamette Basin TMDL for mercury. The Willamette mercury TMDL does not contain waste load allocations, but instead requires development of a mercury reduction plan by the City. At the next revision of the Willamette TMDL, it is possible that waste load allocations will be developed for mercury, most likely as a sector allocation (for example, for municipal wastewater treatment plants or municipal stormwater discharges).

6.2 Topographical and Climate Information Relevant to Stormwater Quality

Source loading occurs throughout the Middle Willamette watershed, including the part of the watershed that lies within the City. Rickreall Creek and North Fork Ash Creek watersheds are subwatersheds of Middle Willamette watershed and are home to the City of Dallas. The Rickreall Creek and the North Fork Ash Creek watersheds span from the flat Willamette Valley—where the City of Dallas is located—to the steeper Coastal Mountain Range.

Most of the piped storm drainage system in the City of Dallas discharges to Rickreall Creek, its tributaries, and the North Fork of Ash Creek.

The period of concern for contaminant loading of the rivers is during the summer months of July through September. This period is important because contaminants tend to accumulate between infrequent rainfall events and are then washed into rivers with relatively low rates of flow. The low summer flow in the river limits the capacity of the river to dilute incoming contaminants. During this period, the dam at Aaron Mercer Reservoir controls most of the flow in Rickreall Creek.

Rainfall is generally an infrequent occurrence during July and August in Dallas; however, because contaminant wash-off is directly related to stormwater runoff, it is necessary to consider the possibility of a runoff event occurring during the critical summer months.

6.3 Types of Contaminants

Contaminants can include the following:

- Nutrients (such as phosphorus and nitrogen)

  In excess, nutrients are a problem to streams because they act as fertilizers for any aquatic plant life. If excessive nutrients are present and other factors such as temperature and sunlight are suitable, then heavy algae blooms will result. Under normal circumstances, this photo-chemical process occurs naturally and, with tolerable nutrient loads, streams can successfully assimilate this type of contaminant.

  Nutrient contaminants can result from such sources as leaking septic or sanitary systems, pet wastes, feedlots, application of fertilizers to lawns or crops, detergents (washing cars), and from decaying plant debris in or near waterways.

- Sediment

  Sediment is considered to be a non-point source contaminant because, in excess quantities, it can cause turbidity in streams and can deposit damaging deposits of silt on top of gravel salmonid spawning beds. It can also cause loss of flood storage volume.

  Sediment transport is the consequence of erosion. Erosion can occur at construction sites, along poorly protected banks of fast moving streams or drainage ditches, from agricultural fields, and from landscaped areas.

- Bacteria

  Generally, the bacteria of concern are those, such as *E. coli*, which result from human or animal wastes. While these bacteria are not harmful for human ingestion in themselves, they are frequently indicators for other harmful bacteria and viruses as well. Fecal coliform bacteria contaminants originate as wastes from warm-blooded animals including humans and can be introduced into the watershed from leaking septic or sanitary systems, wildlife, and from domestic animal or pet feces. Recent work by other regional agencies has indicated that a substantial fraction of bacteria, even in urban settings, may be traced, via DNA analysis, to wildlife, rather than anthropocentric sources.

- Organic Compounds and Solvents (such as benzene, oil, gasoline, and trichloroethane)

  Organic compounds can be soluble or insoluble in water and they can be lighter or heavier than water. Light floating solvents such as gasoline or oil will often be transported by surface "sheet" flow. In small quantities, these substances will be adsorbed by plants and soils along the way, will be broken down by bacteria, will evaporate, or will be carried further downstream. Large quantities, such as those that result from an actual surface spill, will often be detected. Leaking underground fuel tanks, on the other hand, can contribute to groundwater contamination for years without detection. Leaking fuel will generally migrate downward until the water table is reached and then will migrate along the surface gradient of the water table.

  Heavier-than-water insolubles such as trichloroethene tend to migrate downward though the soil horizons rather than be transported by surface runoff. In this regard Dallas has the advantage of fine-grained soils (which slow the migration of any plume) and a water supply that is well upstream in the watershed from industrialized areas or truck routes.

  Soluble organics, such as antifreeze (ethylene glycol), are difficult to remove and will be dissolved in storm runoff and stream flow. Some of these soluble organics will be broken down to simpler compounds naturally and will be assimilated by natural biological processes in the waterway.

  Activities of concern include domestic oil changing, steam cleaning, degreasing, industrial activities, underground fuel tanks, use of pesticides, and improper disposal of household cleaners, paint, etc.

- Metals (primarily lead, cadmium, copper, mercury, and zinc)

  Trace metals are a concern because of their potential toxic effect on aquatic life and their potential impact on drinking water supplies downstream. Metals in the stream sediments can enter the food chain through bottom feeding species and benthic organisms (e.g., clams).

  Metals are often adsorbed by sediments and remain in the streambed near their source unless the sediment itself is washed downstream by a storm event.

  Significant metal contaminants can be produced by industrial processes, leaded gasoline, wearing down of brake pads and tires, building materials, use of zinc or copper-based roof moss removal materials, and other similar activities.

- Temperature

  Increasing water body temperatures are a concern because of the detrimental effect on aquatic life. Some cold water fish, such as salmon, are unable to spawn at elevated water temperatures. Higher temperatures often produce algal blooms that reduce oxygen levels, which also are harmful to aquatic life.

  Thermal pollution is often a byproduct from of heavy industry—primarily power generation facilities. Municipal wastewater treatment plants are also noted, and sometimes regulated, for the temperature of their wastewater treatment plant's effluent.

During the warmer months, stormwater as part of MS4 can cause thermal pollution as heat is transferred from hot, impervious surfaces to stormwater runoff.

6.4 Observed Levels of Contamination

In 1993, DEQ designated Rickreall Creek as a water quality limited stream during the summer months because the low flows in the creek do not provide sufficient dilution of the effluent from the Dallas Sewage Treatment Plant (STP). Downstream of the STP, DEQ reported an inadequate outfall mixing zone, exceedance of acute and chronic chlorine toxicity levels during the summer months, low dissolved oxygen, and high levels of bacteria (DEQ, 1993).

6.5 Methods of Removal

Different types of contamination can be reduced with varying degrees of success by using known options for removal.

6.5.1 Nutrient Removal

Nutrients, where they originate in high concentrations, such as from failed septic systems, leaking sanitary sewers, food processing facilities, feedlots, etc., can be most easily controlled at the source rather than trying to treat the diluted flow further downstream. Other sources of nutrients include pet waste, lawn and landscape fertilizer, and disposal of grass clippings and yard debris directly to streams and/or in places where it (or leachate from it) can be transported by stormwater runoff.

Once they are in-stream, nutrients are most effectively removed by passage through an area where plant uptake of the nutrients is significant.

These areas can be naturally occurring or manmade grassy swales, streambeds, detention ponds, or wet ponds. In each, the objective is to maximize the amount of surface contact and contact time with the plants. Phosphorus remains with the plant growth or adsorbed by bottom sediments, and will be redissolved by future flows when the vegetation ultimately decays or when agitating flows occur. Phosphorus can only be permanently removed from the waterway by removal of the plant growth such as by mowing a grassy swale and then disposing of the clippings elsewhere.

6.5.2 Sediment Removal

In all cases, erosion can be reduced substantially through proper management at the source. Construction sites are often heavy contributors because land is generally left unprotected. Techniques such as straw bales, silt fences, woven matting, detention ponds, and temporary swales can be used to slow the velocity of stormwater runoff to the extent that most of the transported sediments will be deposited and will remain on the site. Another technique that can be used in addition to the above methods is to require graveled exit routes from sites to remove most of the mud from vehicle tires before the vehicle leaves the site.

Some sediment, such as windblown dust or car dirt, will inevitably get transported by stormwater runoff. Sumped catch basins with inverted siphons can be used with moderate success to remove coarser sediments. These same style catch basins will also tend to remove the trace metals that tend to adhere to such sediments, oils, and greases.

6.5.3 Bacteria Removal

Fecal coliform bacteria are to be expected in all surface streams. In-stream concentrations less than 100 colonies per 100 milliliters are considered to be low and concentrations over 1,000 are considered high. When the number of colonies present is high, the concern is that other more dangerous pathogens may be present. High concentrations are not generally caused by normal surface activity in the watershed but rather by such specific contributors as failed septic systems, leaking sewer pipes, feedlots, or by a dead animal in the stream. Recent studies have also suggested that a significant source of bacteria may be from wild animals and birds, even in urban settings. In some cases, this contributor can dwarf the impact of human development and pet activities.

If a non-natural source is suspected, the most effective solution for bacterial contamination is to pinpoint the source through selective testing in the affected watershed and to eliminate the source.

Once in the runoff stream, the same removal options as described under nutrient removal above will have some beneficial effect, but if the primary sources are removed, specific downstream treatment methods are not generally required.

6.5.4 Organic Compounds and Solvent Removal

Oils and grease on pavements can often be effectively removed by catch basins of the siphon type, if regular cleaning and maintenance practices are performed. The floating grease and oils are retained in the catch basin until cleanout. Some significant fraction of the greases and oils will also be removed by the grassy swale and detention options discussed under the nutrient removal section above.

Where oils are stored in bulk or are loaded/offloaded in quantity, the DEQ requires a Spill Prevention, Containment, and Control Plan. This plan requires, among other things, that a means to contain oil spills be installed at facilities that regularly handle bulk quantities of oil. Such measures, if implemented, are effective at controlling major spills at specific commercial and industrial sites.

Spill prevention plans do not prevent an individual, however, from pouring crankcase oil in a catch basin. Education and the availability of a convenient recycle or disposal alternative are the keys to minimizing this source.

Properly used, many household cleaners, herbicides, and pesticides are a great convenience and generally pose no particular threat to the environment. However, improperly used or disposed of, they can be a cause for concern. Again, the method to minimize these sources is through education about the proper use and disposal of these chemicals.

Specific industrial and commercial activities may be of concern depending on the types of chemicals that are used, stored, or manufactured on the site and also depending on how well those chemicals are prevented from being washed into the runoff stream during a rainfall event. It is possible to require the type and amounts of potentially hazardous chemicals that are used, stored, or manufactured onsite to be reported to the City. The City would then be aware of the potential risk at the site and could consider measures for reducing specific risks, or specific types of risks, if appropriate.

6.5.5 Trace Metal Removal

Trace metals can be added to the runoff stream from both diffuse as well as from concentrated sources. Diffuse sources cannot be controlled at the source, but significant removal value can be achieved through the use of sumped catch basins, proprietary treatment systems, and through the use of the removal alternatives discussed for nutrients above. Specific industrial sources are best controlled at the site of origin.

The advantages and disadvantages of grassy swales, wet ponds, and detention ponds, and sumped and siphoned catch basins are summarized below.

6.5.5.1 Grassy Swales, Wet Ponds, and Detention Ponds

Advantages:

- Can often be integrated into landscaped or greenway areas
- Can often be planned to serve multiple drainage purposes such as detention and stormwater conveyance, in addition to water quality enhancement
- Can serve to create opportunities for wildlife habitat enhancement within an urban setting

Disadvantages:

- Are more difficult and time consuming than piped systems to maintain
- Consume more dedicated surface area than piped systems (which can be aligned in roads)

6.5.5.2 Sumped and Siphoned Catch Basins

Advantages:

- Are effective in removal of metals that tend to adhere oils and greases
- Do not consume land area sediments, trace to those sediments

Disadvantages:

- Are more time consuming to clean than self-cleaning catch basins
- Must be cleaned frequently to be of any value, since turbulence from flow through the catch basin will tend to re-entrain the oil and suspend the sediments
- Access for sewer cleaning is more difficult for siphoned catch basins

6.5.6 Temperature

Temperature can be mitigated through the implementation of cooling towers, or chillers at point source discharges, or a shaded channel upstream of the discharge point. Stream bank restoration including replanting can also be used to help regulate cooler temperatures by providing more shade to the stream itself.

6.6 Recommendations

Although future stormwater quality regulations cannot always be accurately predicted, the direction is apparent and several steps may be prudent to take in anticipation of the actual rule promulgation. The following actions are recommended with respect to stormwater quality.

6.6.1 Catch Basin Types

It is recommended that the City consider adoption of the sumped style of catch basins for public facilities and sumped or siphoned style of catch basins for private facilities within the City, and that these styles be used as new catch basins are built or as old catch basins are replaced within the normal schedule of maintenance and improvements.

6.6.2 Preservation of Open Channel Waterways

It is recommended that the City do the following:

- Retain natural existing open channel waterways as such to the extent possible, rather than allow their replacement with piped systems. Exceptions to this policy should include situations where the waterway cannot be maintained sufficiently free from encroaching vegetation or human activities to prevent flooding of adjacent lands due to such encroachment.
- Consider increased detention requirements to manage hydrologic impacts (e.g., channel down-cutting) or if significant growth is expected in a specific stream basin.

Although limitations exist on development in FEMA-designated floodplain areas, these restrictions apply to only a portion of the City’s waterways. Some communities have adopted buffer requirements as part of development code to ensure that stream corridors are not impacted by development on private property. The benefit of stream buffers on water quality in receiving waters for temperature and other pollutants is well documented. EPA has recently published a report titled *Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations* (2005), which is one example of recent work in this area.

6.6.3 Passive Water Quality Treatment Facilities

It is recommended that the City consider including treatment requirements for developments by setting a threshold for increased impervious area; for example, 5,000 to 10,000 square feet is common. More discussion of the various types of allowable treatment facilities, and the interaction with water quantity management techniques, would be appropriate additions to design standards.

In addition, it is recommended that the City evaluate desired outcomes for the water quality treatment criteria and establish an effective approach to developing design flows consistent with expected permit language and effectiveness requirements.

6.6.4 Best Management Practices

The City is a DMA under the Willamette Valley TMDL. As such, the City is required to have a TMDL implementation plan equivalent to the SWMP required of MS4 permittees. Although the exact details of a required SWMP may vary slightly from the current Dallas TMDL Plan, the six minimum control measures will still be included. The best management practices (BMPs) described in general below are part of the Dallas TMDL Plan, with reference to specific action items identified in the Dallas TMDL Plan. Additional action items for each BMP are described in the Dallas TMDL Plan.

6.6.4.1 Public Education

Because stormwater runoff is generated from dispersed land surfaces—pavements, yards, driveways, and roofs—efforts to control stormwater pollution must consider individual, household, and public behaviors, and activities that can generate pollution from these surfaces. These common individual behaviors have the potential to generate stormwater pollution:

- Disposing of pet waste
- Applying lawn chemicals
- Washing cars
- Changing motor-oil on impervious driveways
- Disposing leftover paint and household chemicals

It takes individual behavior change and proper practices to control such pollution. Therefore, it is important to make the public sufficiently aware and concerned about the significance of their behavior for stormwater pollution, through information and education, to promote beneficial changes in behavior.

It is valuable to educate the community about the pollution potential of common activities, and increase awareness of the direct links between land activities, rainfall-runoff, storm drains, and their local water resources. Most important is to give the public clear guidance on steps and specific actions that they can take to reduce their stormwater pollution-potential.

The City has already implemented several control measures related to public education. Following through with measures to ensure that public education measures are getting out to a broad cross section of City residents is a recommended strategy. These tasks include sponsorship of a middle-school class project, development of materials to be included with monthly bills, and fact sheets and workshops related to riparian restoration and stream shading.

6.6.4.2 Public Involvement

A single regulatory agency or municipal office working alone cannot be as effective in reducing stormwater pollution as when it has the participation, partnership, and combined efforts of other groups in the community all working towards the same goal. The point of public involvement is to build on community capital—the wealth of interested citizens and groups—to help spread the message about preventing stormwater pollution, to undertake group activities that highlight storm drain pollution, and contribute volunteer community actions to restore and protect local water resources.

To be effective, opportunities for public involvement should be built into the fundamental process of community stormwater management. For example, a community can offer opportunities to the public to participate in stormwater program development and implementation through positions on a local stormwater management panel.

Public involvement also includes facilitating opportunities for direct action, educational, and volunteer programs such as riparian planting days, volunteer monitoring programs, storm drain marking, or stream-clean-up programs.

Continuing to develop partnerships with watershed councils, the Polk County Soil Water Conservation District, volunteer groups, and others who want to participate in promoting environmental causes will leverage the City's own efforts to encourage public involvement and increase the chances that opportunities for involvement reach the most people possible.

6.6.4.3 Illicit Discharge Detection and Elimination

An illicit discharges is generally any discharge into a storm drain system that is not composed entirely of stormwater. The exceptions include water from firefighting activities, discharges from facilities already under an NPDES permit, and other discharges of un-polluted water (such as foundation drains). Illicit discharges are a problem because unlike wastewater, which flows to a wastewater treatment plant, stormwater generally flows to waterways without any additional treatment. Illicit discharges often include pathogens, nutrients, surfactants, and various toxic pollutants.

In the Dallas TMDL Plan, the City has identified several action items to develop a program to detect and eliminate these illicit discharges. These action items include developing the following:

- Storm sewer system map
- Ordinance prohibiting illicit discharges
- Plan to detect and address these illicit discharges
- Education program on the hazards associated with illicit discharges

An effective illicit discharge program needs to be both reactive and proactive. The program must be reactive in addressing spills and other illicit discharges to the storm drain system as they are discovered. The program must also be proactive in preventing and eliminating illicit discharges through education, training, and enforcement.

6.6.4.4 Construction

Uncontrolled stormwater runoff from construction sites can significantly affect rivers, lakes, and estuaries. Sediment in water bodies from construction sites can reduce the amount of sunlight reaching aquatic plants, clog fish gills, smother aquatic habitat and spawning areas, and impede navigation.

Through its Dallas TMDL Plan and grading permit requirements, the City has taken steps to develop a program to reduce pollutants in stormwater runoff to the storm system for construction sites. In addition to the requirements already stipulated in the grading permit, the following measures could be added to the construction runoff pollution prevention program:

- Requirements to control other (non-sediment) waste at the construction site
- Procedures to receive and consider information/complaints submitted by the public
- Procedures for inspections and enforcement of stormwater requirements at construction sites
- Removal of sediment control measures following construction

6.6.4.5 Post-construction

The best way to mitigate stormwater impacts from new developments is to use practices to treat, store, and infiltrate runoff onsite before it can affect water bodies downstream. Innovative site designs that reduce imperviousness and smaller-scale low impact development practices dispersed throughout a site are excellent ways to achieve the goals of reducing flows and improving water quality. The City has identified incorporation and encouragement of low impact development practices for new development and redevelopment areas as action items in the Dallas TMDL Plan.

In addition to the action items already identified by the city, a program to ensure adequate long-term operation and maintenance of post-construction BMPs should be incorporated into the overall stormwater management program and policies.

6.6.4.6 Good Housekeeping

Municipalities conduct numerous activities that can pose a threat to water quality if practices and procedures are not in place to prevent pollutants from entering the waterways. These activities include winter road maintenance, minor road repairs and other infrastructure work, automobile fleet maintenance, landscaping and park maintenance, and building maintenance. Municipalities also conduct activities that remove pollutants from the storm system when performed properly, such as parking lot and street sweeping and storm drain system cleaning. Finally, municipal facilities can be sources of stormwater pollutants if BMPs are not in place to contain spills, manage trash, and handle non-stormwater discharges.

Because of the benefits to water quality achieved by best maintenance practices, it may be valuable to ensure staff have adequate training about ways to protect waterways, particularly when maintaining stormwater infrastructure and performing daily municipal activities, such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance. This primarily includes:

- Developing inspection and maintenance procedures and schedules for stormwater BMPs
- Implementing BMPs to treat pollutants from transportation infrastructure, maintenance areas, storage yards, sand and salt storage areas, and waste transfer stations
- Establishing procedures for properly disposing of pollutants removed from the stormwater system
- Identifying ways to incorporate water quality controls into new and existing flood management projects.

6.6.5 Potential BMPs for Water Quality Treatment

Four sites were identified as possible locations for water quality BMPs, as shown in Figure 6-1. A conceptual design was developed for three of the four potential water quality facilities based on the ODOT *Hydraulics Manual*. The ODOT *Hydraulics Manual* was selected as an appropriate reference manual for its in-depth guidance for evaluation and design of various types of water quality BMPs. A conceptual design was not developed for the site immediately upstream of the Weyerhaeuser property. This site has been identified as a potential location for an in-line detention pond. Refinement of this concept should include evaluation of opportunities to maximize detention pond design to include water quality considerations.

A more detailed discussion of the evaluation and conceptual facility design of the other three possible locations is presented in Section 7. The Softball Field site is part of the Douglas Drainage System capital improvements plan (CIP) (Section 7.2), while the remaining two are part of the Rickreall Uglow/Orchard System (Section 7.3).

6.6.5.1 BMP Evaluation

Several BMPs described in the ODOT *Hydraulics Manual* were evaluated for each of the locations. Based on the location and setup of the system, some roadway water quality facilities, such as filter strips, would not be appropriate for any of the potential locations. Filter strips consist of the right-of-way parallel to a road and a relatively flat cross slope to maintain sheet flow of the entire length of the strip. Pollutants are removed by filtrations through vegetation, media filtration, and infiltration (ODOT, 2014). The filter strips require sheet flow for effective treatment, and both potential locations in Dallas would have a pipe discharging flow to the water quality facilities, which would make these sites unsuitable for a filter strip application.

Media filtration water quality facilities, such as bioretention facilities, were also evaluated for each of the potential locations. Bioretention facilities are cell, basin, or pond constructed with amended soils, plantings, and may either include an underdrain system or dispose of stormwater entirely through infiltration (based on infiltration tests in situ). With these facilities, stormwater is captured and pollutants are filtered out by the subsurface layers (ODOT, 2014). Because most of the soils in the area are classified by NRCS as belonging to hydrologic soils group C or D, the 24 inches of subsurface soil in the area would need to be excavated and replaced with a superior-draining engineered mixture and an extensive drainage system would need to be installed. However, even with these improvements, the effectiveness of media filtration facilities may still be limited.

Biofiltration swales are open channels engineered to treat stormwater. They have gentle slopes, shallow flows, and are lined with grass. Biofiltration swales have gained popularity because of their low construction and maintenance cost, few design limitations, and ability to be located in median strips and along the shoulders of roadways and parking lots. A trapezoidal cross section is used because of ease of construction and the hydraulic efficient cross-sectional shape that minimizes flow depth and maximizes the amount of runoff flow through vegetation. This creates a condition for filtration as well as infiltration (ODOT, 2014). Even though the hydrologic soils group C and D in the area will require the soil to be excavated and replaced with an engineered mixture, it is only required to be 18 inches deep (bioretention facilities require 24 inches) and the drainage configuration for a biofiltration swale is substantially less than that of a bioretention facility.

6.6.5.2 Design Criteria

The ODOT *Hydraulics Manual* was used for the conceptual design of both water quality treatment facilities. The manual requires that 50 percent of the 2-year, 24-hour storm event must be treated in a water quality facility in the City of Dallas (other regions of the state have different requirements). The future flows developed in Section 5 from the 2-year, 24-hour storm event were used for the sizing of both biofiltration swales.

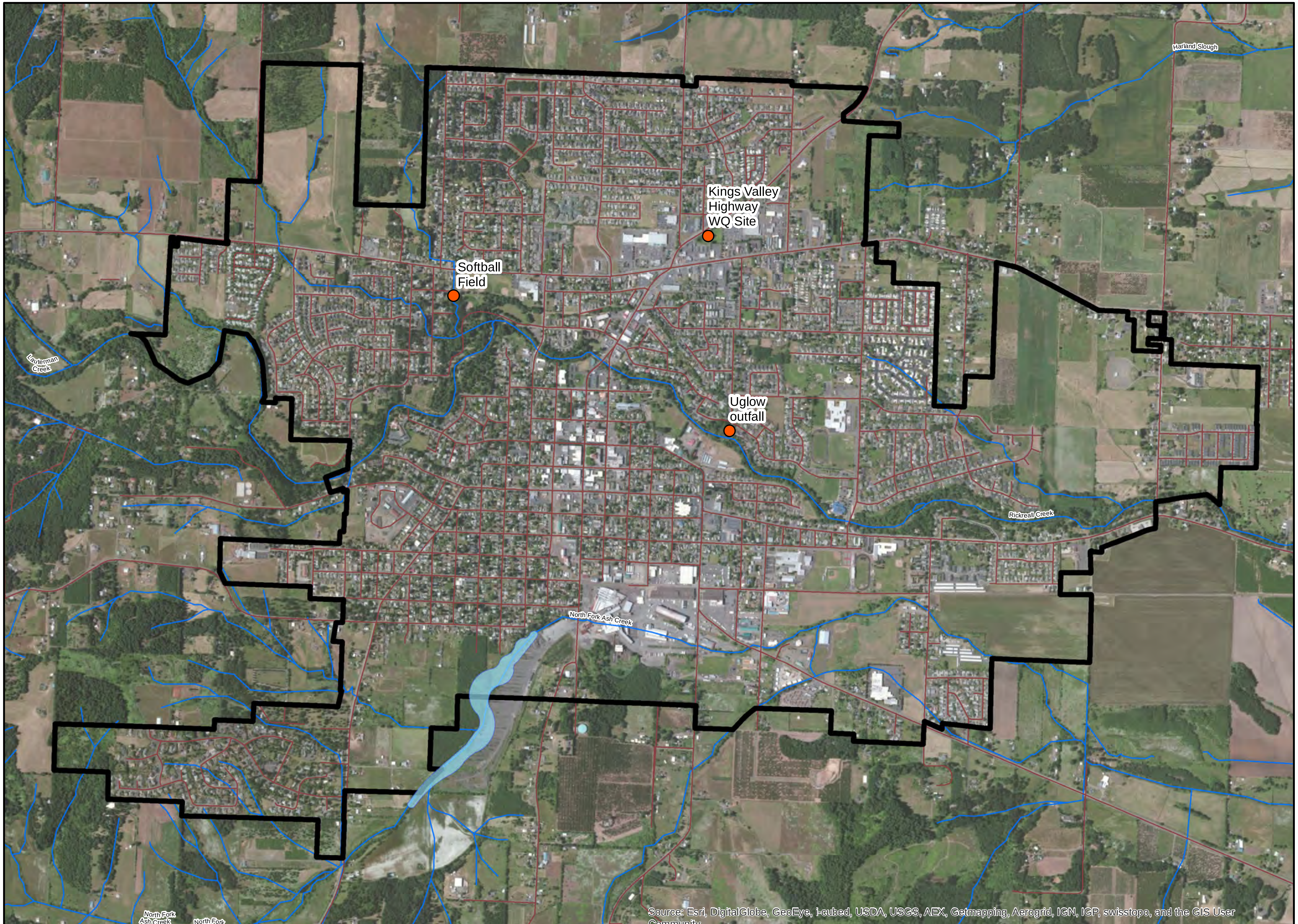


FIGURE 6-1

Possible Locations for Water Quality BMPs

City of Dallas
Stormwater Master Plan

Legend

- Potential Water Quality Site
- City Boundary
- Roads
- Streams
- Potential Detention Pond/Water Quality Treatment Facility

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1 inch equals 1,500 feet

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Date: 1/29/2015

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SECTION 7

Analysis Results and Recommended Improvements

As noted in Section 3.4, a systems approach was taken to group and analyze hydraulically linked problem areas together. As a result, there are fewer analysis areas than there are identified problem areas. Though not identified as a flooding site, Hunter Street was identified as an additional location for needed drainage improvements due to the construction of a house directly on top of a concrete culvert.

In total, there were six areas of analysis:

- West Ellendale at Wyatt
- Douglas Drainage
- Rickreall Uglow/Orchard
- Kings Valley Highway/Highway 223 at the Cemetery
- North Fork Ash Creek
- Hunter Street

These analysis areas are shown in Figure 7-1.

A system analysis was conducted for each of these six areas, using the hydrologic and hydraulic methods described in Section 3. The applicability of the various analysis methods and the complexity of the analysis varied based on the complexity of the system in each area. Analysis of potential water quality improvements was incorporated into the systems analysis for the Douglas Drainage and Rickreall Uglow/Orchard systems.

The system analyses for each area are described in separate sections below. Each section describes the nature of the problem observed in the area; describes the system components included in the analysis; summarizes the hydrologic, hydraulic, and water quality analyses conducted; recommends capital improvements to alleviate identified problems and address water quality goals; and recommends next steps (if any). For the North Fork Ash Creek system, a discussion of regulatory and permitting considerations is also included.

7.1 West Ellendale at Wyatt

7.1.1 Description of Problem

Historically, floodwaters from the Forestry Creek tributary overtop West Ellendale and run down Wyatt Street.

7.1.2 Description of Existing System

The Ellendale drainage system at Wyatt Street considered in this analysis consists of a 5-foot diameter circular concrete culvert (which conveys Forestry Creek under the road), a 3-foot diameter corrugated high-density polyethylene (HDPE) pipe, and a constructed trapezoidal channel, as shown in Figure 7-2. The culvert and pipe both discharge to the channel on the south side of Ellendale Avenue. The channel collects additional flow from the subdivision to the west of Kingsborough Park, from Kingsborough Park, and a small undeveloped grassy area on the east side of Wyatt Avenue.

The constructed channel diverts water from the natural Forestry Creek channel that used to flow to the east and outlet to Rickreall Creek at a point southeast of the existing softball field complex at the southern end of Douglas Avenue. The re-directed Forestry Creek now discharges to Rickreall Creek approximately 1.4 miles upstream of the original point of discharge.

The drainage system also includes a detention pond in Kingsborough Park. The natural channel drains to the detention pond via a 6-inch pipe, and the detention pond drains to the constructed channel via a grassy triangular channel.

Overtopping of Ellendale Avenue and flooding down Wyatt Street have been observed in the past. As a corrective measure, the City has constructed an earthen berm on the north side of Ellendale Avenue to retain floodwaters.

7.1.3 Hydrologic Analysis

The culvert drains approximately 740 acres (subbasins R-NW-C2E, R-NW-C3EW, and R-NW-C3EE) on the north side of Ellendale Avenue. Approximately 89 percent of this area is outside of the City boundary, where for purposes of this analysis, no further development is expected. The remaining 11 percent of this area is part of the Wyatt growth node where homebuilding is expected to occur within the next 20 years. Under current conditions, peak flow at the culvert for the 100-year 24-hour storm is 438 cubic feet per second (cfs). Under future buildout conditions, peak flow at the culvert for the 100-year 24-hour storm increases by 3 cfs, for a total expected flow through the culvert of 441 cfs. The flow from individual subbasins increases by as much as 15 cfs, but peak flows do not simultaneously converge at the culvert, resulting in a relatively small increase between current and buildout conditions at the culvert.

The 3-foot diameter pipe across Ellendale Avenue currently conveys flow from approximately 21 acres (subbasin R-NW-C1N) on the north side of Ellendale Avenue. Flow enters the pipe from both east and west, with flow from the west connecting approximately 25 feet south of the upstream end of the pipe, where water from the east enters the pipe. For purposes of this analysis, all flow was assumed to enter the pipe at the upstream end. The entire tributary area for the pipe is within the City boundary and is part of the Wyatt growth node. Under current conditions, the peak flow at the pipe is 52 cfs. Under future buildout conditions, flow through the pipe increases by 5 cfs, for a total buildout flow of 57 cfs.

Flows were calculated in a HEC-HMS model using SCS methodology. Information about the hydrologic analysis methodology is provided in Section 3.3.

7.1.4 Hydraulic Analysis

An XPSWMM model was built to analyze hydraulic performance of the culvert/pipe/channel system using information from the City's record drawings and field survey data. The slope of the pipe was assumed to match the slope of the culvert. The earthen berm on the north side of Ellendale Avenue was not considered in this analysis on the assumption that it will be removed when development occurs. The abandoned natural channel and detention pond were also not included in the hydraulic analysis, except to quantify the amount of overflow that will exit the constructed channel and flow into the abandoned natural channel. The pipe crossing Kingsborough Park from north to south, which discharges near the outfall of the constructed channel, was also not included in the model.

The model was checked that it reflected observed flooding conditions. However, a true calibration was not possible because there are no flow records. As such, the model cannot accurately estimate surcharge levels or flood volumes under current conditions, but can be used as an evaluative tool to assess capacity improvements required to pass peak flow from the future 100-year design storm.

Model results indicate that the culvert is undersized to carry the buildout peak flow for the 100 year storm. The existing culvert capacity is 197 cfs, corresponding approximately to the peak flow for the 5-year storm (190 cfs). The existing pipe capacity is 41 cfs, corresponding approximately to the peak flow for the 25 year storm (43 cfs).

Model results indicate that under buildout conditions the culvert will surcharge to an elevation of 356.9 feet, approximately 0.1 foot above the road crown elevation, and the pipe will surcharge to an elevation of 361.8 feet, approximately 2 feet below the manhole rim.

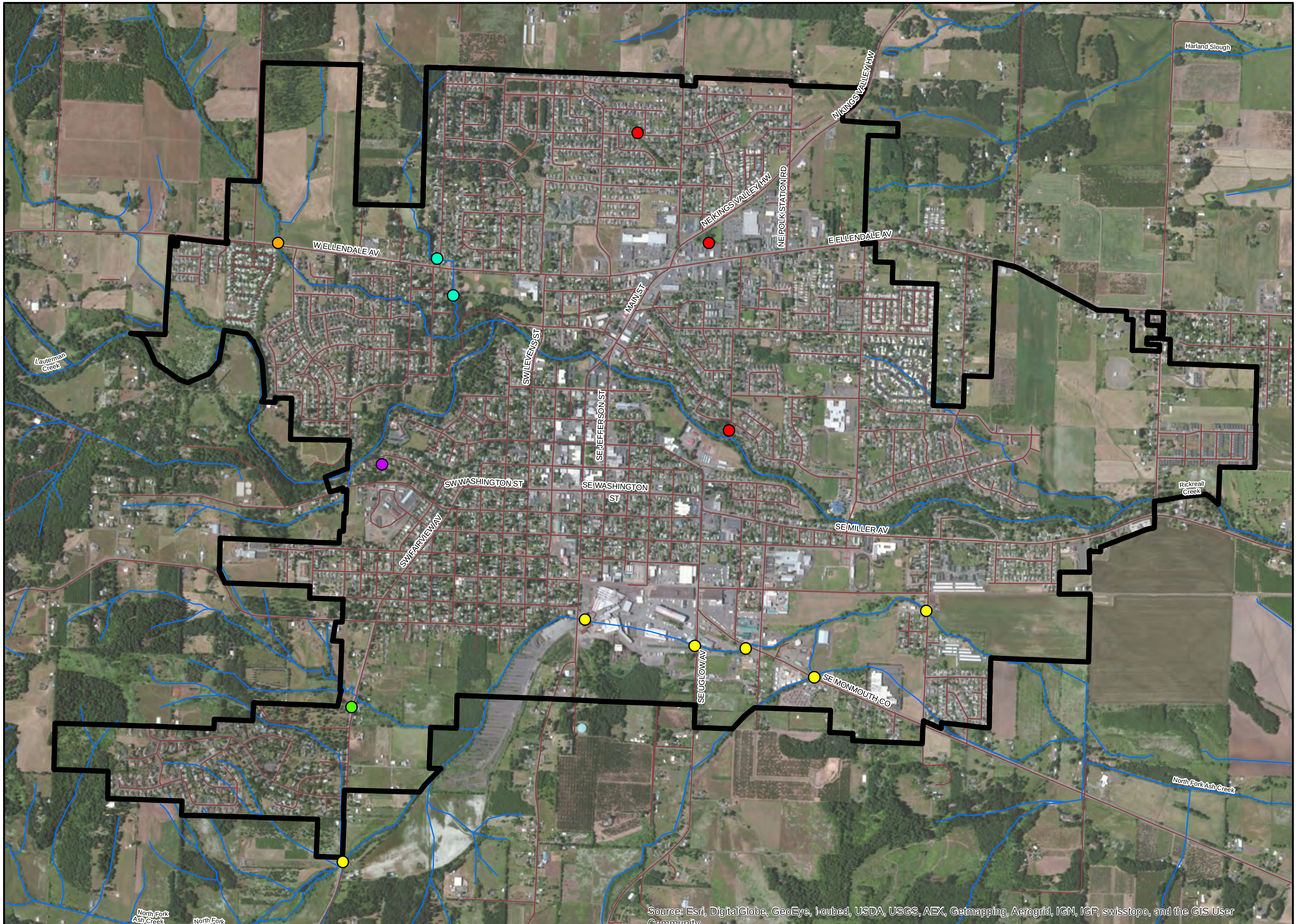

FIGURE 7-1

Capital Improvement Areas of Analysis

City of Dallas
Stormwater Master Plan

Legend

Analysis Area

- Douglas Drainage
- Hunter Street
- Kings Valley Highway at the Cemetery
- North Fork Ash Creek
- Rickreall Uglow/Orchard
- West Ellendale at Wyatt
- City Boundary
- Roads
- Streams

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1 inch equals 1,500 feet

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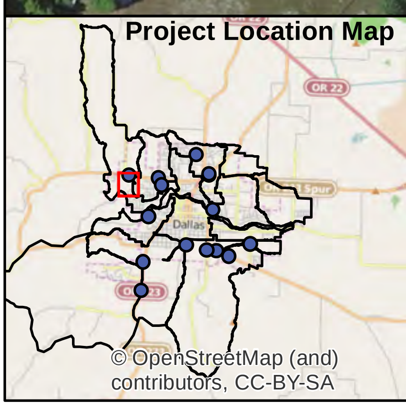

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0 125 250 500 ft

Legend

- Identified Problem Area
- Manhole
- Storm Outlet
- Constructed Channel
- Storm Culverts
- Storm Pipe

FIGURE 7-2
West Ellendale at Wyatt
Existing Conditions
City of Dallas Stormwater Master Plan

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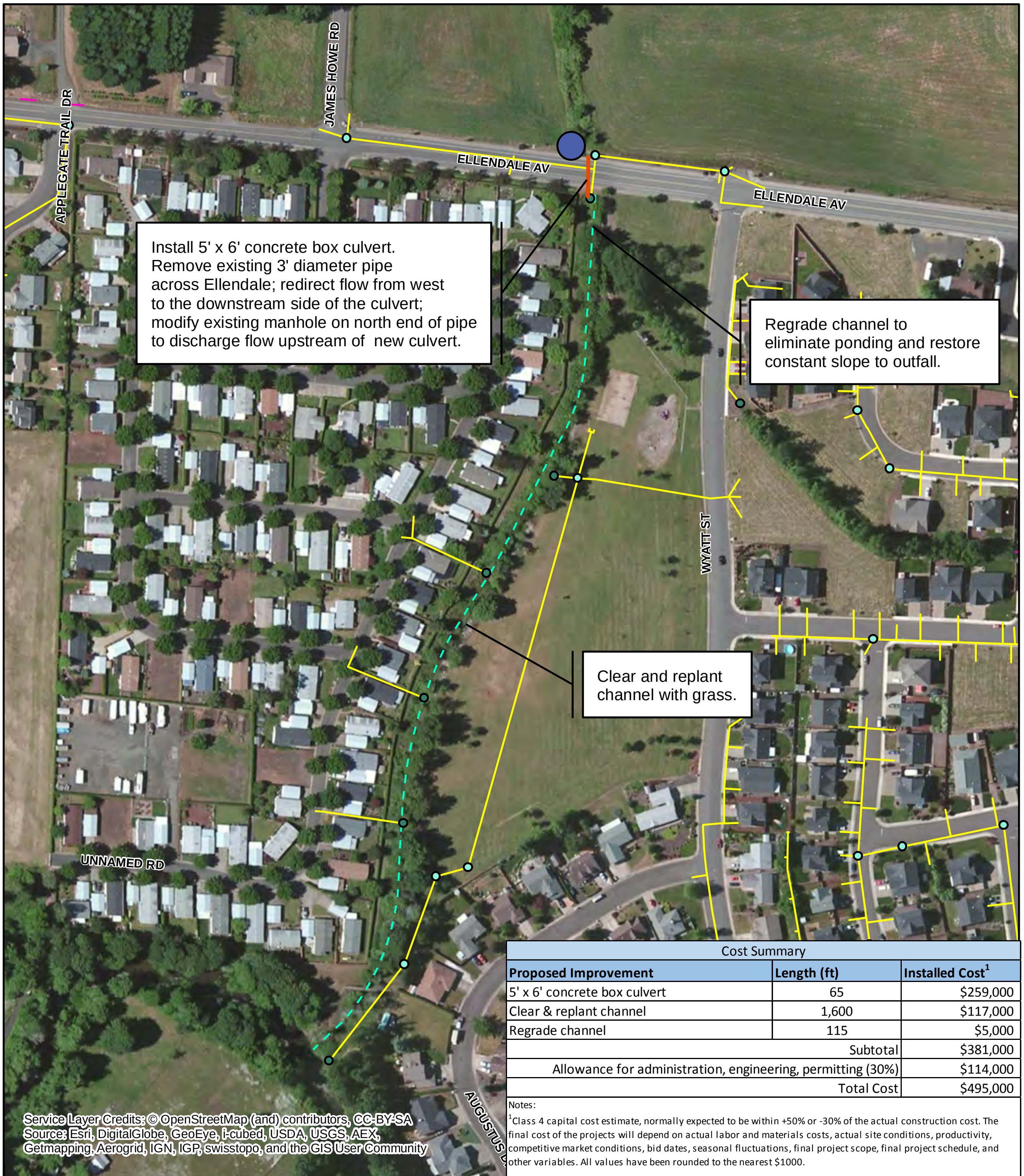
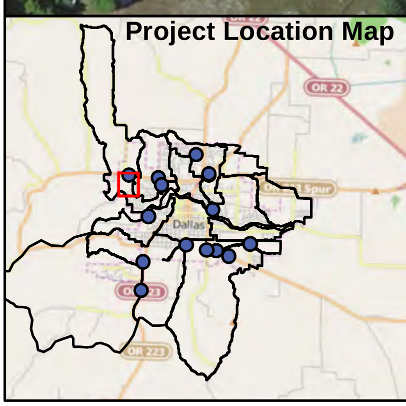


Cost Summary

Proposed Improvement	Length (ft)	Installed Cost[1]
5' x 6' concrete box culvert	65	$259,000
Clear & replant channel	1,600	$117,000
Regrade channel	115	$5,000
Subtotal		$381,000
Allowance for administration, engineering, permitting (30%)		$114,000
Total Cost		$495,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.

Project Location Map



Legend

N

- Proposed Pipe Improvements
- Identified Problem Area
- Manhole
- Storm Outlet
- Constructed Channel
- Storm Culverts
- Storm Pipe

0 125 250 500 ft

FIGURE 7-3
West Ellendale at Wyatt

Recommended
Capital Improvements
City of Dallas Stormwater Master Plan

CH2MHILL

Capacity of the existing channel is limited by the bank elevation on the east side of the channel and the brushy weeds that have grown up on the sides of the channel. A Manning's n value of 0.035 was used in this analysis. Additionally, survey data indicate that a short (40-foot) section of reverse grade has developed in the channel immediately downstream of the culvert, resulting in ponding and impacting hydraulic function. The cause of the reverse grade is unknown; it may be caused by scour at the outlet to the existing culvert or pipe.

Upstream of the point of overflow to the natural channel, depth was conservatively estimated to be approximately 2.6 feet based on survey information. Channel depth downstream of the point of overflow to the natural channel is estimated to be approximately 4 feet based on field inspection.

Performance of the system is highly sensitive to channel parameters. Verification of assumed parameters will facilitate more accurate estimates of channel capacity and will be necessary in later design phases in order to ensure that the recommended improvements are adequate to provide required conveyance capacity.

Based on the existing information and assumptions, channel capacity upstream of the overflow is 409 cfs. Downstream of the overflow, channel capacity is estimated to be 320 cfs, corresponding approximately to the 10-year storm. Channel capacity estimates are highly sensitive to assumptions about channel roughness.

Model results indicate that under existing hydraulic conditions, over 37,000 cubic feet overflow from the constructed channel to the natural channel. This is in addition to the water that overtops the culvert and would flood down Wyatt Street if the earthen berm had not been put in place on the north side of Ellendale Avenue.

7.1.5 Proposed Capital Improvement Projects

The following recommendations are made to improve hydraulic performance of the system, and are made with the assumption that the earthen berm on the north side of Ellendale was not designed as a permanent improvement and will eventually be removed as development occurs.

Hydraulic performance of the system can be improved by modifying the constructed channel and increasing the size of the culvert, as shown in Figure 7-3.

Recommended channel modifications include regrading the channel upstream of the point of overflow to restore a consistent grade of 0.25 percent from the culvert outlet to the existing outfall elevation, and replacing the existing brushy weeds with short grass to achieve smoother channel conditions ($n \leq 0.03$). Regrading, replanting, and maintaining the channel will proved hydraulic capacity. Further analysis to determine the cause of the reverse grade should be undertaken to mitigate the cause and prevent a reverse grade from developing again.

Replacing the existing circular culvert with a 5-foot-by-6-foot concrete box culvert provides capacity for 387 cfs, reducing surcharge to approximately 1.66 feet below the road crown elevation. For purposes of this analysis, box height was selected to match the diameter of the existing culvert in order to preserve the current cover depth of approximately 1.76 feet.

A box culvert was selected as the appropriate configuration for sizing and cost estimating purposes. Fish passage requirements may impact the final culvert configuration.

The existing 3-foot plastic pipe crossing Ellendale Avenue can be removed or abandoned in place. The large manhole on the north side of Ellendale Avenue near the entrance to the culvert will need to be modified to discharge flow to the upstream side of the culvert. Flow from the west that currently connects to the 3-foot diameter pipe will need to be directed to the channel either upstream or downstream of the new culvert.

These proposed improvements reduce surcharge on the existing pipe by 0.6 foot; the water surface elevation in the manhole remains approximately 2.6 feet below the rim elevation.

7.1.6 Recommended Next Steps

The hydrologic and hydraulic analysis and resulting recommended capital improvement projects presented in this report are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects. The following next steps are recommended as part of the design process:

- Add detail about the Kingsborough Park detention pond and the connection to the hydraulic model to better understand interactions between the two and potential impacts to recommended improvements.
- Analyze the possibility of restoring flow to the abandoned natural channel as a design alternative or supplement.
- Analyze the possibility of directing some flow from the upstream side of W. Ellendale Avenue to a former culvert to the east of the Forestry Creek channel.
- Determine cause of existing reverse grade at existing culvert outlet and conduct scour analysis to mitigate the cause and prevent reoccurrence.
- Confirm channel dimensions and grade; adjust length of channel that must be regraded if necessary to provide hydraulic capacity.
- Confirm fish passage requirements and adapt culvert design concept accordingly.

7.2 Douglas Drainage

7.2.1 Description of Problem

Water rises to the surface at the upstream end of the system on Douglas Avenue, where flow from a straightened natural channel enters the piped system.

7.2.2 Description of Existing System

The system analyzed conveys water from the Douglas drainage area in addition to urban stormwater runoff to an outfall at the southwest corner of the softball field complex, as shown in Figure 7-4.

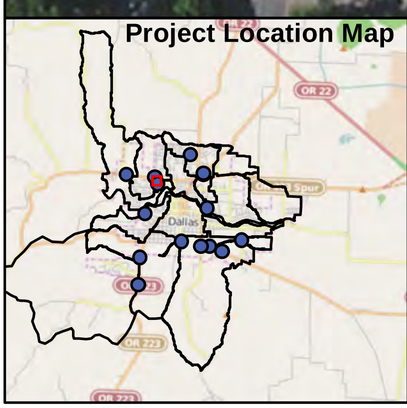
The natural channel enters a constructed channel approximately 1,130 feet upstream of Douglas Avenue, when it crosses the City boundary from the north. The constructed channel enters a 24-inch concrete pipe from the west at Douglas Avenue. The pipe entrance is protected from large debris by a metal grate.

The piped system analyzed starts with the 24-inch pipe on the west side of Douglas Avenue and a 21-inch pipe on the east side of Douglas Avenue. These two pipes are connected by an overflow from the 21-inch to the 24-inch just upstream of the channel. The two pipes then converge at a manhole near the intersection of Douglas and West Ellendale. A 36-inch pipe then runs east down West Ellendale for a distance of 207 feet to the softball complex driveway. Additional flow from the north and east also enters the system at this point. A single 42-inch pipe then runs southward along the west side of the softball complex property for a distance of 312 feet to a manhole at the end of Veazie Street, where additional flow joins the system. A 42-inch pipe then conveys the combined flow another 190 feet to the point of discharge.

7.2.3 Hydrologic Analysis

The natural creek and straightened channel drain an area of 124 acres, 98 of which lie outside the City boundary and are zoned either farm/forest or suburban residential. The 26 acres within the city boundary are zoned light residential. At buildout, peak flow in in the creek at the point where it enters the piped system at Douglas Avenue is 95 cfs for the 100-year storm. Flows were determined using SCS methodology as described in Section 3.3.

The piped system drains an additional 150 acres, most of which lies within the city and is zoned light residential. Approximately 35 acres within the City boundary are currently undeveloped, 33 of which are part of the Wyatt growth node where homebuilding is expected to occur within the next 20 years.



Legend

N

- Identified Problem Area
- Potential Water Quality Site
- Manhole
- Storm Outlet
- Storm Culverts
- ConstructedChannel
- Storm Pipe

0 50 100 200 ft

FIGURE 7-4
Douglas System
Existing Conditions
City of Dallas Stormwater Master Plan

CH2MHILL

The combined buildout peak flow at the outfall is 272 cfs for the 100-year storm.

7.2.4 Hydraulic Analysis

An XPSWMM model was built to analyze hydraulic performance of the channel and the piped system, using information from the City's record drawings and field survey data. There was not sufficient elevation data available to model each pipe and manhole in the system. Pipe lengths were modeled between nodes for which there was both rim and invert elevations data; nodes for which these data were not available were not included in the system. The model was checked that it reflected observed flooding conditions.

However, a true calibration was not possible because there are no flow records. As such, the model cannot accurately estimate surcharge levels or flood volumes under current conditions, but can be used as an evaluative tool to assess capacity improvements required to pass peak flow from the 100-year design storm.

The model was constructed to evaluate capacity of the Douglas channel and downstream system. Inflow hydrographs from subbasins DA1, DA2E, DA2W, and DA3 were added to the downstream system at appropriate nodes, but conveyance within those subbasins was not modeled.

Model results indicate that the drainage system downstream of the Douglas channel does not have capacity to convey the peak flow from the 100-year storm without flooding. Model results show surface flooding occurs at the top of the outfall pipe, where flow from the Veazie Street system is added, and at the channel entrance to the piped system in Douglas Avenue for the 100-year storm event.

The capacity of key system components is presented in Table 7-1, along with the peak flow from the 100- year storm.

TABLE 7-1

Capacity of Key System Components, Douglas Drainage System

City of Dallas Stormwater Master Plan

System Component	Capacity (cfs)	Q100 at Buildout (cfs)
Douglas channel upstream of piped system	6	95
24-inch west side of Douglas	53	95
21-inch east side of Douglas	39	52
36-inch Ellendale	92	147
42-inch west side of softball driveway	107	184
42-inch outfall pipe	115	272

7.2.5 Water Quality Analysis

The City has expressed interest in providing water quality treatment to protect and improve the aquatic habitat of its waters and to prepare for eventual regulatory requirements.

The grassy area in the southwest corner of the softball complex has been identified as a potential site for incorporating a water quality facility. The site is approximately 0.3 acre with a grade of 0.6 percent to the south. Before installation of the outfall pipe, which extends southward from MH 09-92 at the end of Veazie Street, stormwater discharged to an open channel that crossed the site from north to south.

Water quality treatment potential was evaluated using guidance from ODOT's *Hydraulics Manual*. In western Oregon, ODOT requires the treatment of 50 percent of the cumulative rainfall from the 2-year, 24-hour storm for the project site.

A biofiltration swale was selected as the preferred BMP for this site based on site configuration and soil infiltration capacity. Key design parameters for a biofiltration swale are summarized in Table 7-2.

TABLE 7-2
Biofiltration Design Parameters, Douglas Drainage System
City of Dallas Stormwater Master Plan

Parameter	Value	Units	Source
Slope	0.018	feet/foot	Based on existing land surface
Water quality depth	0.33	feet	Provided by ODOT *Hydraulic Manual* for the given slope
Bottom width	15	feet	Estimate based on available existing land
Manning's n	0.24	NA	Provided by ODOT *Hydraulic Manual* for biofiltration swale
Side slope	1V:4H	NA	Maximum side slope provided by ODOT *Hydraulic Manual*
Length	150	feet	Estimate based on available existing land and added sinuosity
Hydraulic residence time	9	minutes	Minimum residence time provided by ODOT *Hydraulic Manual*

NA = not applicable

The peak runoff from the water quality storm for the portion of the Douglas basin tributary to this site is 49.2 cfs. Based on the design parameters in Table 7-2, the total biofiltration bottom-area to treat the total water quality flow of 49.2 cfs is 1.84 acres. The proposed site, however, is only 0.3 acre, and can accommodate a total biofiltration bottom area of 2,250 square feet (0.05 acre). A biofiltration swale designed to fit the site constraints will provide water quality treatment for approximately 1.5 cfs, equivalent to the water quality storm runoff from approximately 16 acres of tributary area and providing treatment for 3 percent of the ODOT water quality storm.

7.2.6 Design Considerations for Water Quality and Conveyance

In order to provide water quality treatment for the maximum 1.5 cfs that can be fully treated by a biofiltration swale designed to fit the site constraints, 1.5 cfs could be diverted from the manhole at the end of Veazie Street into the biofiltration swale. Remaining flows would continue to discharge through an outfall pipe.

However, capacity of the existing outfall must be increased to convey the peak flow for the 100-year storm from the tributary area. A biofiltration swale designed to fit the site constraints can also provide conveyance for the 100-year storm. If the biofiltration swale is used for conveyance, it will pass all flows up to and including the 100-year storm. Water quality treatment performance of the swale will not be as great for high flows due to the reduced hydraulic residence time.

The minimum hydraulic residence time for the water quality flow is 9 minutes, specified by ODOT. With a 9 minute residence time, biofiltration swales have been demonstrated to remove at least 75 percent of oil and grease from stormwater runoff; removal decreases to 49 percent with a retention time of 4.5 minutes (DEQ, 2003).

Although the facility is not designed to provide water quality treatment for the 100-year storm, it will have to convey the peak flow from all rain events, up to and including the 100-year storm. Peak velocity for the 100-year storm in a biofiltration swale designed to fit the site is 2.4 fps. At this velocity, hydraulic residence time is approximately 1.1 minutes. Treatment effectiveness for high flows at this velocity and residence time cannot be accurately estimated, but some pollutant removal is expected to occur. Lower flows will travel at lower velocities and will thus have higher residence times and greater pollutant removal.

Additional water quality treatment for the Douglas drainage area can be achieved by requiring new development to provide treatment facilities upstream of the outfall. These facilities are not included in the recommended capital improvement projects. This would require changes to City code and stormwater management design standards.

7.2.7 Proposed Capital Improvement Projects

The hydraulic model indicates that surface flooding can be prevented by increasing capacity of the piped conveyance system without modifying the Douglas channel. Reconstructing the outfall pipe as an open channel provides both conveyance capacity and water quality treatment.

Proposed capital improvement projects are shown in Figure 7-5 and include:

- Redirect flow in existing Douglas channel at 90-degree bend (approximately 150 feet upstream of entrance to piped system) to new 42-inch pipe
- Replace existing 36-inch pipe in Ellendale with new 42-inch pipe
- Replace pipes between MH 63-92 and MH 09-92 with new 48-inch pipe
- Construct open channel conveyance to replace existing outfall pipe and provide water quality treatment

7.2.8 Recommended Next Steps

The hydrologic and hydraulic analysis and resulting recommended capital improvement projects presented in this report are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects. The following next steps are recommended as part of the design process for the Douglas Drainage system:

- Establish groundwater levels and evaluate potential impacts to proposed outfall biofiltration facility
- Check buoyancy conditions for new large manholes

7.3 Rickreall Uglow/Orchard

7.3.1 Description of Problem

Flooding has been observed in the parking lot of Murphy's Grill; floodwaters cross the parking lot and flow south over Ellendale Avenue to flood the parking areas of the businesses to the south.

7.3.2 Description of Existing System

The modeled system, shown in Figure 7-6, represents the major trunkline for the Uglow/Orchard basin, and provides conveyance via an open natural channel in the upper portion of the basin and a piped system in the middle and lower portions of the basin. The natural channel is crossed by both Fairhaven and Elderberry Lanes before it enters the piped system at the outlet to a wetland area located at the southwest corner of the intersection of Elderberry Lane and Orchard Drive. The culvert crossing at Fairhaven is a 15-inch corrugated polyvinyl chloride pipe, while the crossing at Elderberry Lane is 24-inch plastic.

From that point, the piped system conveys flow to the southeast via parallel 36-inch pipes in Denton Street, crossing the Kings Valley Highway/Highway 223 to the north of Murphy's Bar and Grill. The piped system outlets to a small privately held green space on the south side of the highway, at the northern edge of the Murphy's property. Additional flow joins the system from the east and west at this point. The water then re-enters the piped system via a 48-inch pipe covered with a slant-faced trash rack. The 48-inch pipe connects to a 10-foot diameter manhole to which an 18-inch pipe also connects from the east. Two 36-inch pipes exit the manhole and convey flow to a box culvert crossing Ellendale Avenue at the southwest corner of the Murphy's lot.

This box culvert consists of a 12-foot length of 65-inch wide by 25-inch tall segment of reinforced concrete box culvert connected to a 60-foot length of 48-inch wide by 24-inch tall reinforced concrete box culvert (see diagram) that terminates in a junction box on the south side of Ellendale (City of Dallas, 1997). Additional flow enters the system from the east and west at this junction box.

The junction box drains to parallel 36-inch and 42-inch pipes, which converge into a single 42-inch north of Hankel Street in the parking lot of an apartment complex. The trunkline transitions to a 48-inch at Hankel

Street, then runs down Uglow Street to the outfall. The piped system outlets to a stabilized rock-lined trapezoidal channel that outfalls to Rickreall Creek.

7.3.3 Hydrologic and Hydraulic Analysis

An XPSWMM model was built to evaluate the hydrology and hydraulics of the Uglow/Orchard system. Potential detention and infiltration effects of the wetland area located at the southwest corner of the intersection of Elderberry Lane and Orchard Drive were not included in the hydrologic or hydraulic analysis.

7.3.3.1 Hydrologic Analysis

Hydrologic analysis was conducted according to SCS methodology as described in Section 3.3.

The Uglow/Orchard basin comprises approximately 12 subbasins with a total area of 300 acres, 25 of which lie outside the City boundary. The 275 acres within the City are nearly fully developed, and are primarily zoned light residential, with some areas of commercial. Very little additional development is expected to occur in the basin, with the exception of the uppermost in-city subbasin (R-UO-A6). Existing condition peak flows for all but that subbasin increase by 5 percent or less at buildout; if fully built out to zoning density, flow in R-UO-A6 increases by 11 percent. Buildout condition peak flows for a range of storm events at key points in the system are provided in Table 7-3.

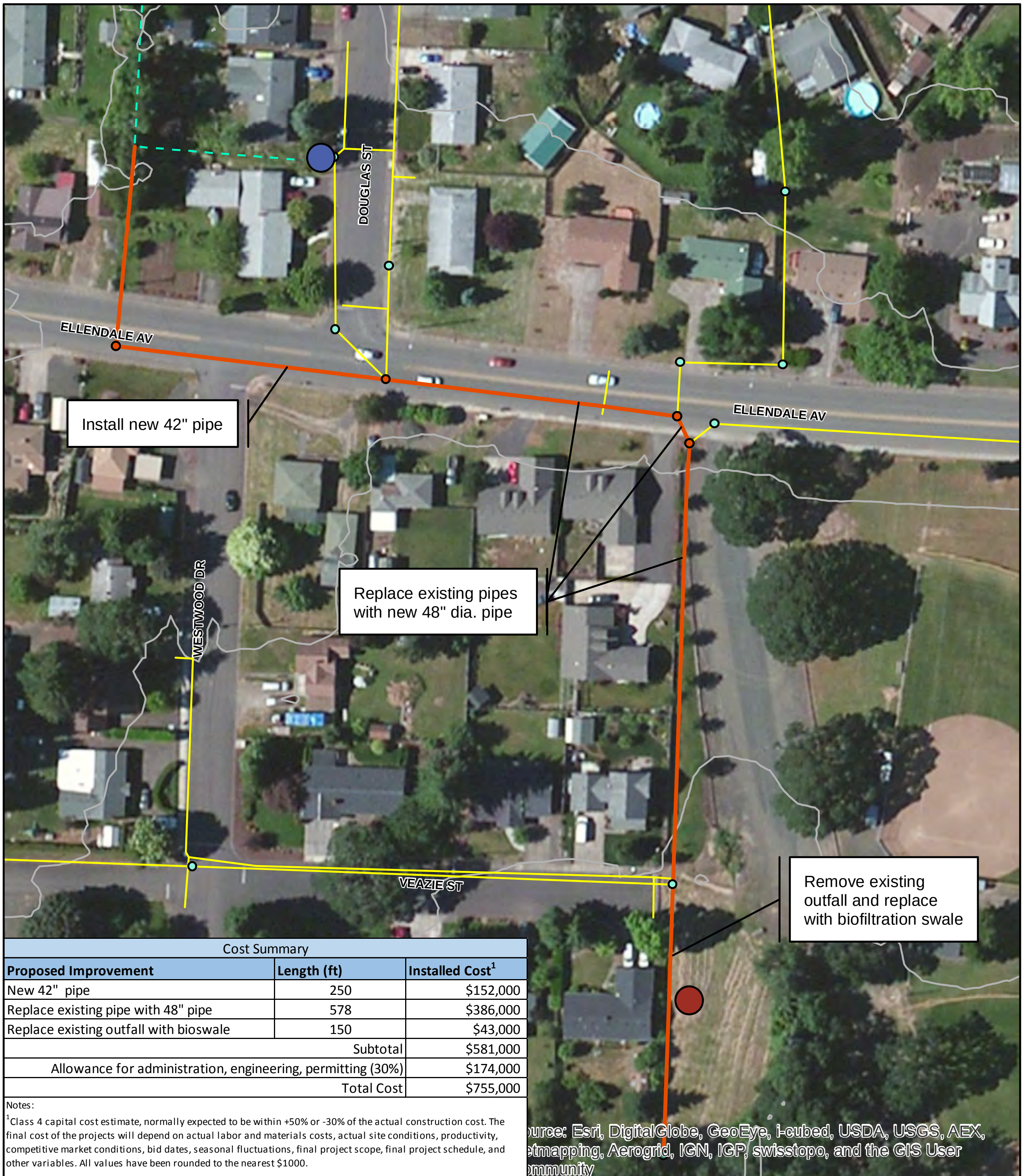
TABLE 7-3
Buildout Condition Peak Flows for Storm Events at Key Points in the System
City of Dallas Stormwater Master Plan

		Peak Storm Flow (cfs)*			
Tributary Basins	**System Component**	**2-year 24-hour**	**10-year 24-hour**	**50-year 24-hour**	**100-year 24-hour**
AB2W, AB2E, AB1	Fairhaven Culvert	8.1	16.2	20.7	23.0
As above + A6, A5W, 5E, A4C, A4W, A4E	Dual 36-inch in Murphy's lot, Ellendale culverts, and downstream system to intersection Uglow and Hankel	102.4	167.8	208.9	224.1
As above + A2	48-inch south of Hankel in Uglow	119.44	195.9	245.6	264.5
As above + A1	Outfall channel	131.9	217.5	277.3	298.8

*Values are based on hydraulic routing for system.

7.3.3.2 Hydraulic Analysis

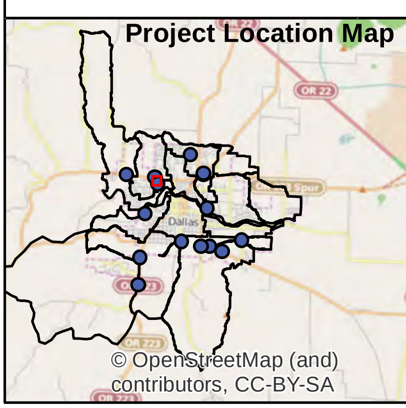
The XPSWMM model was built to analyze hydraulic performance of the Uglow/Orchard trunkline conveyance system, using information from the City's record drawings, GIS topographic data, information from the Uglow/Orchard System Evaluation conducted in 1997 (City of Dallas, 1997), and field survey data. Pipes included in the hydraulic model are indicated in Figure 7-6. There was not sufficient elevation data available to model each pipe and manhole in the system. Pipe lengths were modeled between nodes for which there was both rim and invert elevations data; nodes for which these data were not available were not included in the system. The model was checked that it reflected observed flooding conditions. However, a true calibration was not possible because there are no flow records. As such, the model cannot accurately estimate surcharge levels or flood volumes under current conditions, but can be used as an evaluative tool to assess capacity improvements required to pass peak flow from the 100-year design storm. Model results were used specifically to address deficiencies associated with identified flood-prone areas (the Fairhaven culvert and the Murphy's Grill parking lot).



Cost Summary

Proposed Improvement	Length (ft)	Installed Cost[1]
New 42" pipe	250	$152,000
Replace existing pipe with 48" pipe	578	$386,000
Replace existing outfall with bioswale	150	$43,000
Subtotal		$581,000
Allowance for administration, engineering, permitting (30%)		$174,000
Total Cost		$755,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



Legend

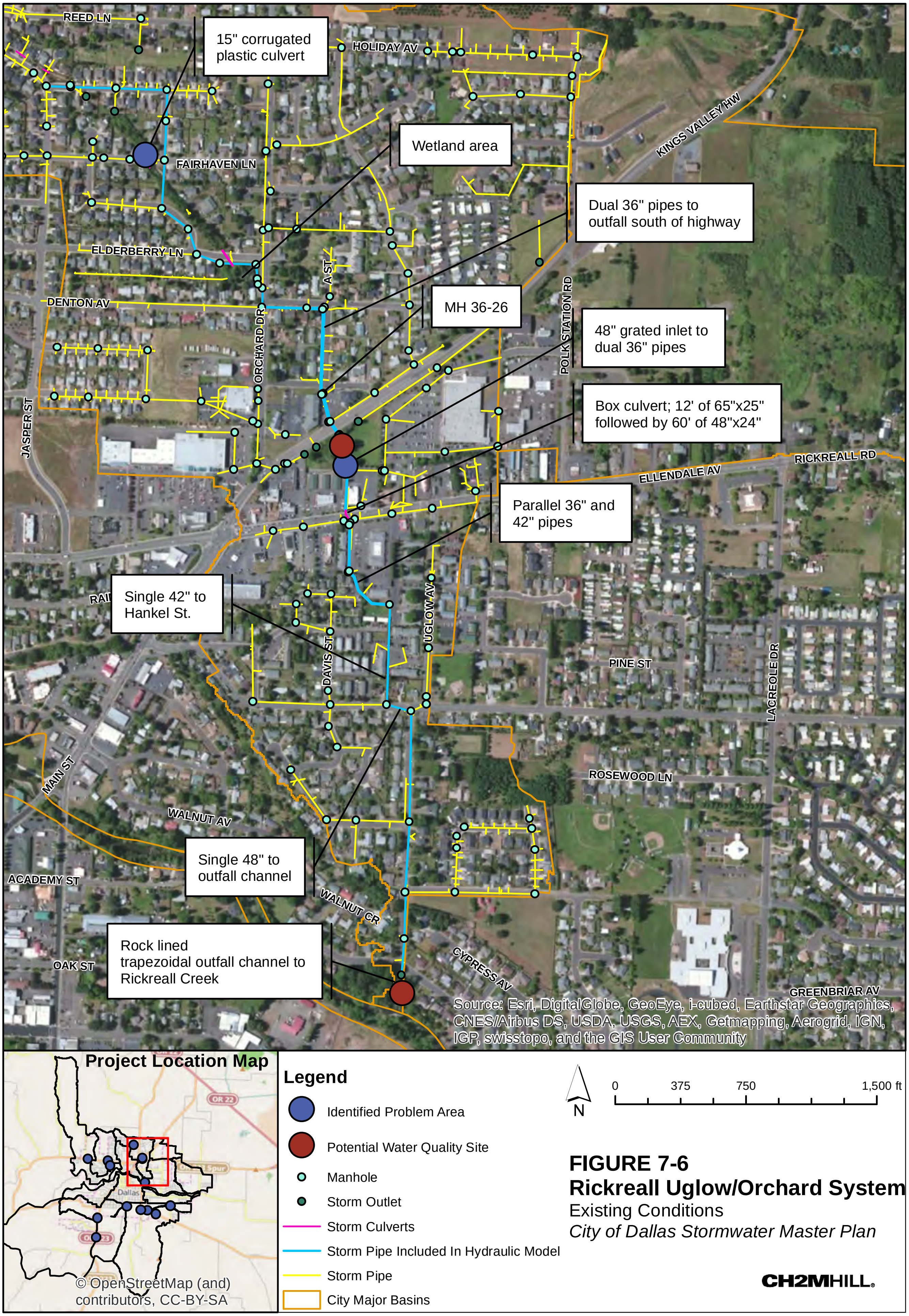
- Identified Problem Area
- Potential Water Quality Site
- Existing Manhole
- Existing Storm Outlet
- Existing Storm Pipe
- ConstructedChannel
- Proposed Manhole Improvement
- Proposed Pipe Improvement

N

0 50 100 200 ft

FIGURE 7- 5
Douglas System
Recommended
Capital Improvements
City of Dallas Stormwater Master Plan

CH2MHILL.



Legend

- Identified Problem Area
- Potential Water Quality Site
- Manhole
- Storm Outlet
- Storm Culverts
- Storm Pipe Included In Hydraulic Model
- Storm Pipe
- City Major Basins

FIGURE 7-6
Rickreall Uglow/Orchard System
Existing Conditions
City of Dallas Stormwater Master Plan

CH2MHILL

Model results indicate that current system is likely to flood at the Murphy's parking lot for all of the storm flows analyzed. System capacity is limited by the flat grade and irregular alignment of the box culvert under Ellendale, as well as the capacity of the system downstream of the Ellendale Crossing. Model results also indicate the Fairhaven culvert will be overtopped in the 50- and 100-year storms.

Additionally, model results indicate that surface flooding may occur for rain events equal to or greater than the 50-year storm at MH36-26, downstream of the wetland area located at the southwest corner of the intersection of Elderberry Lane and Orchard Drive. However, since this location was not identified as a known problem area, it is possible that detention and infiltration effects of the wetland attenuate peak flows that could otherwise cause surface flooding. No further analysis of this location was conducted.

Table 7-4 provides a summary of the existing capacity and 100-year design flow for deficient system components.

TABLE 7-4
Existing Capacity, 100-year Design Flow, and Capacity Deficit for Deficient Components of the Rickreall Uglow/Orchard Drainage System
City of Dallas Stormwater Master Plan

System Component	Existing Capacity (cfs)	100-year storm Design Flow (cfs)	Capacity Deficit (cfs)
Fairhaven Culvert	4.9	23.0	18.1
Dual 36-inch in Murphy's lot	105.2 (combined)	247.2	142.0
Box culvert under Ellendale (most limited section)	92.0	247.2	155.2
Parallel 36-inch & 42-inch south of Ellendale	151.2 (combined capacity of most limited section)	247.2	96.0
42-inch to Hankel St.	104.2	247.2	143.0
48-inch south of Hankel St. to outfall	196.5	292.4	95.9
Final 200 feet of outfall pipe	198.5	325.5	127.0

7.3.4 Water Quality Analysis

The City has expressed interest in providing water quality treatment to protect and improve the aquatic habitat of its waters and to prepare for eventual regulatory requirements.

Two sites in the Uglow/Orchard basin have been identified as potential sites for water quality construction. The first site lies immediately north of the Murphy's Grill parking lot, in an open area to the south of Kings Valley Highway/Highway 223, where flooding occurs at the inlet to the piped system as previously described. The second site is at the existing outfall channel at the end of Uglow Avenue.

Water quality treatment potential for both sites was evaluated using guidance from ODOT's *Hydraulics Manual*. In western Oregon, ODOT requires the treatment of 50 percent of the cumulative rainfall from the 2-year, 24-hour storm for the project site.

7.3.4.1 Kings Valley Highway/Highway 223 Site

Existing Site Conditions

The first potential water quality treatment site is shown in Figure 7-7. The site is approximately 0.4 acre and slopes to the east.

FIGURE 7-7
Potential Kings Valley Highway/Highway 223 Water Quality Treatment Facility Site with Existing Outfall Locations
Outfalls shown as green dots.

As shown in Figure 7-7, there are five outfalls to the potential water quality treatment site. The two side-by-side outfalls near the middle of the area discharge directly to an open channel that crosses the site from north to south. Flows from the northeast and southwest outfalls discharge to ditches that flow toward the open channel. The open channel is approximately 200 feet long and flows in to the piped system.

The side-by-side outfalls are both 36-inch diameter concrete pipes. Together, these pipes convey most of the stormwater from the upstream areas of the Uglow/Orchard basin. The outfall to the northeast conveys primarily runoff from approximately 1,200 linear feet of the Kings Valley Highway/Highway 223, while the SW outfall drains a subbasin approximately 24 acres in size. Both outfalls are 18-inch diameter concrete pipes.

At buildout, peak flow from the 24-acre subbasin drained by the southwest outfall is 15 cfs for the 2-year storm and 34 cfs for the 100-year storm. Peak flow in the open channel, which is fed in part by the southwest outfall, is just over 100 cfs for the 2-year storm and nearly 260 cfs for the 100-year storm.

Water Quality Treatment Potential at the Kings Valley Highway/Highway 223 Site

A biofiltration swale was selected as the preferred BMP for this site based on site configuration and soil infiltration capacity. Flow from the southwest outfall could be redirected to a biofiltration swale with an outlet modification or regrading of the ditch that currently conveys flow from the outfall to the channel in the middle of the site. Approximately 0.21 acre lies to the east of the channel.

A soil base and underdrain system will need to be installed to convey stormwater that has filtered through the swale but cannot be absorbed by the native soil. The topsoil in the biofiltration swale base needs to have 8 to 10 percent organic matter. The soil at this location will need to be amended by placing 6 inches of composted material and rototill into 12 inches of soil for a total of 18 inches of amended soil (ODOT, 2014). Under the amended soil, a perforated drain pipe (with 6 inches of granular drain backfill material) will need to be installed to drain and collect infiltrated stormwater into a perforated drain pipe.

Key design parameters for a biofiltration swale designed to fit within the available area east of the channel are summarized in Table 7-5.

TABLE 7-5
Biofiltration Swale Design Parameters for Kings Valley Highway/Highway 223 Site
City of Dallas Stormwater Master Plan

Parameter	Value	Units	Source
Slope	0.055	feet/foot	Based on existing land surface
Water quality depth	0.25	feet	Provided by ODOT *Hydraulic Manual* for the given slope
Freeboard	1	feet	Provided by ODOT *Hydraulic Manual* minimum
Bottom width	50	feet	Estimate based on available existing land
Manning's n	0.24	NA	Provided by ODOT *Hydraulic Manual* for biofiltration swale
Side slope	1V:4H	NA	Maximum side slope provided by ODOT *Hydraulic Manual*
Length	180	feet	Estimate based on available existing land and added sinuosity
Hydraulic residence time	9	minutes	Minimum residence time provided by ODOT *Hydraulic Manual*

NA = not applicable

A biofiltration swale designed to fit within this 0.21 acre will provide water quality treatment for approximately 4.25 cfs, equivalent to the water quality storm runoff from approximately 14 acres of tributary area and providing treatment for nearly 60 percent of the ODOT water quality storm. This flow could be diverted from the southwest outfall using a flow diversion manhole retrofit to the existing outfall.

7.3.4.2 Uglow Outfall Site

Existing Site Conditions

Flow is discharged from a 48-inch pipe to a straight, rock-lined open channel with a mild slope. The existing channel is approximately 15 feet wide at the top and 125 feet long. All stormwater flows from the Rickreall Uglow-Orchard basin are conveyed through the open channel to Rickreall Creek. There is approximately 5 to 10 feet of clearance on each side of the channel; otherwise the area has heavy vegetation.

At buildout, peak flow from the basin is 153 cfs for the 2-year storm and 382 cfs for the 100-year storm.

Water Quality Treatment Potential at the Uglow Outfall Site

A biofiltration swale was selected as the preferred BMP for this site based on site configuration and soil infiltration capacity. Flow from the outfall could be redirected to a biofiltration swale with an outlet modification.

A soil base and underdrain system will need to be installed to convey stormwater that has filtered through the swale but cannot be absorbed by the native soil. The soil under the biofiltration swale base needs to have 8 to 10 percent organic matter. The soil at this location will need to be amended by placing 6 inches of composted material and rototill into 12 inches of soil for a total of 18 inches of amended soil (ODOT, 2014). Under the amended soil, a perforated drain pipe (with 6 inches of granular drain backfill material) will need to be installed to drain and collect infiltrated stormwater into a perforated drain pipe.

Key design parameters for a biofiltration swale designed to fit within the available clear area are summarized in Table 7-6.

TABLE 7-6
Biofiltration Swale Design Parameters for Uglow Outfall Site
City of Dallas Stormwater Master Plan

Parameter	Value	Units	Source
Slope	0.018	feet/foot	Based on existing land surface
Water quality depth	0.33	feet	Provided by ODOT *Hydraulic Manual* for the given slope
Freeboard	1	feet	Provided by ODOT *Hydraulic Manual* minimum
Bottom width	15	feet	Estimate based on available existing land
Manning's n	0.24	NA	Provided by ODOT *Hydraulic Manual* for biofiltration swale
Side slope	1V:4H	NA	Maximum side slope provided by ODOT *Hydraulic Manual*
Length	150	feet	Estimate based on available existing land and added sinuosity
Hydraulic residence time	9	minutes	Minimum residence time provided by ODOT *Hydraulic Manual*

NA = not applicable

A biofiltration swale designed to fit within the site constraints will provide water quality treatment for approximately 1.38 cfs, equivalent to the water quality storm runoff from approximately 5.3 acres of tributary area and providing treatment for just under 2 percent of the ODOT water quality storm. This flow could be diverted from the outfall using a flow diversion manhole retrofit to the existing outfall.

7.3.5 Proposed Capital Improvement Projects

The hydraulic model indicates that surface flooding at identified problem areas can be prevented by upsizing the Fairhaven culvert and increasing capacity of the trunkline conveyance system downstream of the current inlet at Murphy's Bar and Grill. Surcharge will still occur, but the water surface elevation for the 100-year design storm will be kept below ground.

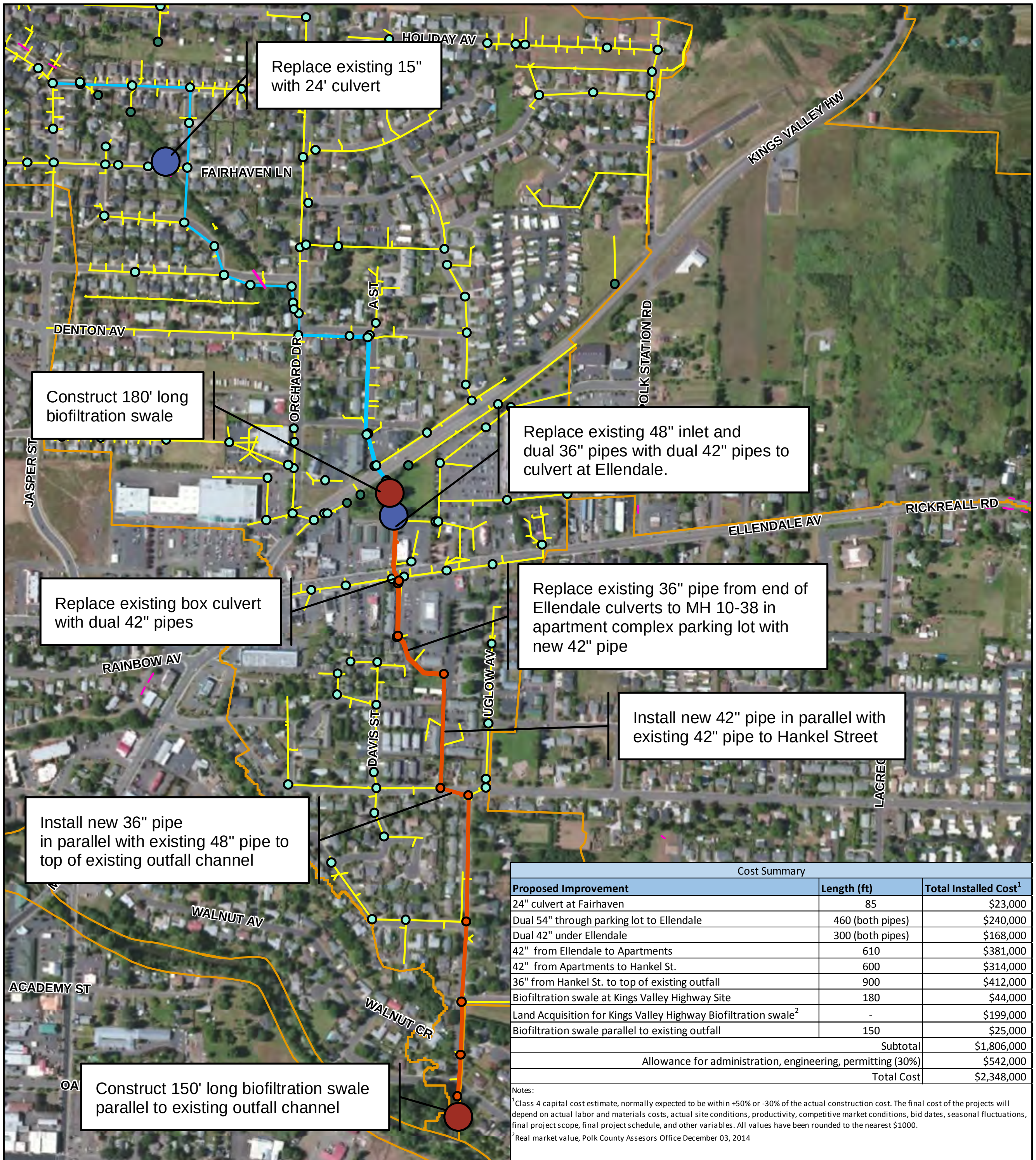
Proposed capital improvement projects are shown in Figure 7-8 and include:

- Replace existing Fairhaven culvert with 24-inch diameter smooth interior wall HDPE culvert
- Construct 180-foot long biofiltration swale at the Kings Valley Highway/Highway 223 site
- Replace existing inlet to piped system at Murphy's Grill parking lot and existing dual pipes at east side of Murphy's Grill lot with parallel 54-inch diameter pipe
- Replace both sections of existing Ellendale culvert with dual 42-inch diameter pipe
- Replace existing 36-inch diameter pipe from the south side of Ellendale to MH 10-38 north of Hankel Street in apartment complex parking lot with 42-inch diameter pipe
- Install new 42-inch pipe in parallel with existing 42-inch pipe from MH 10-38 to Hankel Street
- Install new 36-inch pipe in parallel with existing 48-inch pipe from Hankel Street to the top of the existing outfall channel
- Construct 150-foot long biofiltration swale at existing outfall site, parallel to existing outfall channel

7.3.6 Recommended Next Steps

The hydrologic and hydraulic analysis and resulting recommended capital improvement projects presented in this report are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects. The following next steps are recommended as part of the design process for the Rickreall Uglow/Orchard system:

- Establish groundwater levels and evaluate potential impacts to proposed biofiltration facilities
- Perform additional survey

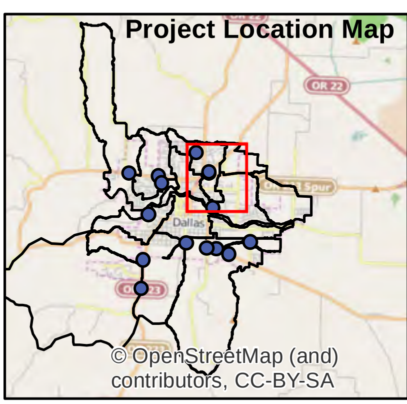


Cost Summary		
Proposed Improvement	**Length (ft)**	**Total Installed Cost[1]**
24" culvert at Fairhaven	85	$23,000
Dual 54" through parking lot to Ellendale	460 (both pipes)	$240,000
Dual 42" under Ellendale	300 (both pipes)	$168,000
42" from Ellendale to Apartments	610	$381,000
42" from Apartments to Hankel St.	600	$314,000
36" from Hankel St. to top of existing outfall	900	$412,000
Biofiltration swale at Kings Valley Highway Site	180	$44,000
Land Acquisition for Kings Valley Highway Biofiltration swale[2]	-	$199,000
Biofiltration swale parallel to existing outfall	150	$25,000
	Subtotal	$1,806,000
	Allowance for administration, engineering, permitting (30%)	$542,000
	Total Cost	$2,348,000

Notes:

[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.

[2]Real market value, Polk County Assesors Office December 03, 2014



Legend

- Identified Problem Area
- Potential Water Quality Site
- Proposed Manhole Improvement
- Proposed Pipe Improvement
- Manhole
- Storm Outlet
- Storm Culverts
- Storm Pipe Included In Hydraulic Model
- Storm Pipe
- City Major Basins

N

0 375 750 1,500 ft

FIGURE 7-8
Rickreall Uglow/Orchard System
Recommended
Capital Improvements
City of Dallas Stormwater Master Plan

CH2MHILL

7.4 Kings Valley Highway/Highway 223 at the Cemetery

7.4.1 Description of Problem

Floodwaters overtop Kings Valley Highway/Highway 223 at the entrance to the cemetery.

7.4.2 Description of Existing System

The system consists of a 24-inch concrete culvert crossing Kings Valley Highway/Highway 223, an 18-inch culvert crossing Kings Valley Highway/Highway 223 approximately 140 feet south, and a roadside ditch and 18-inch driveway culvert connecting the two on the west side of the highway, as shown in Figure 7-9. The 24-inch and 18-inch culverts each discharge to natural watercourses on the east side of the highway. There is a small catch basin at the junction of the driveway culvert and the 18-inch culvert crossing the highway.

There are two small in-line storage ponds upstream of the 24-inch culvert on the west side of the highway. These storage ponds were not included in the hydrologic or hydraulic analysis because their attenuating effect on peak flows is expected to be small, given their size and in-line placement.

The northern culvert discharges to a channel that crosses private property on the east side of Kings Valley Highway/Highway 223. The owner of that property has noted that floodwaters have historically inundated his property. He is currently doing work to clear blackberries and other choking vegetation from the channel at the most downstream portion of his property.

Flooding has also been observed by neighbors at the site of the catch basin on the southern side of the cemetery driveway. City staff has also observed overtopping of the highway near the driveway.

7.4.3 Hydrologic Analysis

The system drains a combined area of approximately 219 acres. The northern (24-inch) culvert receives flow from 186 acres, while the southern (18-inch) culvert receives excess flow that cannot be passed by the 24-inch culvert, in addition to runoff from another 33 acres.

All of the tributary area to this system is currently rural. All but 8 acres is outside of the City boundary, where for purposes of this analysis, no further development is expected. The 8 acres within the City boundary are zoned light residential, and are part of the tributary area to the southern culvert.

Peak future runoff for the 100-year 24-hour storm from the tributary area to the northern culvert is 186 cfs. Under current conditions, 100-year peak flow from the tributary area to the southern culvert is 28.2 cfs, which increases to 36.4 cfs under buildout conditions.

7.4.4 Hydraulic Analysis

An XPSWMM model was built to analyze hydraulic performance of the drainage system, using information from the City's record drawings and field survey data. Slopes for the driveway culvert and southern culvert were calculated from the upstream invert elevation of the driveway culvert and the downstream invert elevation of the southern culvert.

Capacity of the northern culvert is 28 cfs, while capacity of the driveway and southern culverts is 8.5 cfs each. The ditch connecting the two has a capacity of approximately 22 cfs. Downstream elevations of the culverts are limited by the natural watercourses on the east side of the highway.

Based on model results, the current system capacity is less than the peak flows for the 2-year storm, without considering the storage effects of the ponds upstream of the culverts.

Downstream system capacity of the receiving channels and backwater effects on the culverts were not evaluated.

7.4.5 Proposed Capital Improvements

System capacity can be increased to convey the 100-year storm by increasing the size of both culverts crossing the highway and the driveway culvert. The catch basin currently connecting the driveway culvert to the southern culvert will need to be replaced with a grate-topped manhole or junction box.

Proposed capital improvement projects are shown in Figure 7-10 and include:

- Replace the northern culvert with a 3-foot tall by 4-foot wide concrete box culvert
- Replace the driveway culvert with a 2-foot tall by 4-foot wide concrete box culvert
- Replace the existing catch basin with a grate-topped manhole
- Replace the southern culvert with a 2-foot tall by 4-foot wide concrete box culvert

It is important to note that downstream channel capacity and backwater effects were not evaluated as part of this analysis. Increasing the volume of water passed under Kings Valley Highway/Highway 223 may exacerbate downstream flooding problems. Further study of the downstream system should be undertaken in association with design of the proposed capital improvements to better understand impacts to the downstream system and property owners. Detention storage upstream of the existing system could be incorporated into a final design if downstream capacity is insufficient to convey increased flows from the west side of the highway.

7.4.6 Recommended Next Steps

The hydrologic and hydraulic analysis and resulting recommended capital improvement projects presented in this report are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects. The following next steps are recommended as part of the design process for the cemetery site:

- Determine downstream capacity and backwater effects on proposed culvert improvements
- Assess upstream detention storage to mitigate potential effects on downstream system

7.5 North Fork Ash Creek

7.5.1 Description of Problem

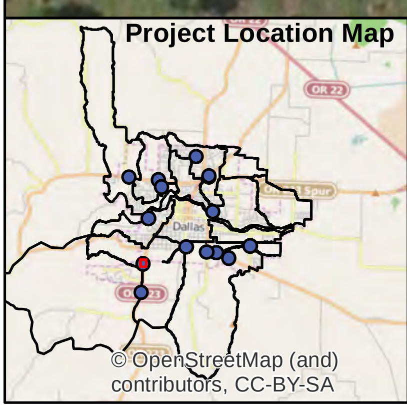
Flooding has been observed at multiple locations in the upper portions of the North Fork Ash Creek watershed, including five road crossings and the former Weyerhaeuser property between Main Street and Uglow Street. Flood conditions are documented in the *Ash Creek Water Control District's Five-Year Plan* as existing flood areas (Whitaker Engineering, 2009).

The storm magnitude at which flooding occurs has not been identified; for purposes of this analysis, the 100-year storm was selected as the design event. Because it is unknown whether the Holman Street culvert (not identified as a flood-prone crossing) would flood at this design storm, it was included in the analysis and evaluated for conveyance capacity of the 100-year storm.

Listed in order from the most upstream to the most downstream, the six road crossings evaluated in this study include:

- Kings Valley Highway/Highway 223 Bridge south of the Bridlewood subdivision
- Uglow Street Culvert
- Monmouth Cutoff Bridge west of Holman Street
- Holman Street Culvert
- Monmouth Cutoff crossing of tributary
- Godsey Road Bridge

These locations are shown in Figure 7-11.



N

0 37.5 75 150 ft

Legend

- Identified Problem Area
- Catch Basin
- Storm Culverts

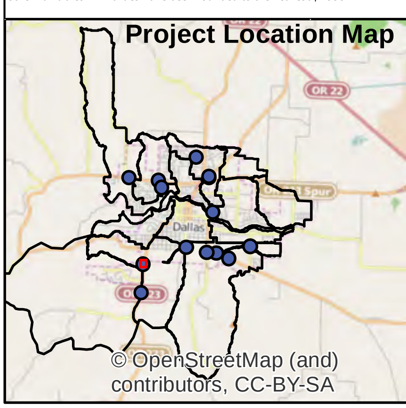
FIGURE 7-9
Kings Valley Hwy @ Cemetery
Existing Conditions
City of Dallas Stormwater Master Plan

CH2MHILL.

Cost Summary		
Proposed Improvement	**Length (ft)**	**Installed Cost[1]**
3' x 4' box culvert	58	$43,000
2' x 4' box culvert (highway)	58	$38,000
2' x 4' box culvert (driveway)	35	$20,000
	Subtotal	$101,000
	Allowance for administration, engineering, permitting (30%)	$30,000
	Total Cost	$131,000

Notes:

[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



N

0 37.5 75 150 ft

Legend

- Identified Problem Area
- Proposed Manhole Improvement
- Proposed Culvert Improvement
- Storm Culverts

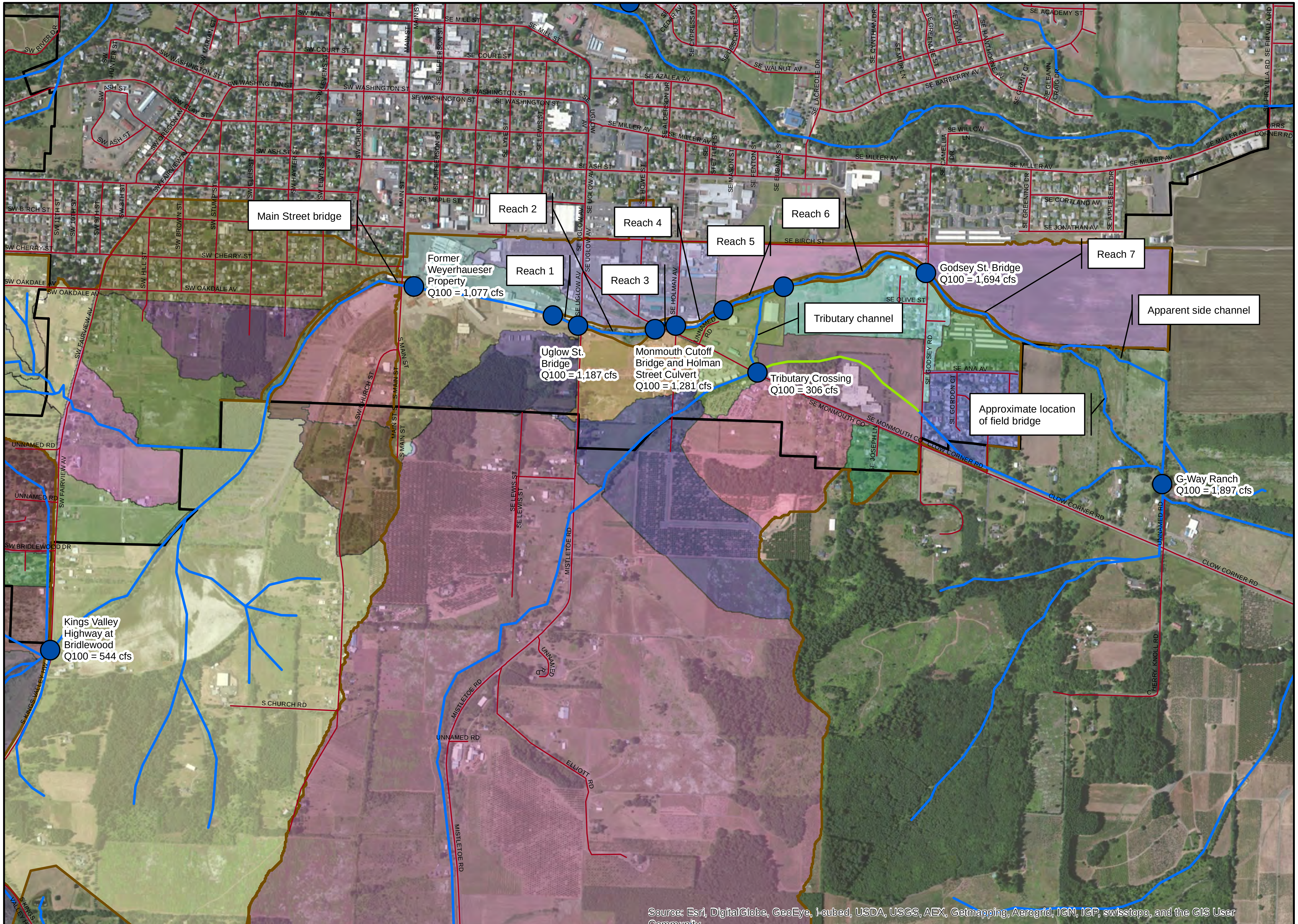
FIGURE 7-10
Kings Valley Hwy @ Cemetery
Recommended
Capital Improvements
City of Dallas Stormwater Master Plan

CH2MHILL

FIGURE 7-11

North Fork Ash Creek Key Points of Analysis with 100-year Flows

City of Dallas
Stormwater Master Plan



Legend

- Key Points of Analysis
- Abandoned Natural Channel
- Streams
- Roads
- Major Basin Boundary
- City Boundary
- Subbasin

N

1 inch equals 1,000 feet

Source:

CH2MHILL

Date: 1/28/2015

7.5.2 Description of Existing System

System components described in this section are shown in Figure 7-11.

The North Fork of Ash Creek that is within the study area consists of a mixture of engineered and natural reaches. The entire creek is piped underground at the former Weyerhaeuser property, resulting in a significant difference in hydraulic characteristics upstream and downstream of that location. Hydraulic interactions downstream of the former Weyerhaeuser property are complex and have not been studied as an interlinked, dynamic system taking into account the interactions between the main stem channel and the tributary channel. The North Fork of Ash Creek was included in the *Ash Creek Flood Study* completed in November 2002 (Streamline Engineering), but the crossings were not shown to be inundated in the HEC-RAS hydraulic model. Study authors acknowledge that calibration efforts were focused on downstream areas of the Ash Creek watershed outside the City of Dallas, and that the model may not accurately reflect conditions in the upper watershed of the North Fork.

The Kings Valley Highway/Highway 223 Bridge at Bridlewood lies approximately 1.1 miles upstream of the Weyerhaeuser property, and is the only crossing upstream of the Weyerhaeuser property analyzed for this study. The Main Street Bridge, located immediately upstream of the Weyerhaeuser property, was not identified as a flood-prone crossing and was therefore not included in this analysis.

Based on visual inspection of aerial imagery and available cross-section data (Streamline Engineering, 2002), it appears that the channel between the Bridlewood Bridge and the Weyerhaeuser property is a natural reach. The Bridlewood Bridge is approximately 22 feet long by 26 feet wide, shedding runoff to the northwest corner of the bridge. Channel vegetation immediately downstream of the bridge consists of heavy brush and trees.

Documentation of the conveyance system under the former Weyerhaeuser property was not publicly available at the time of this analysis. However, previous field investigations by the Ash Creek Water Control District indicate that the underground conveyance system consists of two 8-foot diameter culverts that converge at a junction box and transition to a single 12-foot diameter culvert (Whitaker Engineering, 2014). Flooding is reported to occur at the junction, spilling water to the northeast. Floodwaters then cross Uglow Street to inundate the Lumber Yard property and re-enter the stream channel between the Monmouth Cutoff Bridge and Holman Street culvert. Some floodwater reportedly also flows south down Uglow Street to the crossing of the Mistletoe Road channel, exacerbating flood conditions that occur at that site, which are attributed in part to a straightened, vertical-walled channel section.

The creek emerges to daylight on the east side of the Weyerhaeuser property, approximately 300 feet upstream of Uglow Street. The Uglow Street crossing consists of an arched corrugated metal culvert, approximately 20 feet wide at the upstream flow line. The culvert is approximately 40 feet long; the road deck is approximately 27 feet wide. Vegetation in the channel immediately downstream of Uglow Street is medium grass and brush.

The stream then flows approximately 1,060 feet to the next crossing at the Monmouth Cutoff Highway. The channel between Uglow Street and the Monmouth Cutoff Highway appears to be an unmodified natural reach.

The Monmouth Cutoff Bridge is approximately 28 feet long and 35 feet wide. Retaining walls on the upstream side direct flow under the bridge. A 120-foot section of engineered, rock-gabion channel conveys flow from the Monmouth Cutoff Bridge to the Holman Street culvert. Downstream of Holman Street, the channel appears to be an unmodified natural reach. The Holman Street culvert is part of the intersection of Holman Street and the Monmouth Cutoff Highway, and is approximately 80 feet wide at the widest point.

An un-named tributary enters the North Fork of Ash Creek from the south approximately 1,000 feet downstream of the Holman Street culvert. This tributary crosses under the Monmouth Cutoff Highway into an 840-foot long engineered channel that was constructed in the early 1980s to redirect flow from the natural west-to-east-alignment to flow north instead (Whitaker Engineering, 2009).

The Monmouth Cutoff Highway crossing of the tributary consists of two 4-foot tall by 6-foot wide concrete box culverts. The redirected channel hooks to the west immediately downstream of the culverts, then flows north to the confluence with the mainstem North Fork Ash Creek. Flooding has been reported to occur on both the upstream and downstream side of the Monmouth Cutoff culverts, with flooding on the upstream side presumably exacerbated by tributary channel conditions upstream of the current study area (Whitaker Engineering, 2009). Floodwaters inundate the parking lot and driveways east of the Monmouth Cutoff Highway tributary crossing. On the downstream side of the culverts, water has flowed into the abandoned west-to-east natural channel. As a corrective measure, the City has built up the north side of the channel bank at the point where the channel was realigned. A large of amount of debris and sediment was observed to be obstructing flow at the downstream side of the culverts.

Downstream of the tributary confluence, the mainstem channel continues to the Godsey Road Bridge. This reach is approximately 1,660 feet long and appears to be an unmodified natural channel. The Godsey Road Bridge is approximately 35 feet wide and 25 feet long, and sheds runoff to the southwest.

The next major crossing occurs approximately 3,900 feet downstream of Godsey Road at G-Way Ranch. There have been no observations of flooding at this crossing. This location is outside the study area, but was used to define the downstream boundary condition for hydraulic analysis. There is a small, low crossing in a field approximately 1,150 feet upstream of G-Way Ranch. This field bridge was not considered in this analysis and is expected to be inundated in the 100-year flood event.

7.5.3 Hydrologic Analysis

Hydrologic analysis was conducted to estimate peak flow runoff at various points in the North Fork Ash Creek study area. Three major basins contribute flow to the North Fork of Ash Creek: Ash Creek Bridlewood, Ash Creek Residential, and Ash Creek Industrial. A significant portion of each of these basins lies outside of the study area and are expected to retain their current rural characteristics. Total area of each major basin and the areas of the large, rural basins are provided in Table 7-7.

TABLE 7-7
Basin Area

Major Basin	Rural Basin Outside of Study Area (acres)	Total Major Basin Area (acres)
Ash Creek Bridlewood	1,870	2,056
Ash Creek Residential	558	783
Ash Creek Industrial	1,024	1,379

As noted in Section 3.3, HEC-HMS was used to build a hydrologic model of each major basin. The SCS methodology was used in the HEC-HMS models to estimate and route flows within each major basin. Flow in the North Fork Ash Creek was not routed between major basins; therefore, any attenuation in flow between points of discharge from major basins is not accounted for.

Although no calibration data were available, results of the SCS calculations were considered to significantly over-estimate flows from the large rural basins in the upper North Fork Ash Creek watershed. Flows for these large rural basins were also calculated using regression equations published by the USGS for estimating peak discharges for rural, unregulated streams in western Oregon. The USGS regression equations are calibrated to gaged data and have a standard error of 35 percent for the 100-year storm in western interior watersheds, and were considered to provide a more accurate estimate for peak flows from the large rural basins. Further discussion of the USGS regression equation methodology is provided in Section 3.3.

Estimated peak flows from the 100-year storm are shown in Figure 7-11 at key points of analysis in the North Fork Ash Creek study area. Results of the HEC-HMS models were used for the smaller, urban watersheds within the UGB. Results of the USGS regression equations were used for the larger, rural watersheds outside the UGB. Due to differences between basin size and hydrologic characteristics, peak flow from the tributary channel will not coincide with peak flow in the mainstem of the North Fork.

As can be seen in Figure 7-11, there is an apparent side channel to the mainstem North Fork Ash Creek about half way between Godsey Road and G-Way ranch. Flow in this side channel was not estimated; all flow was kept in the mainstem channel.

Flows were not calculated for tributary areas outside the UGB downstream of the un-named tributary. Flows for these tributary areas were taken from the *Ash Creek Flood Study* (Streamline Engineering, 2002) steady flow data (see further discussion in next section).

7.5.4 Hydraulic Analysis

Hydraulic analysis to identify proposed improvements to alleviate flooding at the seven study sites consisted of review of the existing HEC-RAS hydraulic model, channel analysis using Bentley FlowMaster software, and culvert analysis using HY-8.

7.5.4.1 Review of Existing Hydraulic Model

Hydraulic analysis conducted for this analysis area started with review of the existing HEC-RAS hydraulic model developed by the Ash Creek Water Control District for the *Ash Creek Flood Study*. A CAD file of cross-sections surveyed for the flood study was provided by Streamline Engineering, in addition to the HEC-RAS model.

Six of the seven road crossings evaluated for the stormwater master plan are on the main stem of North Fork Ash Creek. However, one of those six, the Monmouth Cutoff crossing west of Holman Street, was not included in the model. The model also did not include a conveyance structure for the former Weyerhaeuser property; this reach was modeled as an open channel between the Main Street Bridge and the Uglow Street culvert.

The Monmouth Cutoff crossing of the tributary is not part of the HEC-RAS model. The tributary geometry is, however, included in the model cross-section downstream of Holman Street (upstream of the tributary confluence). A cross-section of the tributary channel by itself was also surveyed but not included in the model.

As previously noted, none of the road crossings identified as problem areas were shown to be inundated in the existing model. As a first step in evaluating the hydraulic performance of the North Fork Ash Creek system, the steady flow data were updated with the results of the hydrologic analysis. Flows from tributary subbasins for which updated hydrologic analysis was conducted were mapped to model cross-sections. Incremental flows for tributary areas downstream of the City boundary, outside the area for which updated hydrologic analysis was conducted, were taken from the original (2002) steady flow data set to estimate the cumulative flow at each cross-section downstream of the City boundary.

The modeled water surface profile with this updated flow regime showed inundation at each of the identified problem areas. The water surface profile dropped below the road surface at the G-Way Ranch crossing, consistent with the lack of reported flooding at this location. Model results also showed floodwater outside of the main channel in low points of multiple cross-sections, including in the tributary channel.

Because the model does not include all of the structures on the main stem channel of the North Fork and does not model the interaction between flow in the tributary and flow in the main stem, it cannot be used as an accurate tool for evaluating either existing conditions or potential improvements. However, it did provide a downstream water surface elevation at G-Way Ranch, which was used in the channel analysis.

Additional field data including channel and structure geometry and flow data are required to update and calibrate the existing HEC-RAS model so that it can be used to accurately evaluate existing conditions and potential improvements.

7.5.4.2 Channel and Culvert Analysis

Simplified channel analysis was conducted using Bentley FlowMaster software. Culvert analysis was conducted using FHWA HY-8 software. Existing bridge structures were not evaluated for hydraulic capacity, as each has either been observed or is assumed to flood during the 100-year storm event.

FlowMaster was used to size a trapezoidal channel sufficient to convey peak flows from the 100-year storm in seven different reaches between the Weyerhaeuser property and G-Way Ranch. Channel slope was determined from the cross-sections contained in the HEC-RAS model and from survey information gathered for this stormwater master plan. A side slope of 2H:1V was used for initial sizing, but adjusted to fit approximate existing channel side slopes in some locations to reduce cut and fill volumes. This side slope is assumed to be stable, but scour and stability analyses were not conducted and will vary based on localized geology.

Channel design was conservatively conducted using a roughness coefficient of 0.05, corresponding to a very rough channel with grass. Channel depth was estimated from road deck and channel bottom elevations contained in the HEC-RAS model; this depth was used as the normal depth of flow for determining channel bottom width. Bottom elevations at existing cross-sections were held constant. Depth increases, where required, are assumed to be achieved by constructing a levee to prevent flooding to adjacent low-lying areas.

Varied flow analysis was used to estimate the upstream water surface elevation in a given reach. With the exception of Reach 5, channels were sized for the peak flow at the downstream end of the reach; as a result, water surface elevations at the upstream end will likely be modestly lower than reported. The tributary enters Reach 5 about halfway between the upstream and downstream cross-sections, which were used to define the reach. Tributary flow was not included in the sizing of the proposed Reach 5 channel, as adding it would have resulted in an overly conservative section upstream of the tributary.

The analysis did not consider alternatives for overbank flow outside of the proposed channels, nor did it account for potential floodplain storage effects.

HY-8 was used to determine the necessary size of a culvert to pass the peak flows, based on existing elevations on the upstream and downstream side of each crossing. Culverts were sized to keep the upstream water surface elevation below the road crest elevation, with a target freeboard of 1 foot. A concrete box culvert with straight headwalls was used as the concept design culvert. The concrete box culverts were modeled with a roughness coefficient corresponding to a natural stony-bottomed channel at the bottom of the culvert. This configuration provides the same hydraulic result as modeling with 30 to 75 degree flared wing walls. Fish passage and other permitting considerations at the time of design and construction will affect the final selection of appropriate culvert or bridge replacement geometry and material.

Model output files for each channel section and culvert analyzed are included in Appendix B. Channel and culvert analysis was organized into three components: the Bridlewood crossing, the mainstem North Fork Ash Creek between the former Weyerhaeuser property and G-Way Ranch, and the tributary.

Bridlewood Crossing

The Bridlewood crossing was analyzed independently of the downstream system. The channel downstream of Bridlewood Bridge was modeled as an irregular channel, using the cross-section data from the existing HEC-RAS model and a peak 100-year flow of 544 cfs. The downstream water surface elevation was estimated from the HEC-RAS model run with the updated flow regime, and varied flow analysis was used to estimate the upstream water surface elevation.

The upstream water surface elevation in the channel was then used as a constant tailwater elevation for the culvert analysis. Results of this analysis indicate that two parallel 6-foot by 8-foot concrete box culverts will convey the future 100-year peak flow without requiring modifications to the existing channel.

North Fork Ash Creek from Weyerhaeuser to G-Way Ranch

Hydraulic interactions between the upstream end of the former Weyerhaeuser property and G-Way Ranch were evaluated using a step-backwater approach linking results from channel and culvert analysis to develop a series of channel modifications and road crossing improvements to convey peak flows from the 100-year design storm. Elevations used in this analysis were estimated from the existing HEC-RAS data, survey information gathered for this stormwater master plan, and the City's CAD drawings. Existing road crossing elevations were held constant; culverts were sized to pass flows under the existing road surface elevations.

Analysis was conducted starting with the most downstream point, G-Way Ranch. A trapezoidal channel was sized to convey the peak 100-year flow from the downstream side of Godsey Road to the upstream side of the G-Way Ranch crossing. The downstream water surface elevation of 266 feet was taken from the HEC-RAS model run with the updated flow regime. Varied flow analysis was used to estimate the water depth at the upstream end of the channel. The upstream channel water depth was then used to determine the tailwater elevation at Godsey Road Bridge, and culverts were sized to pass the peak flow with this tailwater condition.

This process of using varied flow channel analysis and tailwater conditions to size culverts was then repeated for each channel section and road crossing, including a culvert through the former Weyerhaeuser property.

An alternative approach to increased conveyance through and immediately downstream of the Weyerhaeuser property could be to construct in-line detention storage of the North Fork Ash Creek. Detention of peak flows could reduce the size of downstream conveyance infrastructure. High level conceptual analysis of this alternative indicates that a 6-foot deep pond approximately 20 acres in size would be required. A conceptual cross-section drawing is provided in Figure 7-12.

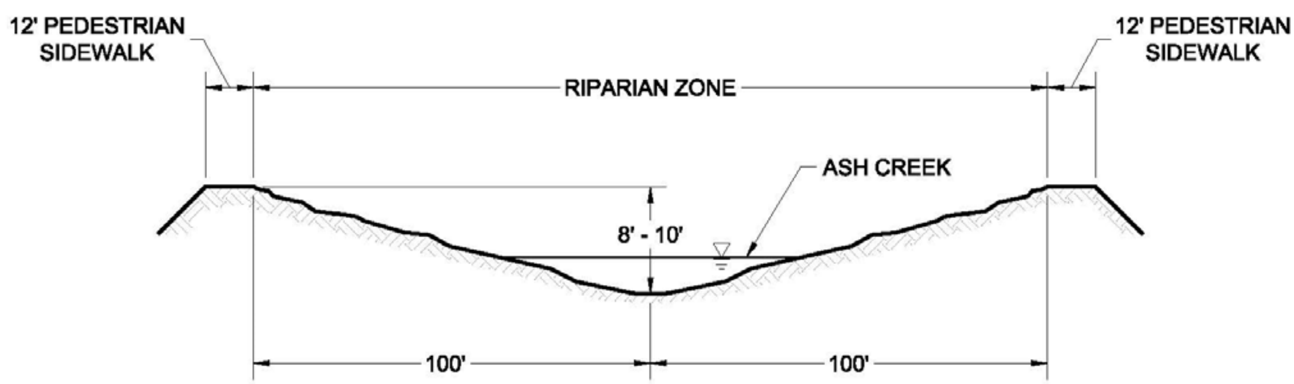


FIGURE 7-12
Conceptual Cross Section of North Fork Ash Creek In-line Detention Storage

Results of the step-backwater analysis were used to construct a stream profile showing proposed channel bottoms and calculated water surface elevations, as shown in Figure 7-13. Road surface elevations are also shown at the upstream end of each culvert crossing. As previously noted, the field bridge between Godsey Road and G-Way Ranch was not considered in this analysis and it is expected to be inundated in the 100-year flood.

Tributary

The tributary channel and two culverts under the Monmouth Cutoff Highway were analyzed for conveyance capacity of the peak 100-year storm flow for the tributary basin. For purposes of this analysis, flooding caused by problems upstream of the culverts were assumed to have been corrected through projects not associated with this stormwater master plan. This assumption results in a conservative estimate of flow for sizing and cost estimating purposes.

While the channel modifications for the mainstem of North Fork Ash Creek were conservatively designed to convey the combined flow from the mainstem and the tributary, it is unlikely that the peaks will occur simultaneously, given the size, hydrologic character, and disparate times of concentration of the tributary basins. In order to estimate the backwater effects of the mainstem on the tributary channel, it was assumed that the 100-year peak of the tributary flow would occur at the same time as the 25-year peak in the mainstem.

The 25-year peak flow at Godsey Road is approximately 73 percent of the 100-year peak flow at that same location, based on the flows used in the *Ash Creek Flood Study*. Applying this percentage to the 100-year peak flow from the updated flow regime yielded an estimated 25-year peak flow at Godsey Road of 1,242 cfs.

Using varied flow analysis to route the estimated 25-year flow through the proposed modified mainstem channel between the tributary and Godsey Road resulted in a depth of 6.43 feet in the mainstem at the confluence. Varied flow analysis was then used to estimate the depth of flow at the upstream end of the tributary channel (the outlet of the culverts). The capacity of the culverts under tailwater conditions was then assessed. It was assumed for this analysis that the culverts were free of debris and sediment.

Tailwater conditions at the culverts were analyzed using two different configurations of the tributary channel. First, the tailwater conditions at the culvert outlet were estimated based on the surveyed cross-section of the tributary channel from the *Ash Creek Flood Study*. The tailwater depth for the surveyed channel cross-section was 5.5 feet. Under these tailwater conditions, the culverts will pass the design flow with a headwater elevation of 294.6 feet.

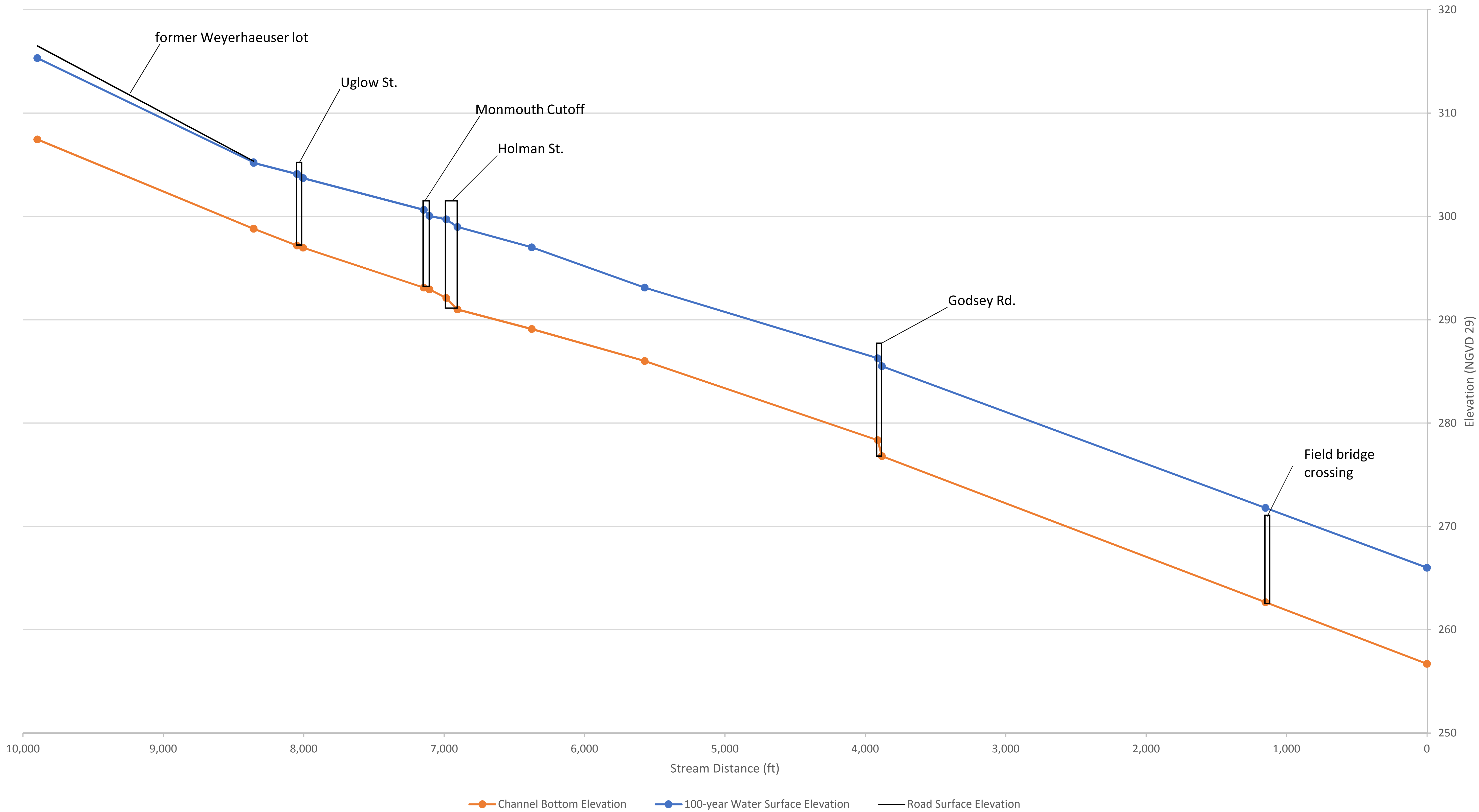
Inspection of the surveyed channel cross-section provides some indication of the presumed design section for the tributary channel. This presumed design was used to estimate tailwater conditions at the culvert. The tailwater depth for the presumed design section was 5.3 feet. Under these tailwater conditions, the culverts will pass the design flow with a headwater elevation of 294.3 feet.

The road surface elevation at the culverts was surveyed at 295.2 feet. However, based on point elevations in the City's CAD files, the elevation of the property to the east of the tributary on the upstream side is only 294.4 feet. Therefore, flooding is likely to occur on the east side if the tributary channel is not modified.

Results of this analysis indicate that clearing the culverts of debris and sediment and restoring the channel to the presumed design cross-section will keep the 100-year water surface elevation below surface elevations of neighboring properties.

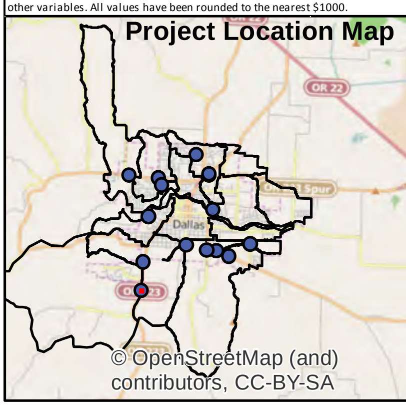
As noted in the description of the existing system, the tributary channel hooks to the west a short way downstream of the culverts. Hydraulic effects of this hook were not included in this analysis. Straightening the channel to eliminate the hook will provide a greater level of assurance that the 100-year water surface elevation will remain below surface elevations. Alternatively, or as an added measure of safety, a levee could be constructed along the eastern bank of the channel upstream of the culverts.

Figure 7-13
North Fork Ash Creek from Former Weyerhaeuser Property to G-Way Ranch
Profile with Proposed Modifications



Cost Summary		
Proposed Improvement	**Length (ft)**	**Installed Cost[1]**
Two 8' x 6' box culverts	37	$131,000
	Subtotal	$131,000
	Allowance for administration, engineering, permitting (30%)	$39,000
	Total Cost	$170,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



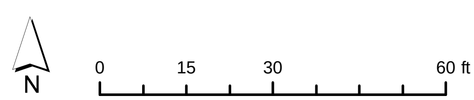


FIGURE 7-14
Kings Valley Highway at Bridlewood
Recommended Capital Improvements
City of Dallas Stormwater Master Plan

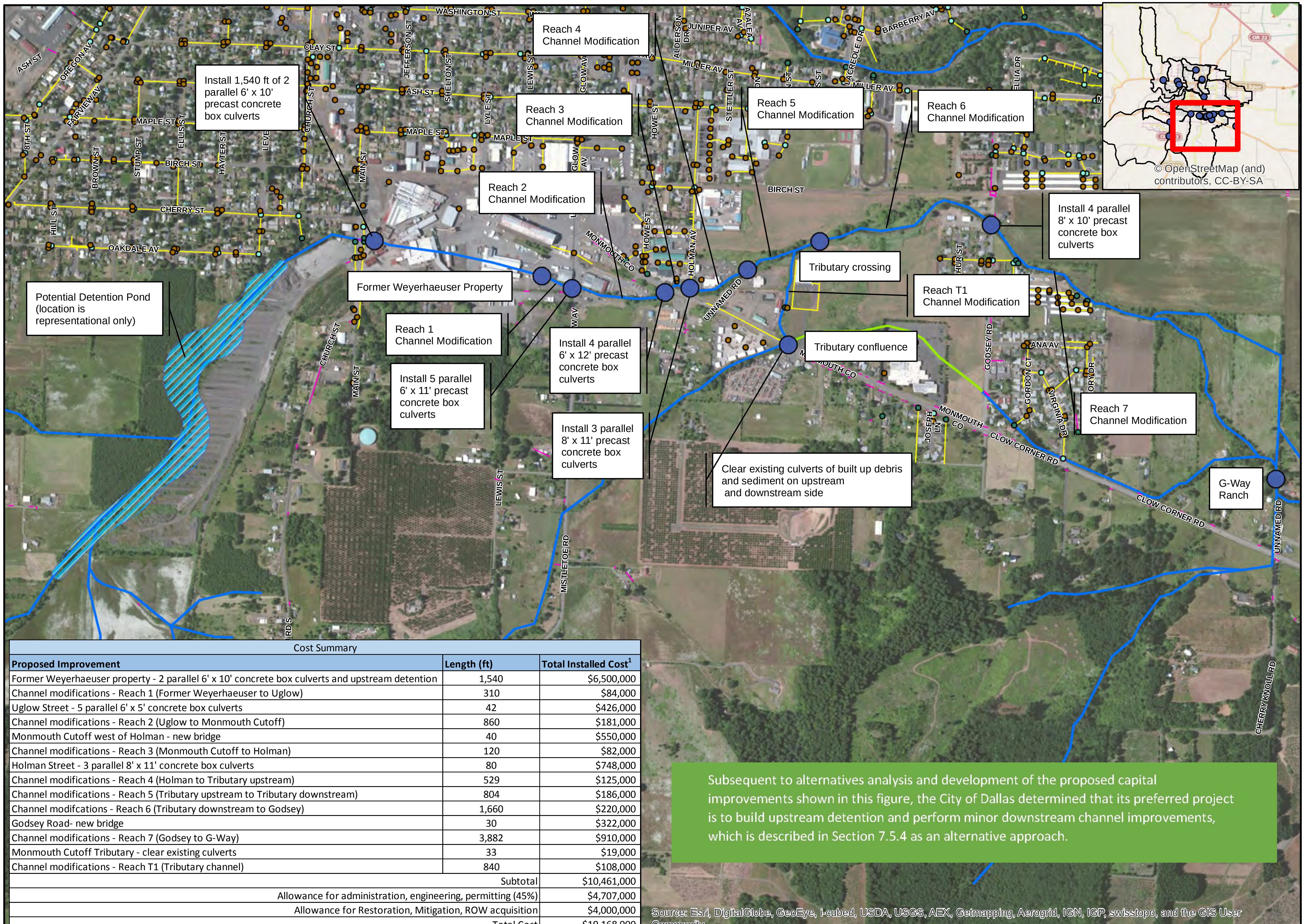
Legend
Identified Problem Area
Storm Culverts

CH2MHILL.

FIGURE 7-15

Weyerhaeuser to G-Way Ranch Proposed Capital Improvements

City of Dallas Stormwater Master Plan



Cost Summary		
Proposed Improvement	**Length (ft)**	**Total Installed Cost[1]**
Former Weyerhaeuser property - 2 parallel 6' x 10' concrete box culverts and upstream detention	1,540	$6,500,000
Channel modifications - Reach 1 (Former Weyerhaeuser to Uglow)	310	$84,000
Uglow Street - 5 parallel 6' x 5' concrete box culverts	42	$426,000
Channel modifications - Reach 2 (Uglow to Monmouth Cutoff)	860	$181,000
Monmouth Cutoff west of Holman - new bridge	40	$550,000
Channel modifications - Reach 3 (Monmouth Cutoff to Holman)	120	$82,000
Holman Street - 3 parallel 8' x 11' concrete box culverts	80	$748,000
Channel modifications - Reach 4 (Holman to Tributary upstream)	529	$125,000
Channel modifications - Reach 5 (Tributary upstream to Tributary downstream)	804	$186,000
Channel modifcations - Reach 6 (Tributary downstream to Godsey)	1,660	$220,000
Godsey Road- new bridge	30	$322,000
Channel modifications - Reach 7 (Godsey to G-Way)	3,882	$910,000
Monmouth Cutoff Tributary - clear existing culverts	33	$19,000
Channel modifications - Reach T1 (Tributary channel)	840	$108,000
Subtotal		$10,461,000
Allowance for administration, engineering, permitting (45%)		$4,707,000
Allowance for Restoration, Mitigation, ROW acquisition		$4,000,000
Total Cost		$19,168,000

Subsequent to alternatives analysis and development of the proposed capital improvements shown in this figure, the City of Dallas determined that its preferred project is to build upstream detention and perform minor downstream channel improvements, which is described in Section 7.5.4 as an alternative approach.

Legend

- Key Point of Analysis
- Catch Basin
- Existing Manhole
- Existing Storm Outlet
- Storm Culverts
- Storm Pipe
- Abandoned Natural Channel
- Streams

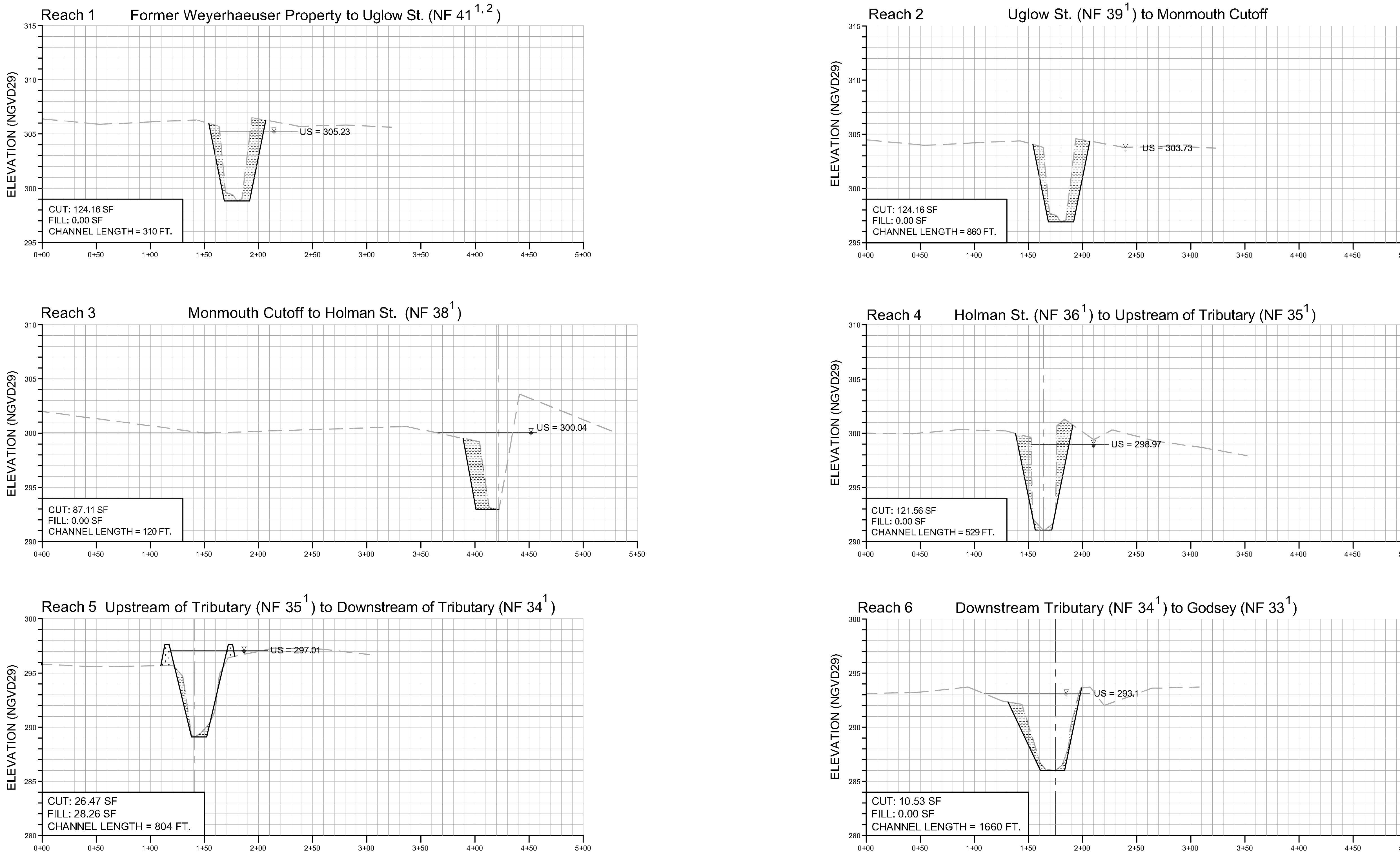
N

1 inch equals 834 feet

Source: CH2MHILL

Date: 2/2/2015

\\rosa\proj\dallascityof\496541stormwater\GIS\MapFiles\ReportFigures_andMXDs\ExistingCondition_and_CIPs\NorthForkAshCreek\Weyerhaeuser_G-Way_CIP.mxd msteine1 2/2/2015



LEGEND

- EXISTING GRADE
- PROPOSED GRADE
- PROPOSED CUT AREA
- PROPOSED FILL AREA
- US = 305.2 — UPSTREAM WATER SURFACE ELEVATION (100-YEAR DESIGN STORM)

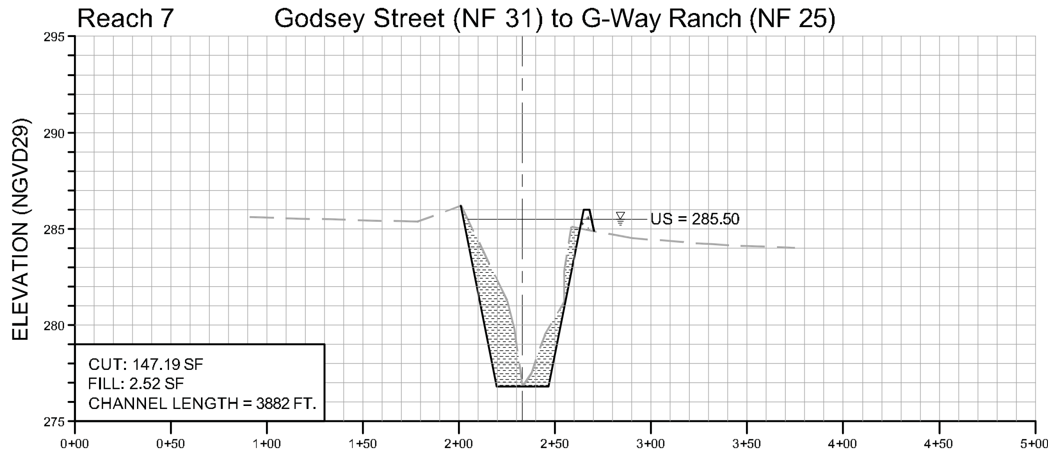
NOTES:

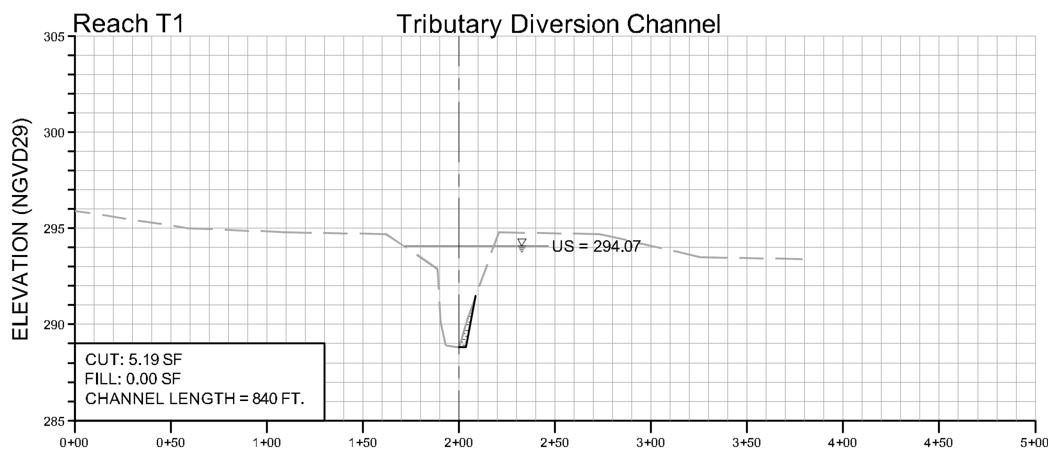
1. NF designations refer to cross section numbers used in the hydraulic model from the Ash Creek Flood Study (Streamline Engineering, 2002). Where no NF number is given, cross sections were developed from best available topographic information including survey data collected for the SWMP.

2. The cross-section for Reach 2 was used as the cross-section for Reach 1 in the absence of an upstream cross-section. Cut volume will vary based on actual cross-section geometry.

FIGURE 7-16
North Fork Ash Creek Proposed Channel Modification
City of Dallas Stormwater Master Plan

CH2MHILL





LEGEND

- EXISTING GRADE
- PROPOSED GRADE
- PROPOSED CUT AREA
- PROPOSED FILL AREA
- US = 305.2 — UPSTREAM WATER SURFACE ELEVATION (100-YEAR DESIGN STORM)

NOTES:

1. NF designations refer to cross section numbers used in the hydraulic model from the Ash Creek Flood Study (Streamline Engineering, 2002). Where no NF number is given, cross sections were developed from best available topographic information including survey data collected for the SWMP.

2. The cross-section for Reach 2 was used as the cross-section for Reach 1 in the absence of an upstream cross-section. Cut volume will vary based on actual cross-section geometry.

FIGURE 7-17
North Fork Ash Creek Proposed Channel Modification
City of Dallas Stormwater Master Plan

CH2MHILL

7.5.4.3 Proposed Capital Improvement Projects

Proposed capital improvement project for the Bridlewood crossing is to replace the Kings Valley Highway/Highway 223 Bridge with two parallel 6-foot tall by 8-foot wide precast concrete box culverts as shown in Figure 7-14. Proposed capital improvements for the North Fork Ash Creek system between the former Weyerhaeuser property and G-Way Ranch include construction of a detention pond as shown in Figure 7-15 and undetermined minor downstream channel improvements. This was described in Section 7.5.4.2 as an alternative approach, but subsequent to the alternatives analysis, the City determined that this was the preferred project. Thus, the project improvements initially analyzed are now designated as an alternative approach.

If the preferred project (upstream detention pond and minor downstream channel improvements) is found to be infeasible, then the alternative approach could be reconsidered. It would include a series of road crossing improvements and channel modifications, as indicated in Figure 7-15. The alternative approach road crossing improvements would include:

- Replace existing Godsey Road Bridge
- Clear existing culverts at the tributary crossing of debris and sediment on upstream and downstream sides
- Replace existing Holman Street arch culvert with three parallel 8-foot tall by 11-foot wide precast concrete box culverts
- Replace existing Monmouth Cutoff Bridge
- Replace existing Uglow Street culvert with five parallel 6-foot tall by 11-foot wide precast concrete box culverts
- Provide sufficient conveyance at Weyerhaeuser property, or upstream detention. For cost estimating purposes, this conveyance was assumed to be provided by two parallel 6-foot tall by 10-foot wide precast concrete box culverts. Actual conveyance geometry will depend on a variety of factors including landowner interests and the effects of upstream detention, if detention is provided.

Cross-sections for the alternative approach channel modifications are shown in Figures 7-16 and 7-7. Improvements to the tributary crossing and tributary channel are also shown on these figures. As shown on the figures, channel modifications mostly consist of widening the channel to increase conveyance capacity. In some locations, a levee is required to contain the water within the design channel and prevent flooding of low-lying areas on either or both sides. The calculated upstream water surface elevation for each reach is also shown on each cross-section. Levees are shown with a 2H:1V side slope and a 4-foot top width, with 1 foot of freeboard above the calculated upstream water surface elevation. These channel improvements are based on hydraulic requirements only and do not, as currently conceptualized, necessarily represent viable projects due to permitting and other regulatory considerations.

7.5.5 Permitting and Regulatory Considerations

The proposed capital improvement projects are based on hydraulic capacity requirements only, with very limited consideration of fish passage or other ecological and permitting challenges. The proposed channel modifications (including levees) and culvert replacements are all located within a regulatory floodplain. The analysis, and resulting proposed capital improvements, did not consider alternatives for overbank flow outside of the proposed channels, nor did it account for potential floodplain storage effects. Wetland mapping was not conducted as part of this project, but it is presumed that this project will have some wetland impacts.

In addition to compliance with City of Dallas and Polk County development code and floodplain ordinances and local permits, the following federal and state permits may be required:

Federal

- **Clean Water Act Section 404 Permit (USACE).** USACE issues permits for dredge and fill activities in U.S. waters, regardless of the amount of area affected by the activity and amount of fill used.
- **National Environmental Policy Act (NEPA) assessment.** A NEPA assessment is required on all projects for which a federal permit is required. This assessment generally starts with an environmental assessment; a full environmental impact statement may be required following review of the environmental assessment.

State of Oregon

- **Clean Water Act Section 401 Water Quality Certification (DEQ).** Section 401 of the Clean Water Act requires DEQ to certify that the proposed activity does not endanger Oregon's streams and wetlands, and to confirm that the plan meets water quality laws and standards.
- **Removal-fill Permit (Oregon Department of State Lands).** Required for fill and removal within state waters, including permanent and temporary disturbance in wetlands or below the ordinary high water elevation for potential culvert improvements.
- **Fish Passage Approval (Oregon Department of Fish and Wildlife).** Required if construction of an artificial obstruction (including culverts) located in waters in which native migratory fish are currently or were historically present.
- **Oregon State Historic Preservation Office Concurrence.** Required to demonstrate consistency with Section 106 of the National Historic Preservation Act and other cultural resources protection regulations.

7.5.6 Recommended Next Steps

The hydrologic and hydraulic analysis and resulting recommended capital improvement projects presented in this report are based on the best available data supplemented by reasonable assumptions. Additional detail is required to refine the concept designs and develop construction ready projects.

A comprehensive project feasibility study is recommended. As noted, the hydraulic interactions between the floodwaters from the former Weyerhaeuser property, the tributary, and the mainstem of the North Fork Ash Creek are complex and are not currently represented by an accurate, interlinked dynamic model. A detailed hydraulic study of this system, including collection of flow monitoring data for model calibration, is recommended before further development of the proposed capital improvements.

The storage effects of the proposed constructed detention pond should be evaluated to assist in the development of corresponding minor downstream channel capital improvement projects. As previously noted, the recommended sizes for the alternative approach conveyance structures did not take into consideration the storage effects of the existing floodplain or a constructed detention pond.

Thorough evaluation of permitting requirements should also be undertaken as part of the recommended feasibility study in order to more thoroughly understand potential regulatory constraints on the proposed projects. Investment in such a study may result in significant overall capital cost saving.

In addition to the feasibility study, it is anticipated that project coordination with other vested parties and other planned city activities such as roadway maintenance, permitting, and coordination of funding resources will result in a long lead time before design and construction of the various projects can begin. Implementation and phasing of the projects will depend on these factors.

7.6 Hunter Street

7.6.1 Description of Problem

A house was built over the top of a 48-inch culvert; the culvert is presumed to be nearing the end of its lifecycle and may start to cause problems for the property owner if not re-aligned.

7.6.2 Description of Existing System

The culvert collects flow from approximately 8.6 acres, most of which lies within the City boundary and is part of the Rickreall Southwest major basin. The area collected by the culvert is mostly developed residential with some vacant lots.

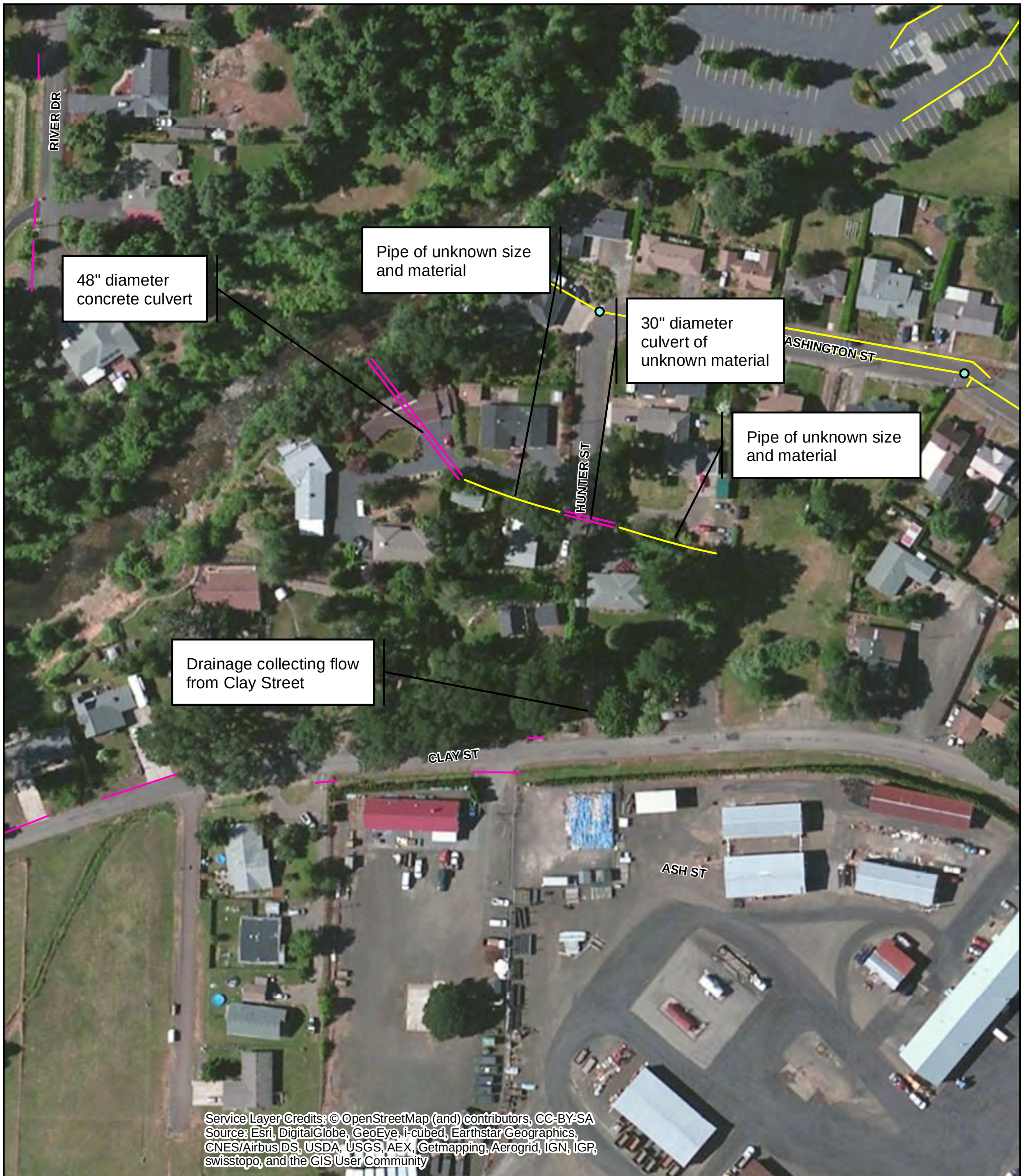
A series of culverts on the north side of Clay Street collects flow from that street, discharging to a small drainage about 900 feet west of the intersection of Clay Street and Oregon Avenue. This small drainage is then collected in a pipe of unknown size, connected to a 30-inch diameter culvert, which in turn connects to another pipe of unknown size before connecting to the 48-inch diameter culvert, which passes under the house to discharge to Rickreall Creek. This existing system is shown in Figure 7-18.

7.6.3 Hydrologic and Hydraulic Analysis

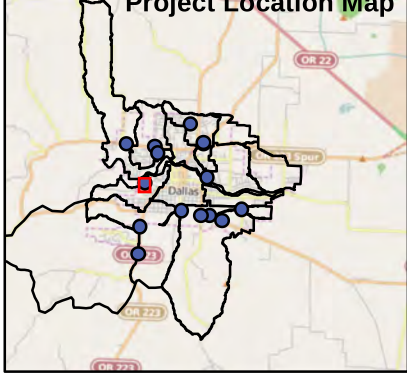
Neither hydrologic nor hydraulic analysis was conducted to determine the flow or capacity of this culvert. There have been no reports of flooding or other problems and as such the culvert is assumed to be adequately sized and just needs to be replaced with a new system that does not pass under the house.

7.6.4 Proposed Capital Improvements

The proposed alignment for a new 48-inch diameter culvert system is shown in Figure 7-19. The existing culvert can be abandoned in place.



Project Location Map



N

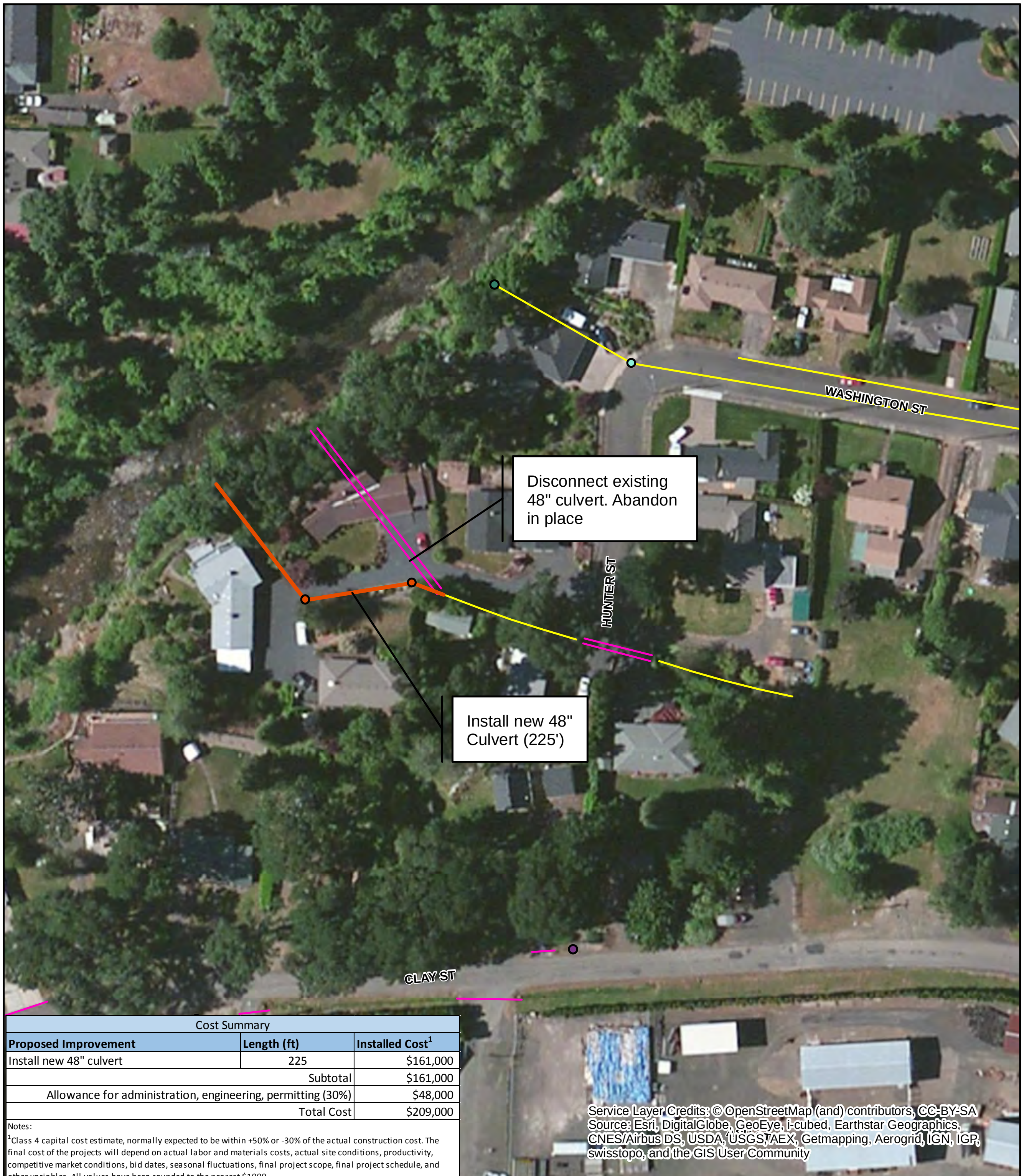
0 75 150 300 ft

Legend

- Manhole
- Storm Outlet
- Storm Culverts
- ConstructedChannel
- Storm Pipe

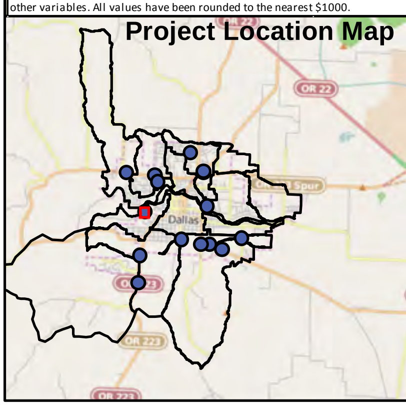
FIGURE 7-18
Hunter Street
Existing Conditions
City of Dallas Stormwater Master Plan

CH2MHILL.



Cost Summary		
Proposed Improvement	**Length (ft)**	**Installed Cost[1]**
Install new 48" culvert	225	$161,000
	Subtotal	$161,000
	Allowance for administration, engineering, permitting (30%)	$48,000
	Total Cost	$209,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



N

0 55 110 220 ft

Legend

- CULVERT_END
- Manhole
- Storm Outlet
- Proposed Manhole Improvement
- Proposed Pipe Improvement
- Storm Culverts
- Storm Pipe

FIGURE 7-19
Hunter Street
Recommended
Capital Improvements
City of Dallas Stormwater Master Plan

CH2MHILL.

SECTION 8

Additional Recommendations and Considerations

8.1 Private Development Drainage Facilities

Other drainage facilities will be needed within developments that occur on the fringes of existing development. These additional facilities are typically provided by the developer as part of the development's infrastructure and are either kept as private drainage facilities or are constructed to City standards and turned over to the City upon acceptance of the construction by the City. It is not the intent of this plan to place restrictions on the alignment of drainage facilities within these currently undeveloped lands, except as specifically provided for in this plan.

Drainage facilities will be planned for these outlying areas as part of the City's normal site design review process. These facilities should have the capacities necessary to handle the flows estimated by this master plan and should provide for continuity of existing drainageways.

8.2 Stormwater Detention Considerations

City standards currently require new developments to detain peak flows such that the outflow from a system does not exceed the historic, predeveloped 100-year design storm runoff from the development area. For the purpose of the master planning analysis, detention from future development was considered to have little effect on necessary improvements to correct system deficiencies at the known problem areas. These sites are experiencing problems under the current condition; problems would be exacerbated by unmitigated flows from new development, but detention of those flows would not eliminate the problem. For the West Ellendale at Wyatt, Douglas Drainage. Cemetery, and North Fork Ash Creek analysis areas, the deficient systems are carrying peak flows from relatively large tributary basins outside of the City. Detention of these flows was not considered a feasible strategy for inclusion in the stormwater master plan.

Stormwater detention can be an effective tool for limiting the increase in peak runoff resulting from continued urbanization. The locations of these facilities within a watershed significantly affect their effectiveness at reducing peak flows in the receiving waters. The effects of detention facilities within a system depend on the timing of peak flows in relation to the timing of adjacent and downstream systems. Therefore, a routing and storage model is needed to assess the effects and benefits of detention. However, there are applications where the benefit is clear. For example, detention facilities located high in the basin can provide peak flow relief for the entire downstream system, ensuring that peak flooding conditions are not worsened as a result of upstream development.

For the Cemetery site, growth within the City boundary contributes approximately 8 cfs to the future buildout flow. This growth occurs at the top of the tributary area. Detention of this increase in runoff could possibly reduce the size of the culverts required to pass the 100-year storm.

For the Douglas Drainage site, flow from the Wyatt growth node enters the piped system far downstream of the identified problem area. Detention of the growth node flows could reduce the size requirements for the recommended outfall channel, but will not affect the requirement for additional capacity in the existing pipe network upstream of the outfall channel.

A more detailed look at timing effects is recommended before pursuing detention storage as a strategy to reduce capital improvement costs.

8.3 Future Service for Growth Nodes

There are three growth nodes within the study area: Wyatt, La Creole, and Barberry. Future service recommendations and considerations for these growth nodes are discussed in the following subsections[4].

8.3.1 Wyatt

The majority of the Wyatt growth node is part of the Rickreall NW major basin, with a small portion on the east side draining to the Douglas Drainage. Potential points of tie-in to the existing stormwater system are shown in Figure 8-1. Flow from this growth node was included in the analysis of the West Ellendale at Wyatt and Douglas Drainage capital improvement areas. A new stormwater drainage system will need to be constructed to provide service for future development in the growth node. Conceptual level alignments for new trunkline pipes are shown on Figure 8-1. Actual length and alignment will depend on the road plan for the growth area.

8.3.2 La Creole

The La Creole growth node lies entirely within the Baskett Slough major basin. A small portion of this growth node is currently developed and served by a local stormwater drainage system, as shown in Figure 8-2. Based on existing topography, it is most likely that future development in this growth node will drain to Harland Slough (a tributary to Baskett Slough). New stormwater drainage facilities will need to be installed to convey flow to this drainage. Conceptual level alignments for new trunkline pipes are shown on Figure 8-2. Actual length and alignment will depend on the road plan for the growth area.

8.3.3 Barberry

The Barberry growth node lies mostly within the Rickreall Barberry Node major basin, though a small portion in the southwest corner of the growth node and the area west of Hawthorne Avenue are included in the Rickreall NE basin. The southwest corner area within the Rickreall NE basin is currently developed and served by a local drainage system, as shown in Figure 8-3.

Stormwater runoff from subbasin R-B-C1 can be routed through the existing storm drainage line in Fir Villa Road. Subbasin R-B-A1 is partially developed, with a local storm drainage system in the southwest portion of the subbasin. Runoff from future development in this subbasin could be routed to the existing subdivision drainage system.

Subbasins R-B-B1 and R-B-B2 are currently undeveloped and have no existing stormwater infrastructure. A new drainage system will need to be constructed to provide service for future development in these areas. Conceptual level alignments for new trunkline pipes are shown on Figure 8-3. Actual length and alignment will depend on the road plan for the growth area.

Capacity analysis of the existing systems to convey runoff from future development was not conducted as part of this project.

8.4 Data Collection

As part of this project, the City has developed a stormwater system database that includes all information about the existing stormwater pipe network. There are several gaps in the data that prevented a more detailed capacity analysis from being conducted as part of this project, and necessitated use of reasonable assumptions in order to develop recommendations for some of the capital improvement analysis areas. Collection of data to complete this database is recommended. A more complete database will provide the information required for future condition assessment and repair/rehabilitation analyses.

[4] Pipe sizes for future service recommendations were determined based on conceptual pipe alignments. Calculations were done using FlowMaster software. Output files for these calculations are provided in Appendix B.

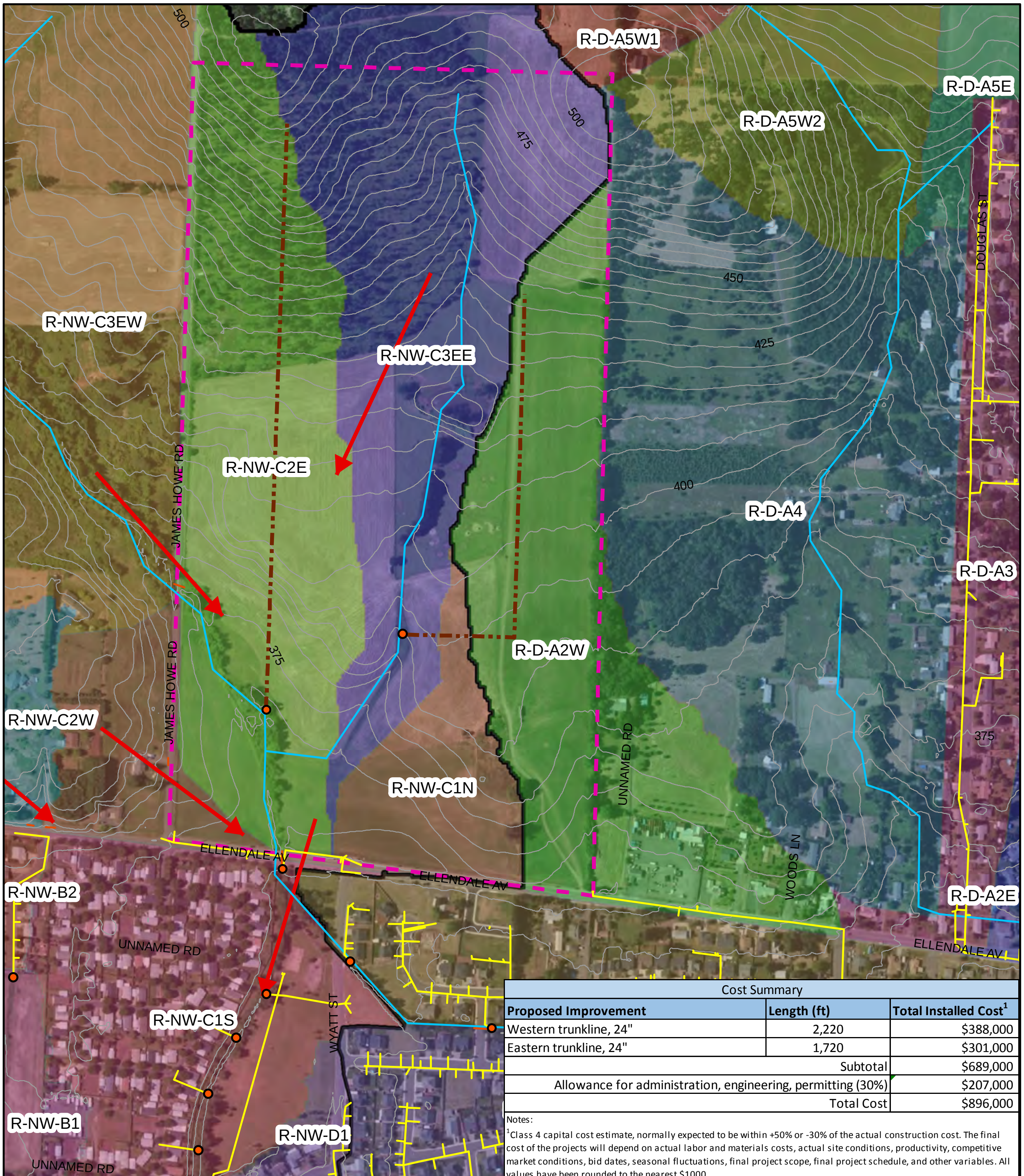
8.5 Condition Assessment

Assessment of the existing condition of the stormwater system is recommended to facilitate prioritization of a proactive pipe rehabilitation and replacement program. The condition assessment would consist of CCTV inspection, evaluation of capacity deficiencies, and estimation of remaining service life.

8.6 Pipe Rehabilitation and Replacement

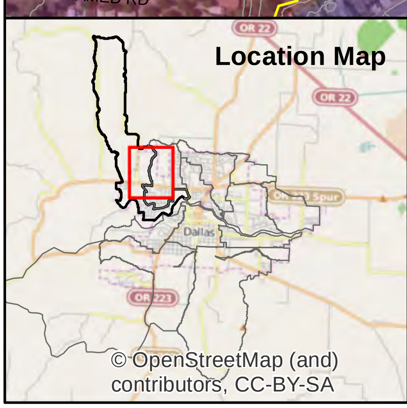
The precise age and condition of much of the City's existing stormwater network is not currently known, but it is acknowledged that much of the system is aging. Development of a prioritized pipe rehabilitation and replacement program is recommended to minimize the risk of failure of the existing infrastructure. Results of the condition assessment should be used to inform rehabilitation and replacement priorities.

A phased ramp-up of rehabilitation and replacement activities is recommended, starting with ¼ percent of the total system repaired or replaced in 2020 and ramping up to 1 percent of the total repaired or replaced in 2040. Repair and rehabilitation would then continue at 1 percent into perpetuity or until a change in practice is deemed necessary by a significant increase or decrease in system performance.



Cost Summary		
Proposed Improvement	**Length (ft)**	**Total Installed Cost[1]**
Western trunkline, 24"	2,220	$388,000
Eastern trunkline, 24"	1,720	$301,000
	Subtotal	$689,000
	Allowance for administration, engineering, permitting (30%)	$207,000
	Total Cost	$896,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



Legend

- Stormwater Outfall
- Proposed Pipe
- Stormwater Culvert
- Stormwater Pipes
- Streams
- Direction of Stormwater Flow
- Wyatt Growth Node
- Contours

Basin Boundary

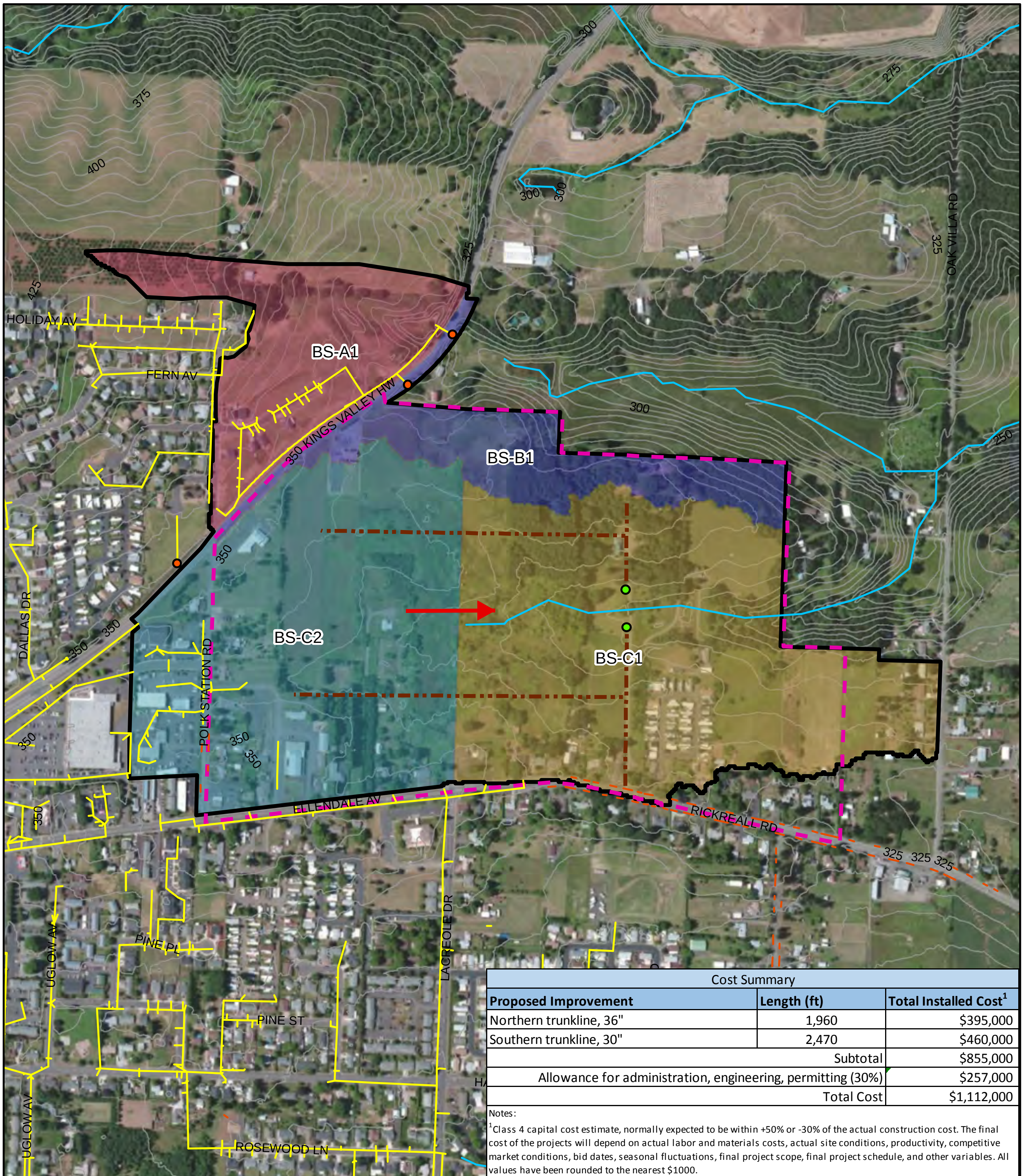
- Rickreall NW

N

0 280 560 1,120 ft

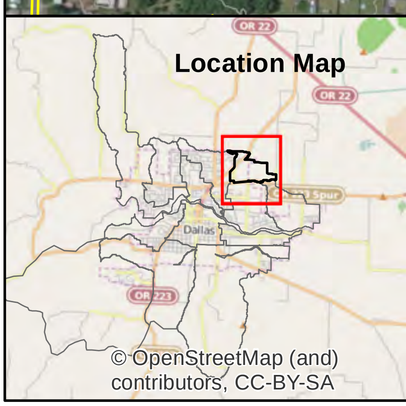
FIGURE 8-1
Future Growth
Wyatt Growth Node
City of Dallas Stormwater Master Plan

CH2MHILL.



Cost Summary		
Proposed Improvement	**Length (ft)**	**Total Installed Cost[1]**
Northern trunkline, 36"	1,960	$395,000
Southern trunkline, 30"	2,470	$460,000
Subtotal		$855,000
Allowance for administration, engineering, permitting (30%)		$257,000
Total Cost		$1,112,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the project will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



Legend

- Proposed Outfall
- Stormwater Outfall
- Proposed Pipe
- Stormwater Culvert
- Stormwater Pipes
- Streams
- Direction of Stormwater Flow
- La Creole

Basin Boundary

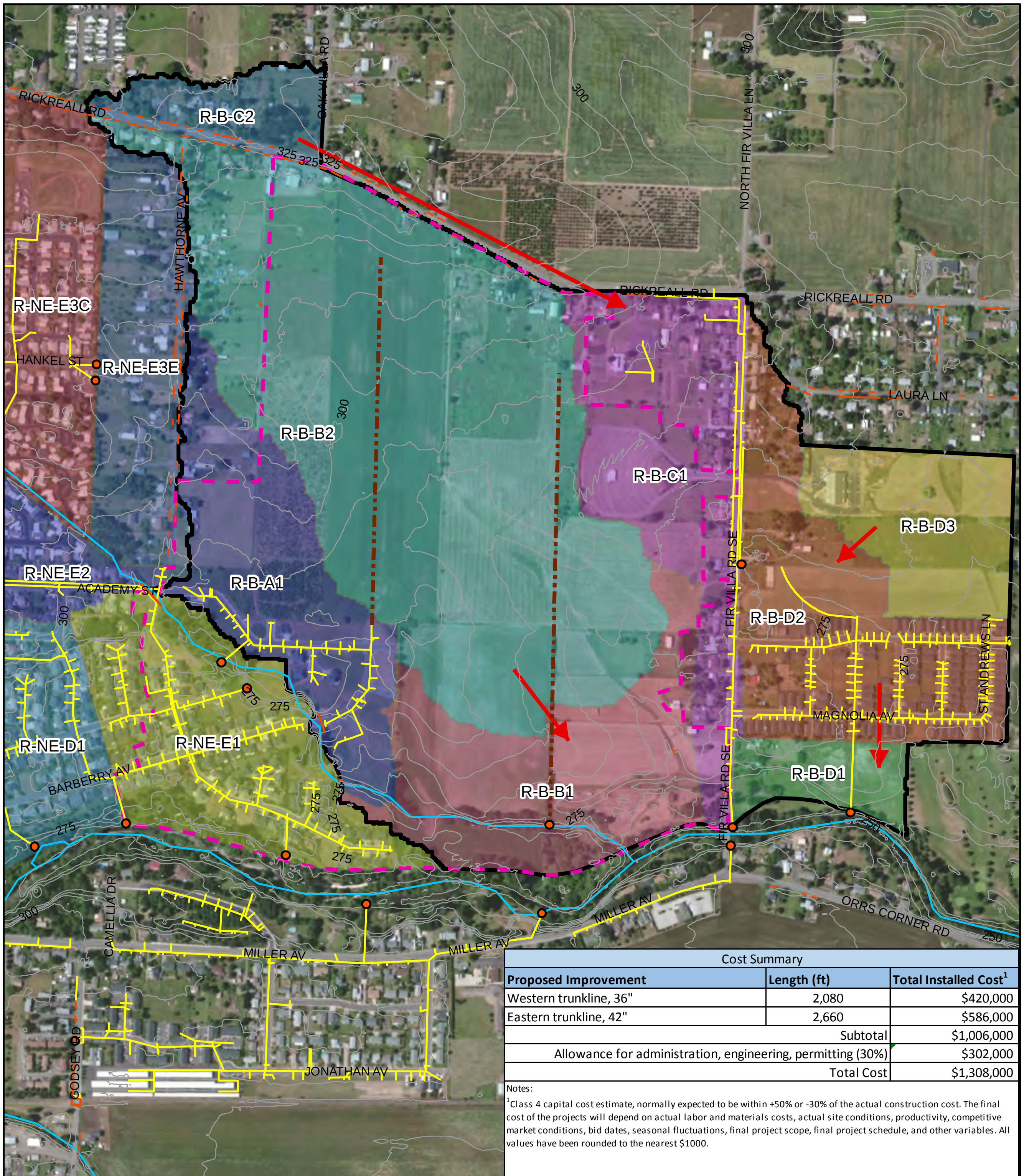
- Baskett Slough
- Contours

N

0 375 750 1,500 ft

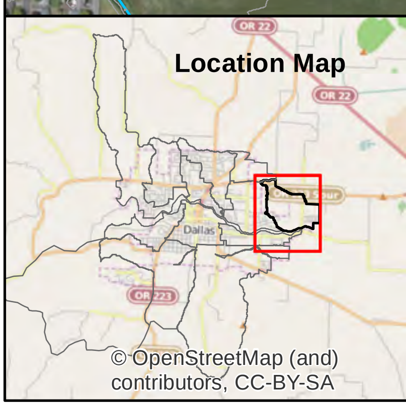
FIGURE 8-2
Future Growth
La Creole Growth Node
City of Dallas Stormwater Master Plan

CH2MHILL.



Cost Summary		
Proposed Improvement	**Length (ft)**	**Total Installed Cost[1]**
Western trunkline, 36"	2,080	$420,000
Eastern trunkline, 42"	2,660	$586,000
	Subtotal	$1,006,000
Allowance for administration, engineering, permitting (30%)		$302,000
	Total Cost	$1,308,000

Notes:
[1]Class 4 capital cost estimate, normally expected to be within +50% or -30% of the actual construction cost. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. All values have been rounded to the nearest $1000.



Legend

- Stormwater Outfall
- Proposed Pipe
- Stormwater Culvert
- Stormwater Pipes
- Contours
- Streams
- Direction of Stormwater Flow
- Barberry Growth Node

Basin Boundary

- Rickreall Barberry Node

N

0 420 840 1,680 ft

FIGURE 8-3
Future Growth
Barberry Growth Node
City of Dallas Stormwater Master Plan

CH2MHILL.

SECTION 9

Capital Cost Estimate

Costs developed for this stormwater master plan are Class 4 project definition estimates as defined by the Association for the Advancement of Cost Engineering (AACE) International and adopted by the American National Standards Institute in *Cost Estimate Classification System* (AACE International, 2011a) and *Cost Estimating Classification System as Applied in Engineering, Procurement, and Construction for the Process Industries* (AACE International, 2011b).

A Class 4 cost estimate corresponds to a level of engineering design detail between project definition and schematic design and is appropriate for this level of capital planning. A Class 4 cost estimate is normally expected to be within +50 percent or -30 percent of the actual construction cost. Figure 9-1 shows the relationship of level of detail to the expected accuracy of the estimate. The final cost of the projects will depend on actual labor and materials costs, actual site conditions, productivity, competitive market conditions, bid dates, seasonal fluctuations, final project scope, final project schedule, and other variables. As a result, the final project costs will vary from the estimates presented in this report.

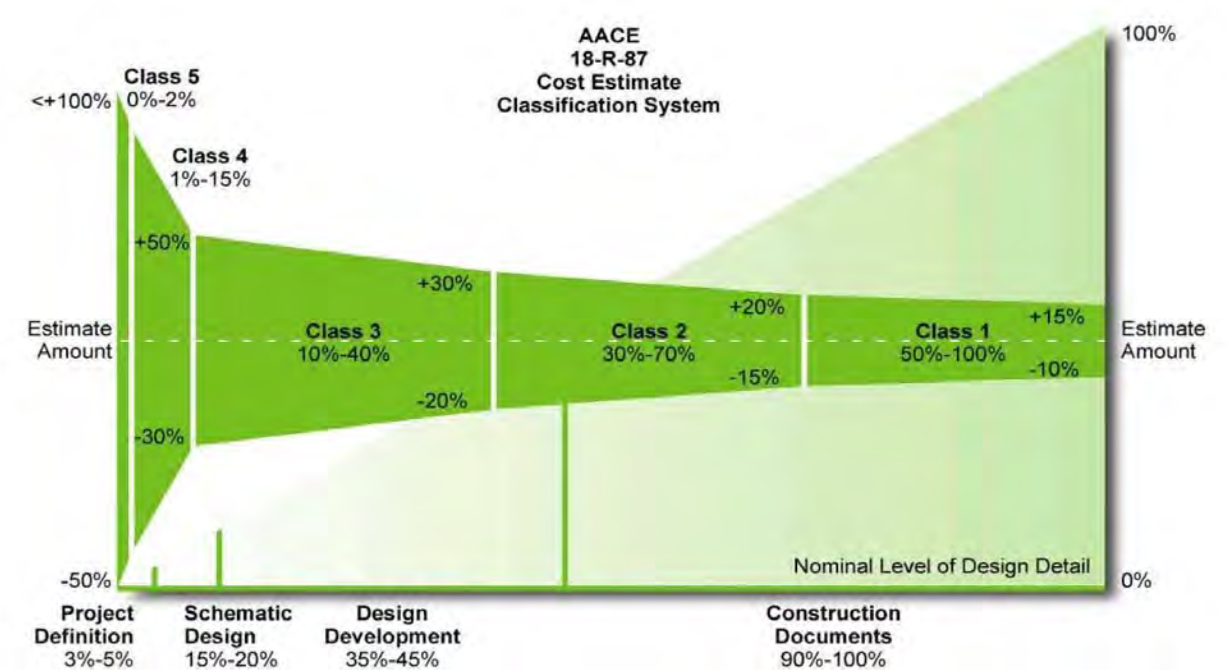


Figure 9-1
AACE International Cost Estimate Classification System

Additionally, the presented costs include an allowance for fees associated with administration, engineering, and permitting. Given the potential difficulty and complexity associated with permitting the proposed capital improvements for the North Fork Ash Creek between the former Weyerhaeuser property and G-Way Ranch, the allowance was increased to 45 percent of the construction cost. All other project sites addressed in this stormwater master plan include a 30 percent allowance.

Capital cost estimates for each of the recommended capital improvements identified in Section 7 are presented in Tables 9-1 through 9-7. Capital cost estimates for the new infrastructure required for service in the three growth nodes are presented in Tables 9-8 through 9-10. Installed costs have been rounded to the nearest $1,000.

A detailed cost estimate report, including a summary of all assumptions used to develop these costs, is provided in Appendix D. Further information related to funding sources and stormwater utility rates is provided in Section 12.

TABLE 9-1
West Ellendale at Wyatt Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	Length (ft)	Installed Cost[a]	Current and Future Rate Payers[b]	Other
5-foot by 6-foot concrete box culvert	65	$259,000	$259,000	$0
Clear and replant channel	1,600	$117,000	$117,000	$0
Regrade channel	115	$5,000	$5,000	$0
Subtotal		$381,000	$381,000	$0
Allowance for administration, engineering, permitting (30%)		$114,000	$114,000	$0
Total Cost		$495,000	$495,000	$0

[a]Class 4 capital cost estimate. Costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

TABLE 9-2
Douglas Drainage Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	Length (ft)	Installed Cost[a]	Current and Future Rate Payers[b]	Other
New 42-inch pipe	250	$152,000	$152,000	$0
Replace existing pipe with 48-inch pipe	578	$386,000	$386,000	$0
Replace existing outfall with bioswale	150	$43,000	$43,000	$0
Subtotal		$581,000	$581,000	$0
Allowance for administration, engineering, permitting (30%)		$174,000	$174,000	$0
Total Cost		$755,000	$755,000	$0

*Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

TABLE 9-3
Rickreall Uglow/Orchard Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	Length (ft)	Installed Cost[a]	Current and Future Rate Payers[b]	Other
24-inch culvert at Fairhaven	85	$23,000	$23,000	$0
Dual 54-inch through parking lot to Ellendale	460 (both pipes)	$240,000	$240,000	$0
Dual 42-inch under Ellendale	300 (both pipes)	$168,000	$168,000	$0
42-inch from Ellendale to Apartments	610	$381,000	$381,000	$0
42-inch from Apartments to Hankel Street	600	$314,000	$314,000	$0
36-inch from Hankel Street to top of existing outfall	900	$412,000	$412,000	$0
Biofiltration swale at Kings Valley Highway/Highway 223 Site	180	$44,000	$44,000	$0
Land acquisition for Kings Valley Highway/Highway 223 bioswale	-	$199,000[c]	$199,000	$0
Biofiltration swale parallel to existing outfall	150	$25,000	$25,000	$0
	Subtotal	$1,806,000	$1,806,000	$0
Allowance for administration, engineering, permitting (30%)		$542,000	$542,000	$0
	Total Cost	$2,348,000	$2,348,000	$0

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

[c]Real market value, Polk County Assessor's Office, December 3, 2014

TABLE 9-4
Kings Valley Highway/Highway 223 at the Cemetery Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	Length (ft)	Installed Cost[a]	Current and Future Rate Payers[b]	Other
3-foot by 4-foot box culvert	58	$43,000	$43,000	$0
2-foot by 4-foot box culvert (highway)	58	$38,000	$38,000	$0
2-foot by 4-foot box culvert (driveway)	35	$20,000	$20,000	$0
	Subtotal	$101,000	$101,000	$0
Allowance for administration, engineering, permitting (30%)		$30,000	$30,000	$0
	Total Cost	$131,000	$131,000	$0

*Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component system development charges. For further detail, refer to Section 12.

TABLE 9-5
Kings Valley Highway/Highway 223 Crossing at Bridlewood Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	**Length (ft)**	**Installed Cost[a]**	**Current and Future Rate Payers**	**Other[b]**
Two 8-foot by 6-foot box culverts	37	$131,000	$0	$131,000
	Subtotal	$131,000	$0	$131,000
Allowance for administration, engineering, permitting (30%)		$39,000	$0	$39,000
	Total Cost	$170,000	$0	$170,000

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.
[b]Funding other agency ODOT or Polk County.

TABLE 9-6
North Fork Ash Creek from former Weyerhaeuser Property to G-Way Ranch Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	**Length (ft)**	**Installed Cost[a]**	**Current and Future Rate Payers[b]**	**Other**
Upstream detention and minor downstream channel improvements		$10,000,000[c]	$3,500,000	$6,500,000[d]
	Total Cost	$10,000,000	$3,500,000	$6,500,000

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.
[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. The $4 million allowance for right-of-way acquisition, mitigation, and restoration is not included in the SDC calculation. For further detail, refer to Section 12.
[c]Estimated by the City of Dallas.
[d]Developer contributions and LIDs, flood control district, and Federal Highway Administration's Highway Bridge Replacement and Rehabilitation program.

TABLE 9-7
Hunter Street Capital Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	**Length (ft)**	**Installed Cost[a]**	**Current and Future Rate Payers[b]**	**Other**
Install new 48-inch culvert	225	$161,000	$161,000	$0
	Subtotal		$161,000	$0
Allowance for administration, engineering, permitting (30%)		$48,000	$48,000	$0
	Total Cost	$209,000	$209,000	$0

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.
[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

TABLE 9-8
Wyatt Growth Node Cost Estimate Summary
City of Dallas Stormwater Master Plan

			Funding Sources	
Recommended Improvement	**Length (ft)**	**Total Installed Cost[a]**	**Current and Future Rate Payers[b]**	**Other[c]**
Western trunkline, 24-inch	2,220	$388,000	$35,000	$353,000
Eastern trunkline, 24-inch	1,720	$301,000	$27,000	$274,000
	Subtotal	$689,000	$62,000	$627,000
Allowance for administration, engineering, permitting (30%)		$207,000	$19,000	$188,000
	Total Cost	$896,000	$81,000	$815,000

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

[c]Developer paid.

TABLE 9-9
La Creole Growth Node Cost Estimate Summary
City of Dallas Stormwater Master Plan

Proposed Improvement	Length (ft)	Total Installed Cost[a]	Funding Sources: Current and Future Rate Payers[b]	Funding Sources: Other[c]
Northern trunkline, 36-inch	1,960	$395,000	$36,000	$359,000
Southern trunkline, 30-inch	2,470	$460,000	$41,000	$419,000
	Subtotal	$855,000	$77,000	$778,000
Allowance for administration, engineering, permitting (30%)		$257,000	$23,000	$233,000
	Total Cost	$1,112,000	$100,000	$1,011,000

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

[c]Developer paid.

TABLE 9-10
Barberry Growth Node Cost Estimate Summary
City of Dallas Stormwater Master Plan

Proposed Improvement	Length (ft)	Total Installed Cost[a]	Funding Sources: Current and Future Rate Payers[b]	Funding Sources: Other[c]
Western trunkline, 36-inch	2,080	$420,000	$38,000	$382,000
Eastern trunkline, 42-inch	2,660	$586,000	$53,000	$533,000
Subtotal		$1,006,000	$91,000	$915,000
Allowance for administration, engineering, permitting (30%)		$302,000	$27,000	$275,000
	Total Cost	$1,308,000	$118,000	$1,190,000

[a]Class 4 capital cost estimate. Installed costs have been rounded to the nearest $1,000.

[b]Based on the number of current and future dwelling units, approximately 9.5% of these costs will be recovered through the improvement fee component of system development charges. For further detail, refer to Section 12.

[c]Developer paid.

SECTION 10

Capital Plan

10.1 Schedule

The objective of this capital plan schedule is to organize the recommended capital improvement projects into a logical sequential order that allows the City to address known problems over a 20-year planning period. The capital plan also includes the recommended data collection, condition assessment, and repair/rehabilitation program costs. Repair and rehabilitation costs are assumed to ramp up over time, growing from 0.25 percent of the total system in 2020 to 0.5 percent by 2030, and increasing to 1 percent by 2040.

The capital plan includes only the portion of project cost for which the City will need financing (the portion to be paid by current and future ratepayers). It is expected that some projects will be paid for in whole by other parties or through grant funding, as identified in Tables 9-1 through 9-10.

Costs for new infrastructure in the growth nodes are assumed to be paid 100 percent paid for by developers in the growth nodes and have therefore not been included in the capital plan.

Additional study is considered critical for the Kings Valley Highway/Highway 223 at the Cemetery and North Fork Ash Creek areas of analysis. Costs for these studies have been included in the capital plan.

The recommended capital plan schedule is provided in Table 10-1.

10.2 Cost Sharing and Grant Funding

The potential for cost sharing has been identified for several of the proposed projects. Potential cost sharing partners include:

- Ash Creek Water Control District
- Polk County
- ODOT
- Private developers

Bridge replacement projects may be eligible for grant funding through the Federal Highway Administration's Highway Bridge Replacement and Rehabilitation (HBRR) program.

TABLE 10-1

Capital Improvement Plan Schedule

City of Dallas Stormwater Master Plan

	Amount to be	Fiscal Year																				
Project Name	**Financed**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**2028/29**	**2029/30**	**2030/31**	**2031/32**	**2032/33**	**2033/34**	**2034/35**	**2035/36**
West Ellendale at Wyatt	$496,000			$159,000	$337,000																	
5-foot-by-6-foot concrete box culvert	$337,000				$337,000																	
Clear & replant channel	$152,000			$152,000																		
Regrade channel	$7,000			$7,000																		
Douglas Drainage	$755,000													$249,000	$506,000							
Rickreall Uglow/Orchard	$2,348,000													$704,000	$822,000	$822,000						
Kings Valley Highway/Highway 223 at the Cemetery[a]	$166,000														$35,000	$55,000	$76,000					
Kings Valley Highway/Highway 223 at Bridlewood[b]	$0																					
North Fork Ash Creek[c]	$3,500,000	$75,000	$225,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$953,000	$ 1,363,000	$ 877,000	$ 76,000	$ -	$ -	$ -	$ -	$ -
Feasibility Study	$300,000	$75,000	$225,000																			
Detention Solution	$3,200,000			$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000									
Hunter Street	$209,000																		$69,000	$140,000		
Subtotal for Site Specific Projects per Fiscal Year		**$75,000**	**$225,000**	**$191,000**	**$369,000**	**$32,000**	**$32,000**	**$32,000**	**$32,000**	**$32,000**	**$32,000**	**$32,000**	**$32,000**	**$953,000**	**$1,363,000**	**$877,000**	**$76,000**	**$0**	**$69,000**	**$140,000**	**$0**	**$0**
Non-Site Specific Projects		$250,000	$ -	$250,000	$ -	$ -	$100,000	$110,000	$120,000	$130,000	$140,000	$150,000	$160,000	$170,000	$180,000	$190,000	$200,000	$220,000	$240,000	$259,000	$279,000	$299,000
Data Collection	$250,000	$250,000																				
Condition Assessment	$250,000			$250,000																		
Pipe Rehabilitation and Replacement[d]	$2,947,000						$100,000	$110,000	$120,000	$130,000	$140,000	$150,000	$160,000	$170,000	$180,000	$190,000	$200,000	$220,000	$240,000	$259,000	$279,000	$299,000
TOTAL PER FISCAL YEAR		**$325,000**	**$225,000**	**$441,000**	**$369,000**	**$32,000**	**$132,000**	**$142,000**	**$152,000**	**$162,000**	**$172,000**	**$182,000**	**$192,000**	**$1,123,000**	**$1,543,000**	**$1,067,000**	**$276,000**	**$220,000**	**$309,000**	**$399,000**	**$279,000**	**$299,000**

[a] Amount to be financed includes $35,000 for recommended downstream capacity analysis.

[b] Kings Valley Highway at Bridlewood will be 100% paid for by others (Polk County or other).

[c] City of Dallas selected updstream detention and minor downstream channel improvements project and estimated the project will cost $10,000,000, 35% to be paid by current and future ratepayers.

[d] Rehabilitation and repair cost assumed to be $120/foot; costs ramp up from 0.25 percent in 2020 to 0.5 percent in 2030 and leveling off at 1 percent by 2040.

SECTION 11

Staffing Analysis

This section evaluates the current and expected future staffing needs for the operation and maintenance (O&M) of the City's stormwater collection system.

11.1 Existing Facilities and Structures

The existing facilities and structures of the City's stormwater conveyance system are summarized in Table 11-1. The system contains about 47 miles of piped conveyance systems (length and size details in Table 11-22 and 11-3) and 23 miles of open ditch. In order to operate sufficiently, yearly maintenance on the collection system must be performed, including cleaning catch basins, cleaning and closed-circuit television inspection of storm pipes, and street sweeping, as well as gradually upgrading old street drains and outdated infrastructure.

TABLE 11-1
City of Dallas Existing Stormwater Facilities and Structures
City of Dallas Stormwater Master Plan

Facility/Structure	Quantity
Storm manholes	822
Storm catch basins (most 17-inch by 26-inch type)	1,943
State-owned catch basins	50
Piped conveyance (total miles)	46.9
Open ditch (miles)	23.4

TABLE 11-2
City of Dallas Approximate Length of Most Common Existing Stormwater Pipes
City of Dallas Stormwater Master Plan

	Length of Specified Pipe Type (feet)			
Pipe Size (inches)	3034 PVC	F679 PVC	Concrete	Corrugated High-density Polyethylene
4	1,380		90	-
6	12,890		2,420	-
8	14,530		10,950	590
10	12,560		17,740	-
12	27,320		29,471	11,250
15	5,570		13,860	2,390
18	-	5,800	13,020	4,730
21	-	760	5,250	1,110
24	-	1,100	7,930	3,225
27	-	180	150	150
28	-	-	-	950
30	-	960	3,950	3,880
36	-	350	2,880	6,530
42	-	-	360	2,400
48	-	1,180	1,940	230
60	-	-	120	390

TABLE 11-3
City of Dallas Approximate Length of Other Existing Stormwater Pipes
City of Dallas Stormwater Master Plan

Pipe Material	Pipe Size (inches)	Length of Pipe (feet)
Reinforced concrete (RCP)	15	900
Concrete cylinder (CCP)	18	1,040
Perforated	4	320
Perforated	6	4,720
Perforated	8	1,160
Perforated	10	900
Perforated	12	230
High-density polyethylene	24	1,200
High-density polyethylene	36	2,170
Aluminum corrugated metal pipe (ACMP)	30	320
Corrugated metal pipe (CMP)	36	430
Corrugated metal pipe (CMP)	54	110
Steel	6	150
Ductile iron (DI)	16	260
Total (from Table 11-2 and 11-3)		**247,445 (47 miles)**

11.2 Current Staffing and Activities

The stormwater O&M activities are currently supported by a sewer fund that supports both sanitary and stormwater sewer systems. At this time, the O&M staff consists of five individuals who are responsible for continued upkeep and maintenance of the stormwater and sanitary sewer systems. The O&M supervisor is responsible for managing staff for all stormwater and sanitary tasks. One full time equivalent (FTE) is dedicated to street sweeping, and the remaining stormwater and sanitary system duties are covered as necessary by the remaining staff.

Table 11-4 outlines the O&M activities performed each year for the stormwater collection system, based on information gathered from the City and estimates by the consultant. The approximate staff-hours per year are estimated for each activity. This list represents the majority of completed activities for both preventive and unplanned maintenance completed by the O&M personnel.

TABLE 11-4
Current General Stormwater-Related O&M Tasks and Estimated Time Required to Complete per Year
City of Dallas Stormwater Master Plan

O&M Activity	Approximate Time Spent per Year (hours)
Street sweeping	1,800
Clean and camera storm systems	Unknown
Clean catch basins (about 1,060 catch basins per year)	1,050
Upgrade old street drains (about 6 per year)	150
Mow and clean ditches during summer	140
Place placards on drains (Eagle Scout Project)	None
Total Hours per Year	**3,140**
FTEs	**1.5**

The main stormwater system maintenance activities performed by permanent O&M staff include street sweeping to keep drains from getting clogged, cleaning storm systems and catch basins, and upgrading old catch basins. Summer help staff has been used to keep open ditches mowed and cleaned. Additionally, epoxy fish placards were placed on drains as part of a volunteer Eagle Scout Project for community education, but did not require O&M staff time. O&M activities total approximately 3,140 staff-hours per year, or approximately 1.5 FTEs. The current O&M staffing levels are adequate to complete these activities.

11.3 Future Staffing and Activities

The master plan and stormwater CIP identifies necessary and desirable projects and improvements to the stormwater system. Proposed improvements described in Sections 7 and 8 will be implemented over the 20-year master plan period. These improvements to the stormwater system will require an increase in O&M and administrative tasks. Along with these increases, enhanced O&M and administrative activities that employ BMPs to comply with the Dallas TMDL Plan and potential future permit requirements are recommended. The times required to complete the activities are estimates to reach maintenance activity frequency goals, but these requirements may be adjusted over time based on the condition of the stormwater infrastructure and field observations.

Currently, the City is not required to possess an NPDES MS4 permit to regulate the stormwater system discharges. However, the City is a DMA under the Willamette TMDL, and as such, was required to develop a program equivalent to the stormwater management program required of MS4 permittees. In the future, the City may be required to obtain an NPDES permit and develop a formal stormwater management program. Stormwater management programs are required to have the following six program elements, or “minimum control measures,” that work together to reduce pollutant discharged into streams:

1. Public education and outreach
2. Public participation/involvement
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post-construction runoff control
6. Pollution prevention/good housekeeping

These requirements form the basis of the Dallas TMDL Plan (City of Dallas, 2008a). Implementation of some tasks in the future will require additional staff, as described in the following paragraphs.

11.3.1 Administration

Administrative and/or technician personnel will be necessary to plan and implement CIP projects, coordinate personnel/activities, develop plans and programs, and track performance. If an NPDES MS4 permit is required for the City, additional administrative and technician personnel time will be needed for permit applications and reporting, tracking and evaluating goals, and education and outreach activities. Table 11-5 outline expected administrative/technology tasks and the estimated time necessary for completion per year. Many requirements for the NPDES MS4 permit are satisfied with activities contained in the Dallas TMDL Plan. Because some activities in the Dallas TMDL Plan were not reported by City staff as occurring annually, the recommended activities for the TMDL requirements and for general continued activities are listed in Table 11-5. Additional NPDES MS4 permit requirements not covered by the Dallas TMDL Plan are shown in Table 11-6. Most of the requirements for the NPDES MS4 permit are met by activities required by the Dallas TMDL Plan.

Administrative personnel can perform tasks related to coordinating staff and activities, billing, tracking and evaluating activities, and public education and involvement. A stormwater technician is recommended to assist with permit applications and tracking, creating stormwater plans, and the more technical aspects of the program. Some of the activities related to implementing the CIP projects and low impact development/green infrastructure projects can be covered by engineering or public works staff, so an FTE requirement has been included for engineering or public works staff. This requirement can be filled by existing engineering or public works staff or by specific stormwater staff.

TABLE 11-5
Projected Administrative/Technician Activities and Estimated Time Required to Complete per Year
City of Dallas Stormwater Master Plan

O&M Activity	Staff Type	Approximate Time Required per Year (hours)
General Future Projections:		
Coordinate and manage O&M staff/activities	Administrative	600
Plan and implement CIP projects	Engineering/Public Works	1000
Incorporate low impact development/green infrastructure projects	Engineering/Public Works	500
Utility billing	Administrative	300
Track and evaluate best management practices	Administrative	100
Total Hours per Year	Administrative	**1,000 hours**
FTEs		**0.5 FTE**
Total Hours per Year	**Engineering/Public Works**	**1,500 hours**
FTEs		**0.75 FTE**
Requirements to Meet Dallas TMDL Plan:		
Public education and outreach (school outreach, public education, utility bill mailings, riparian protection/restoration)	Administrative or Technician	150
Public involvement activities (storm drain marking, stream clean up, wetland planting, stream monitoring). Coordinate with other entities (watershed councils, volunteer organizations, businesses)	Administrative or Technician	150
Revise code to facilitate and encourage low impact development and redevelopment	Administrative or Technician	100
Create and implement plan to detect and address illegal dumping (including code modification); develop private stormwater detention inspection and enforcement program	Technician	100
Total Hours per Year	Administrative or Technician	**500 hours**
FTEs		**0.25 FTE**

TABLE 11-6
Additional Projected Administrative/Technician Activities and Estimated Time Required to Complete per Year for NPDES MS4 Permit
City of Dallas Stormwater Master Plan

O&M Activity	Staff Type	Approximate Time Required per Year (hours)
Develop stormwater management program and measureable goals	Engineering/Public Works	500
Track and evaluate the effectiveness of the program/permit compliance	Administrative/Technician (or Engineering/Public Works)	250
Permit application and reporting	Technician	250
Total Hours per Year	Administrative and Technician	**500 hours**
FTEs		**0.25 FTE**
Total Hours per Year	Engineering/Public Works	**500 hours**
FTEs		**0.25 FTE**

11.3.2 Operations and Maintenance

Recommended activities, frequencies, and the estimated time per year necessary to perform the activities are shown in Tables 11-7 and 11-8. The recommended frequencies are based on recommendations from the EPA for the NPDES permit and stormwater O&M plans for other cities. It is recommended to invest more time in street sweeping and cleaning catch basins than in cleaning pipes to prevent sediments from entering the system.

At a minimum, the O&M staff will need to continue the current reported activities. Increased time is recommended to perform O&M activities on existing stormwater facilities based on recommended frequencies for O&M activities. As the identified CIP projects are implemented, increased O&M activities will be required. Activities are also recommended to implement provisions of the Dallas TMDL Plan that were not reported as being performed, currently. These are shown in Table 11-7.

Maintenance and operation activities are recommended to be performed by field crews, in teams of two or more persons as needed. No specific educational or prior experience are necessary for field crews, but all O&M work should be overseen by a supervisor with 10 to 15 years of appropriate experience.

TABLE 11-7
Projected O&M Activities and Estimated Time Required to Complete per Year
City of Dallas Stormwater Master Plan

O&M Activity	Recommended Frequency	Approximate Time Spent per Year (hours)
Continued Requirements:		
Street sweeping	Monthly, varies based on use and season	1,800
Clean catch basins	1 to 2 times per year	2,900
Clean and inspect/camera storm sewers	10-15% of pipe system per year	1,800
Upgrade old street drains	About 10 per year	250
Mow and clean ditches during summer	Inspect once a year; mow 1 to 2 times per year	200
Total Hours per Year		**6,950 hours**
FTEs		**3.3 FTE**
Requirements to Meet Dallas TMDL Plan:		
Municipal vehicle and equipment maintenance (cleaning and training); develop facilities for washing large equipment like fire trucks	Ongoing, clean vehicles as needed	150
Materials management and storage (spill response and area inspections, identify materials, labeling, training)	Ongoing	200
Trash removal/debris management	1 time per year (more as needed)	1,000
Install/retrofit current system with treatment systems (water quality facilities) where necessary (based on inspections) and as redevelopment occurs	Around 2 installations/retrofits per year	400
Inspect and enforce proper O&M of private storm detention facilities	2 times per year	150
Enforce construction sediment control program/permit (during construction)	1 site inspection per project	500
Total Hours per Year		**2,400 hours**
FTEs		**1.2 FTE**

Again, if an NPDES MS4 permit is required for the City, supplementary O&M activities will be required. Many requirements for the NPDES MS4 permit are satisfied with tasks listed in the Dallas TMDL Plan. Activities for the NPDES MS4 permit in addition to the Dallas TMDL Plan requirements are provided in Table 11-8.

TABLE 11-8
Additional Projected O&M Activities and Estimated Time per Year Required for NPDES MS4 Phase II Permit
City of Dallas Stormwater Master Plan

O&M Activity	Recommended Frequency	Approximate Time Spent per Year (hours)
Roadway and bridge maintenance (vegetation maintenance, clean runoff control structures)	1 to 2 times per year	500
Water quality facility maintenance	1 time per year	500
Total Hours per Year		**1,000 hours**
FTEs		**0.5 FTE**

11.3.3 Overall Staffing Recommendations

Recommended staffing for all stormwater O&M activities, including administration, are summarized in Table 11-9.

TABLE 11-9
Recommended Staffing Need Summary
City of Dallas Stormwater Master Plan

Role	FTE for CIP and Regular O&M Activities	FTE for Full Implementation of Dallas TMDL Plan*	FTE for NPDES MS4 Permit	Total
Administration	1.0	0.25	0.5	**1.75**
O&M	3.3	1.2	0.5	**5**
Total FTEs	**4.3**	**1.45**	**1.0**	**6.75**

*City of Dallas Willamette TMDL Implementation Plan (City of Dallas, 2008a).

In order to increase current O&M activities to the recommended frequencies, an additional 1.8 FTEs for O&M are recommended to be added to the existing 1.5 FTE, bringing the total to 3.3 FTEs for the CIP and regular O&M activities. Administration of the proposed CIP requires 1 FTE.

An additional 1.2 FTEs O&M are recommended for full implementation of the Dallas TMDL Plan, and an additional 0.5 FTE O&M is recommended for compliance with an NPDES permit (in addition to the Dallas TMDL Plan).

Administrative needs increase from 1FTE for coordination and administration of the CIP and regular O&M, to 1.25 FTEs to add full implementation of the Dallas TMDL Plan; adding MS4 permit compliance brings the administrative need to a total of 2 FTEs.

A summary of the specific positions and education/experience requirements for each is provided in Table 11-10. Administrative activities can be covered by administrative, technician, or engineering/public works staff, depending on the task and available staff. The O&M activities are covered by a supervisor and field workers (combined in Table 11-10). Field workers should work in teams of two or more.

TABLE 11-10
Recommended Staffing Needs by Position
City of Dallas Stormwater Master Plan

Position	Minimum Educational/ Experience Requirements	FTE for CIP and Dallas TMDL Plan	FTE for Dallas TMDL Plan and NPDES MS4 Permit
Administrative	2-year degree	0.5	0.5
Administrative or Technician	2-year or 4-year degree	0.25	0.5
Engineering/Public Works	4-year degree	0.75	1
O&M Supervisor	10 to15 years of experience	4.5	5
Field Workers	None, some experience recommended		
Total FTEs		**6**	**7**

11.3.4 Additional Staffing Implementation Schedule

As discussed in Section 10, the stormwater system rehabilitation and replacement activities will be gradually increased over the course of the master planning period. O&M staffing levels should be similarly increased to keep pace with increased demands, starting with 0.25 FTE in the first 2 years for the data collection and condition assessment tasks and increasing to a total of 3.3 FTEs at the end of the master planning period. The 1 FTE administrative role should be filled in the first year of the CIP.

Implementation of the Dallas TMDL Plan is behind schedule. The 1.2 FTEs for O&M and 0.25 FTE for administration should be added in the first year of the master planning period.

In summary, a total of 1.45 FTEs for O&M and 1.25 FTEs for administration are recommended to be added in the first year of the capital plan. Maintenance staffing will increase to a total of 3.3 by the end of the master planning period *if an MS4 permit is not required*, and administration will remain at 1.25 FTEs through the planning period *if an MS4 permit is not required*.

Staffing needs of 0.5 FTE for O&M and 0. 5 FTE for administration should be added if and when an MS4 permit becomes required.

SECTION 12

Rate Study

12.1 Introduction

Dallas is the sole provider of stormwater management (SWM) services to customers within the urban services boundary of the City. Revenues required to fund the delivery of these services are obtained from monthly user fees, which are set by the City Council via its City charter authority. This study addresses the revenue required from rates to support future operations and maintenance costs for the utility along with a funding plan for capital needs identified in this stormwater master plan. In addition to analyzing utility rates, this study updated the methodologies used by the City for the calculation of system development charges (SDC) for SWM services.

With the active involvement of City staff, and input from the CH2M HILL engineering team, 20-year planning models were developed for this project; however, the focus for the rate study is the 5-year near-term forecast for fiscal years 2016 through 2020. These financial models were reviewed with the City as they were developed and will be provided to Dallas as a project deliverable enabling the City to make future updates.

The purpose of this study is to develop a cost-of-service-based methodology that will accurately determine the cost the City incurs to deliver SWM services. The models developed for this project were populated with data developed in the master planning process. These model runs simulated the current service level of the SWM program, and sensitivity cases for a number of funding issues facing the program. The results of each model run were expressed in terms of the rate impacts on the average single family residential customer's monthly bill for SWM services, and in the case of SDCs, the impact on a newly constructed single family residence.

12.1.1 Existing Stormwater Management Infrastructure Conditions

The City is responsible for the management of the surface waters that flow over and through its jurisdictional boundaries. The existing drainage facilities within the City discharge to several natural creeks, but the primary drainage is Rickreall Creek. In undeveloped areas, open system conveyance to one of these creek systems is common, while in the more intensively developed areas, piped systems are the norm. SWM services within the UGB are provided through the Public Works Department. City staff members are responsible for managing both the quantity and quality of stormwater runoff while ensuring there is adequate stormwater drainage capacity. These activities are performed in a manner consistent with the City's goal of protecting local streams and habitat to ensure that connections to the stormwater system are constructed and maintained in compliance with applicable laws, ordinances, regulations, and standards. City records indicate the stormwater collection infrastructure consists of the following:

- Storm manholes: 822
- Catch basins: 1,943
- Miles of pipes: approximately 47
- Miles of open ditch: 23

Current maintenance activities include street sweeping to keep drains clear, cleaning and closed circuit television (CCTV) inspection of storm pipes, cleaning catch basins, minor upgrades to the oldest parts of the system, and cleaning and mowing open ditches. These operations and maintenance tasks have been estimated to consume a total of 3,140 staff-hours each year, or 1.5 full time equivalents (FTEs). The City currently has five operations and maintenance staff members responsible for operations and maintenance of both the sanitary sewer and stormwater sewer systems.

12.1.2 Existing Stormwater Management Financial Conditions

The costs the City incurs to manage the SWM system are principally funded from wastewater rates, with some contributions from stormwater SDCs for capital improvements. There is no dedicated funding source for stormwater operations at this time.

During the 2013 utilities cost of service study, City staff estimated that approximately 6 percent of its total wastewater operating fund budget was spent on stormwater maintenance and system cleaning (i.e., approximately $175,000 at that time). The total breakdown of the pro forma wastewater operating expense budget is shown in Figure 12-1. From the monthly rate perspective of an average single family residential customer, 6 percent of the current monthly wastewater bill of $42.90 amounts to $2.57 for SWM services.

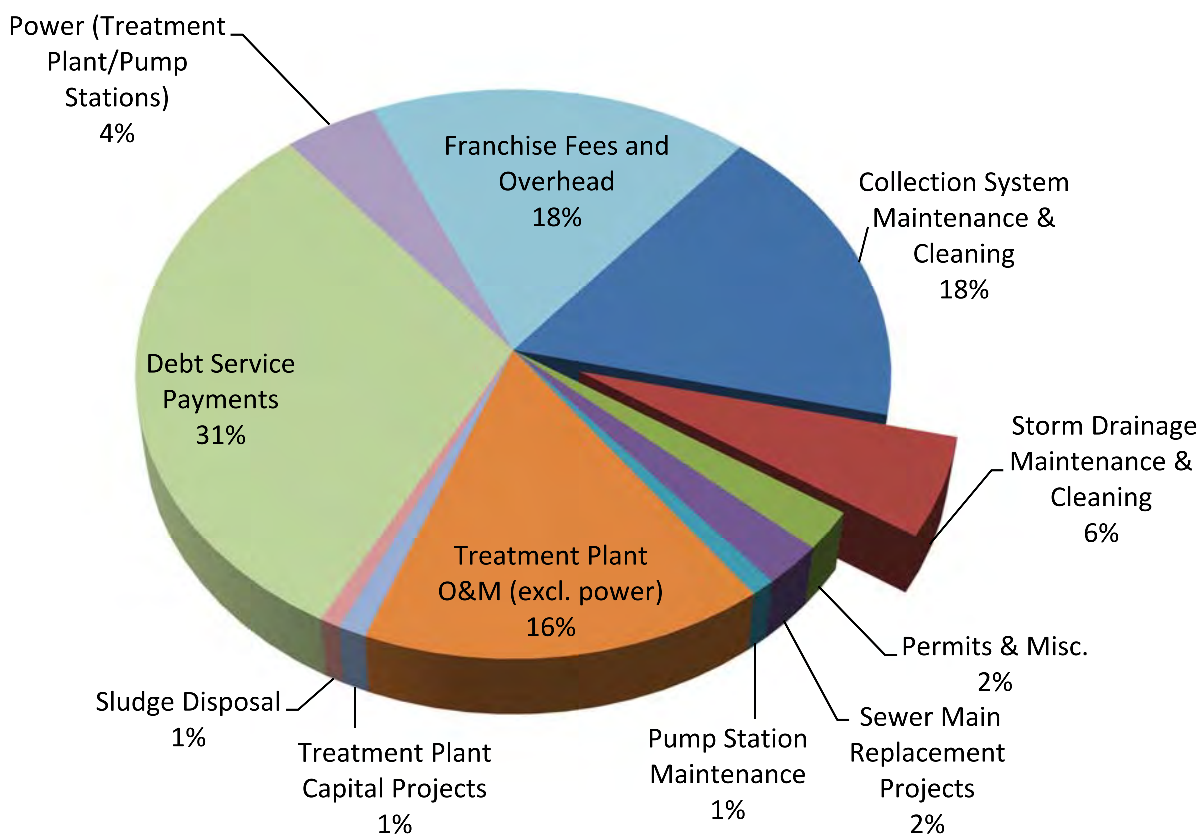


FIGURE 12-1
Breakdown of the Wastewater Expense Budget

The cost of service study estimated that for a community the size of Dallas, a stormwater program budget should be in the range of $300,000 to $700,000, assuming a minimal capital improvement program. Unfortunately, the City does not have a current stormwater master plan, and the fiscal 2013 budget actually called for a reduction in stormwater system maintenance and cleaning. After considerable discussion with City staff and the Utility Rate Advisory Committee (URAC), it was suggested the City commission a new stormwater master plan, and once completed, revisit the subject of establishing a dedicated rate and revenue stream (stormwater utility). Development of the master plan would provide the City with a better understanding of its stormwater system, maintenance requirements, future capital needs/costs, and the effect of federal stormwater regulations on Dallas into the future.

The current condition of the stormwater program was presented to the URAC at its January and February 2013 meetings, and consensus was reached that stormwater costs will continue to increase and will occupy a growing proportion of the wastewater rate over time. URAC members felt the appropriate future policy for stormwater funding would be a dedicated, fee-based, funding source for the program, and to establish an enterprise fund to budget and account for stormwater finances. However, before any action is considered for the creation of a standalone stormwater utility, the City should commission a new stormwater master plan to guide future planning for the program. With the completion and adoption of this stormwater master plan, the City will be in a position to revisit the merits of establishing a city-wide SWM utility.

12.2 Stormwater Utilities

12.2.1 Overview

SWM utilities are authorized by Oregon statute as enterprise funds within a City's budget structure. They are defined as being financially self-sufficient and can be designed to furnish a comprehensive set of services related to stormwater quantity and quality management. Services that SWM utilities provide include not only the construction and maintenance of facilities necessary to control flooding and improve the character of surface runoff, but also implementation of BMPs designed to address nonpoint source pollution. These BMPs may include water quality sampling, public education and plan review, stormwater system maintenance, site inspections, and basin planning.

SWM utilities are also a well-established, efficient, and feasible financing option that provides a dedicated revenue source for stormwater management. An SWM utility operates similarly to water or sewer utilities, which are funded through service fees and administered separately from the general tax fund, ensuring stable and adequate funding for these public services. Generally, there are three major advantages of SWM utilities over funds generated through property tax revenues: (1) increased stability and predictability, (2) greater equity, and (3) the opportunity for incorporating incentives for implementation of onsite stormwater management. Today SWM utilities serve cities with populations ranging from under 5,000 to over 3.5 million. SWM utilities differ from most other utilities such as power or drinking water utilities because consumers often do not see an immediate benefit from paying their fee. Since most consumers want, for example, electricity, they are willing to pay in advance to receive it on demand. On the other hand, SWM ratepayers are being asked to pay to prevent something they don't want, flooding and water pollution. If residents have never thought about stormwater, they probably will not recognize or appreciate the benefits of preventing flooding and stormwater pollution, and therefore will not want it in the same way as a power utility. This will likely affect their willingness to pay. Moreover, there is less an individual can do to change the magnitude of the fee. Improving the public's knowledge and understanding of the benefits of flooding and stormwater pollution prevention can go a long way to increasing their acceptance of a SWM utility. Nonetheless, these problems are even greater with respect to taxes, and can be minimized (and explained) by linking the fee to a property's contribution to downstream flooding and stormwater pollution.

12.2.2 Fees Based on Impervious Area

Most SWM utilities in Oregon generate revenues based on fees, and the basis for those fees is impervious area. The amount of impervious surface on a property is the single most important factor affecting the amount of water flowing off a property, how quickly that water flows off a property, and the amount of pollution picked up by the water from that property. Because of this, basing stormwater utility fees on the impervious area on a property is one of the most common methods used to determine stormwater utility fees in Oregon and the nation.

For this rate study effort, it was assumed that a Dallas SWM utility fee would be applied to customers based on an "equivalent residential units" (ERU) approach. Under this structure, a single-family home is counted as one ERU and, on average, contains 3,200 square feet of impervious area. All non-single-family residential customers are charged based on their measured impervious area for each developed property, which is then divided by the ERU value of 3,200 square feet of impervious surface. This determines the total number of ERUs billed to that non-single-family residential customer.

The hydrologic section of this master plan used a number of data sources and methods to estimate the total amount of impervious area by land use designation. The land use designations are based on the City's current comprehensive plan. For utility rate-making purposes, this total impervious area inventory has to be adjusted to eliminate the amount of impervious area attributable to streets, municipally-owned properties/structures, and parks/open spaces. This "elimination" process was done with the use of digital Polk County assessor files and other GIS tools. The results of this analysis produced an inventory of estimated total billable impervious area. From this total, the project team solved for the total amount of billable ERUs. The data are shown in Table 12-1.

TABLE 12-1
Forecast of Existing Equivalent Residential Units
City of Dallas Stormwater Master Plan

Land Use*	Square Feet Billable Impervious Area	Assumed ERU	Billable ERUs
Residential:			
Residential low density	11,423,581	3,200	3,570
Residential medium density	1,309,097	3,200	409
Residential high density	2,360,310	3,200	738
Subtotal residential	15,092,988	3,200	4,717
Nonresidential:			
Commercial neighborhood	309,671	3,200	97
Commercial general	1,959,802	3,200	612
Central business district	1,238,400	3,200	387
Industrial	5,633,556	3,200	1,760
Subtotal nonresidential	9,141,429	3,200	2,857

Dallas Comprehensive Plan land use definitions:

Residential low density (4 to 9 dwelling units per buildable acre)

Residential medium density (6 to 16 dwelling units per buildable acre)

Residential high density (10 to 40 dwelling units per buildable acre)

The Commercial Neighborhood (CN) District applies to limited commercial areas that primarily serve the immediate, surrounding neighborhood. It provides neighborhood goods and services at a smaller scale than the Commercial General District and is focused at designated arterial crossroads locations.

The Commercial General (CG) District applies to commercial areas outside or adjacent to the central business area. It provides opportunities for a mix of community-oriented businesses such as grocery stores, and restaurants, highway oriented commercial uses, and other services adjacent to medium- and high-density housing areas.

The Central Business District (CBD) serves as the commercial and civic core of the community. It is the location of city and county offices, downtown commercial uses, and tourism oriented uses. The CBD provides opportunities for mixed-use development, with a variety of commercial retail and services, office uses, high-density housing, and civic facilities.

The Industrial (I) district is intended to provide for land use compatibility while providing a high-quality environment for a wide range of businesses. The Industrial district also provides suitable locations for heavy industrial uses (e.g., raw materials processing; and manufacturing, assembly, packaging or distribution of heavy or large goods) that would not otherwise be compatible in other districts.

SECTION 13
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Appendix A
XPSWMM Analysis Reports

```
CEMETERY DESIGN: SELECTED TABLES
Current Directory:   C:\PROGRA~2\XPSOLU~1\XPSWMM~1
 Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE



 Input File : :\dallascityof\496541stormwater\Hydrology\SWMM\Cemetery_Design.XP
          *================================================*
          |                    xpswmm                      |
          |     Storm and Wastewater Management Model      |
          |         Developed by XP Solutions Inc.         |
          |================================================|
          |                                                |
          | Last Update      : Jan., 2013                  |
          | Interface Version: 2012                        |
          | Engine Version   : 12.0                        |
          | Data File Version: 12.5                        |
          |                                                |
          |                                                |
          *================================================*

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

 *============================================================*
 |        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE              |
 |                                                            |
 | Table E1   - Basic Conduit Data                            |
 | Table E3a  - Junction Data                                 |
 | Table E4   - Conduit Connectivity Data                     |
 | Table E9   - Junction  Summary  Statistics                 |
 | Table E10  - Conduit   Summary  Statistics                 |
 | Table E12  - Mean conduit information                      |
 | Table E15  - Spreadsheet Info List                         |
 | Table E15a - Spreadsheet Reach List                        |
 | Table E16  - New Conduit Output Section                    |
 | Table E20  - Junction Flooding and Volume List             |
 *============================================================*
 Time Control from Hydraulics Job Control
 Year.........    2014 Month.......       1
 Day..........       1 Hour........       0
 Minute.......       0 Second......       0

 Control information for simulation
 ----------------------------------

 Integration cycles.................      1440
 Length of integration step is......     60.00 seconds
 Simulation length..................     24.00 hours
 Do not create equiv. pipes(NEQUAL).         0
 Use U.S. customary units for I/O...         0
 Printing starts in cycle...........         1
 Intermediate printout intervals of.       500 cycles
 Intermediate printout intervals of.    500.00 minutes
 Summary printout intervals of......       500 cycles
 Summary printout time interval of..    500.00 minutes
 Hot start file parameter (REDO)....         0
 Initial time.......................      0.00 hours

 Iteration variables: Flow Tolerance.   0.00010
                      Head Tolerance.   0.00050
     Minimum depth (m or ft).........   0.00001
     Underrelaxation parameter.......   0.85000
     Time weighting parameter........   0.85000
     Conduit roughness factor........   1.00000
     Flow adjustment factor..........   1.00000
     Initial Condition Smoothing.....         0
     Courant Time Step Factor........   1.00000
     Default Expansion/Contraction K.   0.00000
     Default Entrance/Exit K.........   0.00000
     Routing Method..................   Dynamic Wave
 Default surface area of junctions...     12.57 square feet.
 Minimum Junction/Conduit Depth......   0.00001 feet.
 Ponding Area Coefficient............   5000.00
 Ponding Area Exponent...............    1.0000
 Minimum Orifice Length..............   1000.00 feet.
 NJSW input hydrograph junctions.....     2
      or user defined hydrographs....

 *==================================================*
 |          Table E1 - Conduit Data                 |
 *==================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	ditch	186.0000	Trapezoid	6.0000	0.0300	1.0000	2.0000	1.0000	1.0000
2	driveway	35.0000	Circular	1.7671	0.0140	1.5000	1.5000		
3	southculv	57.5000	Circular	1.7671	0.0130	1.5000	1.5000		
4	northculv	57.5000	Circular	4.9087	0.0140	2.5000	2.5000		
5	Link5	57.5000	Circular	1.7671	0.0130	1.5000	1.5000		

Total length of all conduits .... 393.5000 feet

```
 *==================================================*
 |           Table E3a - Junction Data              |
 *==================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	fromditch	354.1700	352.8600	350.2000	0.0000	0.0000	100.0000
2	Node2	353.1700	351.8100	349.1700	0.0000	0.0000	100.0000
3	culvstart	353.5000	352.7600	350.7000	0.0000	0.0000	100.0000
4	catchbasin	353.1400	351.9900	350.4900	0.0000	0.0000	100.0000
5	outlet	353.0600	351.5600	348.0600	0.0000	0.0000	100.0000
6	Node6	353.0600	351.5600	348.0600	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	ditch	fromditch	culvstart	350.8600	350.7600	No Design
2	driveway	culvstart	catchbasin	350.7600	350.4900	No Design
3	southculv	catchbasin	outlet	350.4900	350.0600	No Design
4	northculv	fromditch	Node2	350.3300	349.3100	No Design
5	Link5	catchbasin	Node6	350.4900	350.0600	No Design

Table E9 - JUNCTION SUMMARY STATISTICS
The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
fromditch	354.1700	352.8600	354.1700	7	49	1.3100	0.0000	12.5660	0.0000	0.0000	0.0000
Node2	353.1700	351.8100	351.6700	7	33	0.0000	1.5000	12.5660	0.0000	0.0000	0.0000
culvstart	353.5000	352.7600	353.5000	7	41	0.7400	0.0000	12.5660	0.0000	0.0000	0.0000
catchbasin	353.1400	351.9900	353.1400	7	46	1.1500	0.0000	12.5660	0.0000	0.0000	0.0000
outlet	353.0600	351.5600	349.5600	7	30	0.0000	3.5000	12.5660	0.0000	0.0000	0.0000
Node6	353.0600	351.5600	349.5600	7	30	0.0000	3.5000	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS
Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
ditch	6.4300	1.0717	39.7200	43.3340	8	28	3.1258	8	37	6.7393	354.1700	353.5000	1.000	0.828	*
driveway	8.5671	4.8480	18.0000	16.1076	9	7	9.0700	9	7	1.8802	353.5000	353.1400	1.827	1.767	
southculv	9.0838	5.1404	18.0000	17.4727	7	47	9.8443	7	47	1.9235	353.1400	351.5600	1.767	1.000	
northculv	50.7279	10.3342	30.0000	77.3474	8	28	15.7095	8	28	1.5248	354.1700	351.8100	1.536	1.000	
Link5	9.0838	5.1404	18.0000	17.4727	7	47	9.8443	7	47	1.9235	353.1400	351.5600	1.767	1.000	
FREE # 1	Undefnd	Undefnd	Undefn	77.4012	8	21									
FREE # 2	Undefnd	Undefnd	Undefn	17.4852	8	21									
FREE # 3	Undefnd	Undefnd	Undefn	17.4852	8	21									

Table E12. Mean Conduit Flow Information

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
ditch	4.2186	364483.60	0.0002	0.9683	0.2797	0.5865	3.4524	0.0300
driveway	2.7895	241010.40	0.0001	0.9647	0.7693	0.2998	0.8047	0.0140
southculv	4.4096	380987.13	0.0001	0.9852	1.0715	0.3452	0.9549	0.0130
northculv	30.0345	2594979.8	0.0005	0.9961	1.5896	0.6390	3.1674	0.0140
Link5	4.4096	380987.13	0.0001	0.9852	1.0715	0.3452	0.9549	0.0130
FREE # 1	30.0347	2594997.1						
FREE # 2	4.4096	380990.88						
FREE # 3	4.4096	380990.88						

Table E15 - SPREADSHEET INFO LIST
Conduit Flow and Junction Depth Information for use in spreadsheets. The maximum values in this table are the true maximum values because they sample every time step. The values in the review results may only be the maximum of a subset of all the time steps in the run. Note: These flows are only the flows in a single barrel.

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
ditch	43.3340	364483.6036	3.1258	2269.4940	##	fromditch	350.2000	354.1700
driveway	16.1076	241010.4049	9.0700	64.6364	##	Node2	349.1700	351.6700
southculv	17.4727	380987.1334	9.8443	101.8588	##	culvstart	350.7000	353.5000
northculv	77.3474	2594979.819	15.7095	288.7744	##	catchbasin	350.4900	353.1400
Link5	17.4727	380987.1334	9.8443	101.8588	##	outlet	348.0600	349.5600
FREE # 1	77.4012	2594997.084	0.0000	0.0000	##	Node6	348.0600	349.5600

FREE # 2	17.4852	380990.8813	0.0000	0.0000	##
FREE # 3	17.4852	380990.8813	0.0000	0.0000	##

```
*===================================================*
|     Table E15a - SPREADSHEET REACH LIST           |
| Peak flow and Total Flow listed by Reach or those |
|      conduits or diversions having the same       |
|      upstream and downstream nodes.               |
*===================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
fromditch	culvstart	43.3340	364483.604
culvstart	catchbasin	16.1076	241010.405
catchbasin	outlet	17.4727	380987.133
fromditch	Node2	77.3474	2594979.82
catchbasin	Node6	17.4727	380987.133

```
#########################################################
# Table E16. New Conduit Information Section            #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
ditch	fromditch	culvstart	350.8600	350.7600	354.1700	353.5000	Trapezoid
driveway	culvstart	catchbasin	350.7600	350.4900	353.5000	353.1400	Circular
southculv	catchbasin	outlet	350.4900	350.0600	353.1400	351.5600	Circular
northculv	fromditch	Node2	350.3300	349.3100	354.1700	351.8100	Circular
Link5	catchbasin	Node6	350.4900	350.0600	353.1400	351.5600	Circular

```
*=====================================================*
| Table E20 - Junction Flooding and Volume Listing.   |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max   |
|             volume at any time. The volume in the   |
|             flooded storage area is the total volume|
|             above the ground elevation, where the   |
|             flooded pond storage area starts.       |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*=====================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
fromditch	116.4659	47.8667	112423.5046	49.8870	0.0000
Node2	0.0000	0.0000	0.0000	31.4150	0.0000
culvstart	103.4015	86.0927	123449.9636	35.1848	0.0000
catchbasin	115.7689	35.2037	14835.0188	33.2999	0.0000
outlet	0.0000	0.0000	0.0000	18.8490	0.0000
Node6	0.0000	0.0000	0.0000	18.8490	0.0000

```
*==================================*
| Simulation Specific Information  |
*==================================*
Number of Input Conduits..........         5 Number of Simulated Conduits......         8
Number of Natural Channels........         0 Number of Junctions...............         6
Number of Storage Junctions.......         0 Number of Weirs...................         0
Number of Orifices................         0 Number of Pumps...................         0
Number of Free Outfalls...........         3 Number of Tide Gate Outfalls......         0
```

```
*=========================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*=========================================================*
```

```
The Conduit with the largest average change was..northculv  with     0.000 percent
The Junction with the largest average change was.fromditch  with     0.038 percent
The Conduit with the largest sinuosity was.......ditch      with    13.610
```

CEMETERY EXISTING: SELECTED TABLES
Current Directory: C:\PROGRA~2\XPSOLU~1\XPSWMM~1
Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

Input File : P:\dallascityof\496541stormwater\Hydrology\SWMM\Cemetery.XP

```
*==============================================*
|                    xpswmm                    |
|     Storm and Wastewater Management Model    |
|         Developed by XP Solutions Inc.       |
|==============================================|
|                                              |
| Last Update      : Jan., 2013                |
| Interface Version: 2012                      |
| Engine Version   : 12.0                      |
| Data File Version: 12.5                      |
|                                              |
|                                              |
*==============================================*
```

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

```
*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE               |
| Table E1   - Basic Conduit Data                          |
| Table E3a  - Junction Data                               |
| Table E4   - Conduit Connectivity Data                   |
| Table E9   - Junction  Summary  Statistics               |
| Table E10  - Conduit   Summary  Statistics               |
| Table E12  - Mean conduit information                    |
| Table E15  - Spreadsheet Info List                       |
| Table E15a - Spreadsheet Reach List                      |
| Table E16  - New Conduit Output Section                  |
| Table E20  - Junction Flooding and Volume List           |
*=========================================================*
```

```
Time Control from Hydraulics Job Control
Year.........    2014 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0
```

Control information for simulation

```
Integration cycles.................      1440
Length of integration step is......     60.00 seconds
Simulation length..................     24.00 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.       500 cycles
Intermediate printout intervals of.    500.00 minutes
Summary printout intervals of......       500 cycles
Summary printout time interval of..    500.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         0
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     12.57 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............   5000.00
Ponding Area Exponent...............    1.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....     2
     or user defined hydrographs....
```

```
*==================================================*
|          Table E1 - Conduit Data                 |
*==================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	ditch	186.0000	Trapezoid	5.0000	0.0300	0.5000	2.0000	1.0000	1.0000
2	18driveway	35.0000	Circular	1.7671	0.0140	1.5000	1.5000		
3	18culv	57.5000	Circular	1.7671	0.0140	1.5000	1.5000		
4	24culv	57.5000	Circular	3.1416	0.0140	2.0000	2.0000		

Total length of all conduits .... 336.0000 feet

```
*===================================================*
|           Table E3a - Junction Data               |
*===================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	fromditch	354.1700	354.1400	350.7000	0.0000	0.0000	100.0000
2	Node2	353.1700	351.6700	349.6700	0.0000	0.0000	100.0000
3	culvstart	353.5000	352.7600	350.7600	0.0000	0.0000	100.0000
4	catchbasin	353.1400	351.9900	350.4900	0.0000	0.0000	100.0000
5	outlet	353.0600	351.5600	349.5600	0.0000	0.0000	100.0000

Table E3b - Junction Data

Inp Num	Junction Name	X Coord.	Y Coord.	Type of Manhole	Type of Inlet	Maximum Capacity	Pavement Shape	Pavement Slope
1	fromditch	0.0000	0.0000	F	Normal		0	0.0000
2	Node2	0.0000	0.0000	No P	Normal		0	0.0000
3	culvstart	0.0000	0.0000	F	Normal		0	0.0000
4	catchbasin	0.0000	0.0000	F	Normal		0	0.0000
5	outlet	0.0000	0.0000	No P	Normal		0	0.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	ditch	fromditch	culvstart	352.1400	350.7600	No Design
2	18driveway	culvstart	catchbasin	350.7600	350.4900	No Design
3	18culv	catchbasin	outlet	350.4900	350.0600	No Design
4	24culv	fromditch	Node2	350.7000	349.6700	No Design

Table E9 - JUNCTION SUMMARY STATISTICS

The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
fromditch	354.1700	354.1400	357.2845	9	16	3.1445	0.0000	112615.50	0.0000	0.0000	0.0000
Node2	353.1700	351.6700	353.1700	3	2	1.5000	0.0000	12.5660	0.0000	0.0000	0.0000
culvstart	353.5000	352.7600	357.2799	9	18	4.5199	0.0000	219069.19	0.0000	0.0000	0.0000
catchbasin	353.1400	351.9900	356.0288	10	6	4.0388	0.0000	89859.027	0.0000	0.0000	0.0000
outlet	353.0600	351.5600	351.0600	4	53	0.0000	2.0000	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS

Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
ditch	18.5691	3.7138	78.2171	93.6316	8	13	3.6519	8	9	5.0423	357.2845	357.2799	0.789	1.000	*
18driveway	8.5671	4.8480	18.0000	19.3761	8	47	10.7438	8	47	2.2617	357.2799	356.0288	4.347	3.693	
18culv	8.4350	4.7732	18.0000	27.5185	10	6	15.3357	10	6	3.2624	356.0288	351.5600	3.693	1.000	
24culv	28.1150	8.9493	24.0000	56.8473	9	16	17.8521	9	16	2.0220	357.2845	353.1700	3.292	1.750	
FREE # 1	Undefnd	Undefnd	Undefn	27.5185	10	6									

Table E11. Area assumptions used in the analysis

Subcritical and Critical flow assumptions from Subroutine Head. See Figure 17-1 in the manual for further information.

Conduit Name	Duration of Dry Flow(min)	Duration of Sub-Critical Flow(min)	Durat. of Upstream Critical Flow(min)	Durat. of Downstream Critical Flow(min)	Maximum Hydraulic Radius-m	Maximum X-Sect Area(ft^2)	Maximum Vel*D (ft^2/s)
ditch	122.3000	1317.7000	0.0000	0.0000	2.1989	38.0023	19.0503
18driveway	122.4000	1317.6000	0.0000	0.0000	0.4553	1.8519	63.8748
18culv	122.4000	0.0000	0.0000	1317.6000	0.4560	1.8324	53.9724
24culv	98.0000	1342.0000	0.0000	0.0000	0.5976	3.2795	90.0146

Table E12. Mean Conduit Flow Information

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
ditch	9.4172	813644.94	0.0001	0.9967	0.2601	1.0437	10.9814	0.0300
18driveway	9.3896	811262.00	0.0000	0.9967	0.6415	0.3768	1.7003	0.0140
18culv	15.5904	1347009.0	0.0000	0.9967	1.4895	0.3805	1.7121	0.0140
24culv	26.1187	2256655.9	0.0001	0.9987	0.9053	0.4991	3.1530	0.0140
FREE # 1	15.5904	1347008.0						

Table E15 - SPREADSHEET INFO LIST

Conduit Flow and Junction Depth Information for use in spreadsheets. The maximum values in this table are the

| true maximum values because they sample every time step.|
| The values in the review results may only be the |
| maximum of a subset of all the time steps in the run. |
| Note: These flows are only the flows in a single barrel.|

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)
ditch	93.6316	813644.9441	3.6519	6898.1610
18driveway	19.3761	811262.0050	10.7438	64.8132
18culv	27.5185	1347009.025	15.3357	102.4805
24culv	56.8473	2256655.907	17.8521	181.5041
FREE # 1	27.5185	1347008.021	0.0000	0.0000

Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
fromditch	350.7000	357.2845
Node2	349.6700	353.1700
culvstart	350.7600	357.2799
catchbasin	350.4900	356.0288
outlet	349.5600	351.0600

Table E15a - SPREADSHEET REACH LIST
Peak flow and Total Flow listed by Reach or those conduits or diversions having the same upstream and downstream nodes.

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
fromditch	culvstart	93.6316	813644.944
culvstart	catchbasin	19.3761	811262.005
catchbasin	outlet	27.5185	1347009.02
fromditch	Node2	56.8473	2256655.91

Table E16. New Conduit Information Section
Conduit Invert (IE) Elevation and Conduit Maximum Water Surface (WS) Elevations

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
ditch	fromditch	culvstart	352.1400	350.7600	357.2845	357.2799	Trapezoid
18driveway	culvstart	catchbasin	350.7600	350.4900	357.2799	356.0288	Circular
18culv	catchbasin	outlet	350.4900	350.0600	356.0288	351.5600	Circular
24culv	fromditch	Node2	350.7000	349.6700	357.2845	353.1700	Circular

Table E20 - Junction Flooding and Volume Listing.
The maximum volume is the total volume in the node including the volume in the flooded storage area. This is the max volume at any time. The volume in the flooded storage area is the total volume above the ground elevation, where the flooded pond storage area starts.
The fourth column is instantaneous, the fifth is the sum of the flooded volume over the entire simulation
Units are either ft^3 or m^3 depending on the units.

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
fromditch	529.2667	524.8833	0.0000	107659.1025	120347.1402
Node2	1320.8889	1257.9375	2.2565E+06	43.9810	0.0000
culvstart	887.7000	615.7833	0.0000	214103.6214	235608.5846
catchbasin	1128.3667	608.6167	0.0000	84892.3268	99803.7690
outlet	0.0000	0.0000	0.0000	18.8490	0.0000

Simulation Specific Information

Number of Input Conduits..........	4	Number of Simulated Conduits......	5
Number of Natural Channels........	0	Number of Junctions..............	5
Number of Storage Junctions.......	0	Number of Weirs..................	0
Number of Orifices................	0	Number of Pumps..................	0
Number of Free Outfalls...........	1	Number of Tide Gate Outfalls......	0

Average % Change in Junction or Conduit is defined as:
Conduit % Change ==> 100.0 (Q(n+1) - Q(n)) / Qfull
Junction % Change ==> 100.0 (Y(n+1) - Y(n)) / Yfull

The Conduit with the largest average change was..ditch with 0.000 percent
The Junction with the largest average change was.fromditch with 0.075 percent

The Conduit with the largest sinuosity was.......ditch with 13.749

```
DOUGLAS ELLEDALE DESIGN: SELECTED TABLES
Current Directory:   C:\XPS\XPSWMM~4
 Engine Name: c:\xps\XPSWMM~4\SWMMEN~1.EXE


 Input File : ocuments\Projects\Dallas\SWMM\Douglas\Douglas_EllendaleDESIGN2.XP

          *===============================================*
          |                   xpswmm                      |
          |     Storm and Wastewater Management Model     |
          |         Developed by XP Solutions Inc.        |
          |===============================================|
          |                                               |
          | Last Update      : Oct., 2011                 |
          | Interface Version: 2012 SP1                   |
          | Engine Version   : 12.0                       |
          | Data File Version: 12.4                       |
          |                                               |
          |                                               |
          *===============================================*

Engine Name: c:\xps\XPSWMM~4\SWMMEN~1.EXE

 *===========================================================*
 |        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE                |
 | Table E1   - Basic Conduit Data                            |
 | Table E3a  - Junction Data                                 |
 | Table E3b  - Junction Data                                 |
 | Table E4   - Conduit Connectivity Data                     |
 | Table E9   - Junction  Summary  Statistics                 |
 | Table E10  - Conduit   Summary  Statistics                 |
 | Table E15  - Spreadsheet Info List                         |
 | Table E15a - Spreadsheet Reach List                        |
 | Table E16  - New Conduit Output Section                    |
 | Table E20  - Junction Flooding and Volume List             |
 *===========================================================*

 Time Control from Hydraulics Job Control
 Year.........    2014 Month.......       1
 Day..........       1 Hour........       0
 Minute.......       0 Second......       0


 Control information for simulation
 ----------------------------------

 Integration cycles.................      1440
 Length of integration step is......     60.00 seconds
 Simulation length..................     24.00 hours
 Do not create equiv. pipes(NEQUAL).         0
 Use U.S. customary units for I/O...         0
 Printing starts in cycle...........         1
 Intermediate printout intervals of.        -1 cycles
 Intermediate printout intervals of.     -1.00 minutes
 Summary printout intervals of......        -1 cycles
 Summary printout time interval of..     -1.00 minutes
 Hot start file parameter (REDO)....         0
 Initial time.......................      0.00 hours

 Iteration variables: Flow Tolerance.   0.00010
                      Head Tolerance.   0.00050
     Minimum depth (m or ft).........   0.00001
     Underrelaxation parameter.......   0.85000
     Time weighting parameter........   0.85000
     Conduit roughness factor........   1.00000
     Flow adjustment factor..........   1.00000
     Initial Condition Smoothing.....         0
     Courant Time Step Factor........   1.00000
     Default Expansion/Contraction K.   0.00000
     Default Entrance/Exit K.........   0.00000
     Routing Method..................   Dynamic Wave
 Default surface area of junctions...     12.57 square feet.
 Minimum Junction/Conduit Depth......   0.00001 feet.
 Ponding Area Coefficient............   5000.00
 Ponding Area Exponent...............    1.0000
 Minimum Orifice Length..............   1000.00 feet.
 NJSW input hydrograph junctions.....     4
      or user defined hydrographs....

 *===================================================*
 |          Table E1 - Conduit Data                  |
 *===================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	P-A4	250.0000	Circular	9.6211	0.0130	3.5000	3.5000		
2	NewChannel	191.3600	Trapezoid	99.0000	0.0350	4.0000	4.5000	4.0000	4.0000
3	OverQ	44.1600	Circular	3.1416	0.0130	2.0000	2.0000		
4	DougE	161.7000	Circular	2.4053	0.0130	1.7500	1.7500		
5	DougW	172.1500	Circular	7.0686	0.0130	3.0000	3.0000		
6	Ellen48	228.0000	Circular	12.5664	0.0130	4.0000	4.0000		
7	New48	312.1000	Circular	12.5664	0.0130	4.0000	4.0000		
8	Link27	33.0000	Trapezoid	12.0000	0.0140	2.0000	2.0000	2.0000	2.0000
9	Link28	50.0000	Trapezoid	150.0000	0.0140	5.0000	5.0000	5.0000	5.0000
10	Link29	33.0000	Trapezoid	36.0000	0.0140	3.0000	3.0000	3.0000	3.0000
11	36inch	340.0000	Circular	7.0686	0.0120	3.0000	3.0000		

Total length of all conduits ....   1815.4700 feet

```
 *===================================================*
 |           Table E3a - Junction Data               |
 *===================================================*

 Inp         Junction     Ground     Crown    Invert    Qinst  Initial  Interface
```

Num	Name	Elevation	Elevation	Elevation	cfs	Depth-ft	Flow (%)
1	FlowJA4	352.0000	349.1800	345.6800	0.0000	0.0000	100.0000
2	J-A4	349.3400	348.6700	345.6300	0.0000	0.0000	100.0000
3	Outfall	336.9250	336.9250	332.4250	0.0000	0.0000	100.0000
4	OFlow	351.6400	348.6400	346.6400	0.0000	0.0000	100.0000
5	MH 64-85	347.7900	345.6000	341.6000	0.0000	0.0000	100.0000
6	MH65-92JA2	347.2500	342.3000	338.0000	0.0000	0.0000	100.0000
7	MH09-92JA1	340.0000	339.0300	334.5300	0.0000	0.0000	100.0000
8	FA3	351.7060	348.7060	346.7060	0.0000	0.0000	100.0000
9	JA1B	351.6000	351.6000	346.6000	0.0000	0.0000	100.0000
10	FA2E	347.2500	341.3300	338.3300	0.0000	0.0000	100.0000
11	Node30	345.1000	342.6500	337.6500	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	P-A4	FlowJA4	MH 64-85	345.6800	341.6000	No Design
2	NewChannel	MH09-92JA1	Outfall	334.5300	332.4250	No Design
3	OverQ	OFlow	J-A4	346.6400	345.6700	No Design
4	DougE	OFlow	MH 64-85	346.6400	341.6000	No Design
5	DougW	J-A4	MH 64-85	345.6700	341.6000	No Design
6	Ellen48	MH 64-85	MH65-92JA2	341.6000	338.3000	No Design
7	New48	MH65-92JA2	MH09-92JA1	338.0000	334.5300	No Design
8	Link27	FA3	OFlow	346.7060	346.6400	No Design
9	Link28	JA1B	Node30	346.6000	337.6500	No Design
10	Link29	FA2E	MH65-92JA2	338.3300	338.0000	No Design
11	36inch	Node30	MH09-92JA1	337.6500	334.8300	No Design

Table E9 - JUNCTION SUMMARY STATISTICS

The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
FlowJA4	352.0000	349.1800	351.9083	8	10	2.7283	0.0917	12.5660	0.0000	0.0000	0.0000
J-A4	349.3400	348.6700	346.8947	8	10	0.0000	2.4453	12.5660	0.0000	0.0000	0.0000
Outfall	336.9250	336.9250	335.2953	8	7	0.0000	1.6297	12.5660	0.0000	0.0000	0.0000
OFlow	351.6400	348.6400	348.1034	8	11	0.0000	3.5366	12.5660	0.0000	0.0000	0.0000
MH 64-85	347.7900	345.6000	344.9060	8	10	0.0000	2.8840	12.5660	0.0000	0.0000	0.0000
MH65-92JA2	347.2500	342.3000	342.4417	8	10	0.1417	4.8083	12.5660	0.0000	0.0000	0.0000
MH09-92JA1	340.0000	339.0300	337.4009	8	7	0.0000	2.5991	12.5660	0.0000	0.0000	0.0000
FA3	351.7060	348.7060	348.2963	8	11	0.0000	3.4097	12.5660	0.0000	0.0000	0.0000
JA1B	351.6000	351.6000	347.1170	8	1	0.0000	4.4830	12.5660	0.0000	0.0000	0.0000
FA2E	347.2500	341.3300	342.4404	8	10	1.1104	4.8096	12.5660	0.0000	0.0000	0.0000
Node30	345.1000	342.6500	343.0918	8	2	0.4418	2.0082	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS

Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS
P-A4	128.5287	13.3590	42.0000	95.3850	8	10	9.8925	8	10	0.7421	351.9083	344.9060	1.780	0.945
NewChannel	792.0623	8.0006	54.0000	271.4369	8	7	6.1072	8	7	0.3427	337.4009	335.2953	0.638	0.638
OverQ	33.5282	10.6724	24.0000	29.6566	8	11	12.0451	8	12	0.8845	348.1034	347.1333	0.732	0.732
DougE	27.9739	11.6302	21.0000	22.0795	8	12	11.0274	8	26	0.7893	348.1034	344.9060	0.836	1.889
DougW	102.5555	14.5086	36.0000	29.6684	8	11	9.6410	8	22	0.2893	346.8947	344.9060	0.408	1.102
Ellen48	172.8124	13.7520	48.0000	147.1336	8	11	14.3444	8	22	0.8514	344.9060	342.4417	0.826	1.035
New48	151.4618	12.0529	48.0000	184.7004	8	10	14.5040	8	21	1.2195	342.4417	337.4009	1.110	0.718
Link27	60.5689	5.0474	24.0000	51.7041	8	11	6.8586	8	23	0.8536	348.2963	348.1034	0.795	0.732
Link28	12993.56	86.6237	65.3020	92.6815	8	1	9.7809	7	40	0.0071	347.1170	343.0918	0.095	1.000
Link29	531.0392	14.7511	53.3006	38.8555	8	6	1.8702	2	41	0.0732	342.4404	342.4417	0.925	1.000
36inch	65.8056	9.3096	36.0000	92.2616	8	2	13.0165	8	2	1.4020	343.0918	337.6817	1.814	0.951
FREE # 1	Undefnd	Undefnd	Undefn	271.4372	8	7								

Table E12. Mean Conduit Flow Information

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
P-A4	22.3496	1931005.8	0.0007	0.9860	0.8296	0.8105	5.2795	0.0130
NewChannel	54.5973	4717207.2	0.0022	0.9953	0.5997	0.8810	14.8968	0.0350
OverQ	4.7765	412685.34	0.0002	0.9938	1.8374	0.3021	0.6974	0.0130
DougE	4.9663	429087.17	0.0002	0.9938	1.8075	0.3112	0.7427	0.0130
DougW	4.7759	412633.53	0.0002	0.9935	1.4974	0.3137	0.9178	0.0130
Ellen48	32.0859	2772218.4	0.0011	0.9938	1.6746	0.6785	3.4115	0.0130
New48	38.8280	3354740.2	0.0014	0.9938	1.4870	0.7659	4.2818	0.0130

Link27	9.7436	841845.54	0.0004	0.9939	1.0939	0.4463	2.3747	0.0140
Link28	15.7890	1364173.0	0.0011	0.9954	2.9712	0.2260	2.5963	0.0140
Link29	6.7492	583128.36	0.0004	0.9926	0.1968	0.7341	9.2060	0.0140
36inch	15.7755	1363002.7	0.0009	0.9954	1.3027	0.5600	2.3168	0.0120
FREE # 1	54.5977	4717240.4						

```
*=========================================================*
|     Table E15 - SPREADSHEET INFO LIST                   |
| Conduit Flow and Junction Depth Information for use in  |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the        |
| maximum of a subset of all the time steps in the run.   |
| Note: These flows are only the flows in a single barrel.|
*=========================================================*
```

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
P-A4	95.3850	1931005.774	9.8925	1930.3259	##	FlowJA4	345.6800	351.9083
NewChannel	271.4369	4717207.219	6.1072	8500.6334	##	J-A4	345.6300	346.8947
OverQ	29.6566	412685.3363	12.0451	108.7373	##	Outfall	332.4250	335.2953
DougE	22.0795	429087.1692	11.0274	248.7178	##	OFlow	346.6400	348.1034
DougW	29.6684	412633.5253	9.6410	710.1587	##	MH 64-85	341.6000	344.9060
Ellen48	147.1336	2772218.432	14.3444	2728.4205	##	MH65-92JA2	338.0000	342.4417
New48	184.7004	3354740.220	14.5040	2923.1947	##	MH09-92JA1	334.5300	337.4009
Link27	51.7041	841845.5415	6.8586	254.7038	##	FA3	346.7060	348.2963
Link28	92.6815	1364172.992	9.7809	2078.5030	##	JA1B	346.6000	347.1170
Link29	38.8555	583128.3563	1.8702	2233.9258	##	FA2E	338.3300	342.4404
36inch	92.2616	1363002.742	13.0165	2386.5395	##	Node30	337.6500	343.0918
FREE # 1	271.4372	4717240.399	0.0000	0.0000	##			

```
*===================================================*
|     Table E15a - SPREADSHEET REACH LIST           |
| Peak flow and Total Flow listed by Reach or those |
|      conduits or diversions having the same       |
|      upstream and downstream nodes.               |
*===================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
FlowJA4	MH 64-85	95.3850	1931005.77
MH09-92JA1	Outfall	271.4369	4717207.22
OFlow	J-A4	29.6566	412685.336
OFlow	MH 64-85	22.0795	429087.169
J-A4	MH 64-85	29.6684	412633.525
MH 64-85	MH65-92JA2	147.1336	2772218.43
MH65-92JA2	MH09-92JA1	184.7004	3354740.22
FA3	OFlow	51.7041	841845.542
JA1B	Node30	92.6815	1364172.99
FA2E	MH65-92JA2	38.8555	583128.356
Node30	MH09-92JA1	92.2616	1363002.74

```
#########################################################
# Table E16. New Conduit Information Section            #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
P-A4	FlowJA4	MH 64-85	345.6800	341.6000	351.9083	344.9060	Circular
NewChannel	MH09-92JA1	Outfall	334.5300	332.4250	337.4009	335.2953	Trapezoid
OverQ	OFlow	J-A4	346.6400	345.6700	348.1034	347.1333	Circular
DougE	OFlow	MH 64-85	346.6400	341.6000	348.1034	344.9060	Circular
DougW	J-A4	MH 64-85	345.6700	341.6000	346.8947	344.9060	Circular
Ellen48	MH 64-85	MH65-92JA2	341.6000	338.3000	344.9060	342.4417	Circular
New48	MH65-92JA2	MH09-92JA1	338.0000	334.5300	342.4417	337.4009	Circular

Link27	FA3	OFlow	346.7060	346.6400	348.2963	348.1034	Trapezoid
Link28	JA1B	Node30	346.6000	337.6500	347.1170	343.0918	Trapezoid
Link29	FA2E	MH65-92JA2	338.3300	338.0000	342.4404	342.4417	Trapezoid
36inch	Node30	MH09-92JA1	337.6500	334.8300	343.0918	337.6817	Circular

Table E20 - Junction Flooding and Volume Listing. The maximum volume is the total volume in the node including the volume in the flooded storage area. This is the max volume at any time. The volume in the flooded storage area is the total volume above the ground elevation, where the flooded pond storage area starts. The fourth column is instantaneous, the fifth is the sum of the flooded volume over the entire simulation. Units are either ft^3 or m^3 depending on the units.

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
FlowJA4	94.8095	0.0000	0.0000	78.2647	0.0000
J-A4	0.0000	0.0000	0.0000	15.8924	0.0000
Outfall	0.0000	0.0000	0.0000	36.0676	0.0000
OFlow	0.0000	0.0000	0.0000	18.3895	0.0000
MH 64-85	0.0000	0.0000	0.0000	41.5427	0.0000
MH65-92JA2	8.5769	0.0000	0.0000	55.8144	0.0000
MH09-92JA1	0.0000	0.0000	0.0000	36.0753	0.0000
FA3	0.0000	0.0000	0.0000	19.9832	0.0000
JA1B	0.0000	0.0000	0.0000	6.4971	0.0000
FA2E	26.6167	0.0000	0.0000	51.6519	0.0000
Node30	10.8942	0.0000	0.0000	68.3821	0.0000

Simulation Specific Information

Number of Input Conduits..........	11	Number of Simulated Conduits......	12
Number of Natural Channels........	0	Number of Junctions...............	11
Number of Storage Junctions.......	0	Number of Weirs...................	0
Number of Orifices................	0	Number of Pumps...................	0
Number of Free Outfalls...........	1	Number of Tide Gate Outfalls......	0

Average % Change in Junction or Conduit is defined as:
Conduit % Change ==> 100.0 (Q(n+1) - Q(n)) / Qfull
Junction % Change ==> 100.0 (Y(n+1) - Y(n)) / Yfull

The Conduit with the largest average change was..FREE # 1 with 0.003 percent
The Junction with the largest average change was.Node30 with 0.063 percent
The Conduit with the largest sinuosity was.......36inch with 2.941

DOUGLAS EXISTING SYSTEM BUILDOUT FLOWS: SELECTED TABLES
Current Directory: C:\PROGRA~2\XPSOLU~1\XPSWMM~1
Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

Input File : MM\Douglas\ExistingSystem\Douglas_ExistingSystem_BuildoutFlows.XP

```
*==============================================*
|                   xpswmm                     |
|     Storm and Wastewater Management Model    |
|         Developed by XP Solutions Inc.       |
|==============================================|
|                                              |
| Last Update      : Jan., 2013                |
| Interface Version: 2012                      |
| Engine Version   : 12.0                      |
| Data File Version: 12.5                      |
|                                              |
|                                              |
*==============================================*
```

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

```
*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE                |
| Table E1   - Basic Conduit Data                         |
| Table E3a  - Junction Data                              |
| Table E4   - Conduit Connectivity Data                  |
| Table E9   - Junction  Summary  Statistics              |
| Table E10  - Conduit   Summary  Statistics              |
| Table E12  - Mean conduit information                   |
| Table E15  - Spreadsheet Info List                      |
| Table E15a - Spreadsheet Reach List                     |
| Table E16  - New Conduit Output Section                 |
| Table E20  - Junction Flooding and Volume List          |
*=========================================================*
Time Control from Hydraulics Job Control
Year.........    2014 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0


Control information for simulation
----------------------------------

Integration cycles.................      1440
Length of integration step is......     60.00 seconds
Simulation length..................     24.00 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.        -1 cycles
Intermediate printout intervals of.     -1.00 minutes
Summary printout intervals of......        -1 cycles
Summary printout time interval of..     -1.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         0
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     12.57 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............   5000.00
Ponding Area Exponent...............    1.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....     4
     or user defined hydrographs....

*==================================================*
|          Table E1 - Conduit Data                 |
*==================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	OC-A4	150.0000	Trapezoid	7.6400	0.0350	2.2000	2.0000	0.7800	0.8400
2	42inch	191.3600	Circular	9.6211	0.0120	3.5000	3.5000		
3	21inOverQ	44.1600	Circular	3.1416	0.0130	2.0000	2.0000		
4	21inch	161.7000	Circular	2.4053	0.0130	1.7500	1.7500		
5	24inch	172.1500	Circular	3.1416	0.0130	2.0000	2.0000		
6	Ellendal36	228.0000	Circular	7.0686	0.0130	3.0000	3.0000		
7	42in.	312.1000	Circular	9.6211	0.0130	3.5000	3.5000		
8	Link27	33.0000	Trapezoid	12.0000	0.0140	2.0000	2.0000	2.0000	2.0000
9	Link28	50.0000	Trapezoid	150.0000	0.0140	5.0000	5.0000	5.0000	5.0000
10	Link29	33.0000	Trapezoid	36.0000	0.0140	3.0000	3.0000	3.0000	3.0000
11	36inch	340.0000	Circular	7.0686	0.0120	3.0000	3.0000		

Total length of all conduits ....   1715.4700 feet

```
*===================================================*
|           Table E3a - Junction Data               |
*===================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	FlowJA4	351.6000	347.6800	345.6800	0.0000	0.0000	100.0000
2	J-A4	349.3400	347.6700	345.6300	0.0000	0.0000	100.0000
3	Outfall	337.2000	335.9250	332.4250	0.0000	0.0000	100.0000
4	Overflow	351.6400	348.6400	346.6400	0.0000	0.0000	100.0000
5	MH 64-85	347.7900	344.6000	341.6000	0.0000	0.0000	100.0000
6	MH65-92JA2	347.2500	341.5000	338.0000	0.0000	0.0000	100.0000
7	MH09-92JA1	340.0000	338.0300	334.5300	0.0000	0.0000	100.0000
8	FA3	351.7060	348.7060	346.7060	0.0000	0.0000	100.0000
9	JA1B	351.6000	351.6000	346.6000	0.0000	0.0000	100.0000
10	FA2E	375.0000	341.3300	338.3300	0.0000	0.0000	100.0000
11	MH09-81	345.1000	342.6500	337.6500	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	OC-A4	FlowJA4	J-A4	345.6800	345.6300	No Design
2	42inch	MH09-92JA1	Outfall	334.5300	332.4250	No Design
3	21inOverQ	Overflow	J-A4	346.6400	345.6700	No Design
4	21inch	Overflow	MH 64-85	346.6400	341.6000	No Design
5	24inch	J-A4	MH 64-85	345.6700	341.6000	No Design
6	Ellendal36	MH 64-85	MH65-92JA2	341.6000	338.3000	No Design
7	42in.	MH65-92JA2	MH09-92JA1	338.0000	334.5300	No Design
8	Link27	FA3	Overflow	346.7060	346.6400	No Design
9	Link28	JA1B	MH09-81	346.6000	337.6500	No Design
10	Link29	FA2E	MH65-92JA2	338.3300	338.0000	No Design
11	36inch	MH09-81	MH09-92JA1	337.6500	334.8300	No Design

Conduit Convergence Criteria

Conduit Name	Full Flow	Conduit Slope
OC-A4	6.0778	0.0003
42inch	114.3149	0.0110
21inOverQ	33.5282	0.0220
21inch	27.9739	0.0312
24inch	34.7842	0.0236
Ellendal36	80.2426	0.0145
42in.	106.0860	0.0111
Link27	60.5689	0.0020
Link28	12993.5578	0.1790
Link29	531.0392	0.0100
36inch	65.8056	0.0083

Table E9 - JUNCTION SUMMARY STATISTICS

The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
FlowJA4	351.6000	347.6800	350.0730	8	10	2.3930	1.5270	12.5660	0.0000	0.0000	0.0000
J-A4	349.3400	347.6700	349.3400	7	46	1.6700	0.0000	12.5660	0.0000	0.0000	0.0000
Outfall	337.2000	335.9250	335.9250	7	40	0.0000	1.2750	12.5660	0.0000	0.0000	0.0000
Overflow	351.6400	348.6400	349.8491	8	10	1.2091	1.7909	12.5660	0.0000	0.0000	0.0000
MH 64-85	347.7900	344.6000	345.1499	8	6	0.5499	2.6401	12.5660	0.0000	0.0000	0.0000
MH65-92JA2	347.2500	341.5000	343.1871	8	6	1.6871	4.0629	12.5660	0.0000	0.0000	0.0000
MH09-92JA1	340.0000	338.0300	340.0000	7	48	1.9700	0.0000	12.5660	0.0000	0.0000	0.0000
FA3	351.7060	348.7060	349.8512	8	10	1.1452	1.8548	12.5660	0.0000	0.0000	0.0000
JA1B	351.6000	351.6000	347.1170	8	1	0.0000	4.4830	12.5660	0.0000	0.0000	0.0000
FA2E	375.0000	341.3300	343.1865	8	6	1.8565	31.8135	12.5660	0.0000	0.0000	0.0000
MH09-81	345.1000	342.6500	345.1000	7	58	2.4500	0.0000	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS

Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
OC-A4	6.0778	0.7955	52.7155	95.3831	8	10	3.8622	8	10	15.6936	350.0730	349.3400	1.000	0.845	*
42inch	114.3149	11.8816	42.0000	159.4514	7	54	16.5198	7	54	1.3948	340.0000	335.9250	1.563	1.000	
21inOverQ	33.5282	10.6724	24.0000	24.4147	8	10	7.7405	8	10	0.7282	349.8491	349.3400	1.605	1.835	
21inch	27.9739	11.6302	21.0000	29.3981	9	3	12.1812	9	3	1.0509	349.8491	345.1499	1.834	2.029	
24inch	34.7842	11.0722	24.0000	41.0155	9	19	12.9434	9	19	1.1791	349.3400	345.1499	1.835	1.775	
Ellendal36	80.2426	11.3520	36.0000	70.4127	9	3	12.7965	9	5	0.8775	345.1499	343.1871	1.183	1.629	
42in.	106.0860	11.0264	42.0000	101.9935	8	6	11.6187	9	23	0.9614	343.1871	340.0000	1.482	1.563	
Link27	60.5689	5.0474	38.5092	51.7154	8	11	5.2178	7	32	0.8538	349.8512	349.8491	0.980	1.000	*
Link28	12993.56	86.6237	89.4000	92.6811	8	1	9.1219	7	37	0.0071	347.1170	345.1000	0.069	1.000	*
Link29	531.0392	14.7511	62.2451	39.5125	8	5	1.8280	2	33	0.0744	343.1865	343.1871	0.936	1.000	*
36inch	65.8056	9.3096	36.0000	89.1667	8	5	12.5025	8	5	1.3550	345.1000	340.0000	2.483	1.723	
FREE # 1	Undefnd	Undefnd	Undefn	159.5472	8	19									

| Table E12. Mean Conduit Flow Information |

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
OC-A4	22.3500	1931036.7	0.0006	0.9929	0.3753	1.1363	10.1942	0.0350
42inch	51.6459	4462206.3	0.0017	0.9954	1.5472	0.8188	5.1687	0.0120
21inOverQ	2.5962	224314.57	0.0005	0.9940	0.9410	0.3538	1.2646	0.0130
21inch	7.1458	617399.72	0.0004	0.9940	1.7152	0.3345	1.0282	0.0130
24inch	22.4735	1941708.5	0.0005	0.9932	1.7360	0.5175	2.1926	0.0130
Ellendal36	29.6144	2558687.7	0.0007	0.9939	1.5262	0.6691	3.4315	0.0130
42in.	36.3481	3140473.0	0.0009	0.9939	1.3297	0.7641	4.5498	0.0130
Link27	9.7434	841827.16	0.0005	0.9940	0.8451	0.6018	5.3973	0.0140
Link28	15.7894	1364199.9	0.0011	0.9955	2.7618	0.2569	4.7028	0.0140
Link29	6.7448	582751.52	0.0009	0.9927	0.1632	0.9021	15.7170	0.0140
36inch	15.7723	1362725.7	0.0008	0.9955	1.1916	0.5770	2.7448	0.0120
FREE # 1	51.6473	4462323.0						

Table E15 - SPREADSHEET INFO LIST
Conduit Flow and Junction Depth Information for use in spreadsheets. The maximum values in this table are the true maximum values because they sample every time step. The values in the review results may only be the maximum of a subset of all the time steps in the run. Note: These flows are only the flows in a single barrel.

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
OC-A4	95.3831	1931036.684	3.8622	3335.3937	##	FlowJA4	345.6800	350.0730
42inch	159.4514	4462206.297	16.5198	1885.3613	##	J-A4	345.6300	349.3400
21inOverQ	24.4147	224314.5670	7.7405	139.4702	##	Outfall	332.4250	335.9250
21inch	29.3981	617399.7240	12.1812	275.5945	##	Overflow	346.6400	349.8491
24inch	41.0155	1941708.480	12.9434	474.0092	##	MH 64-85	341.6000	345.1499
Ellendal36	70.4127	2558687.708	12.7965	1634.8573	##	MH65-92JA2	338.0000	343.1871
42in.	101.9935	3140472.993	11.6187	3052.5998	##	MH09-92JA1	334.5300	340.0000
Link27	51.7154	841827.1623	5.2178	875.6041	##	FA3	346.7060	349.8512
Link28	92.6811	1364199.864	9.1219	4908.6527	##	JA1B	346.6000	347.1170
Link29	39.5125	582751.5247	1.8280	2994.6531	##	FA2E	338.3300	343.1865
36inch	89.1667	1362725.690	12.5025	2435.5746	##	MH09-81	337.6500	345.1000
FREE # 1	159.5472	4462322.982	0.0000	0.0000	##			

Table E15a - SPREADSHEET REACH LIST
Peak flow and Total Flow listed by Reach or those conduits or diversions having the same upstream and downstream nodes.

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
FlowJA4	J-A4	95.3831	1931036.68
MH09-92JA1	Outfall	159.4514	4462206.30
Overflow	J-A4	24.4147	224314.567
Overflow	MH 64-85	29.3981	617399.724
J-A4	MH 64-85	41.0155	1941708.48
MH 64-85	MH65-92JA2	70.4127	2558687.71
MH65-92JA2	MH09-92JA1	101.9935	3140472.99
FA3	Overflow	51.7154	841827.162
JA1B	MH09-81	92.6811	1364199.86
FA2E	MH65-92JA2	39.5125	582751.525
MH09-81	MH09-92JA1	89.1667	1362725.69

###

```
# Table E16. New Conduit Information Section          #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
OC-A4	FlowJA4	J-A4	345.6800	345.6300	350.0730	349.3400	Trapezoid
42inch	MH09-92JA1	Outfall	334.5300	332.4250	340.0000	335.9250	Circular
21inOverQ	Overflow	J-A4	346.6400	345.6700	349.8491	349.3400	Circular
21inch	Overflow	MH 64-85	346.6400	341.6000	349.8491	345.1499	Circular
24inch	J-A4	MH 64-85	345.6700	341.6000	349.3400	345.1499	Circular
Ellendal36	MH 64-85	MH65-92JA2	341.6000	338.3000	345.1499	343.1871	Circular
42in.	MH65-92JA2	MH09-92JA1	338.0000	334.5300	343.1871	340.0000	Circular
Link27	FA3	Overflow	346.7060	346.6400	349.8512	349.8491	Trapezoid
Link28	JA1B	MH09-81	346.6000	337.6500	347.1170	345.1000	Trapezoid
Link29	FA2E	MH65-92JA2	338.3300	338.0000	343.1865	343.1871	Trapezoid
36inch	MH09-81	MH09-92JA1	337.6500	334.8300	345.1000	340.0000	Circular

```
*=====================================================*
| Table E20 - Junction Flooding and Volume Listing.   |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max    |
|             volume at any time. The volume in the    |
|             flooded storage area is the total volume|
|             above the ground elevation, where the    |
|             flooded pond storage area starts.        |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*=====================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
FlowJA4	852.9916	0.0000	0.0000	55.2024	0.0000
J-A4	168.7889	93.5201	213253.5667	46.6199	0.0000
Outfall	0.0000	0.0000	0.0000	43.9810	0.0000
Overflow	106.3750	0.0000	0.0000	40.3257	0.0000
MH 64-85	34.0026	0.0000	0.0000	44.6082	0.0000
MH65-92JA2	47.0030	0.0000	0.0000	65.1812	0.0000
MH09-92JA1	78.6471	31.4331	40565.3076	68.7360	0.0000
FA3	105.5764	0.0000	0.0000	39.5228	0.0000
JA1B	0.0000	0.0000	0.0000	6.4970	0.0000
FA2E	49.1217	0.0000	0.0000	61.0266	0.0000
MH09-81	33.4303	6.8000	1085.0393	93.6167	0.0000

```
*=============================================================*
|             SWMM Simulation Date and Time Summary            |
*=============================================================*
| Starting Date... October    23, 2014  Time...   10:44:38:26  |
|   Ending Date... October    23, 2014  Time...   10:44:42:58  |
|  Elapsed Time...    0.07200 minutes or      4.32000 seconds  |
*=============================================================*
```

ELLENDALE DESIGN ALTERNATIVE 4 BUILDOUT FLOWS: SELECTED TABLES
Current Directory: C:\PROGRA~2\XPSOLU~1\XPSWMM~1
Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

Input File : 41stormwater\Hydrology\SWMM\Ellendale_DesignAlt4_BuildoutFlows.XP

```
*==============================================*
|                    xpswmm                    |
|     Storm and Wastewater Management Model    |
|         Developed by XP Solutions Inc.       |
|==============================================|
|                                              |
| Last Update      : Jan., 2013                |
| Interface Version: 2012                      |
| Engine Version   : 12.0                      |
| Data File Version: 12.5                      |
|                                              |
|                                              |
*==============================================*
```

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

```
*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE          |
| Table E1   - Basic Conduit Data                          |
| Table E3a  - Junction Data                               |
| Table E3b  - Junction Data                               |
| Table E4   - Conduit Connectivity Data                   |
| Table E9   - Junction  Summary  Statistics               |
| Table E10  - Conduit   Summary  Statistics               |
| Table E12  - Mean conduit information                    |
| Table E15  - Spreadsheet Info List                       |
| Table E15a - Spreadsheet Reach List                      |
| Table E16  - New Conduit Output Section                  |
| Table E20  - Junction Flooding and Volume List           |
*=========================================================*
```

Time Control from Hydraulics Job Control

```
Year.........    2014 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0
```

Control information for simulation

```
Integration cycles.................      2879
Length of integration step is......     60.00 seconds
Simulation length..................     47.98 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.       500 cycles
Intermediate printout intervals of.    500.00 minutes
Summary printout intervals of......       500 cycles
Summary printout time interval of..    500.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         0
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     12.57 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............   5000.00
Ponding Area Exponent...............    1.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....     2
     or user defined hydrographs....
```

```
*================================================*
|          Table E1 - Conduit Data               |
*================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	Culvert	70.0000	Rectangle	30.0000	0.0150	6.0000	5.0000		
2	Pipe	70.0000	Circular	7.0686	0.0180	3.0000	3.0000		
3	Link7	33.0000	Trapezoid	18.0000	0.0140	3.0000	3.0000	1.0000	1.0000
4	Link8	33.0000	Trapezoid	50.0000	0.0140	5.0000	5.0000	1.0000	1.0000
5	Link11	1600.0000	Trapezoid	90.0819	0.0300	3.5000	6.6702	1.5000	1.5000

Total length of all conduits ....   1806.0000 feet

```
*==================================================*
|           Table E3a - Junction Data              |
*==================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	JC2Culvert	363.8500	361.7000	356.7000	0.0000	0.0000	100.0000
2	JC1Pipe	363.8500	360.0000	357.0000	0.0000	0.0000	100.0000

3	TopChannel	363.8500	362.8502	356.1800	0.0000	0.0000	100.0000
4	Outfall	361.0000	358.9202	352.2500	0.0000	0.0000	100.0000
5	Node9	363.8500	360.2400	357.0000	0.0000	0.0000	100.0000
6	Node10	363.8500	361.9400	356.9400	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	Culvert	JC2Culvert	TopChannel	356.7000	356.2000	No Design
2	Pipe	JC1Pipe	TopChannel	357.0000	356.4900	No Design
3	Link7	Node9	JC1Pipe	357.2400	357.0000	No Design
4	Link8	Node10	JC2Culvert	356.9400	356.7000	No Design
5	Link11	TopChannel	Outfall	356.1800	352.2500	Design

FREE OUTFALL DATA (DATA GROUP I1)
BOUNDARY CONDITION ON DATA GROUP J1

Outfall at Junction....Outfall has boundary condition number... 1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
FREE # 1	Outfall	BOUNDARY

Boundary Condition Information
Data Groups J1-J4

BC NUMBER.. 1 has no control water surface.

Conduit Convergence Criteria

Conduit Name	Full Flow	Conduit Slope
Culvert	308.8758	0.0071
Pipe	41.1171	0.0073
Link7	219.8362	0.0073
Link8	858.4121	0.0073
Link11	487.1765	0.0025

Table E9 - JUNCTION SUMMARY STATISTICS
The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
JC2Culvert	363.8500	361.7000	363.7731	8	41	2.0731	0.0769	12.5660	0.0000	0.0000	0.0000
JC1Pipe	363.8500	360.0000	363.2911	8	16	3.2911	0.5589	12.5660	0.0000	0.0000	0.0000
TopChannel	363.8500	362.8502	362.7573	8	41	0.0000	1.0927	12.5660	0.0000	0.0000	0.0000
Outfall	361.0000	358.9202	358.8252	8	41	0.0000	2.1748	12.5660	0.0000	0.0000	0.0000
Node9	363.8500	360.2400	363.2897	8	16	3.0497	0.5603	12.5660	0.0000	0.0000	0.0000
Node10	363.8500	361.9400	363.7450	8	41	1.8050	0.1050	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS
Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
Culvert	308.8758	10.2959	60.0000	441.1953	8	43	14.6768	8	43	1.4284	363.7731	362.7573	1.415	1.311	
Pipe	41.1171	5.8169	36.0000	56.6450	8	9	7.9607	8	9	1.3777	363.2911	362.7573	2.097	2.089	
Link7	219.8362	12.2131	75.4938	56.9192	8	9	2.3082	4	10	0.2589	363.2897	363.2911	0.962	1.000	
Link8	858.4121	17.1682	84.8770	441.1885	8	43	5.6027	7	47	0.5140	363.7450	363.7731	0.962	1.000	*
Link11	487.1765	5.4082	80.0418	471.5473	8	41	5.3645	8	42	0.9679	362.7573	358.8252	0.986	0.986	
FREE # 1	Undefnd	Undefnd	Undefn	471.5471	8	41									

Table E12. Mean Conduit Flow Information

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
Culvert	61.8178	10678404.	0.0017	0.9771	0.6170	1.3439	18.2827	0.0150

Pipe	5.2179	901336.65	0.0002	0.9511	0.1940	0.7116	5.8245	0.0180
Link7	5.2185	901449.32	0.0004	0.9638	0.1108	1.3622	16.7053	0.0140
Link8	61.8183	10678500.	0.0017	0.9662	0.5409	1.6798	25.4981	0.0140
Link11	67.0629	11584440.	0.0017	0.9967	0.3625	1.8770	34.1650	0.0300
FREE # 1	67.0644	11584711.						

```
*=======================================================*
|     Table E15 - SPREADSHEET INFO LIST                 |
| Conduit Flow and Junction Depth Information for use in |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the      |
| maximum of a subset of all the time steps in the run.  |
| Note: These flows are only the flows in a single barrel.|
*=======================================================*
```

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
Culvert	441.1953	10678404.24	14.6768	2106.1358	##	JC2Culvert	356.7000	363.7731
Pipe	56.6450	901336.6502	7.9607	517.7280	##	JC1Pipe	357.0000	363.2911
Link7	56.9192	901449.3247	2.3082	1867.4412	##	TopChannel	356.1800	362.7573
Link8	441.1885	10678500.14	5.6027	2734.0471	##	Outfall	352.2500	358.8252
Link11	471.5473	11584439.54	5.3645	140614.5865	##	Node9	357.0000	363.2897
FREE # 1	471.5471	11584710.74	0.0000	0.0000	##	Node10	356.9400	363.7450

```
*==================================================*
|     Table E15a - SPREADSHEET REACH LIST          |
| Peak flow and Total Flow listed by Reach or those |
|      conduits or diversions having the same       |
|      upstream and downstream nodes.               |
*==================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
JC2Culvert	TopChannel	441.1953	10678404.2
JC1Pipe	TopChannel	56.6450	901336.650
Node9	JC1Pipe	56.9192	901449.325
Node10	JC2Culvert	441.1885	10678500.1
TopChannel	Outfall	471.5473	11584439.5

```
#########################################################
# Table E16. New Conduit Information Section            #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
Culvert	JC2Culvert	TopChannel	356.7000	356.2000	363.7731	362.7573	Rectangle
Pipe	JC1Pipe	TopChannel	357.0000	356.4900	363.2911	362.7573	Circular
Link7	Node9	JC1Pipe	357.2400	357.0000	363.2897	363.2911	Trapezoid
Link8	Node10	JC2Culvert	356.9400	356.7000	363.7450	363.7731	Trapezoid
Link11	TopChannel	Outfall	356.1800	352.2500	362.7573	358.8252	Trapezoid

```
*====================================================*
| Table E20 - Junction Flooding and Volume Listing.  |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max   |
|             volume at any time. The volume in the   |
|             flooded storage area is the total volume|
|             above the ground elevation, where the   |
|             flooded pond storage area starts.       |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*====================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
JC2Culvert	127.4138	0.0000	0.0000	88.8806	0.0000
JC1Pipe	568.8800	0.0000	0.0000	79.0544	0.0000
TopChannel	0.0000	0.0000	0.0000	82.6500	0.0000

Outfall	0.0000	0.0000	0.0000	82.6240	0.0000
Node9	369.4231	0.0000	0.0000	79.0363	0.0000
Node10	111.3448	0.0000	0.0000	85.5119	0.0000

```
*===================================*
| Simulation Specific Information  |
*===================================*
Number of Input Conduits..........         5 Number of Simulated Conduits......         6
Number of Natural Channels........         0 Number of Junctions...............         6
Number of Storage Junctions.......         0 Number of Weirs...................         0
Number of Orifices................         0 Number of Pumps...................         0
Number of Free Outfalls...........         1 Number of Tide Gate Outfalls......         0

*==========================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*==========================================================*

The Conduit with the largest average change was..FREE # 1   with     0.002 percent
The Junction with the largest average change was.TopChannel with     0.027 percent
The Conduit with the largest sinuosity was.......Pipe       with     3.140
```

ELLENDALE EXISTING SYSTEM BUILDOUT FLOWS: SELECTED TABLES
Current Directory: C:\PROGRA~2\XPSOLU~1\XPSWMM~1
Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

Input File : ormwater\Hydrology\SWMM\Ellendale_ExistingSystem_BuildoutFlows.XP

```
*=============================================*
|                  xpswmm                     |
|     Storm and Wastewater Management Model   |
|         Developed by XP Solutions Inc.      |
|=============================================|
|                                             |
| Last Update      : Jan., 2013               |
| Interface Version: 2012                     |
| Engine Version   : 12.0                     |
| Data File Version: 12.5                     |
|                                             |
|                                             |
*=============================================*
```

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

```
*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE                |
| Table E1   - Basic Conduit Data                          |
| Table E3a  - Junction Data                               |
| Table E4   - Conduit Connectivity Data                   |
| Table E9   - Junction  Summary  Statistics               |
| Table E10  - Conduit   Summary  Statistics               |
| Table E12  - Mean conduit information                    |
| Table E15  - Spreadsheet Info List                       |
| Table E15a - Spreadsheet Reach List                      |
| Table E16  - New Conduit Output Section                  |
| Table E20  - Junction Flooding and Volume List           |
*=========================================================*
```

Time Control from Hydraulics Job Control
Year......... 2014 Month....... 1
Day.......... 1 Hour........ 0
Minute....... 0 Second...... 0

Control information for simulation

```
Integration cycles.................      2879
Length of integration step is......     60.00 seconds
Simulation length..................     47.98 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.       500 cycles
Intermediate printout intervals of.    500.00 minutes
Summary printout intervals of......       500 cycles
Summary printout time interval of..    500.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         0
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     12.57 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............   5000.00
Ponding Area Exponent...............    1.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....     3
     or user defined hydrographs....
```

```
*==================================================*
|          Table E1 - Conduit Data                 |
*==================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	Culvert	70.0000	Circular	19.6350	0.0150	5.0000	5.0000		
2	TrapChan	75.0000	Trapezoid	28.0800	0.0350	8.2000	2.6000	1.0000	1.0000
3	Pipe	70.0000	Circular	7.0686	0.0180	3.0000	3.0000		
4	Link5	1080.0000	Trapezoid	48.8000	0.0350	8.2000	4.0000	1.0000	1.0000
5	Link6	40.0000	Trapezoid	25.7280	0.0350	8.2000	2.4000	0.7600	1.3400
6	Link7	33.0000	Trapezoid	18.0000	0.0140	3.0000	3.0000	1.0000	1.0000
7	Link8	33.0000	Trapezoid	50.0000	0.0140	5.0000	5.0000	1.0000	1.0000

Total length of all conduits .... 1401.0000 feet

```
*==================================================*
|           Table E3a - Junction Data              |
*==================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	JC2Culvert	365.0000	361.7000	356.7000	0.0000	0.0000	100.0000
2	JC1Pipe	365.0000	360.0000	357.0000	0.0000	0.0000	100.0000

3	TopChannel	365.0000	361.1800	356.1800	0.0000	0.0000	100.0000
4	ToOverflow	359.5000	359.0000	355.0000	0.0000	0.0000	100.0000
5	Outfall	356.6000	351.6000	347.6000	0.0000	0.0000	100.0000
6	Node8	359.5000	359.4900	356.8900	0.0000	0.0000	100.0000
7	Node9	365.0000	360.2400	357.0000	0.0000	0.0000	100.0000
8	Node10	365.0000	361.9400	356.9400	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	Culvert	JC2Culvert	TopChannel	356.7000	356.1800	No Design
2	TrapChan	Node8	ToOverflow	356.8900	355.0000	No Design
3	Pipe	JC1Pipe	TopChannel	357.0000	356.4900	No Design
4	Link5	ToOverflow	Outfall	355.0000	347.6000	No Design
5	Link6	Node8	TopChannel	356.8900	356.5900	No Design
6	Link7	Node9	JC1Pipe	357.2400	357.0000	No Design
7	Link8	Node10	JC2Culvert	356.9400	356.7000	No Design

FREE OUTFALL DATA (DATA GROUP I1)
BOUNDARY CONDITION ON DATA GROUP J1

Outfall at Junction....Outfall has boundary condition number... 1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
FREE # 1	Outfall	BOUNDARY

Boundary Condition Information
Data Groups J1-J4

BC NUMBER.. 1 has no control water surface.

Table E9 - JUNCTION SUMMARY STATISTICS

The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
JC2Culvert	365.0000	361.7000	363.8635	8	43	2.1635	1.1365	12.5660	0.0000	0.0000	0.0000
JC1Pipe	365.0000	360.0000	361.8443	8	13	1.8443	3.1557	12.5660	0.0000	0.0000	0.0000
TopChannel	365.0000	361.1800	361.2044	8	40	0.0244	3.7956	12.5660	0.0000	0.0000	0.0000
ToOverflow	359.5000	359.0000	360.0759	8	40	1.0759	0.0000	8893.3466	0.0000	0.0000	0.0000
Outfall	356.6000	351.6000	352.6759	8	40	1.0759	3.9241	12.5660	0.0000	0.0000	0.0000
Node8	359.5000	359.4900	360.7762	8	41	1.2862	0.0000	17914.852	0.0000	0.0000	0.0000
Node9	365.0000	360.2400	361.8402	8	13	1.6002	3.1598	12.5660	0.0000	0.0000	0.0000
Node10	365.0000	361.9400	363.8366	8	43	1.8966	1.1634	12.5660	0.0000	0.0000	0.0000

Table E10 - CONDUIT SUMMARY STATISTICS

Note: The peak flow may be less than the design flow and the conduit may still surcharge because of the downstream boundary conditions.

* denotes an open conduit that has been overtopped this is a potential source of severe errors

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
Culvert	194.5435	9.9080	60.0000	441.1884	8	43	22.4089	8	43	2.2678	363.8635	361.2044	1.433	1.005	
TrapChan	280.5992	9.9929	60.9093	471.5524	8	41	9.6216	8	42	1.6805	360.7762	360.0759	0.766	1.000	*
Pipe	41.1171	5.8169	36.0000	56.9134	8	9	8.0220	8	9	1.3842	361.8443	361.2044	1.615	1.571	
Link5	315.9812	6.4750	60.9104	491.2295	8	41	7.2899	8	41	1.5546	360.0759	352.6759	1.000	1.000	*
Link6	134.1972	5.2160	55.3715	-471.777	8	40	-8.0053	8	38	-3.5155	361.2044	360.7762	0.935	0.907	
Link7	219.8362	12.2131	58.1319	57.0696	8	9	2.1153	4	10	0.2596	361.8402	361.8443	0.950	1.000	
Link8	858.4121	17.1682	85.9619	441.1842	8	43	7.0776	9	55	0.5140	363.8366	363.8635	0.963	1.000	
FREE # 1	Undefnd	Undefnd	Undefn	491.2294	8	41									

Table E12. Mean Conduit Flow Information

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
Culvert	61.8188	10678572.	0.0015	0.9970	1.0010	1.1542	10.5645	0.0150
TrapChan	67.0362	11579838.	0.0014	0.9742	0.8395	1.2474	18.0624	0.0350
Pipe	5.2189	901511.36	0.0002	0.9072	0.2376	0.7130	4.5333	0.0180
Link5	70.3846	12158238.	0.0019	0.9970	0.5757	1.5772	25.8506	0.0350

Link6	-67.0368	-1.16E+07	0.0017	0.9742	0.5924	1.5155	24.2778	0.0350
Link7	5.2192	901571.28	0.0003	0.9172	0.1567	0.9880	9.3767	0.0140
Link8	61.8186	10678547.	0.0014	0.9235	0.5852	1.4762	20.8577	0.0140
FREE # 1	70.3853	12158357.						

```
*=======================================================*
|     Table E15 - SPREADSHEET INFO LIST                 |
| Conduit Flow and Junction Depth Information for use in  |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the        |
| maximum of a subset of all the time steps in the run.   |
| Note: These flows are only the flows in a single barrel.|
*=======================================================*
```

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
Culvert	441.1884	10678571.91	22.4089	1391.3459	##	JC2Culvert	356.7000	363.8635
TrapChan	471.5524	11579837.73	9.6216	4265.3636	##	JC1Pipe	357.0000	361.8443
Pipe	56.9134	901511.3600	8.0220	518.3887	##	TopChannel	356.1800	361.2044
Link5	491.2295	12158237.97	7.2899	49920.0594	##	ToOverflow	355.0000	360.0759
Link6	471.7766	11579941.66	8.0053	2153.5416	##	Outfall	347.6000	352.6759
Link7	57.0696	901571.2770	2.1153	1203.3297	##	Node8	356.8900	360.7762
Link8	441.1842	10678547.17	7.0776	2791.0428	##	Node9	357.0000	361.8402
FREE # 1	491.2294	12158356.96	0.0000	0.0000	##	Node10	356.9400	363.8366

```
*==================================================*
|     Table E15a - SPREADSHEET REACH LIST          |
| Peak flow and Total Flow listed by Reach or those  |
|      conduits or diversions having the same       |
|      upstream and downstream nodes.               |
*==================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
JC2Culvert	TopChannel	441.1884	10678571.9
Node8	ToOverflow	471.5524	11579837.7
JC1Pipe	TopChannel	56.9134	901511.360
ToOverflow	Outfall	491.2295	12158238.0
Node8	TopChannel	471.7766	11579941.7
Node9	JC1Pipe	57.0696	901571.277
Node10	JC2Culvert	441.1842	10678547.2

```
#########################################################
# Table E16. New Conduit Information Section            #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
Culvert	JC2Culvert	TopChannel	356.7000	356.1800	363.8635	361.2044	Circular
TrapChan	Node8	ToOverflow	356.8900	355.0000	360.7762	360.0759	Trapezoid
Pipe	JC1Pipe	TopChannel	357.0000	356.4900	361.8443	361.2044	Circular
Link5	ToOverflow	Outfall	355.0000	347.6000	360.0759	352.6759	Trapezoid
Link6	Node8	TopChannel	356.8900	356.5900	360.7762	361.2044	Trapezoid
Link7	Node9	JC1Pipe	357.2400	357.0000	361.8402	361.8443	Trapezoid
Link8	Node10	JC2Culvert	356.9400	356.7000	363.8366	363.8635	Trapezoid

```
*===================================================*
| Table E20 - Junction Flooding and Volume Listing.   |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max   |
|             volume at any time. The volume in the   |
|             flooded storage area is the total volume|
|             above the ground elevation, where the   |
|             flooded pond storage area starts.       |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*===================================================*
```

Junction	Surcharged	Flooded	Out of 1D-System (Flooded	Maximum	Passed to 2D cell OR Volume Stored in allowed Flood

Name	Time (min)	Time(min)	Volume)	Volume	Pond of 1D-System
JC2Culvert	94.1935	0.0000	0.0000	90.0164	0.0000
JC1Pipe	151.5540	0.0000	0.0000	60.8733	0.0000
TopChannel	16.0009	0.0000	0.0000	63.1363	0.0000
ToOverflow	110.7774	75.0968	0.0000	3949.8936	10882.6726
Outfall	110.5774	0.0000	0.0000	63.7833	0.0000
Node8	152.8425	151.8345	0.0000	12947.6493	15279.8395
Node9	126.5606	0.0000	0.0000	60.8222	0.0000
Node10	81.3871	0.0000	0.0000	86.6633	0.0000

```
*===================================*
| Simulation Specific Information  |
*===================================*
Number of Input Conduits..........         7 Number of Simulated Conduits......         8
Number of Natural Channels........         0 Number of Junctions...............         8
Number of Storage Junctions.......         0 Number of Weirs...................         0
Number of Orifices................         0 Number of Pumps...................         0
Number of Free Outfalls...........         1 Number of Tide Gate Outfalls......         0

*=========================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*=========================================================*

The Conduit with the largest average change was..FREE # 1   with     0.002 percent
The Junction with the largest average change was.JC2Culvert with     0.031 percent
The Conduit with the largest sinuosity was.......Link6      with     7.048
```

```
UPGLOW/ORCHARD EXISTING FAIRHAVEN VERSION 2 100-YEAR 24-HOUR: SELECTED TABLES
Current Directory:   \\rosa\groups\NWW\Ruark\Dallas\XPSWMM
 Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE


 Input File : \\rosa\groups\NWW\Ruark\Dallas\XPSWMM\Fairhaven_v2_100yr24hr.XP

          *================================================*
          |                    xpswmm                      |
          |      Storm and Wastewater Management Model     |
          |          Developed by XP Solutions Inc.        |
          |================================================|
          |                                                |
          | Last Update      : Jan., 2013                  |
          | Interface Version: 2012                        |
          | Engine Version   : 12.0                        |
          | Data File Version: 12.5                        |
          |                                                |
          |                                                |
          *================================================*

 ######################################################
 #    Entry made to the Runoff Layer(Block) of SWMM    #
 #    Last Updated Jan., 2013 by XP Solutions          #

 *=========================================================*
 |         SELECTED RUNOFF TABLES IN THE OUTPUT FILE.                |
 |  These are the more important tables in the output file. |
 |  You can use your editor to find the table numbers,       |
 |  for example: search for Table R3 to check continuity.    |
 |  This output file can be imported into a Word Processor   |
 |  and printed on US letter or A4 paper using portrait      |
 |  mode, courier font, a size of 8 pt. and margins of 0.75 |
 |                                                           |
 | Table R1  - Physical Hydrology Data                       |
 | Table R2  - Infiltration data                             |
 | Table R3  - Raingage and Infiltration Database Names     |
 *=========================================================*

                    A1

###########################################
#             RUNOFF JOB CONTROL          #
###########################################

 Snowmelt parameter - ISNOW......................           0
 Number of rain gages - NRGAG....................           1
 Quality is not simulated - KWALTY...............           0
 Default evaporation rate used - IVAP............           0
 Hour of day at start of storm - NHR.............           0
 Minute of hour at start of storm - NMN..........           0
 Time TZERO at start of storm (hours)............       0.000
 Use U.S. Customary units for most I/O - METRIC...          0
 Runoff input print control...                              0
 Runoff graph plot control....                              0
 Runoff output print control..                              0
 Limit number of groundwater convergence messages to    10000

 Print headers every 50 lines - NOHEAD (0=yes, 1=no)        0

 Print land use load percentages -LANDUPR (0=no, 1=yes)     0
 Month, day, year of start of storm is:             1/ 1/1993
 Wet time step length (seconds).......                  300.0
 Dry time step length (seconds).......                86400.0
 Wet/Dry time step length (seconds)...                  300.0
 Simulation length is......                              24.0 Hours

 If Horton infiltration model is being used
 A mixture of infiltration options may be used in
 XP-SWMM2000 as a watershed specific option.
 Rate for regeneration of infiltration = REGEN * DECAY
 Decay is read in for each subcatchment
 REGEN = ............................................  0.01000


 Raingage #...............................          1
 KTYPE  - Rainfall input type.............          0
 NHISTO - Total number of rainfall values..       240
 KINC   - Rainfall values(pairs) per line..        10
 KPRINT - Print rainfall(0-Yes,1-No).......         0
 KTIME  - Precipitation time units
 0 --> Minutes  1 --> Hours...............          1
 KPREP  - Precipitation unit type
 0 --> Intensity  1 --> Volume............          1
 KTHIS - Variable rainfall intervals
 0 --> No, > 1 --> Yes....................          0
 THISTO - Rainfall time interval..........       0.10
 TZRAIN - Starting time(KTIME units).......      0.00


######################################
# Rainfall input summary from Runoff #
######################################

 Total rainfall for gage #     1 is    6.3000 inches

   #############################
   #        Data Group F1      #
   # Evaporation Rate (in/day) #
   #############################

  JAN.  FEB.  MAR.  APR.  MAY   JUN.  JUL.  AUG.  SEP.  OCT.  NOV  DEC.
  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ---- ----
 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100
```

```
####################################################
#  Table R1.  S U B C A T C H M E N T   D A T A    #
#             Physical Hydrology Data              #
####################################################
```

Subcatchment Number	Subcatchment Name	Channel or inlet	Width (ft)	Area (ac)	Per-cent Imperv	Slope ft/ft	"n" Imprv	"n" Perv	Deprs -sion Storge Imprv	Deprs -sion Strge Perv	Prcnt Zero Deten -tion
1	AB1#1	AB1	1000.0	1.3000	0.00	1.000	0.020	0.020	0.000	0.000	0.00
2	AB2W#1	AB2W	1000.0	24.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
3	AB2E#1	AB2E	1000.0	13.300	0.00	1.000	0.020	0.020	0.000	0.000	0.00
4	A6#1	A6	1000.0	29.800	0.00	1.000	0.020	0.020	0.000	0.000	0.00
5	A5W#1	A5W	1000.0	26.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
6	A5E#1	A5E	1000.0	41.400	0.00	1.000	0.020	0.020	0.000	0.000	0.00
7	A4C#1	A4C	1000.0	13.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
8	A4E#1	A4E	1000.0	36.000	0.00	1.000	0.020	0.020	0.000	0.000	0.00
9	A4W#1	A4W	1000.0	24.700	0.00	1.000	0.020	0.020	0.000	0.000	0.00
10	A3#1	A3	1000.0	35.400	0.00	1.000	0.020	0.020	0.000	0.000	0.00
11	A2#1	A2	1000.0	34.500	0.00	1.000	0.020	0.020	0.000	0.000	0.00
12	A1#1	A1	1000.0	28.800	0.00	1.000	0.020	0.020	0.000	0.000	0.00

```
#########################################################################################################
#          Table R2.  SUBCATCHMENT  DATA                                                                #
#                     Infiltration or Time of Concentration Data                                        #
#                                                                                                       #
# Infiltration Type      Infl #1(#5)       Infl #2(#6)        Infl #3(#7)           Infl #4(#8)  #
# SCS                  ->   Comp CN           Time Conc         Shape Factor        Depth or Fraction  #
# SBUH                 ->   Comp CN           Time Conc                  N/A                      N/A  #
# Green Ampt           ->   Suction           Hydr Cond           Initial MD                      N/A  #
# Horton               ->  Max Rate            Min Rate    Decay Rate (1/sec)     Max. Infilt. Volume  #
# Proportional         ->  Constant                 N/A                  N/A                      N/A  #
# Initial/Cont Loss    ->   Initial          Continuing                  N/A                      N/A  #
# Initial/Proportional ->   Initial            Constant                  N/A                      N/A  #
# Laurenson Parameters ->   B Value         Pervious "n"      Impervious Cont                 Exponent  #
# Rational Formula     -> Tc Method    Flow Path Length      Flow Path Slope  Roughness or Retardance  #
#                             (#1 - #4 is Impervious Data / #5 - #8 is Pervious Data)                  #
#                       Rational Formula Tc Method: 1 = Constant                                       #
#                                                   2 = Friend's Equation                              #
#                                                   3 = Kinematic Wave                                 #
#                                                   4 = Alameda Method                                 #
#                                                   5 = Izzard's Formula                               #
#                                                   6 = Kerby's Equation                               #
#                                                   7 = Kirpich's Equation                             #
#                                                   8 = Bransby Williams Equation                      #
#                                                   9 = Federal Aviation Authority Equation            #
#########################################################################################################
```

Subcatchment Number	Subcatchment Name	Infl # 1	Infl # 2	Infl # 3	Infl # 4	Infl # 5	Infl # 6	Infl # 7	Infl # 8
1	AB1#1	87.3500	0.5333	484.0000	0.2000				
2	AB2W#1	77.4700	0.3500	484.0000	0.2000				
3	AB2E#1	89.2400	0.2333	484.0000	0.2000				
4	A6#1	88.6800	0.5667	484.0000	0.2000				
5	A5W#1	91.2800	0.4000	484.0000	0.2000				
6	A5E#1	90.7200	0.4000	484.0000	0.2000				
7	A4C#1	90.2700	0.2000	484.0000	0.2000				
8	A4E#1	89.2500	0.5167	484.0000	0.2000				
9	A4W#1	93.3500	0.3833	484.0000	0.2000				
10	A3#1	95.9800	0.2167	484.0000	0.2000				
11	A2#1	93.0400	0.3500	484.0000	0.2000				
12	A1#1	88.6600	0.4667	484.0000	0.2000				

```
############################################################
#     Table R3.  SUBCATCHMENT  DATA                        #
#                Rainfall and Infiltration Database Names  #
############################################################
```

Subcatchment Number	Subcatchment Name	Gage No	Infiltration Type	Routing Type
1	AB1#1	1	SCS Method	SCS curvilinear
2	AB2W#1	1	SCS Method	SCS curvilinear
3	AB2E#1	1	SCS Method	SCS curvilinear
4	A6#1	1	SCS Method	SCS curvilinear
5	A5W#1	1	SCS Method	SCS curvilinear
6	A5E#1	1	SCS Method	SCS curvilinear
7	A4C#1	1	SCS Method	SCS curvilinear
8	A4E#1	1	SCS Method	SCS curvilinear
9	A4W#1	1	SCS Method	SCS curvilinear
10	A3#1	1	SCS Method	SCS curvilinear
11	A2#1	1	SCS Method	SCS curvilinear
12	A1#1	1	SCS Method	SCS curvilinear

```
Total Number of Subcatchments...            12
Total Tributary Area (acres)....        310.90
Impervious Area (acres).........          0.00
Pervious Area (acres)...........        310.90
Total Width (feet)..............      12000.00
Impervious Area (%).............          0.00
```

```
####################################################
#          S U B C A T C H M E N T   D A T A       #
#   Default, Ratio values for subcatchment data    #
#   Used with the calibrate node in the runoff.    #
# 1 - width     2 - area       3 - impervious %    #
# 4 - slope     5 - imp "n"    6 - perv "n"        #
# 7 - imp ds    8 - perv ds    9 - 1st infil       #
#10 - 2nd infil               11 - 3rd infil       #
####################################################
```

Column	1	2	3	4	5	6	7	8	9	10	11
Default	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ratio	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

```
*********************************************************
*     Arrangement of Subcatchments and Channel/Pipes    *
*********************************************************


    Inlet
AB1           No Tributary Channel/Pipes
              Tributary Subareas........ AB1#1
AB2W          No Tributary Channel/Pipes
              Tributary Subareas........ AB2W#1
AB2E          No Tributary Channel/Pipes
              Tributary Subareas........ AB2E#1
A6            No Tributary Channel/Pipes
              Tributary Subareas........ A6#1
A5W           No Tributary Channel/Pipes
              Tributary Subareas........ A5W#1
A5E           No Tributary Channel/Pipes
              Tributary Subareas........ A5E#1
A4C           No Tributary Channel/Pipes
              Tributary Subareas........ A4C#1
A4E           No Tributary Channel/Pipes
              Tributary Subareas........ A4E#1
A4W           No Tributary Channel/Pipes
              Tributary Subareas........ A4W#1
A3            No Tributary Channel/Pipes
              Tributary Subareas........ A3#1
A2            No Tributary Channel/Pipes
              Tributary Subareas........ A2#1
A1            No Tributary Channel/Pipes
              Tributary Subareas........ A1#1

***********************************************************
* Hydrographs will be stored for the following  12 INLETS *
***********************************************************
AB1       AB2W      AB2E      A6        A5W       A5E
A4C       A4E       A4W       A3        A2        A1

************************************************
*  Quality Simulation not included in this run *
************************************************



***************************************************
*  Precipitation Interface File Summary           *
*  Number of precipitation station....        1   *
***************************************************

Location Station Number
-------- -------------
       1.              1

XXX End of Header Section XXX

#######################################################
#    Entry made to the HYDRAULIC Layer of XP-SWMM     #
#    Last Updated in Jan., 2013 by XP Solutions       #

#######################################################
#    Entry made to the Runoff Layer(Block) of SWMM    #
#    Last Updated Jan., 2013 by XP Solutions          #

*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE            |
| Table E1   - Basic Conduit Data                         |
| Table E3a  - Junction Data                              |
| Table E4   - Conduit Connectivity Data                  |
| Table E9   - Junction  Summary  Statistics              |
| Table E10  - Conduit   Summary  Statistics              |
| Table E12  - Mean conduit information                   |
| Table E15  - Spreadsheet Info List                      |
| Table E15a - Spreadsheet Reach List                     |
| Table E16  - New Conduit Output Section                 |
| Table E20  - Junction Flooding and Volume List          |
*=========================================================*

Time Control from Hydraulics Job Control
Year.........    1993 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0


Control information for simulation
----------------------------------

Integration cycles.................        576
Length of integration step is......    300.00 seconds
Simulation length..................     48.00 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.        -1 cycles
Intermediate printout intervals of.     -5.00 minutes
Summary printout intervals of......        -1 cycles
Summary printout time interval of..     -5.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours
```

```
Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         0
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     12.57 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............   5000.00
Ponding Area Exponent...............    1.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....      0
     or user defined hydrographs....
```

==
| Table E1 - Conduit Data |
==

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	PA1	1512.7100	Circular	12.5664	0.0130	4.0000	4.0000		
2	OUTLET	200.0000	Circular	12.5664	0.0130	4.0000	4.0000		
3	PA2G	144.5800	Circular	12.5664	0.0130	4.0000	4.0000		
4	OCA3	205.0000	Trapezoid	435.0000	0.0350	25.0000	5.0000	12.4000	12.4000
5	OCA5E	1011.9400	Trapezoid	280.0000	0.0350	22.0000	5.0000	6.8000	6.8000
6	PA5	1281.3600	Circular	4.9087	0.0130	2.5000	2.5000		
7	PA3	774.3100	Circular	7.0686	0.0130	3.0000	3.0000		
8	OCA6	996.5300	Trapezoid	595.0000	0.0350	18.0000	5.0000	20.2000	20.2000
9	PA6	277.1800	Circular	0.7854	0.0130	1.0000	1.0000		
10	Link138	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
11	Link139	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
12	Link140	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
13	Link141	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
14	Link142	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
15	Link143	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
16	Link144	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
17	Link145	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
18	OCAB1	336.0000	Trapezoid	595.0000	0.0350	18.0000	5.0000	20.2000	20.2000
19	Link100	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
20	Link102	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
21	Link101	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
22	PA2E1	336.8900	Circular	7.0686	0.0130	3.0000	3.0000		
23	PA2E2	332.2400	Circular	9.6211	0.0130	3.5000	3.5000		
24	PA2A	24.1400	Circular	12.5664	0.0130	4.0000	4.0000		
25	PA2F	577.1700	Circular	9.6211	0.0130	3.5000	3.5000		
26	PA2B	229.7400	Circular	7.0686	0.0130	3.0000	3.0000		
27	PA2CB	60.0000	Rectangle	8.0000	0.0130	4.0000	2.0000		
28	PA2CA	12.0000	Rectangle	11.2836	0.0130	5.4170	2.0830		
29	PA2D2	271.1900	Circular	9.6211	0.0130	3.5000	3.5000		
30	PA2D1	269.8300	Circular	7.0686	0.0130	3.0000	3.0000		
31	P1614	108.1500	Circular	4.9087	0.0130	2.5000	2.5000		
32	P2014A	359.0000	Circular	7.0686	0.0130	3.0000	3.0000		
33	P2026	497.9400	Circular	7.0686	0.0130	3.0000	3.0000		
34	P3626	163.6500	Circular	7.0686	0.0130	3.0000	3.0000		
35	P4227E	93.9300	Circular	7.0686	0.0130	3.0000	3.0000		
36	P2014B	347.9300	Circular	7.0686	0.0130	3.0000	3.0000		
37	P2025	488.1300	Circular	7.0686	0.0130	3.0000	3.0000		
38	P3725	163.6500	Circular	7.0686	0.0130	3.0000	3.0000		
39	P4227W	94.6400	Circular	7.0686	0.0130	3.0000	3.0000		
40	FairC	80.7000	Circular	1.2272	0.0130	1.2500	1.2500		
41	FairW	40.0000	Trapezoid	20.2000	0.0350	0.1000	2.0000	5.0000	5.0000

Total length of all conduits .... 11840.5300 feet

==
| Table E3a - Junction Data |
==

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	A4C	345.3700	345.3700	340.3700	0.0000	0.0000	100.0000
2	AB2E	397.5600	392.5600	387.5600	0.0000	0.0000	100.0000
3	A5E	357.0000	355.7100	350.7100	0.0000	0.0000	100.0000
4	A4E	347.5000	347.5000	342.5000	0.0000	0.0000	100.0000
5	A2	323.2900	323.2900	318.2900	0.0000	0.0000	100.0000
6	AB2W	436.4100	436.4100	431.4100	0.0000	0.0000	100.0000
7	A4W	346.4700	346.4700	341.4700	0.0000	0.0000	100.0000
8	A3	339.5400	339.5400	334.5400	0.0000	0.0000	100.0000
9	A5W	356.5400	356.5400	351.5400	0.0000	0.0000	100.0000
10	BDRY	290.5000	289.5000	285.5000	0.0000	0.0000	100.0000
11	AB1	375.4400	373.5100	368.5100	0.0000	0.0000	100.0000
12	A6	386.1000	386.1000	381.1000	0.0000	0.0000	100.0000
13	A1	294.5500	294.5500	289.5500	0.0000	0.0000	100.0000
14	JAB1	375.4400	375.4400	368.2600	0.0000	0.0000	100.0000
15	JA5	357.0000	356.2900	351.2900	0.0000	0.0000	100.0000
16	JA4	342.6900	342.4600	337.4600	0.0000	0.0000	100.0000
17	JA3	339.2900	339.2900	334.2900	0.0000	0.0000	100.0000
18	JA2	323.0400	323.0400	318.0400	0.0000	0.0000	100.0000
19	JA1	294.3000	294.3000	289.3000	0.0000	0.0000	100.0000
20	JAB2	397.4100	390.0000	385.0000	0.0000	0.0000	100.0000
21	FairDS	375.4400	375.4400	367.8000	0.0000	0.0000	100.0000
22	AB2EDS	397.3100	392.3100	387.3100	0.0000	0.0000	100.0000
23	A6DS	385.8500	385.8500	380.8500	0.0000	0.0000	100.0000
24	A4EDS	347.2500	347.2500	342.2500	0.0000	0.0000	100.0000
25	MH2938	324.5000	323.5000	319.5000	0.0000	0.0000	100.0000
26	MH1038	330.6600	329.1600	325.6600	0.0000	0.0000	100.0000
27	MH0430	336.3100	332.1000	329.1000	0.0000	0.0000	100.0000
28	MH0431	336.2100	332.2300	328.7300	0.0000	0.0000	100.0000
29	JA2D	336.4100	334.5800	331.0800	0.0000	0.0000	100.0000

30	JA2CB	337.7000	334.7830	332.7000	0.0000	0.0000	100.0000
31	JA2B	340.3500	338.1800	334.1800	0.0000	0.0000	100.0000
32	JA2CA	337.7600	335.7600	332.7600	0.0000	0.0000	100.0000
33	MH2014	355.4600	355.4600	349.0600	0.0000	0.0000	100.0000
34	MH2026	350.4000	348.0000	344.4000	0.0000	0.0000	100.0000
35	MH2025	350.0000	349.2700	344.2200	0.0000	0.0000	100.0000
36	MH3626	345.1200	345.1200	338.0700	0.0000	0.0000	100.0000
37	MH3725	345.3900	341.0100	338.0100	0.0000	0.0000	100.0000
38	MH4227W	346.2200	346.2200	338.0100	0.0000	0.0000	100.0000
39	MH4227E	346.1800	341.1000	338.0100	0.0000	0.0000	100.0000

==
| Table E4 - Conduit Connectivity |
==

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	PA1	JA2	JA1	318.0400	289.3000	No Design
2	OUTLET	JA1	BDRY	289.3000	285.5000	No Design
3	PA2G	MH2938	JA2	319.5000	318.0400	No Design
4	OCA3	JA4	JA3	337.4600	334.2900	No Design
5	OCA5E	FairDS	JA5	367.8000	351.2900	No Design
6	PA5	A6DS	JA5	380.8500	351.2900	No Design
7	PA3	A4EDS	MH4227E	342.2500	338.1000	No Design
8	OCA6	AB2W	JAB2	431.4100	385.0000	No Design
9	PA6	AB2EDS	JAB2	387.3100	385.0000	No Design
10	Link138	AB1	JAB1	368.5100	368.2600	No Design
11	Link139	A5W	JA5	351.5400	351.2900	No Design
12	Link140	A5E	MH2014	350.7100	350.4600	No Design
13	Link141	A4C	MH3626	340.3700	340.1200	No Design
14	Link142	A4W	MH4227W	341.4700	341.2200	No Design
15	Link143	A3	JA3	334.5400	334.2900	No Design
16	Link144	A2	JA2	318.2900	318.0400	No Design
17	Link145	A1	JA1	289.5500	289.3000	No Design
18	OCAB1	JAB2	JAB1	385.0000	368.2600	No Design
19	Link100	AB2E	AB2EDS	387.5600	387.3100	No Design
20	Link102	A4E	A4EDS	342.5000	342.2500	No Design
21	Link101	A6	A6DS	381.1000	380.8500	No Design
22	PA2E1	MH0430	MH1038	329.1000	325.6600	No Design
23	PA2E2	MH0431	MH1038	328.7300	325.6600	No Design
24	PA2A	JA3	JA2B	334.2900	334.1800	No Design
25	PA2F	MH1038	MH2938	325.6600	319.5000	No Design
26	PA2B	JA2B	JA2CA	334.1800	332.7600	No Design
27	PA2CB	JA2CB	JA2D	332.7000	332.4000	No Design
28	PA2CA	JA2CA	JA2CB	332.7600	332.7000	No Design
29	PA2D2	JA2D	MH0431	331.0800	328.7300	No Design
30	PA2D1	JA2D	MH0430	331.0800	329.1000	No Design
31	P1614	JA5	MH2014	351.2900	349.8600	No Design
32	P2014A	MH2014	MH2026	349.0600	345.0000	No Design
33	P2026	MH2026	MH3626	344.4000	338.0700	No Design
34	P3626	MH3626	MH4227E	338.0700	338.0100	No Design
35	P4227E	MH4227E	JA4	338.0100	337.4600	No Design
36	P2014B	MH2014	MH2025	349.0600	346.2700	No Design
37	P2025	MH2025	MH3725	344.2200	338.0100	No Design
38	P3725	MH3725	MH4227W	338.0100	338.0100	No Design
39	P4227W	MH4227W	JA4	338.0100	337.4600	No Design
40	FairC	JAB1	FairDS	368.2600	367.8000	No Design
41	FairW	JAB1	FairDS	373.4400	373.4400	No Design

===
| FREE OUTFALL DATA (DATA GROUP I1) |
| BOUNDARY CONDITION ON DATA GROUP J1 |
===

Outfall at Junction....BDRY has boundary condition number... 1

===
| INTERNAL CONNECTIVITY INFORMATION |
===

CONDUIT	JUNCTION	JUNCTION
FREE # 1	BDRY	BOUNDARY

==
| Boundary Condition Information |
| Data Groups J1-J4 |
==

BC NUMBER.. 1 has no control water surface.

==================================
| Conduit Convergence Criteria |
==================================

Conduit Name	Full Flow	Conduit Slope
PA1	197.9935	0.0190
OUTLET	197.9986	0.0190
PA2G	144.3470	0.0101
OCA3	4682.8854	0.0155
OCA5E	3218.6373	0.0163
PA5	62.2991	0.0231
PA3	48.8295	0.0054
OCA6	10574.6457	0.0466
PA6	3.2525	0.0083
Link138	868.6535	0.0050
Link139	868.6535	0.0050
Link140	868.6535	0.0050
Link141	868.6535	0.0050

Link142	868.6535	0.0050
Link143	868.6535	0.0050
Link144	868.6535	0.0050
Link145	868.6535	0.0050
OCAB1	10937.3804	0.0498
Link100	868.6535	0.0050
Link102	868.6535	0.0050
Link101	868.6535	0.0050
PA2E1	67.3985	0.0102
PA2E2	96.7127	0.0092
PA2A	86.9803	0.0037
PA2F	103.9390	0.0107
PA2B	52.4374	0.0062
PA2CB	49.3465	0.0050
PA2CA	47.7100	0.0020
PA2D2	93.6563	0.0087
PA2D1	57.1351	0.0073
P1614	47.1650	0.0132
P2014A	70.9302	0.0113
P2026	75.2019	0.0127
P3626	12.7712	0.0004
P4227E	51.0381	0.0059
P2014B	59.7271	0.0080
P2025	75.2304	0.0127
P3725	2.1092	0.0000
P4227W	50.8463	0.0058
FairC	4.8771	0.0057
FairW	2.6859	0.0000

===
| Table E9 - JUNCTION SUMMARY STATISTICS |
| The Maximum area is only the area of the node, it |
| does not include the area of the surrounding conduits|
===

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
A4C	345.3700	345.3700	344.4498	8	16	0.0000	0.9202	12.5660	0.0000	0.0000	0.0000
AB2E	397.5600	392.5600	397.3154	8	7	4.7554	0.2446	12.5660	0.0000	0.0000	0.0000
A5E	357.0000	355.7100	352.1125	8	10	0.0000	4.8875	12.5660	0.0000	0.0000	0.0000
A4E	347.5000	347.5000	345.0486	8	21	0.0000	2.4514	12.5660	0.0000	0.0000	0.0000
A2	323.2900	323.2900	320.5814	8	10	0.0000	2.7086	12.5660	0.0000	0.0000	0.0000
AB2W	436.4100	436.4100	431.6800	8	12	0.0000	4.7300	12.5660	0.0000	0.0000	0.0000
A4W	346.4700	346.4700	342.6133	8	10	0.0000	3.8567	12.5660	0.0000	0.0000	0.0000
A3	339.5400	339.5400	339.5400	7	48	0.0000	0.0000	12.5660	0.0000	0.0000	0.0000
A5W	356.5400	356.5400	355.2130	8	32	0.0000	1.3270	12.5660	0.0000	0.0000	0.0000
BDRY	290.5000	289.5000	288.4331	8	12	0.0000	2.0669	12.5660	0.0000	0.0000	0.0000
AB1	375.4400	373.5100	374.4612	8	39	0.9512	0.9788	12.5660	0.0000	0.0000	0.0000
A6	386.1000	386.1000	382.3148	8	20	0.0000	3.7852	12.5660	0.0000	0.0000	0.0000
A1	294.5500	294.5500	292.2376	8	11	0.0000	2.3124	12.5660	0.0000	0.0000	0.0000
JAB1	375.4400	375.4400	374.4612	8	39	0.0000	0.9788	12.5660	0.0000	0.0000	0.0000
JA5	357.0000	356.2900	355.2127	8	32	0.0000	1.7873	12.5660	0.0000	0.0000	0.0000
JA4	342.6900	342.4600	339.5808	7	49	0.0000	3.1092	12.5660	0.0000	0.0000	0.0000
JA3	339.2900	339.2900	339.5605	7	49	0.2705	0.0000	6552.3815	0.0000	0.0000	0.0000
JA2	323.0400	323.0400	320.5652	8	10	0.0000	2.4748	12.5660	0.0000	0.0000	0.0000
JA1	294.3000	294.3000	292.2335	8	11	0.0000	2.0665	12.5660	0.0000	0.0000	0.0000
JAB2	397.4100	390.0000	385.2952	8	14	0.0000	12.1148	12.5660	0.0000	0.0000	0.0000
FairDS	375.4400	375.4400	368.1145	8	44	0.0000	7.3255	12.5660	0.0000	0.0000	0.0000
AB2EDS	397.3100	392.3100	397.3100	8	7	5.0000	0.0000	12.5660	0.0000	0.0000	0.0000
A6DS	385.8500	385.8500	382.1209	8	20	0.0000	3.7291	12.5660	0.0000	0.0000	0.0000
A4EDS	347.2500	347.2500	345.0410	8	21	0.0000	2.2090	12.5660	0.0000	0.0000	0.0000
MH2938	324.5000	323.5000	321.9361	8	10	0.0000	2.5639	12.5660	0.0000	0.0000	0.0000
MH1038	330.6600	329.1600	328.5324	7	51	0.0000	2.1276	12.5660	0.0000	0.0000	0.0000
MH0430	336.3100	332.1000	330.8266	7	50	0.0000	5.4834	12.5660	0.0000	0.0000	0.0000
MH0431	336.2100	332.2300	330.6492	7	50	0.0000	5.5608	12.5660	0.0000	0.0000	0.0000
JA2D	336.4100	334.5800	333.0549	7	49	0.0000	3.3551	12.5660	0.0000	0.0000	0.0000
JA2CB	337.7000	334.7830	335.5989	7	49	0.8159	2.1011	12.5660	0.0000	0.0000	0.0000
JA2B	340.3500	338.1800	336.9696	7	49	0.0000	3.3804	12.5660	0.0000	0.0000	0.0000
JA2CA	337.7600	335.7600	335.8552	7	49	0.0952	1.9048	12.5660	0.0000	0.0000	0.0000
MH2014	355.4600	355.4600	351.2744	8	15	0.0000	4.1856	12.5660	0.0000	0.0000	0.0000
MH2026	350.4000	348.0000	348.2662	8	15	0.2662	2.1338	12.5660	0.0000	0.0000	0.0000
MH2025	350.0000	349.2700	346.2263	8	15	0.0000	3.7737	12.5660	0.0000	0.0000	0.0000
MH3626	345.1200	345.1200	344.4498	8	16	0.0000	0.6702	12.5660	0.0000	0.0000	0.0000
MH3725	345.3900	341.0100	342.2643	8	15	1.2543	3.1257	12.5660	0.0000	0.0000	0.0000
MH4227W	346.2200	346.2200	341.2551	8	15	0.0000	4.9649	12.5660	0.0000	0.0000	0.0000
MH4227E	346.1800	341.1000	342.5750	8	18	1.4750	3.6050	12.5660	0.0000	0.0000	0.0000

===
| Table E10 - CONDUIT SUMMARY STATISTICS |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the |
| downstream boundary conditions. |
| |
| * denotes an open conduit that has been overtopped |
| this is a potential source of severe errors |
===

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS
PA1	197.9935	15.7558	48.0000	143.4145	8	10	16.0090	8	55	0.7243	320.5652	292.2335	0.631	0.733
OUTLET	197.9986	15.7562	48.0000	175.6032	8	12	17.7872	8	12	0.8869	292.2335	288.4331	0.733	0.733
PA2G	144.3470	11.4868	48.0000	98.6915	7	51	13.1509	9	34	0.6837	321.9361	320.5652	0.609	0.631
OCA3	4682.885	10.7653	63.2458	194.9914	8	15	0.7181	8	15	0.0416	339.5808	339.5604	0.402	1.000
OCA5E	3218.637	11.4951	60.0000	17.9703	8	44	0.5922	24	11	0.0056	368.1145	355.2127	0.063	0.785
PA5	62.2991	12.6915	30.0000	32.0100	8	20	8.9058	8	20	0.5138	382.1209	355.2127	0.508	1.569
PA3	48.8295	6.9080	36.0000	39.9898	8	23	5.8234	8	29	0.8190	345.0410	342.5750	0.930	1.492
OCA6	10574.65	17.7725	60.0000	21.0783	8	12	3.1693	8	11	0.0020	431.6800	385.2952	0.054	0.059
PA6	3.2525	4.1412	12.0000	4.6225	8	14	8.4970	8	14	1.4212	397.3100	385.2952	10.00	0.295
Link138	868.6535	5.7910	74.4123	1.0239	8	42	0.1136	24	21	0.0012	374.4612	374.4612	0.960	1.000 *
Link139	868.6535	5.7910	60.0000	32.3185	8	13	0.9532	7	52	0.0372	355.2130	355.2127	0.735	0.785

Link140	868.6535	5.7910	60.0000	50.5943	8	10	3.5978	8	10	0.0582	352.1125	351.5033	0.280	0.209	
Link141	868.6535	5.7910	60.0000	16.1195	8	0	1.8908	7	31	0.0186	344.4498	344.4498	0.816	0.866	
Link142	868.6535	5.7910	60.0000	31.6064	8	10	3.1397	8	10	0.0364	342.6133	342.0351	0.229	0.163	
Link143	868.6535	5.7910	63.2458	-96.7384	8	15	0.9135	1	2	-0.1114	339.5400	339.5604	0.949	1.000	
Link144	868.6535	5.7910	60.0000	45.1666	8	10	1.1081	8	10	0.0520	320.5814	320.5652	0.458	0.505	
Link145	868.6535	5.7910	60.0000	33.1113	8	15	0.6335	8	20	0.0381	292.2376	292.2335	0.538	0.587	
OCAB1	10937.38	18.3822	74.4123	25.6276	8	14	0.4017	1	48	0.0023	385.2952	374.4612	0.048	1.000	*
Link100	868.6535	5.7910	119.9958	21.7028	8	7	0.2859	3	45	0.0250	397.3152	397.3100	0.976	1.000	*
Link102	868.6535	5.7910	60.0000	40.1755	8	19	1.5124	8	56	0.0463	345.0486	345.0410	0.510	0.558	
Link101	868.6535	5.7910	60.0000	32.0907	8	20	2.3131	8	15	0.0369	382.3148	382.1209	0.243	0.254	
PA2E1	67.3985	9.5349	36.0000	42.4093	7	50	7.7952	7	50	0.6292	330.8266	328.5324	0.576	0.957	
PA2E2	96.7127	10.0521	42.0000	56.3328	7	50	8.3457	7	49	0.5825	330.6492	328.5324	0.548	0.821	
PA2A	86.9803	6.9217	48.0000	98.7746	7	49	8.8928	7	49	1.1356	339.5605	336.9696	1.318	0.697	
PA2F	103.9390	10.8032	42.0000	98.6212	7	51	12.5871	7	52	0.9488	328.5324	321.9361	0.821	0.696	
PA2B	52.4374	7.4184	36.0000	49.3345	7	49	7.0763	10	56	0.9408	336.9695	335.8552	0.930	1.032	
PA2CB	49.3465	6.1683	24.0000	98.7166	7	50	12.3243	7	50	2.0005	335.5989	334.4000	1.449	1.000	
PA2CA	47.7100	4.2283	24.9960	98.7171	7	50	8.7293	7	50	2.0691	335.8552	335.5989	1.486	1.392	
PA2D2	93.6563	9.7344	42.0000	56.4145	7	50	10.2625	7	50	0.6024	333.0549	330.6492	0.564	0.548	
PA2D1	57.1351	8.0830	36.0000	42.4777	7	50	9.2346	7	50	0.7435	333.0549	330.8265	0.658	0.576	
P1614	47.1650	9.6084	30.0000	66.7427	8	32	13.5697	8	32	1.4151	355.2127	352.3600	1.569	1.000	
P2014A	70.9302	10.0346	36.0000	59.5335	8	9	11.0970	8	6	0.8393	351.2744	348.2662	0.738	1.089	
P2026	75.2019	10.6389	36.0000	58.7007	8	15	8.6550	8	47	0.7806	348.2662	344.4498	1.289	2.127	
P3626	12.7712	1.8068	36.0000	72.1146	8	14	10.1478	8	13	5.6466	344.4498	342.5750	2.127	1.522	
P4227E	51.0381	7.2204	36.0000	110.7517	8	18	17.6862	8	18	2.1700	342.5750	339.5808	1.522	0.707	
P2014B	59.7271	8.4497	36.0000	53.3574	8	15	9.5490	8	15	0.8934	351.2744	348.4831	0.738	0.738	
P2025	75.2304	10.6429	36.0000	53.3827	8	16	9.0652	8	23	0.7096	346.2263	342.2644	0.669	1.418	
P3725	2.1092	0.0000	36.0000	53.3941	8	16	7.4268	8	16	25.3150	342.2643	341.2551	1.418	1.082	
P4227W	50.8463	7.1933	36.0000	84.4120	8	15	13.2065	8	15	1.6601	341.2551	339.5808	1.082	0.707	
FairC	4.8771	3.9742	15.0000	10.3115	8	43	12.8748	8	43	2.1143	374.4612	368.1145	4.961	0.252	
FairW	2.6859	0.0000	24.0000	7.8959	8	39	1.9811	8	39	2.9398	374.4612	374.1170	0.511	0.339	
FREE # 1	Undefnd	Undefnd	Undefn	175.6032	8	12									

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| Table E12. Mean Conduit Flow Information |
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Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
PA1	27.1044	4683634.7	0.0000	0.9996	1.9910	0.7707	4.2733	0.0130
OUTLET	30.0539	5193318.7	0.0000	0.9995	2.2607	0.7869	4.4561	0.0130
PA2G	23.2395	4015788.0	0.0000	0.9996	1.6361	0.7914	4.4611	0.0130
OCA3	21.5375	3721688.5	0.0000	0.9978	0.0922	1.1628	116.6308	0.0350
OCA5E	3.3201	573710.47	0.0000	0.9882	0.1564	0.4864	19.1865	0.0350
PA5	2.9946	517462.01	0.0000	0.9576	0.9841	0.3978	1.3588	0.0130
PA3	3.7089	640904.12	0.0000	0.9747	0.7842	0.5403	2.3776	0.0130
OCA6	1.9136	330674.06	0.0000	0.9469	0.7859	0.0994	2.3609	0.0350
PA6	1.2734	220043.52	0.0000	0.9563	2.7287	0.1643	0.4269	0.0130
Link138	0.1297	22403.617	0.0000	0.9679	0.0012	1.9823	105.1529	0.0350
Link139	2.8998	501090.67	0.0000	0.9791	0.1088	0.6607	12.9120	0.0350
Link140	4.4076	761632.79	0.0000	0.9925	0.6060	0.3663	4.1753	0.0350
Link141	1.4681	253684.04	0.0000	0.9925	0.5424	0.3205	6.2014	0.0350
Link142	2.7292	471600.25	0.0000	0.9982	0.6042	0.2991	3.0111	0.0350
Link143	1.6966	293179.58	0.0000	0.9845	0.0182	1.7062	70.1213	0.0350
Link144	3.8632	667568.88	0.0000	0.9827	0.0772	0.8041	16.2388	0.0350
Link145	2.9488	509557.54	0.0000	0.9778	0.0469	0.8486	18.1358	0.0350
OCAB1	3.1929	551729.92	0.0000	0.9886	0.0361	0.9914	199.1804	0.0350
Link100	1.3825	238891.94	0.0000	0.9865	0.0188	2.8888	240.0560	0.0350
Link102	3.7084	640812.01	0.0000	0.9729	0.2485	0.4800	6.8973	0.0350
Link101	2.9945	517456.04	0.0000	0.9798	0.3531	0.3597	3.9944	0.0350
PA2E1	10.0669	1739565.3	0.0000	0.9996	1.1005	0.6558	3.2036	0.0130
PA2E2	13.1712	2275988.5	0.0000	0.9996	1.1469	0.7267	3.8393	0.0130
PA2A	23.2359	4015162.0	0.0000	0.9996	0.9589	0.9208	7.3619	0.0130
PA2F	23.2389	4015690.3	0.0000	0.9996	1.4974	0.7954	4.5189	0.0130
PA2B	23.2364	4015242.4	0.0000	0.9996	1.0122	0.6895	3.7015	0.0130
PA2CB	23.2368	4015322.8	0.0000	0.9995	1.1617	0.7150	5.9003	0.0130
PA2CA	23.2365	4015274.4	0.0000	0.9996	0.7638	0.8071	8.1683	0.0130
PA2D2	13.1707	2275895.8	0.0000	0.9996	1.3676	0.6687	3.1965	0.0130
PA2D1	10.0667	1739524.9	0.0000	0.9996	1.2946	0.6186	2.7105	0.0130
P1614	9.2146	1592274.4	0.0000	0.9932	1.6539	0.5221	2.0903	0.0130
P2014A	7.3874	1276536.0	0.0000	0.9926	1.6841	0.4995	1.9304	0.0130
P2026	7.3881	1276667.5	0.0000	0.9919	0.9110	0.6059	3.0107	0.0130
P3626	8.8566	1530421.9	0.0000	0.9919	0.5917	0.7266	4.0245	0.0130

P4227E	12.5660	2171405.4	0.0000	0.9910	2.2848	0.5459	2.6005	0.0130
P2014B	6.2362	1077607.2	0.0000	0.9926	1.4226	0.5005	1.9112	0.0130
P2025	6.2366	1077684.1	0.0000	0.9920	0.8758	0.5715	2.5918	0.0130
P3725	6.2367	1077698.1	0.0000	0.9982	0.5239	0.6794	3.4162	0.0130
P4227W	8.9660	1549332.7	0.0000	0.9982	2.0602	0.5141	2.2453	0.0130
FairC	3.0723	530899.71	0.0000	0.9887	3.7771	0.2069	0.6454	0.0130
FairW	0.2498	43169.103	0.0000	0.3738	0.1270	0.0737	0.4339	0.0350
FREE # 1	30.0548	5193461.5						

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*=======================================================*
|     Table E15 - SPREADSHEET INFO LIST                 |
| Conduit Flow and Junction Depth Information for use in  |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the       |
| maximum of a subset of all the time steps in the run.   |
| Note: These flows are only the flows in a single barrel.|
*=======================================================*
```

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
PA1	143.4145	4683634.728	16.0090	1400.5171	##	A4C	340.3700	344.4498
OUTLET	175.6032	5193318.749	17.7872	1520.2764	##	AB2E	387.5600	397.3154
PA2G	98.6915	4015788.013	13.1509	1183.0252	##	A5E	350.7100	352.1125
OCA3	194.9914	3721688.472	0.7181	54972.6938	##	A4E	342.5000	345.0486
OCA5E	17.9703	573710.4716	0.5922	18707.2837	##	A2	318.2900	320.5814
PA5	32.0100	517462.0079	8.9058	689.1358	##	AB2W	431.4100	431.6800
PA3	39.9898	640904.1239	5.8234	5423.9319	##	A4W	341.4700	342.6133
OCA6	21.0783	330674.0560	3.1693	42.4191	##	A3	334.5400	339.5400
PA6	4.6225	220043.5236	8.4970	16.8363	##	A5W	351.5400	355.2130
Link138	1.0239	22403.6174	0.1136	10750.1416	##	BDRY	285.5000	288.4331
Link139	32.3185	501090.6713	0.9532	4539.9089	##	AB1	368.5100	374.4612
Link140	50.5943	761632.7911	3.5978	680.9545	##	A6	381.1000	382.3148
Link141	16.1195	253684.0352	1.8908	5445.5865	##	A1	289.5500	292.2376
Link142	31.6064	471600.2518	3.1397	485.7320	##	JAB1	368.2600	374.4612
Link143	-96.7384	293179.5768	0.9135	7854.3056	##	JA5	351.2900	355.2127
Link144	45.1666	667568.8752	1.1081	2052.3374	##	JA4	337.4600	339.5808
Link145	33.1113	509557.5405	0.6335	2671.9551	##	JA3	334.2900	339.5605
OCAB1	25.6276	551729.9172	0.4017	39944.3547	##	JA2	318.0400	320.5652
Link100	21.7028	238891.9389	0.2859	26849.5218	##	JA1	289.3000	292.2335
Link102	40.1755	640812.0121	1.5124	2426.2704	##	JAB2	385.0000	385.2952
Link101	32.0907	517456.0367	2.3131	696.1629	##	FairDS	367.8000	368.1145
PA2E1	42.4093	1739565.348	7.7952	1546.4663	##	AB2EDS	387.3100	397.3100
PA2E2	56.3328	2275988.540	8.3457	2121.1425	##	A6DS	380.8500	382.1209
PA2A	98.7746	4015161.952	8.8928	327.6528	##	A4EDS	342.2500	345.0410
PA2F	98.6212	4015690.310	12.5871	1772.0558	##	MH2938	319.5000	321.9361
PA2B	49.3345	4015242.394	7.0763	3127.6289	##	MH1038	325.6600	328.5324
PA2CB	98.7166	4015322.767	12.3243	480.5387	##	MH0430	329.1000	330.8266
PA2CA	98.7171	4015274.398	8.7293	340.7203	##	MH0431	328.7300	330.6492
PA2D2	56.4145	2275895.808	10.2625	1212.4354	##	JA2D	331.0800	333.0549
PA2D1	42.4777	1739524.880	9.2346	1070.2078	##	JA2CB	332.7000	335.5989
P1614	66.7427	1592274.424	13.5697	535.4930	##	JA2B	334.1800	336.9696
P2014A	59.5335	1276535.978	11.0970	1873.0364	##	JA2CA	332.7600	335.8552
P2026	58.7007	1276667.480	8.6550	3540.4941	##	MH2014	349.0600	351.2744
P3626	72.1146	1530421.879	10.1478	1212.6732	##	MH2026	344.4000	348.2662
P4227E	110.7517	2171405.448	17.6862	590.5738	##	MH2025	344.2200	346.2263
P2014B	53.3574	1077607.155	9.5490	1538.2128	##	MH3626	338.0700	344.4498
P2025	53.3827	1077684.062	9.0652	2113.6166	##	MH3725	338.0100	342.2643

P3725	53.3941	1077698.082	7.4268	1198.8574	##	MH4227W	338.0100	341.2551
P4227W	84.4120	1549332.724	13.2065	592.4383	##	MH4227E	338.0100	342.5750
FairC	10.3115	530899.7057	12.8748	37.7468	##			
FairW	7.8959	43169.1025	1.9811	149.5482	##			
FREE # 1	175.6032	5193461.465	0.0000	0.0000	##			

```
*===================================================*
|     Table E15a - SPREADSHEET REACH LIST           |
| Peak flow and Total Flow listed by Reach or those  |
|      conduits or diversions having the same        |
|      upstream and downstream nodes.                |
*===================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
JA2	JA1	143.4145	4683634.73
JA1	BDRY	175.6032	5193318.75
MH2938	JA2	98.6915	4015788.01
JA4	JA3	194.9914	3721688.47
FairDS	JA5	17.9703	573710.472
A6DS	JA5	32.0100	517462.008
A4EDS	MH4227E	39.9898	640904.124
AB2W	JAB2	21.0783	330674.056
AB2EDS	JAB2	4.6225	220043.524
AB1	JAB1	1.0239	22403.6174
A5W	JA5	32.3185	501090.671
A5E	MH2014	50.5943	761632.791
A4C	MH3626	16.1195	253684.035
A4W	MH4227W	31.6064	471600.252
A3	JA3	-96.7384	293179.577
A2	JA2	45.1666	667568.875
A1	JA1	33.1113	509557.540
JAB2	JAB1	25.6276	551729.917
AB2E	AB2EDS	21.7028	238891.939
A4E	A4EDS	40.1755	640812.012
A6	A6DS	32.0907	517456.037
MH0430	MH1038	42.4093	1739565.35
MH0431	MH1038	56.3328	2275988.54
JA3	JA2B	98.7746	4015161.95
MH1038	MH2938	98.6212	4015690.31
JA2B	JA2CA	98.6691	4015242.39
JA2CB	JA2D	98.7166	4015322.77
JA2CA	JA2CB	98.7171	4015274.40
JA2D	MH0431	56.4145	2275895.81
JA2D	MH0430	42.4777	1739524.88
JA5	MH2014	66.7427	1592274.42
MH2014	MH2026	59.5335	1276535.98
MH2026	MH3626	58.7007	1276667.48
MH3626	MH4227E	72.1146	1530421.88
MH4227E	JA4	110.7517	2171405.45
MH2014	MH2025	53.3574	1077607.15
MH2025	MH3725	53.3827	1077684.06
MH3725	MH4227W	53.3941	1077698.08
MH4227W	JA4	84.4120	1549332.72
JAB1	FairDS	18.1792	574068.808

```
##########################################################
# Table E16. New Conduit Information Section             #
#             Conduit Invert (IE) Elevation and Conduit  #
```

Maximum Water Surface (WS) Elevations
##

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
PA1	JA2	JA1	318.0400	289.3000	320.5652	292.2335	Circular
OUTLET	JA1	BDRY	289.3000	285.5000	292.2335	288.4331	Circular
PA2G	MH2938	JA2	319.5000	318.0400	321.9361	320.5652	Circular
OCA3	JA4	JA3	337.4600	334.2900	339.5808	339.5604	Trapezoid
OCA5E	FairDS	JA5	367.8000	351.2900	368.1145	355.2127	Trapezoid
PA5	A6DS	JA5	380.8500	351.2900	382.1209	355.2127	Circular
PA3	A4EDS	MH4227E	342.2500	338.1000	345.0410	342.5750	Circular
OCA6	AB2W	JAB2	431.4100	385.0000	431.6800	385.2952	Trapezoid
PA6	AB2EDS	JAB2	387.3100	385.0000	397.3100	385.2952	Circular
Link138	AB1	JAB1	368.5100	368.2600	374.4612	374.4612	Trapezoid
Link139	A5W	JA5	351.5400	351.2900	355.2130	355.2127	Trapezoid
Link140	A5E	MH2014	350.7100	350.4600	352.1125	351.5033	Trapezoid
Link141	A4C	MH3626	340.3700	340.1200	344.4498	344.4498	Trapezoid
Link142	A4W	MH4227W	341.4700	341.2200	342.6133	342.0351	Trapezoid
Link143	A3	JA3	334.5400	334.2900	339.5400	339.5604	Trapezoid
Link144	A2	JA2	318.2900	318.0400	320.5814	320.5652	Trapezoid
Link145	A1	JA1	289.5500	289.3000	292.2376	292.2335	Trapezoid
OCAB1	JAB2	JAB1	385.0000	368.2600	385.2952	374.4612	Trapezoid
Link100	AB2E	AB2EDS	387.5600	387.3100	397.3152	397.3100	Trapezoid
Link102	A4E	A4EDS	342.5000	342.2500	345.0486	345.0410	Trapezoid
Link101	A6	A6DS	381.1000	380.8500	382.3148	382.1209	Trapezoid
PA2E1	MH0430	MH1038	329.1000	325.6600	330.8266	328.5324	Circular
PA2E2	MH0431	MH1038	328.7300	325.6600	330.6492	328.5324	Circular
PA2A	JA3	JA2B	334.2900	334.1800	339.5605	336.9696	Circular
PA2F	MH1038	MH2938	325.6600	319.5000	328.5324	321.9361	Circular
PA2B	JA2B	JA2CA	334.1800	332.7600	336.9695	335.8552	Circular
PA2CB	JA2CB	JA2D	332.7000	332.4000	335.5989	334.4000	Rectangle
PA2CA	JA2CA	JA2CB	332.7600	332.7000	335.8552	335.5989	Rectangle
PA2D2	JA2D	MH0431	331.0800	328.7300	333.0549	330.6492	Circular
PA2D1	JA2D	MH0430	331.0800	329.1000	333.0549	330.8265	Circular
P1614	JA5	MH2014	351.2900	349.8600	355.2127	352.3600	Circular
P2014A	MH2014	MH2026	349.0600	345.0000	351.2744	348.2662	Circular
P2026	MH2026	MH3626	344.4000	338.0700	348.2662	344.4498	Circular
P3626	MH3626	MH4227E	338.0700	338.0100	344.4498	342.5750	Circular
P4227E	MH4227E	JA4	338.0100	337.4600	342.5750	339.5808	Circular
P2014B	MH2014	MH2025	349.0600	346.2700	351.2744	348.4831	Circular
P2025	MH2025	MH3725	344.2200	338.0100	346.2263	342.2644	Circular
P3725	MH3725	MH4227W	338.0100	338.0100	342.2643	341.2551	Circular
P4227W	MH4227W	JA4	338.0100	337.4600	341.2551	339.5808	Circular
FairC	JAB1	FairDS	368.2600	367.8000	374.4612	368.1145	Circular
FairW	JAB1	FairDS	373.4400	373.4400	374.4612	374.1170	Trapezoid

==
| Table E20 - Junction Flooding and Volume Listing. |
| The maximum volume is the total volume |
| in the node including the volume in the |
| flooded storage area. This is the max |
| volume at any time. The volume in the |
| flooded storage area is the total volume|
| above the ground elevation, where the |
| flooded pond storage area starts. |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
==

Junction	Surcharged	Flooded	Out of 1D-System (Flooded	Maximum	Passed to 2D cell OR Volume Stored in allowed Flood

Name	Time (min)	Time(min)	Volume)	Volume	Pond of 1D-System
A4C	0.0000	0.0000	0.0000	51.2671	0.0000
AB2E	717.2068	0.0000	0.0000	122.5839	0.0000
A5E	0.0000	0.0000	0.0000	17.6235	0.0000
A4E	0.0000	0.0000	0.0000	32.0251	0.0000
A2	0.0000	0.0000	0.0000	28.7936	0.0000
AB2W	0.0000	0.0000	0.0000	3.3928	0.0000
A4W	0.0000	0.0000	0.0000	14.3665	0.0000
A3	0.0000	100.4137	426801.6594	62.8300	0.0000
A5W	0.0000	0.0000	0.0000	46.1547	0.0000
BDRY	0.0000	0.0000	0.0000	36.8574	0.0000
AB1	445.6707	0.0000	0.0000	74.7824	0.0000
A6	0.0000	0.0000	0.0000	15.2656	0.0000
A1	0.0000	0.0000	0.0000	33.7721	0.0000
JAB1	0.0000	0.0000	0.0000	77.9239	0.0000
JA5	0.0000	0.0000	0.0000	49.2928	0.0000
JA4	0.0000	0.0000	0.0000	26.6494	0.0000
JA3	126.2534	126.2534	0.0000	1615.2115	8116.5410
JA2	0.0000	0.0000	0.0000	31.7322	0.0000
JA1	0.0000	0.0000	0.0000	36.8629	0.0000
JAB2	0.0000	0.0000	0.0000	3.7101	0.0000
FairDS	0.0000	0.0000	0.0000	3.9519	0.0000
AB2EDS	744.2376	133.3336	19389.6908	125.6600	0.0000
A6DS	0.0000	0.0000	0.0000	15.9698	0.0000
A4EDS	0.0000	0.0000	0.0000	35.0723	0.0000
MH2938	0.0000	0.0000	0.0000	30.6122	0.0000
MH1038	0.0000	0.0000	0.0000	36.0945	0.0000
MH0430	0.0000	0.0000	0.0000	21.6958	0.0000
MH0431	0.0000	0.0000	0.0000	24.1164	0.0000
JA2D	0.0000	0.0000	0.0000	24.8164	0.0000
JA2CB	316.1667	0.0000	0.0000	36.4282	0.0000
JA2B	0.0000	0.0000	0.0000	35.0539	0.0000
JA2CA	116.8522	0.0000	0.0000	38.8944	0.0000
MH2014	0.0000	0.0000	0.0000	27.8257	0.0000
MH2026	12.7469	0.0000	0.0000	48.5825	0.0000
MH2025	0.0000	0.0000	0.0000	25.2116	0.0000
MH3626	0.0000	0.0000	0.0000	80.1684	0.0000
MH3725	53.5845	0.0000	0.0000	53.4603	0.0000
MH4227W	0.0000	0.0000	0.0000	40.7785	0.0000
MH4227E	52.7397	0.0000	0.0000	57.3637	0.0000

```
*==================================*
| Simulation Specific Information  |
*==================================*
Number of Input Conduits..........        41 Number of Simulated Conduits......        42
Number of Natural Channels........         0 Number of Junctions...............        39
Number of Storage Junctions.......         0 Number of Weirs...................         0
Number of Orifices................         0 Number of Pumps...................         0
Number of Free Outfalls...........         1 Number of Tide Gate Outfalls......         0
```

```
*=======================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*=======================================================*

The Conduit with the largest average change was..OCA3       with     0.000 percent
The Junction with the largest average change was.A3         with     0.039 percent
The Conduit with the largest sinuosity was.......P3725      with    50.781
```

```
UPGLOW/ORCHARD DESIGN FAIRHAVEN 2 DESIGN EAC 100-YEAR 24-HOUR
Uglow/Orchard Proposed
Current Directory:   P:\dallascityof\496541stormwater\Hydrology\SWMM\Murphys\M
 Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE


 Input File : ogy\SWMM\Murphys\MurphysDesign\Fairhaven2_Design_EAC_100yr24hr.XP

          *==============================================*
          |                   xpswmm                     |
          |     Storm and Wastewater Management Model    |
          |         Developed by XP Solutions Inc.       |
          |==============================================|
          |                                              |
          | Last Update      : Jan., 2013                |
          | Interface Version: 2012                      |
          | Engine Version   : 12.0                      |
          | Data File Version: 12.5                      |
          |                                              |
          |                                              |
          *==============================================*

Engine Name: C:\PROGRA~2\XPSOLU~1\XPSWMM~1\SWMMEN~2.EXE

 ########################################################
 #    Entry made to the Runoff Layer(Block) of SWMM    #
 #    Last Updated Jan., 2013 by XP Solutions          #

 *=========================================================*
 |         RUNOFF TABLES IN THE OUTPUT FILE.               |
 |                                                         |
 | Table R1  - Physical Hydrology Data                     |
 | Table R2  - Infiltration data                           |
 | Table R3  - Raingage and Infiltration Database Names    |
 *=========================================================*

                    A1

###########################################
#             RUNOFF JOB CONTROL          #
###########################################

 Snowmelt parameter - ISNOW......................           0
 Number of rain gages - NRGAG....................           1
 Quality is not simulated - KWALTY...............           0
 Default evaporation rate used - IVAP............           0
 Hour of day at start of storm - NHR.............           0
 Minute of hour at start of storm - NMN..........           0
 Time TZERO at start of storm (hours)............       0.000
 Use U.S. Customary units for most I/O - METRIC...          0
 Runoff input print control...                              0
 Runoff graph plot control....                              0
 Runoff output print control..                              0
 Limit number of groundwater convergence messages to    10000

 Print headers every 50 lines - NOHEAD (0=yes, 1=no)        0

 Print land use load percentages -LANDUPR (0=no, 1=yes)     0
 Month, day, year of start of storm is:            1/ 1/1993
 Wet time step length (seconds).......                  300.0
 Dry time step length (seconds).......                86400.0
 Wet/Dry time step length (seconds)...                  300.0
 Simulation length is......                              24.0 Hours

 If Horton infiltration model is being used
 A mixture of infiltration options may be used in
 XP-SWMM2000 as a watershed specific option.
 Rate for regeneration of infiltration = REGEN * DECAY
 Decay is read in for each subcatchment
 REGEN = ............................................  0.01000


 Raingage #...............................          1
 KTYPE  - Rainfall input type.............          0
 NHISTO - Total number of rainfall values..       240
 KINC   - Rainfall values(pairs) per line..        10
 KPRINT - Print rainfall(0-Yes,1-No).......         0
 KTIME  - Precipitation time units
 0 --> Minutes  1 --> Hours...............          1
 KPREP  - Precipitation unit type
 0 --> Intensity  1 --> Volume............          1
 KTHIS - Variable rainfall intervals
 0 --> No, > 1 --> Yes....................          0
 THISTO - Rainfall time interval..........       0.10
 TZRAIN - Starting time(KTIME units).......      0.00


######################################
# Rainfall input summary from Runoff #
######################################

 Total rainfall for gage #     1 is    6.3000 inches

   ############################
   #        Data Group F1     #
   # Evaporation Rate (in/day) #
   ############################

  JAN.  FEB.  MAR.  APR.  MAY   JUN.  JUL.  AUG.  SEP.  OCT.  NOV  DEC.
  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ---- ----
 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100


  ###################################################
```

```
#  Table R1.  S U B C A T C H M E N T   D A T A    #
#             Physical Hydrology Data               #
####################################################
```

Subcatchment Number	Subcatchment Name	Channel or inlet	Width (ft)	Area (ac)	Per-cent Imperv	Slope ft/ft	"n" Imprv	"n" Perv	Deprs -sion Storge Imprv	Deprs -sion Strge Perv	Prcnt Zero Deten -tion
1	A4C#1	A4C	1000.0	13.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
2	A5E#1	A5E	1000.0	41.400	0.00	1.000	0.020	0.020	0.000	0.000	0.00
3	AB1#1	AB1	1000.0	1.3000	0.00	1.000	0.020	0.020	0.000	0.000	0.00
4	AB2W#1	AB2W	1000.0	24.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
5	AB2E#1	AB2E	1000.0	13.300	0.00	1.000	0.020	0.020	0.000	0.000	0.00
6	A6#1	A6	1000.0	29.800	0.00	1.000	0.020	0.020	0.000	0.000	0.00
7	A5W#1	A5W	1000.0	26.900	0.00	1.000	0.020	0.020	0.000	0.000	0.00
8	A4W#1	A4W	1000.0	24.700	0.00	1.000	0.020	0.020	0.000	0.000	0.00
9	A4E#1	A4E	1000.0	36.000	0.00	1.000	0.020	0.020	0.000	0.000	0.00
10	A3#1	A3	1000.0	35.400	0.00	1.000	0.020	0.020	0.000	0.000	0.00
11	A2#1	A2	1000.0	34.500	0.00	1.000	0.020	0.020	0.000	0.000	0.00
12	A1#1	A1	1000.0	28.800	0.00	1.000	0.020	0.020	0.000	0.000	0.00

```
##########################################################################################################
#          Table R2.  SUBCATCHMENT  DATA                                                                 #
#                     Infiltration or Time of Concentration Data                                         #
#                                                                                                        #
# Infiltration Type       Infl #1(#5)       Infl #2(#6)          Infl #3(#7)            Infl #4(#8)  #
# SCS                   ->   Comp CN           Time Conc         Shape Factor        Depth or Fraction  #
# SBUH                  ->   Comp CN           Time Conc                  N/A                      N/A  #
# Green Ampt            ->   Suction           Hydr Cond           Initial MD                      N/A  #
# Horton                ->  Max Rate            Min Rate    Decay Rate (1/sec)      Max. Infilt. Volume  #
# Proportional          ->  Constant                 N/A                  N/A                      N/A  #
# Initial/Cont Loss     ->   Initial          Continuing                  N/A                      N/A  #
# Initial/Proportional ->   Initial            Constant                  N/A                      N/A  #
# Laurenson Parameters ->   B Value         Pervious "n"      Impervious Cont                 Exponent  #
# Rational Formula      -> Tc Method   Flow Path Length      Flow Path Slope  Roughness or Retardance  #
#                                 (#1 - #4 is Impervious Data / #5 - #8 is Pervious Data)                #
#                       Rational Formula Tc Method: 1 = Constant                                         #
#                                                   2 = Friend's Equation                                #
#                                                   3 = Kinematic Wave                                   #
#                                                   4 = Alameda Method                                   #
#                                                   5 = Izzard's Formula                                 #
#                                                   6 = Kerby's Equation                                 #
#                                                   7 = Kirpich's Equation                               #
#                                                   8 = Bransby Williams Equation                        #
#                                                   9 = Federal Aviation Authority Equation              #
##########################################################################################################
```

Subcatchment Number	Name	Infl # 1	Infl # 2	Infl # 3	Infl # 4	Infl # 5	Infl # 6	Infl # 7	Infl # 8
1	A4C#1	90.2700	0.2000	484.0000	0.2000				
2	A5E#1	90.7200	0.4000	484.0000	0.2000				
3	AB1#1	87.3500	0.5333	484.0000	0.2000				
4	AB2W#1	77.4700	0.3500	484.0000	0.2000				
5	AB2E#1	89.2400	0.2333	484.0000	0.2000				
6	A6#1	88.6800	0.5667	484.0000	0.2000				
7	A5W#1	91.2800	0.4000	484.0000	0.2000				
8	A4W#1	93.3500	0.3833	484.0000	0.2000				
9	A4E#1	89.2500	0.5167	484.0000	0.2000				
10	A3#1	95.9800	0.2167	484.0000	0.2000				
11	A2#1	93.0400	0.3500	484.0000	0.2000				
12	A1#1	88.6600	0.4667	484.0000	0.2000				

```
############################################################
#     Table R3.  SUBCATCHMENT  DATA                        #
#                Rainfall and Infiltration Database Names  #
############################################################
```

Subcatchment Number	Subcatchment Name	Gage No	Infiltration Type	Routing Type
1	A4C#1	1	SCS Method	SCS curvilinear
2	A5E#1	1	SCS Method	SCS curvilinear
3	AB1#1	1	SCS Method	SCS curvilinear
4	AB2W#1	1	SCS Method	SCS curvilinear
5	AB2E#1	1	SCS Method	SCS curvilinear
6	A6#1	1	SCS Method	SCS curvilinear
7	A5W#1	1	SCS Method	SCS curvilinear
8	A4W#1	1	SCS Method	SCS curvilinear
9	A4E#1	1	SCS Method	SCS curvilinear
10	A3#1	1	SCS Method	SCS curvilinear
11	A2#1	1	SCS Method	SCS curvilinear
12	A1#1	1	SCS Method	SCS curvilinear

Total Number of Subcatchments...	12
Total Tributary Area (acres)....	310.90
Impervious Area (acres).........	0.00
Pervious Area (acres)...........	310.90
Total Width (feet)..............	12000.00
Impervious Area (%).............	0.00

```
####################################################
#         S U B C A T C H M E N T   D A T A        #
#   Default, Ratio values for subcatchment data    #
#   Used with the calibrate node in the runoff.    #
# 1 - width     2 - area      3 - impervious %     #
# 4 - slope     5 - imp "n"   6 - perv "n"         #
# 7 - imp ds    8 - perv ds   9 - 1st infil        #
#10 - 2nd infil              11 - 3rd infil        #
####################################################
```

Column	1	2	3	4	5	6	7	8	9	10	11

```
Default     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Ratio       1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000

*********************************************************
*     Arrangement of Subcatchments and Channel/Pipes    *
*********************************************************


    Inlet
A4C            No Tributary Channel/Pipes
               Tributary Subareas........ A4C#1
A5E            No Tributary Channel/Pipes
               Tributary Subareas........ A5E#1
AB1            No Tributary Channel/Pipes
               Tributary Subareas........ AB1#1
AB2W           No Tributary Channel/Pipes
               Tributary Subareas........ AB2W#1
AB2E           No Tributary Channel/Pipes
               Tributary Subareas........ AB2E#1
A6             No Tributary Channel/Pipes
               Tributary Subareas........ A6#1
A5W            No Tributary Channel/Pipes
               Tributary Subareas........ A5W#1
A4W            No Tributary Channel/Pipes
               Tributary Subareas........ A4W#1
A4E            No Tributary Channel/Pipes
               Tributary Subareas........ A4E#1
A3             No Tributary Channel/Pipes
               Tributary Subareas........ A3#1
A2             No Tributary Channel/Pipes
               Tributary Subareas........ A2#1
A1             No Tributary Channel/Pipes
               Tributary Subareas........ A1#1


***********************************************************
* Hydrographs will be stored for the following  12 INLETS *
***********************************************************
A4C       A5E       AB1       AB2W      AB2E      A6
A5W       A4W       A4E       A3        A2        A1


************************************************
*  Quality Simulation not included in this run *
************************************************




***************************************************
*  Precipitation Interface File Summary           *
*  Number of precipitation station....        1   *
***************************************************

Location Station Number
-------- --------------
       1.             1

XXX End of Header Section XXX

#######################################################
#    Entry made to the HYDRAULIC Layer of XP-SWMM     #
#    Last Updated in Jan., 2013 by XP Solutions       #

*=========================================================*
|        SELECTED HYDRAULICS TABLES IN THE OUTPUT FILE              |
|                                                         |
| Table E1   - Basic Conduit Data                         |
| Table E3a  - Junction Data                              |
| Table E4   - Conduit Connectivity Data                  |
| Table E9   - Junction  Summary  Statistics              |
| Table E10  - Conduit   Summary  Statistics              |
| Table E12  - Mean conduit information                   |
| Table E15  - Spreadsheet Info List                      |
| Table E15a - Spreadsheet Reach List                     |
| Table E20  - Junction Flooding and Volume List          |
*=========================================================*

Time Control from Hydraulics Job Control
Year.........    1993 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0


Control information for simulation
----------------------------------

Integration cycles.................       576
Length of integration step is......    300.00 seconds
Simulation length..................     48.00 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.        -1 cycles
Intermediate printout intervals of.     -5.00 minutes
Summary printout intervals of......        -1 cycles
Summary printout time interval of..     -5.00 minutes
Hot start file parameter (REDO)....         0
Initial time.......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00050
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.85000
    Time weighting parameter........   0.85000
    Conduit roughness factor........   1.00000
```

Flow adjustment factor.......... 1.00000
Initial Condition Smoothing..... 0
Courant Time Step Factor........ 1.00000
Default Expansion/Contraction K. 0.00000
Default Entrance/Exit K......... 0.00000
Routing Method.................. Dynamic Wave
Default surface area of junctions... 12.57 square feet.
Minimum Junction/Conduit Depth...... 0.00001 feet.
Ponding Area Coefficient........... 5000.00
Ponding Area Exponent.............. 1.0000
Minimum Orifice Length............. 1000.00 feet.
NJSW input hydrograph junctions..... 0
or user defined hydrographs....

Table E1 - Conduit Data

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes	
1	OCA3	205.0000	Trapezoid	435.0000	0.0350	25.0000	5.0000	12.4000	12.4000
2	OCA5E	1011.9400	Trapezoid	280.0000	0.0350	22.0000	5.0000	6.8000	6.8000
3	PA5	1281.3600	Circular	4.9087	0.0130	2.5000	2.5000		
4	PA3	774.3100	Circular	7.0686	0.0130	3.0000	3.0000		
5	OCA6	996.5300	Trapezoid	595.0000	0.0350	18.0000	5.0000	20.2000	20.2000
6	PA6	277.1800	Circular	0.7854	0.0130	1.0000	1.0000		
7	Link138	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
8	Link139	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
9	Link140	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
10	Link141	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
11	Link142	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
12	Link143	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
13	Link144	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
14	Link145	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
15	OCAB1	336.0000	Trapezoid	595.0000	0.0350	18.0000	5.0000	20.2000	20.2000
16	Link100	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
17	Link102	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
18	Link101	50.0000	Trapezoid	150.0000	0.0350	5.0000	5.0000	5.0000	5.0000
19	PA2E	332.2400	Circular	9.6211	0.0130	3.5000	3.5000		
20	PA2F	577.1700	Circular	9.6211	0.0130	3.5000	3.5000		
21	PA2D	271.1900	Circular	9.6211	0.0130	3.5000	3.5000		
22	P1614	108.1500	Circular	4.9087	0.0130	2.5000	2.5000		
23	P2014A	359.0000	Circular	7.0686	0.0130	3.0000	3.0000		
24	P2026	497.9400	Circular	7.0686	0.0130	3.0000	3.0000		
25	P3626	163.6500	Circular	7.0686	0.0130	3.0000	3.0000		
26	P4227E	93.9300	Circular	7.0686	0.0130	3.0000	3.0000		
27	P2014B	347.9300	Circular	7.0686	0.0130	3.0000	3.0000		
28	P2025	488.1300	Circular	7.0686	0.0130	3.0000	3.0000		
29	P3725	163.6500	Circular	7.0686	0.0130	3.0000	3.0000		
30	P4227W	94.6400	Circular	7.0686	0.0130	3.0000	3.0000		
31	PA2AB	253.8800	Circular	15.9043	0.0130	4.5000	4.5000		
32	PA2C	72.0000	Circular	9.6211	0.0130	3.5000	3.5000		
33	FairC	80.7000	Circular	3.1416	0.0130	2.0000	2.0000		
34	FairW	40.0000	Trapezoid	20.2000	0.0350	0.1000	2.0000	5.0000	5.0000
35	Extg48	144.5800	Circular	12.5664	0.0130	4.0000	4.0000		
36	New36	144.5800	Circular	7.0686	0.0130	3.0000	3.0000		
37	Ext48PA1	1512.7100	Circular	12.5664	0.0130	4.0000	4.0000		
38	New36PA1	1512.7100	Circular	7.0686	0.0140	3.0000	3.0000		
39	Extg	200.0000	Circular	12.5664	0.0130	4.0000	4.0000		
40	New	200.0000	Circular	7.0686	0.0130	3.0000	3.0000		

Total length of all conduits .... 13091.1000 feet

Table E3a - Junction Data

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	A4C	345.3700	345.3700	340.3700	0.0000	0.0000	100.0000
2	AB2E	400.5600	392.5600	387.5600	0.0000	0.0000	100.0000
3	A5E	357.0000	355.7100	350.7100	0.0000	0.0000	100.0000
4	A4E	347.5000	347.5000	342.5000	0.0000	0.0000	100.0000
5	A2	323.2900	323.2900	318.2900	0.0000	0.0000	100.0000
6	AB2W	436.4100	436.4100	431.4100	0.0000	0.0000	100.0000
7	A4W	346.4700	346.4700	341.4700	0.0000	0.0000	100.0000
8	A3	339.5400	339.5400	334.5400	0.0000	0.0000	100.0000
9	A5W	356.5400	356.5400	351.5400	0.0000	0.0000	100.0000
10	BDRY	290.5000	289.5000	285.5000	0.0000	0.0000	100.0000
11	AB1	375.4400	373.5100	368.5100	0.0000	0.0000	100.0000
12	A6	386.1000	386.1000	381.1000	0.0000	0.0000	100.0000
13	A1	294.5500	294.5500	289.5500	0.0000	0.0000	100.0000
14	JAB1	375.4400	375.4400	368.2600	0.0000	0.0000	100.0000
15	JA5	357.0000	356.2900	351.2900	0.0000	0.0000	100.0000
16	JA4	342.6900	342.4600	337.4600	0.0000	0.0000	100.0000
17	JA3	339.2900	339.2900	333.0700	0.0000	0.0000	100.0000
18	JA2	323.0400	323.0400	318.0400	0.0000	0.0000	100.0000
19	JA1	294.3000	294.3000	289.3000	0.0000	0.0000	100.0000
20	JAB2	397.4100	390.0000	385.0000	0.0000	0.0000	100.0000
21	FairDS	375.4400	375.4400	367.8000	0.0000	0.0000	100.0000
22	AB2EDS	400.3100	392.3100	387.3100	0.0000	0.0000	100.0000
23	A6DS	385.8500	385.8500	380.8500	0.0000	0.0000	100.0000
24	A4EDS	347.2500	347.2500	342.2500	0.0000	0.0000	100.0000
25	MH2938	324.5000	323.5000	319.5000	0.0000	0.0000	100.0000
26	MH1038	330.6600	329.1600	325.6600	0.0000	0.0000	100.0000
27	MH0431	336.2100	332.2300	328.7300	0.0000	0.0000	100.0000
28	JA2D	336.4100	334.5800	331.0800	0.0000	0.0000	100.0000
29	JA2CA	337.7600	336.3000	331.8000	0.0000	0.0000	100.0000
30	MH2014	355.4600	355.4600	349.0600	0.0000	0.0000	100.0000
31	MH2026	350.4000	348.0000	344.4000	0.0000	0.0000	100.0000
32	MH2025	350.0000	349.2700	344.2200	0.0000	0.0000	100.0000
33	MH3626	350.1200	345.1200	338.0700	0.0000	0.0000	100.0000
34	MH3725	345.3900	341.0100	338.0100	0.0000	0.0000	100.0000

35	MH4227W	346.2200	346.2200	338.0100	0.0000	0.0000	100.0000
36	MH4227E	346.1800	341.1000	338.0100	0.0000	0.0000	100.0000

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	OCA3	JA4	JA3	337.4600	333.0700	No Design
2	OCA5E	FairDS	JA5	367.8000	351.2900	No Design
3	PA5	A6DS	JA5	380.8500	351.2900	No Design
4	PA3	A4EDS	MH4227E	342.2500	338.1000	No Design
5	OCA6	AB2W	JAB2	431.4100	385.0000	No Design
6	PA6	AB2EDS	JAB2	387.3100	385.0000	No Design
7	Link138	AB1	JAB1	368.5100	368.2600	No Design
8	Link139	A5W	JA5	351.5400	351.2900	No Design
9	Link140	A5E	MH2014	350.7100	350.4600	No Design
10	Link141	A4C	MH3626	340.3700	340.1200	No Design
11	Link142	A4W	MH4227W	341.4700	341.2200	No Design
12	Link143	A3	JA3	334.5400	334.2900	No Design
13	Link144	A2	JA2	318.2900	318.0400	No Design
14	Link145	A1	JA1	289.5500	289.3000	No Design
15	OCAB1	JAB2	JAB1	385.0000	368.2600	No Design
16	Link100	AB2E	AB2EDS	387.5600	387.3100	No Design
17	Link102	A4E	A4EDS	342.5000	342.2500	No Design
18	Link101	A6	A6DS	381.1000	380.8500	No Design
19	PA2E	MH0431	MH1038	328.7300	325.6600	No Design
20	PA2F	MH1038	MH2938	325.6600	319.5000	No Design
21	PA2D	JA2D	MH0431	331.0800	328.7300	No Design
22	P1614	JA5	MH2014	351.2900	349.8600	No Design
23	P2014A	MH2014	MH2026	349.0600	345.0000	No Design
24	P2026	MH2026	MH3626	344.4000	338.0700	No Design
25	P3626	MH3626	MH4227E	338.0700	338.0100	No Design
26	P4227E	MH4227E	JA4	338.0100	337.4600	No Design
27	P2014B	MH2014	MH2025	349.0600	346.2700	No Design
28	P2025	MH2025	MH3725	344.2200	338.0100	No Design
29	P3725	MH3725	MH4227W	338.0100	338.0100	No Design
30	P4227W	MH4227W	JA4	338.0100	337.4600	No Design
31	PA2AB	JA3	JA2CA	333.0700	331.8000	No Design
32	PA2C	JA2CA	JA2D	331.8000	331.0800	No Design
33	FairC	JAB1	FairDS	368.2600	367.8000	No Design
34	FairW	JAB1	FairDS	373.4400	373.4400	No Design
35	Extg48	MH2938	JA2	319.5000	318.0400	No Design
36	New36	MH2938	JA2	319.5000	318.0400	No Design
37	Ext48PA1	JA2	JA1	318.0400	289.3000	No Design
38	New36PA1	JA2	JA1	318.0400	289.3000	No Design
39	Extg	JA1	BDRY	289.3000	285.5000	No Design
40	New	JA1	BDRY	289.3000	285.5000	No Design

FREE OUTFALL DATA (DATA GROUP I1)
BOUNDARY CONDITION ON DATA GROUP J1

Outfall at Junction....BDRY has boundary condition number... 1

===> Warning !! Outfall Junction BDRY has two or more connecting conduits.

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
FREE # 1	BDRY	BOUNDARY

Boundary Condition Information
Data Groups J1-J4

BC NUMBER.. 1 has no control water surface.

Conduit Convergence Criteria

Conduit Name	Full Flow	Conduit Slope
OCA3	5510.8191	0.0214
OCA5E	3218.6373	0.0163
PA5	62.2991	0.0231
PA3	48.8295	0.0054
OCA6	10574.6457	0.0466
PA6	3.2525	0.0083
Link138	868.6535	0.0050
Link139	868.6535	0.0050
Link140	868.6535	0.0050
Link141	868.6535	0.0050
Link142	868.6535	0.0050
Link143	868.6535	0.0050
Link144	868.6535	0.0050
Link145	868.6535	0.0050
OCAB1	10937.3804	0.0498
Link100	868.6535	0.0050
Link102	868.6535	0.0050
Link101	868.6535	0.0050
PA2E	96.7127	0.0092

PA2F	103.9390	0.0107
PA2D	93.6563	0.0087
P1614	47.1650	0.0132
P2014A	70.9302	0.0113
P2026	75.2019	0.0127
P3626	12.7712	0.0004
P4227E	51.0381	0.0059
P2014B	59.7271	0.0080
P2025	75.2304	0.0127
P3725	2.1092	0.0000
P4227W	50.8463	0.0058
PA2AB	139.0848	0.0050
PA2C	100.6098	0.0100
FairC	17.0797	0.0057
FairW	2.6859	0.0000
Extg48	144.3470	0.0101
New36	67.0251	0.0101
Ext48PA1	197.9935	0.0190
New36PA1	85.3682	0.0190
Extg	197.9986	0.0190
New	91.9374	0.0190

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*=====================================================*
|      Table E9 - JUNCTION SUMMARY STATISTICS         |
| The Maximum area is only the area of the node, it   |
| does not include the area of the surrounding conduits|
*=====================================================*
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Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
A4C	345.3700	345.3700	345.3700	8	9	0.0000	0.0000	12.5660	0.0000	0.0000	0.0000
AB2E	400.5600	392.5600	398.2009	10	9	5.6409	2.3591	12.5660	0.0000	0.0000	0.0000
A5E	357.0000	355.7100	352.1125	8	10	0.0000	4.8875	12.5660	0.0000	0.0000	0.0000
A4E	347.5000	347.5000	346.5624	8	23	0.0000	0.9376	12.5660	0.0000	0.0000	0.0000
A2	323.2900	323.2900	320.9844	8	17	0.0000	2.3056	12.5660	0.0000	0.0000	0.0000
AB2W	436.4100	436.4100	431.6800	8	12	0.0000	4.7300	12.5660	0.0000	0.0000	0.0000
A4W	346.4700	346.4700	342.9875	8	17	0.0000	3.4825	12.5660	0.0000	0.0000	0.0000
A3	339.5400	339.5400	338.4495	8	20	0.0000	1.0905	12.5660	0.0000	0.0000	0.0000
A5W	356.5400	356.5400	355.9978	8	31	0.0000	0.5422	12.5660	0.0000	0.0000	0.0000
BDRY	290.5000	289.5000	288.8330	8	17	0.0000	1.6670	12.5660	0.0000	0.0000	0.0000
AB1	375.4400	373.5100	371.5106	8	26	0.0000	3.9294	12.5660	0.0000	0.0000	0.0000
A6	386.1000	386.1000	382.3150	8	20	0.0000	3.7850	12.5660	0.0000	0.0000	0.0000
A1	294.5500	294.5500	292.6352	8	17	0.0000	1.9148	12.5660	0.0000	0.0000	0.0000
JAB1	375.4400	375.4400	371.5105	8	26	0.0000	3.9295	12.5660	0.0000	0.0000	0.0000
JA5	357.0000	356.2900	355.9978	8	31	0.0000	1.0022	12.5660	0.0000	0.0000	0.0000
JA4	342.6900	342.4600	338.4629	8	18	0.0000	4.2271	12.5660	0.0000	0.0000	0.0000
JA3	339.2900	339.2900	338.4490	8	20	0.0000	0.8410	12.5660	0.0000	0.0000	0.0000
JA2	323.0400	323.0400	320.9786	8	17	0.0000	2.0614	12.5660	0.0000	0.0000	0.0000
JA1	294.3000	294.3000	292.6332	8	17	0.0000	1.6668	12.5660	0.0000	0.0000	0.0000
JAB2	397.4100	390.0000	385.2942	8	14	0.0000	12.1158	12.5660	0.0000	0.0000	0.0000
FairDS	375.4400	375.4400	368.1632	8	31	0.0000	7.2768	12.5660	0.0000	0.0000	0.0000
AB2EDS	400.3100	392.3100	398.2009	10	10	5.8909	2.1091	12.5660	0.0000	0.0000	0.0000
A6DS	385.8500	385.8500	382.1212	8	20	0.0000	3.7288	12.5660	0.0000	0.0000	0.0000
A4EDS	347.2500	347.2500	346.5617	8	23	0.0000	0.6883	12.5660	0.0000	0.0000	0.0000
MH2938	324.5000	323.5000	322.7166	8	18	0.0000	1.7834	12.5660	0.0000	0.0000	0.0000
MH1038	330.6600	329.1600	328.9202	8	22	0.0000	1.7398	12.5660	0.0000	0.0000	0.0000
MH0431	336.2100	332.2300	332.5897	8	21	0.3597	3.6203	12.5660	0.0000	0.0000	0.0000
JA2D	336.4100	334.5800	335.8166	8	21	1.2366	0.5934	12.5660	0.0000	0.0000	0.0000
JA2CA	337.7600	336.3000	336.7049	8	21	0.4049	1.0551	12.5660	0.0000	0.0000	0.0000
MH2014	355.4600	355.4600	351.6014	8	19	0.0000	3.8586	12.5660	0.0000	0.0000	0.0000
MH2026	350.4000	348.0000	349.0956	8	19	1.0956	1.3044	12.5660	0.0000	0.0000	0.0000
MH2025	350.0000	349.2700	348.3945	8	17	0.0000	1.6055	12.5660	0.0000	0.0000	0.0000
MH3626	350.1200	345.1200	345.3743	8	9	0.2543	4.7457	12.5660	0.0000	0.0000	0.0000
MH3725	345.3900	341.0100	344.3104	8	17	3.3004	1.0796	12.5660	0.0000	0.0000	0.0000
MH4227W	346.2200	346.2200	342.9402	8	17	0.0000	3.2798	12.5660	0.0000	0.0000	0.0000
MH4227E	346.1800	341.1000	343.9499	8	25	2.8499	2.2301	12.5660	0.0000	0.0000	0.0000

```
*=====================================================*
|      Table E10 - CONDUIT SUMMARY STATISTICS         |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the  |
| downstream boundary conditions.                     |
|                                                     |
| * denotes an open conduit that has been overtopped  |
|   this is a potential source of severe errors       |
*=====================================================*
```

Conduit Name	Design Flow (cfs)	Conduit Design Velocity (ft/s)	Maximum Vertical Depth (in)	Maximum Computed Flow (cfs)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (ft/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (ft)	Dwnstrm (ft)	Ratio d/D US	DS	
OCA3	5510.819	12.6685	64.5480	192.8427	8	18	0.9162	10	22	0.0350	338.4629	338.4490	0.186	1.000	*
OCA5E	3218.637	11.4951	60.0000	22.9781	8	31	0.5640	24	8	0.0071	368.1632	355.9978	0.073	0.942	
PA5	62.2991	12.6915	30.0000	32.0224	8	20	8.8978	8	20	0.5140	382.1212	355.9978	0.508	1.883	
PA3	48.8295	6.9080	36.0000	38.9441	8	23	5.4861	8	23	0.7976	346.5617	343.9499	1.437	1.950	
OCA6	10574.65	17.7725	60.0000	21.0834	8	12	3.1759	8	11	0.0020	431.6800	385.2942	0.054	0.059	
PA6	3.2525	4.1412	12.0000	4.4937	8	20	8.3448	8	24	1.3816	398.2009	385.2942	10.89	0.294	
Link138	868.6535	5.7910	60.0000	1.6504	8	51	0.0690	25	35	0.0019	371.5106	371.5105	0.600	0.650	
Link139	868.6535	5.7910	60.0000	31.5150	8	15	0.8233	7	51	0.0363	355.9978	355.9978	0.892	0.942	
Link140	868.6535	5.7910	60.0000	50.5968	8	10	3.5979	8	10	0.0582	352.1125	351.6014	0.281	0.228	
Link141	868.6535	5.7910	63.0602	14.7660	8	9	1.7992	7	20	0.0170	345.3700	345.3743	0.951	1.000	
Link142	868.6535	5.7910	60.0000	31.4145	8	11	3.0990	8	5	0.0362	342.9874	342.9402	0.303	0.344	
Link143	868.6535	5.7910	60.0000	49.2753	8	5	2.1220	5	17	0.0567	338.4495	338.4490	0.782	0.832	
Link144	868.6535	5.7910	60.0000	44.7611	8	9	1.1760	7	55	0.0515	320.9844	320.9786	0.539	0.588	
Link145	868.6535	5.7910	60.0000	32.7711	8	15	0.6229	8	58	0.0377	292.6352	292.6332	0.617	0.667	
OCAB1	10937.38	18.3822	60.0000	25.4602	8	14	0.4211	1	40	0.0023	385.2942	371.5105	0.059	0.650	
Link100	868.6535	5.7910	130.6905	11.1017	8	4	0.6232	1	40	0.0128	398.2009	398.2009	0.977	1.000	*
Link102	868.6535	5.7910	60.0000	39.4650	8	20	1.5087	8	56	0.0454	346.5624	346.5617	0.812	0.862	
Link101	868.6535	5.7910	60.0000	32.0889	8	20	2.3106	8	19	0.0369	382.3150	382.1212	0.243	0.254	
PA2E	96.7127	10.0521	42.0000	111.9961	8	21	11.8504	8	8	1.1580	332.5897	328.9202	1.103	0.931	
PA2F	103.9390	10.8032	42.0000	112.0037	8	23	12.2560	8	37	1.0776	328.9202	322.7166	0.931	0.919	

PA2D	93.6563	9.7344	42.0000	112.0300	8	20	11.4156	8	18	1.1962	335.8166	332.5897	1.353	1.103
P1614	47.1650	9.6084	30.0000	75.4479	8	31	15.3228	8	31	1.5997	355.9978	352.3600	1.883	1.000
P2014A	70.9302	10.0346	36.0000	58.0942	8	19	10.9254	8	1	0.8190	351.6014	349.0956	0.847	1.365
P2026	75.2019	10.6389	36.0000	58.0950	8	19	8.1691	8	19	0.7725	349.0956	345.3743	1.565	2.435
P3626	12.7712	1.8068	36.0000	67.7490	8	9	9.5123	8	9	5.3048	345.3743	343.9499	2.435	1.980
P4227E	51.0381	7.2204	36.0000	101.6575	8	21	21.0084	8	23	1.9918	343.9499	338.4629	1.980	0.334
P2014B	59.7271	8.4497	36.0000	61.3877	8	19	9.6421	8	20	1.0278	351.6014	348.7952	0.847	0.842
P2025	75.2304	10.6429	36.0000	61.3988	8	19	9.0481	8	37	0.8161	348.3945	344.3103	1.391	2.100
P3725	2.1092	0.0000	36.0000	61.4117	8	20	8.6399	8	20	29.1163	344.3104	342.9402	2.100	1.643
P4227W	50.8463	7.1933	36.0000	91.5130	8	17	18.9247	8	17	1.7998	342.9402	338.4629	1.643	0.334
PA2AB	139.0848	8.7451	54.0000	112.1500	8	11	7.1842	8	6	0.8063	338.4490	336.7049	1.195	1.090
PA2C	100.6098	10.4572	42.0000	112.0349	8	20	11.6165	8	20	1.1136	336.7049	335.8166	1.401	1.353
FairC	17.0797	5.4366	24.0000	23.0877	8	27	12.0891	8	27	1.3518	371.5105	368.1632	1.625	0.182
FairW	2.6859	0.0000	24.0000	0.0000	0	0	0.0000	0	0	0.0000	368.1632	368.1632	.0000	.0000
Extg48	144.3470	11.4868	48.0000	147.6979	8	19	14.4279	8	36	1.0232	322.7166	320.9786	0.804	0.735
New36	67.0251	9.4821	36.0000	78.0724	8	30	11.7625	8	45	1.1648	322.7166	320.9786	1.072	0.980
Ext48PA1	197.9935	15.7558	48.0000	175.9741	8	17	16.8013	8	17	0.8888	320.9786	292.6332	0.735	0.833
New36PA1	85.3682	12.0771	36.0000	89.9465	8	35	13.4739	8	42	1.0536	320.9786	292.6332	0.980	1.111
Extg	197.9986	15.7562	48.0000	200.7095	8	17	17.9600	8	25	1.0137	292.6332	288.8330	0.833	0.833
New	91.9374	13.0065	36.0000	98.7612	8	5	14.8256	8	47	1.0742	292.6332	288.8330	1.111	1.111
FREE # 1	Undefnd	Undefnd	Undefn	296.7518	8	17								

==
| Table E12. Mean Conduit Flow Information |
==

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
OCA3	21.6836	3746926.6	0.0001	0.9969	0.2329	0.7522	54.4111	0.0350
OCA5E	3.5159	607549.45	0.0000	0.9903	0.1606	0.4986	20.8027	0.0350
PA5	2.9942	517400.04	0.0000	0.9569	0.9623	0.3917	1.3394	0.0130
PA3	3.7083	640801.12	0.0000	0.9729	0.7679	0.5317	2.4262	0.0130
OCA6	1.9136	330672.11	0.0000	0.9514	0.7553	0.1002	2.3852	0.0350
PA6	1.4722	254392.00	0.0000	0.9609	3.0098	0.1670	0.4397	0.0130
Link138	0.1290	22291.920	0.0000	0.9696	0.0051	0.6155	10.8223	0.0350
Link139	2.8997	501063.85	0.0000	0.9796	0.1037	0.6798	14.8857	0.0350
Link140	4.4069	761516.52	0.0000	0.9922	0.6167	0.3585	4.0902	0.0350
Link141	1.4264	246473.67	0.0000	0.9922	0.5491	0.3779	10.9468	0.0350
Link142	2.7288	471540.07	0.0000	0.9973	0.6090	0.2970	3.0936	0.0350
Link143	4.1663	719939.65	0.0000	0.9993	0.4058	0.5247	10.6525	0.0350
Link144	3.8630	667523.67	0.0000	0.9809	0.1295	0.6333	11.1568	0.0350
Link145	2.9483	509459.51	0.0000	0.9737	0.0887	0.6537	12.0578	0.0350
OCAB1	3.3871	585295.77	0.0000	0.9905	0.1512	0.3726	23.7572	0.0350
Link100	1.4226	245829.17	0.0013	0.9870	0.0143	3.5990	339.6825	0.0350
Link102	3.7083	640792.11	0.0000	0.9725	0.2383	0.5047	8.9774	0.0350
Link101	2.9945	517449.61	0.0000	0.9801	0.3470	0.3528	3.9205	0.0350
PA2E	25.8518	4467182.9	0.0001	0.9992	1.4302	0.6269	3.0528	0.0130
PA2F	25.8534	4467471.7	0.0000	0.9991	1.4588	0.6235	2.9856	0.0130
PA2D	25.8510	4467057.2	0.0000	0.9992	1.3393	0.6352	3.1563	0.0130
P1614	9.4105	1626136.2	0.0000	0.9941	1.6790	0.5151	2.0650	0.0130
P2014A	7.4361	1284962.6	0.0000	0.9941	1.6844	0.4932	1.9508	0.0130
P2026	7.4369	1285103.1	0.0000	0.9940	0.8986	0.5989	3.0114	0.0130
P3626	8.8627	1531472.5	0.0000	0.9941	0.5732	0.7207	4.0141	0.0130
P4227E	12.5715	2172361.7	0.0000	0.9925	2.7426	0.4963	2.3020	0.0130
P2014B	6.3823	1102865.2	0.0000	0.9941	1.4306	0.4961	1.9176	0.0130
P2025	6.3834	1103045.5	0.0000	0.9938	0.8786	0.5657	2.6053	0.0130
P3725	6.3833	1103038.0	0.0000	0.9973	0.5132	0.6738	3.4076	0.0130
P4227W	9.1125	1574647.0	0.0000	0.9973	2.4388	0.4649	1.9425	0.0130
PA2AB	25.8507	4467002.1	0.0001	0.9992	0.8907	0.7873	5.1190	0.0130
PA2C	25.8505	4466964.5	0.0000	0.9992	1.3980	0.6252	3.0807	0.0130
FairC	3.5162	607600.66	0.0000	0.9901	2.9547	0.3072	0.9674	0.0130
FairW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0350
Extg48	14.7335	2545950.6	0.0001	0.9991	1.6072	0.6364	3.1779	0.0130
New36	11.1199	1921510.6	0.0000	0.9991	1.5120	0.5814	2.5767	0.0130
Ext48PA1	17.3737	3002173.9	0.0001	0.9990	1.9884	0.6160	3.0154	0.0130
New36PA1	12.3461	2133398.4	0.0000	0.9990	1.7494	0.5654	2.4502	0.0140
Extg	18.6540	3223403.2	0.0001	0.9989	2.3146	0.6245	3.1046	0.0130

New	14.0135	2421524.2	0.0000	0.9989	2.1479	0.5698	2.5091	0.0130
FREE # 1	32.6695	5645294.4						

```
*=======================================================*
|     Table E15 - SPREADSHEET INFO LIST                 |
| Conduit Flow and Junction Depth Information for use in |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the       |
| maximum of a subset of all the time steps in the run.  |
| Note: These flows are only the flows in a single barrel.|
*=======================================================*
```

Conduit Name	Maximum Flow (cfs)	Total Flow (ft^3)	Maximum Velocity (ft/s)	Maximum Volume (ft^3)	##	Junction Name	Invert Elevation (ft)	Maximum Elevation (ft)
OCA3	192.8427	3746926.640	0.9162	45542.2178	##	A4C	340.3700	345.3700
OCA5E	22.9781	607549.4536	0.5640	29837.2302	##	AB2E	387.5600	398.2009
PA5	32.0224	517400.0376	8.8978	859.0521	##	A5E	350.7100	352.1125
PA3	38.9441	640801.1180	5.4861	5533.3153	##	A4E	342.5000	346.5624
OCA6	21.0834	330672.1083	3.1759	42.1631	##	A2	318.2900	320.9844
PA6	4.4937	254391.9956	8.3448	16.6955	##	AB2W	431.4100	431.6800
Link138	1.6504	22291.9197	0.0690	3213.6822	##	A4W	341.4700	342.9875
Link139	31.5150	501063.8478	0.8233	6389.8527	##	A3	334.5400	338.4495
Link140	50.5968	761516.5196	3.5979	708.6124	##	A5W	351.5400	355.9978
Link141	14.7660	246473.6659	1.7992	7849.1441	##	BDRY	285.5000	288.8330
Link142	31.4145	471540.0659	3.0990	1008.8761	##	AB1	368.5100	371.5106
Link143	49.2753	719939.6474	2.1220	5074.2346	##	A6	381.1000	382.3150
Link144	44.7611	667523.6727	1.1760	2669.3074	##	A1	289.5500	292.6352
Link145	32.7711	509459.5146	0.6229	3359.1189	##	JAB1	368.2600	371.5105
OCAB1	25.4602	585295.7732	0.4211	6933.1339	##	JA5	351.2900	355.9978
Link100	11.1017	245829.1679	0.6232	31668.9508	##	JA4	337.4600	338.4629
Link102	39.4650	640792.1146	1.5087	5414.9346	##	JA3	333.0700	338.4490
Link101	32.0889	517449.6078	2.3106	696.4182	##	JA2	318.0400	320.9786
PA2E	111.9961	4467182.889	11.8504	6423.5632	##	JA1	289.3000	292.6332
PA2F	112.0037	4467471.713	12.2560	5589.5211	##	JAB2	385.0000	385.2942
PA2D	112.0300	4467057.199	11.4156	5294.1053	##	FairDS	367.8000	368.1632
P1614	75.4479	1626136.221	15.3228	536.7437	##	AB2EDS	387.3100	398.2009
P2014A	58.0942	1284962.632	10.9254	2450.5668	##	A6DS	380.8500	382.1212
P2026	58.0950	1285103.090	8.1691	3566.0465	##	A4EDS	342.2500	346.5617
P3626	67.7490	1531472.459	9.5123	1189.9719	##	MH2938	319.5000	322.7166
P4227E	101.6575	2172361.701	21.0084	407.6675	##	MH1038	325.6600	328.9202
P2014B	61.3877	1102865.160	9.6421	2004.5305	##	MH0431	328.7300	332.5897
P2025	61.3988	1103045.493	9.0481	3470.4328	##	JA2D	331.0800	335.8166
P3725	61.4117	1103038.031	8.6399	1201.0988	##	JA2CA	331.8000	336.7049
P4227W	91.5130	1574646.997	18.9247	410.3242	##	MH2014	349.0600	351.6014
PA2AB	112.1500	4467002.055	7.1842	7945.3632	##	MH2026	344.4000	349.0956
PA2C	112.0349	4466964.459	11.6165	1294.4609	##	MH2025	344.2200	348.3945
FairC	23.0877	607600.6627	12.0891	98.8185	##	MH3626	338.0700	345.3743
FairW	0.0000	0.0000	0.0000	0.0004	##	MH3725	338.0100	344.3104
Extg48	147.6979	2545950.578	14.4279	1493.7977	##	MH4227W	338.0100	342.9402
New36	78.0724	1921510.562	11.7625	1034.4797	##	MH4227E	338.0100	343.9499
Ext48PA1	175.9741	3002173.940	16.8013	1835.6971	##			
New36PA1	89.9465	2133398.445	13.4739	1261.3433	##			
Extg	200.7095	3223403.244	17.9600	1950.7052	##			
New	98.7612	2421524.217	14.8256	1290.4362	##			
FREE # 1	296.7518	5645294.371	0.0000	0.0000	##			

```
*=================================================*
|     Table E15a - SPREADSHEET REACH LIST          |
| Peak flow and Total Flow listed by Reach or those |
```

```
|      conduits or diversions having the same        |
|      upstream and downstream nodes.                |
*====================================================*
```

Upstream Node	Downstream Node	Maximum Flow (cfs)	Total Flow (ft^3)
JA4	JA3	192.8427	3746926.64
FairDS	JA5	22.9781	607549.454
A6DS	JA5	32.0224	517400.038
A4EDS	MH4227E	38.9441	640801.118
AB2W	JAB2	21.0834	330672.108
AB2EDS	JAB2	4.4937	254391.996
AB1	JAB1	1.6504	22291.9197
A5W	JA5	31.5150	501063.848
A5E	MH2014	50.5968	761516.520
A4C	MH3626	14.7660	246473.666
A4W	MH4227W	31.4145	471540.066
A3	JA3	49.2753	719939.647
A2	JA2	44.7611	667523.673
A1	JA1	32.7711	509459.515
JAB2	JAB1	25.4602	585295.773
AB2E	AB2EDS	11.1017	245829.168
A4E	A4EDS	39.4650	640792.115
A6	A6DS	32.0889	517449.608
MH0431	MH1038	223.9921	4467182.89
MH1038	MH2938	224.0073	4467471.71
JA2D	MH0431	224.0600	4467057.20
JA5	MH2014	75.4479	1626136.22
MH2014	MH2026	58.0942	1284962.63
MH2026	MH3626	58.0950	1285103.09
MH3626	MH4227E	67.7490	1531472.46
MH4227E	JA4	101.6575	2172361.70
MH2014	MH2025	61.3877	1102865.16
MH2025	MH3725	61.3988	1103045.49
MH3725	MH4227W	61.4117	1103038.03
MH4227W	JA4	91.5130	1574647.00
JA3	JA2CA	224.3001	4467002.06
JA2CA	JA2D	224.0698	4466964.46
JAB1	FairDS	23.0877	607600.663
MH2938	JA2	224.1788	4467461.14
JA2	JA1	264.1449	5135572.39
JA1	BDRY	296.7518	5644927.46

```
#########################################################
# Table E16. New Conduit Information Section            #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#########################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
OCA3	JA4	JA3	337.4600	333.0700	338.4629	338.4490	Trapezoid
OCA5E	FairDS	JA5	367.8000	351.2900	368.1632	355.9978	Trapezoid
PA5	A6DS	JA5	380.8500	351.2900	382.1212	355.9978	Circular
PA3	A4EDS	MH4227E	342.2500	338.1000	346.5617	343.9499	Circular
OCA6	AB2W	JAB2	431.4100	385.0000	431.6800	385.2942	Trapezoid
PA6	AB2EDS	JAB2	387.3100	385.0000	398.2009	385.2942	Circular
Link138	AB1	JAB1	368.5100	368.2600	371.5106	371.5105	Trapezoid
Link139	A5W	JA5	351.5400	351.2900	355.9978	355.9978	Trapezoid
Link140	A5E	MH2014	350.7100	350.4600	352.1125	351.6014	Trapezoid

Link141	A4C	MH3626	340.3700	340.1200	345.3700	345.3743	Trapezoid
Link142	A4W	MH4227W	341.4700	341.2200	342.9874	342.9402	Trapezoid
Link143	A3	JA3	334.5400	334.2900	338.4495	338.4490	Trapezoid
Link144	A2	JA2	318.2900	318.0400	320.9844	320.9786	Trapezoid
Link145	A1	JA1	289.5500	289.3000	292.6352	292.6332	Trapezoid
OCAB1	JAB2	JAB1	385.0000	368.2600	385.2942	371.5105	Trapezoid
Link100	AB2E	AB2EDS	387.5600	387.3100	398.2009	398.2009	Trapezoid
Link102	A4E	A4EDS	342.5000	342.2500	346.5624	346.5617	Trapezoid
Link101	A6	A6DS	381.1000	380.8500	382.3150	382.1212	Trapezoid
PA2E	MH0431	MH1038	328.7300	325.6600	332.5897	328.9202	Circular
PA2F	MH1038	MH2938	325.6600	319.5000	328.9202	322.7166	Circular
PA2D	JA2D	MH0431	331.0800	328.7300	335.8166	332.5897	Circular
P1614	JA5	MH2014	351.2900	349.8600	355.9978	352.3600	Circular
P2014A	MH2014	MH2026	349.0600	345.0000	351.6014	349.0956	Circular
P2026	MH2026	MH3626	344.4000	338.0700	349.0956	345.3743	Circular
P3626	MH3626	MH4227E	338.0700	338.0100	345.3743	343.9499	Circular
P4227E	MH4227E	JA4	338.0100	337.4600	343.9499	338.4629	Circular
P2014B	MH2014	MH2025	349.0600	346.2700	351.6014	348.7952	Circular
P2025	MH2025	MH3725	344.2200	338.0100	348.3945	344.3103	Circular
P3725	MH3725	MH4227W	338.0100	338.0100	344.3104	342.9402	Circular
P4227W	MH4227W	JA4	338.0100	337.4600	342.9402	338.4629	Circular
PA2AB	JA3	JA2CA	333.0700	331.8000	338.4490	336.7049	Circular
PA2C	JA2CA	JA2D	331.8000	331.0800	336.7049	335.8166	Circular
FairC	JAB1	FairDS	368.2600	367.8000	371.5105	368.1632	Circular
FairW	JAB1	FairDS	373.4400	373.4400	368.1632	368.1632	Trapezoid
Extg48	MH2938	JA2	319.5000	318.0400	322.7166	320.9786	Circular
New36	MH2938	JA2	319.5000	318.0400	322.7166	320.9786	Circular
Ext48PA1	JA2	JA1	318.0400	289.3000	320.9786	292.6332	Circular
New36PA1	JA2	JA1	318.0400	289.3000	320.9786	292.6332	Circular
Extg	JA1	BDRY	289.3000	285.5000	292.6332	288.8330	Circular
New	JA1	BDRY	289.3000	285.5000	292.6332	288.8330	Circular

```
*====================================================*
| Table E20 - Junction Flooding and Volume Listing.   |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max   |
|             volume at any time. The volume in the   |
|             flooded storage area is the total volume|
|             above the ground elevation, where the   |
|             flooded pond storage area starts.       |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*====================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of 1D-System (Flooded Volume)	Maximum Volume	Passed to 2D cell OR Volume Stored in allowed Flood Pond of 1D-System
A4C	0.0000	23.6075	7091.1824	62.8300	0.0000
AB2E	995.3378	0.0000	0.0000	133.7136	0.0000
A5E	0.0000	0.0000	0.0000	17.6240	0.0000
A4E	0.0000	0.0000	0.0000	51.0485	0.0000
A2	0.0000	0.0000	0.0000	33.8573	0.0000
AB2W	0.0000	0.0000	0.0000	3.3933	0.0000
A4W	0.0000	0.0000	0.0000	19.0681	0.0000
A3	0.0000	0.0000	0.0000	49.1262	0.0000
A5W	0.0000	0.0000	0.0000	56.0171	0.0000
BDRY	0.0000	0.0000	0.0000	41.8830	0.0000
AB1	0.0000	0.0000	0.0000	37.7050	0.0000
A6	0.0000	0.0000	0.0000	15.2677	0.0000

A1	0.0000	0.0000	0.0000	38.7688	0.0000
JAB1	0.0000	0.0000	0.0000	40.8462	0.0000
JA5	0.0000	0.0000	0.0000	59.1578	0.0000
JA4	0.0000	0.0000	0.0000	12.6028	0.0000
JA3	0.0000	0.0000	0.0000	67.5928	0.0000
JA2	0.0000	0.0000	0.0000	36.9261	0.0000
JA1	0.0000	0.0000	0.0000	41.8852	0.0000
JAB2	0.0000	0.0000	0.0000	3.6967	0.0000
FairDS	0.0000	0.0000	0.0000	4.5636	0.0000
AB2EDS	1008.0000	0.0000	0.0000	136.8551	0.0000
A6DS	0.0000	0.0000	0.0000	15.9734	0.0000
A4EDS	0.0000	0.0000	0.0000	54.1807	0.0000
MH2938	0.0000	0.0000	0.0000	40.4195	0.0000
MH1038	0.0000	0.0000	0.0000	40.9671	0.0000
MH0431	22.9081	0.0000	0.0000	48.5008	0.0000
JA2D	27.7902	0.0000	0.0000	59.5207	0.0000
JA2CA	20.0153	0.0000	0.0000	61.6355	0.0000
MH2014	0.0000	0.0000	0.0000	31.9357	0.0000
MH2026	41.2755	0.0000	0.0000	59.0054	0.0000
MH2025	0.0000	0.0000	0.0000	52.4567	0.0000
MH3626	34.2914	0.0000	0.0000	91.7856	0.0000
MH3725	62.7168	0.0000	0.0000	79.1713	0.0000
MH4227W	0.0000	0.0000	0.0000	61.9533	0.0000
MH4227E	79.9877	0.0000	0.0000	74.6406	0.0000

```
*==================================*
| Simulation Specific Information  |
*==================================*
Number of Input Conduits..........        40 Number of Simulated Conduits......        41
Number of Natural Channels........         0 Number of Junctions...............        36
Number of Storage Junctions.......         0 Number of Weirs...................         0
Number of Orifices................         0 Number of Pumps...................         0
Number of Free Outfalls...........         1 Number of Tide Gate Outfalls......         0

*=========================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*=========================================================*

The Conduit with the largest average change was..Link100    with     0.001 percent
The Junction with the largest average change was.AB2E       with     0.066 percent
The Conduit with the largest sinuosity was.......P3725      with    60.142
```

Appendix B
FlowMaster and HY-8 Analysis Reports

Kings Valley Highway Crossing at Bridlewood

HY-8 Culvert Analysis Report

NORTH FORK ASH CREEK
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Kings Valley Highway Crossing at Bridlewood

City of Dallas Stormwater Master Plan

Water Surface Profile Plot for Culvert: Bridlewood

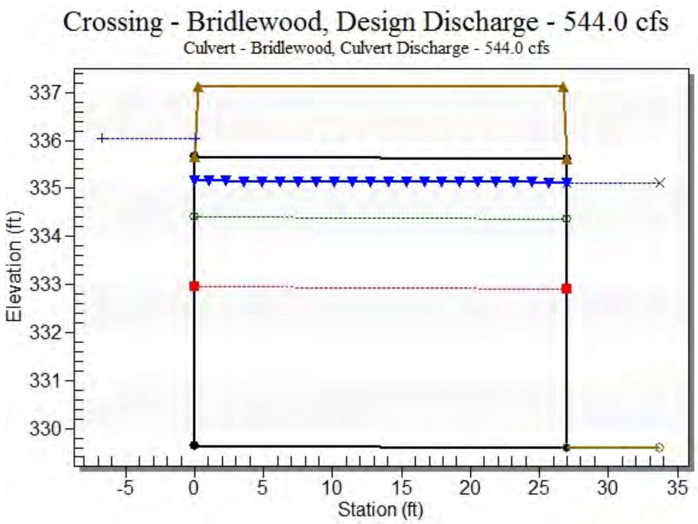


Table 1 - Culvert Summary Table: Bridlewood

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10.00	10.00	335.12	0.394	5.470	3-M1t	0.239	0.230	5.520	5.520	0.113	0.000
89.70	89.70	335.15	1.701	5.495	3-M1t	1.308	0.992	5.520	5.520	1.016	0.000
169.40	169.40	335.21	2.598	5.560	3-M1t	2.026	1.516	5.520	5.520	1.918	0.000
249.10	249.10	335.31	3.347	5.664	3-M1t	2.663	1.960	5.520	5.520	2.820	0.000
328.80	328.80	335.46	4.005	5.807	3-M1t	3.256	2.358	5.520	5.520	3.723	0.000
408.50	408.50	335.64	4.612	5.990	3-M1t	3.823	2.725	5.520	5.520	4.625	0.000
488.20	488.20	335.86	5.187	6.212	7-M1t	4.371	3.069	5.520	5.520	5.528	0.000
544.00	544.00	336.04	5.579	6.391	7-M1t	4.746	3.299	5.520	5.520	6.159	0.000
647.60	647.60	336.42	6.304	6.772	7-M1t	5.432	3.705	5.520	5.520	7.332	0.000
727.30	727.30	336.76	6.873	7.108	3-M2t	6.000	4.004	5.520	5.520	8.235	0.000
807.00	807.00	337.13	7.463	7.480	3-M2t	6.000	4.291	5.520	5.520	9.137	0.000

****

Straight Culvert

Inlet Elevation (invert): 329.65 ft, Outlet Elevation (invert): 329.60 ft

Culvert Length: 27.00 ft, Culvert Slope: 0.0019

****

Site Data - Bridlewood

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 329.65 ft

Outlet Station: 27.00 ft

Outlet Elevation: 329.60 ft

Number of Barrels: 2

Culvert Data Summary - Bridlewood

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0150

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 10 cfs

Design Flow: 544 cfs

Maximum Flow: 807 cfs

Table 2 - Summary of Culvert Flows at Crossing: Bridlewood

Headwater Elevation (ft)	Total Discharge (cfs)	Bridlewood Discharge (cfs)	Roadway Discharge (cfs)	Iterations
335.12	10.00	10.00	0.00	1
335.15	89.70	89.70	0.00	1
335.21	169.40	169.40	0.00	1
335.31	249.10	249.10	0.00	1
335.46	328.80	328.80	0.00	1
335.64	408.50	408.50	0.00	1
335.86	488.20	488.20	0.00	1
336.04	544.00	544.00	0.00	1
336.42	647.60	647.60	0.00	1
336.76	727.30	727.30	0.00	1
337.13	807.00	807.00	0.00	1
337.13	807.02	807.02	0.00	Overtopping

Table 3 - Downstream Channel Rating Curve* (Crossing: Bridlewood)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
10.00	335.12	5.52
89.70	335.12	5.52
169.40	335.12	5.52
249.10	335.12	5.52
328.80	335.12	5.52
408.50	335.12	5.52
488.20	335.12	5.52
544.00 (design flow)	335.12	5.52
647.60	335.12	5.52
727.30	335.12	5.52
807.00	335.12	5.52

***Downstream depth based on constant tailwater elevation for design flow.**

Tailwater Channel Data - Bridlewood

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 335.12 ft

Roadway Data for Crossing: Bridlewood

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 23.00 ft

Crest Elevation: 337.13 ft

Roadway Surface: Paved

Roadway Top Width: 26.40 ft

Worksheet for BridlewoodNatural

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00447	ft/ft
Discharge	544.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
-0+27	337.10
0+17	336.80
0+61	336.80
1+08	337.00
1+58	337.00
1+65	336.90
1+69	330.90
1+73	329.70
1+79	329.60
1+83	329.90
1+86	337.00
2+03	338.00
2+19	337.30
2+64	336.80
3+11	337.60
3+77	338.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+27, 337.10)	(3+77, 338.80)	0.035

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method

Worksheet for BridlewoodNatural

Options

Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		5.49	ft
Elevation Range	329.60 to 338.80 ft		
Flow Area		84.66	ft²
Wetted Perimeter		24.85	ft
Hydraulic Radius		3.41	ft
Top Width		18.98	ft
Normal Depth		5.49	ft
Critical Depth		3.79	ft
Critical Slope		0.01594	ft/ft
Velocity		6.43	ft/s
Velocity Head		0.64	ft
Specific Energy		6.13	ft
Froude Number		0.54	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth		6.54	ft
Length		1096.00	ft
Number Of Steps		100	

GVF Output Data

Upstream Depth		5.52	ft
Profile Description	M1		
Profile Headloss		3.87	ft
Downstream Velocity		5.17	ft/s
Upstream Velocity		6.39	ft/s
Normal Depth		5.49	ft
Critical Depth		3.79	ft
Channel Slope		0.00447	ft/ft
Critical Slope		0.01594	ft/ft

Growth Nodes

Worksheet for BarberryEast_EastWestPortion

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.00455	ft/ft
Normal Depth	3.18	ft
Diameter	3.18	ft
Discharge	57.00	ft³/s

Results

Diameter	3.18	ft
Normal Depth	3.18	ft
Flow Area	7.95	ft²
Wetted Perimeter	10.00	ft
Hydraulic Radius	0.80	ft
Top Width	0.00	ft
Critical Depth	2.42	ft
Percent Full	100.0	%
Critical Slope	0.00528	ft/ft
Velocity	7.17	ft/s
Velocity Head	0.80	ft
Specific Energy	3.98	ft
Froude Number	0.00	
Maximum Discharge	61.32	ft³/s
Discharge Full	57.00	ft³/s
Slope Full	0.00455	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BarberryEast_EastWestPortion

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.18	ft
Critical Depth	2.42	ft
Channel Slope	0.00455	ft/ft
Critical Slope	0.00528	ft/ft

Messages

Notes

assume 1/2 flow from subsbasin R-B-B2= 57
Start elevation - 295
end elevation - 285
length - 2200
slope - 0.00454545

use 40" for cost estimate

Worksheet for BarberryEast_NorthSouthPortion

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.01220	ft/ft
Normal Depth	3.23	ft
Diameter	3.23	ft
Discharge	97.00	ft³/s

Results

Diameter	3.23	ft
Normal Depth	3.23	ft
Flow Area	8.18	ft²
Wetted Perimeter	10.14	ft
Hydraulic Radius	0.81	ft
Top Width	0.00	ft
Critical Depth	2.99	ft
Percent Full	100.0	%
Critical Slope	0.01056	ft/ft
Velocity	11.85	ft/s
Velocity Head	2.18	ft
Specific Energy	5.41	ft
Froude Number	0.00	
Maximum Discharge	104.34	ft³/s
Discharge Full	97.00	ft³/s
Slope Full	0.01220	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BarberryEast_NorthSouthPortion

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.23	ft
Critical Depth	2.99	ft
Channel Slope	0.01220	ft/ft
Critical Slope	0.01056	ft/ft

Messages

Notes

assume 1/2 flow from subsbasin R-B-B2= 57 plus all flow from R-B-B1 = 40 cfs for total flow of 97 cfs
Start elevation - 285
end elevation - 270
length - 1230
slope - 0.01219512

use 40" for cost estimate

Worksheet for BarberryWest

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.00962	ft/ft
Normal Depth	2.77	ft
Diameter	2.77	ft
Discharge	57.00	ft³/s

Results

Diameter	2.77	ft
Normal Depth	2.77	ft
Flow Area	6.00	ft²
Wetted Perimeter	8.69	ft
Hydraulic Radius	0.69	ft
Top Width	0.00	ft
Critical Depth	2.45	ft
Percent Full	100.0	%
Critical Slope	0.00859	ft/ft
Velocity	9.49	ft/s
Velocity Head	1.40	ft
Specific Energy	4.17	ft
Froude Number	0.00	
Maximum Discharge	61.32	ft³/s
Discharge Full	57.00	ft³/s
Slope Full	0.00961	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BarberryWest

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.77	ft
Critical Depth	2.45	ft
Channel Slope	0.00962	ft/ft
Critical Slope	0.00859	ft/ft

Messages

Notes

assume 1/2 flow from subsbasin R-B-B2= 57
Start elevation - 310
end elevation - 290
length -2080
slope - 0.00961538

use 33" for cost estimate

Worksheet for BaskettSlough_BS-C1North

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.02791	ft/ft
Normal Depth	2.33	ft
Diameter	2.33	ft
Discharge	61.50	ft³/s

Results

Diameter	2.33	ft
Normal Depth	2.33	ft
Flow Area	4.26	ft²
Wetted Perimeter	7.32	ft
Hydraulic Radius	0.58	ft
Top Width	0.00	ft
Critical Depth	2.28	ft
Percent Full	100.0	%
Critical Slope	0.02500	ft/ft
Velocity	14.43	ft/s
Velocity Head	3.23	ft
Specific Energy	5.56	ft
Froude Number	0.00	
Maximum Discharge	66.16	ft³/s
Discharge Full	61.50	ft³/s
Slope Full	0.02791	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BaskettSlough_BS-C1North

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.33	ft
Critical Depth	2.28	ft
Channel Slope	0.02791	ft/ft
Critical Slope	0.02500	ft/ft

Messages

Notes

assume 1/2 flow from sub-basin C2 = 38.5 plus 1/3 flow from subsbasin C1= 23 for total flow of 61.5
start elevation- 337
end elevation - 325
length - 430
slope - 0.02790698

use 30" for cost estimate

Worksheet for BaskettSlough_BS-C1South

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.02513	ft/ft
Normal Depth	2.38	ft
Diameter	2.38	ft
Discharge	61.50	ft³/s

Results

Diameter	2.38	ft
Normal Depth	2.38	ft
Flow Area	4.43	ft²
Wetted Perimeter	7.46	ft
Hydraulic Radius	0.59	ft
Top Width	0.00	ft
Critical Depth	2.32	ft
Percent Full	100.0	%
Critical Slope	0.02233	ft/ft
Velocity	13.87	ft/s
Velocity Head	2.99	ft
Specific Energy	5.37	ft
Froude Number	0.00	
Maximum Discharge	66.16	ft³/s
Discharge Full	61.50	ft³/s
Slope Full	0.02513	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BaskettSlough_BS-C1South

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.38	ft
Critical Depth	2.32	ft
Channel Slope	0.02513	ft/ft
Critical Slope	0.02233	ft/ft

Messages

Notes

assume 1/2 flow from sub-basin C2 = 38.5 plus 1/3 flow from subsbasin C1= 23 for total flow of 61.5
start elevation- 340
end elevation - 320
length - 796
slope - 0.02512563

use 30" for cost estimate

Worksheet for BaskettSlough_BS-C2North

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.00652	ft/ft
Normal Depth	2.75	ft
Diameter	2.75	ft

Results

Discharge	46.27	ft³/s
Flow Area	5.94	ft²
Wetted Perimeter	8.64	ft
Hydraulic Radius	0.69	ft
Top Width	0.00	ft
Critical Depth	2.25	ft
Percent Full	100.0	%
Critical Slope	0.00654	ft/ft
Velocity	7.79	ft/s
Velocity Head	0.94	ft
Specific Energy	3.69	ft
Froude Number	0.00	
Maximum Discharge	49.77	ft³/s
Discharge Full	46.27	ft³/s
Slope Full	0.00652	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for BaskettSlough_BS-C2North

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	2.75	ft
Critical Depth	2.25	ft
Channel Slope	0.00652	ft/ft
Critical Slope	0.00654	ft/ft

Messages

Notes

assume 1/2 flow from sub-basin = 38.5
start elevation- 345
end elevation - 335
length - 1533
slope - 0.00652316

use 33" for cost estimate

Worksheet for BaskettSlough_BS-C2South

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.00897	ft/ft
Normal Depth	2.42	ft
Diameter	2.42	ft
Discharge	38.50	ft³/s

Results

Diameter	2.42	ft
Normal Depth	2.42	ft
Flow Area	4.59	ft²
Wetted Perimeter	7.60	ft
Hydraulic Radius	0.60	ft
Top Width	0.00	ft
Critical Depth	2.10	ft
Percent Full	100.0	%
Critical Slope	0.00822	ft/ft
Velocity	8.38	ft/s
Velocity Head	1.09	ft
Specific Energy	3.51	ft
Froude Number	0.00	
Maximum Discharge	41.41	ft³/s
Discharge Full	38.50	ft³/s
Slope Full	0.00897	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for BaskettSlough_BS-C2South

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.42	ft
Critical Depth	2.10	ft
Channel Slope	0.00897	ft/ft
Critical Slope	0.00822	ft/ft

Messages

Notes

assume 1/2 flow from sub-basin = 38.5
start elevation- 345
end elevation - 330
length - 1672
slope - 0.00897129

use 33" for cost estimate

Worksheet for Wyatt_east_R-D-A2W

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.04847	ft/ft
Normal Depth	2.00	ft
Diameter	2.00	ft
Discharge	53.95	ft³/s

Results

Discharge	53.95	ft³/s
Normal Depth	2.00	ft
Flow Area	3.14	ft²
Wetted Perimeter	6.28	ft
Hydraulic Radius	0.50	ft
Top Width	0.00	ft
Critical Depth	1.99	ft
Percent Full	100.0	%
Critical Slope	0.04512	ft/ft
Velocity	17.17	ft/s
Velocity Head	4.58	ft
Specific Energy	6.58	ft
Froude Number	0.00	
Maximum Discharge	58.03	ft³/s
Discharge Full	53.95	ft³/s
Slope Full	0.04847	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for Wyatt_east_R-D-A2W

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.00	ft
Critical Depth	1.99	ft
Channel Slope	0.04847	ft/ft
Critical Slope	0.04512	ft/ft

Messages

Notes

start elevation = 490
end elevation = 370
length = 2476
slope = 0.04846527
use 24" for cost estimate

Worksheet for Wyatt_West_R-NW-C2E

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.04370	ft/ft
Normal Depth	1.94	ft
Diameter	1.94	ft
Discharge	47.00	ft^3/s

Results

Diameter	1.94	ft
Normal Depth	1.94	ft
Flow Area	2.94	ft^2
Wetted Perimeter	6.08	ft
Hydraulic Radius	0.48	ft
Top Width	0.00	ft
Critical Depth	1.92	ft
Percent Full	100.0	%
Critical Slope	0.04036	ft/ft
Velocity	15.96	ft/s
Velocity Head	3.96	ft
Specific Energy	5.89	ft
Froude Number	0.00	
Maximum Discharge	50.56	ft^3/s
Discharge Full	47.00	ft^3/s
Slope Full	0.04370	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for Wyatt_West_R-NW-C2E

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.94	ft
Critical Depth	1.92	ft
Channel Slope	0.04370	ft/ft
Critical Slope	0.04036	ft/ft

Messages

Notes

start elevation = 435
end elevation = 365
length = 2336
slope = 0.02996575

use 24" for cost estimate

Former Weyerhaeuser Property to G-Way Ranch

HY-8 Culvert Analysis Report

NORTH FORK ASH CREEK
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Former Weyerhaeuser Property to G-Way Ranch

City of Dallas Stormwater Master Plan

Water Surface Profile Plot for Culvert: Godsey

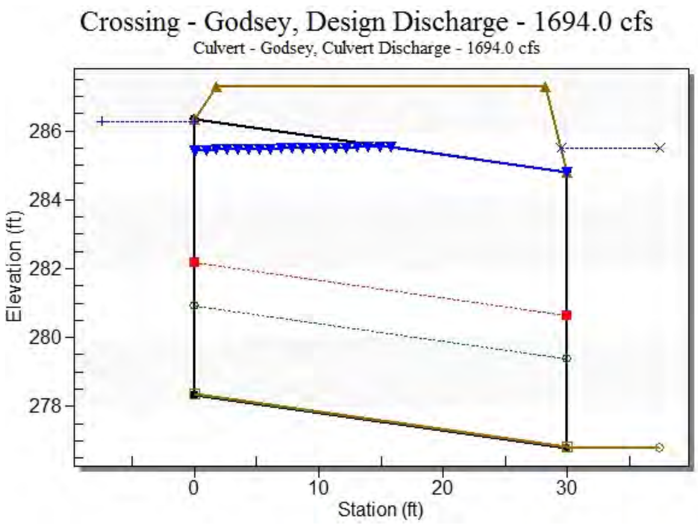


Table 1 - Culvert Summary Table: Godsey

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	285.50	0.785	7.154	1-S1f	0.330	0.571	7.992	8.700	0.344	0.000
347.40	347.40	285.53	1.946	7.184	1-S1f	0.926	1.322	7.992	8.700	1.195	0.000
594.80	594.80	285.59	2.787	7.246	1-S1f	1.316	1.909	7.992	8.700	2.047	0.000
842.20	842.20	285.69	3.514	7.340	1-S1f	1.639	2.405	7.992	8.700	2.898	0.000
1089.60	1089.60	285.82	4.175	7.468	1-S1f	1.926	2.855	7.992	8.700	3.749	0.000
1337.00	1337.00	285.98	4.825	7.628	1-S1f	2.207	3.269	7.992	8.700	4.601	0.000
1584.40	1584.40	286.17	5.475	7.822	1-S1f	2.445	3.662	7.992	8.700	5.452	0.000
1694.00	1694.00	286.27	5.743	7.919	1-S1f	2.551	3.824	7.992	8.700	5.829	0.000
2079.20	2079.20	286.66	6.605	8.314	1-S1f	2.920	4.371	7.992	8.700	7.155	0.000
2326.60	2326.60	286.96	7.158	8.613	1-S1f	3.128	4.711	7.992	8.700	8.006	0.000
2574.00	2574.00	287.30	7.786	8.951	1-S1f	3.337	5.041	7.992	8.700	8.857	0.000

****

Straight Culvert

Inlet Elevation (invert): 278.35 ft, Outlet Elevation (invert): 276.81 ft

Culvert Length: 30.04 ft, Culvert Slope: 0.0513

****

Site Data - Godsey

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 278.34 ft

Outlet Station: 30.00 ft

Outlet Elevation: 276.80 ft

Number of Barrels: 4

Culvert Data Summary - Godsey

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.10 in

Barrel Manning's n: 0.0150 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 100 cfs

Design Flow: 1694 cfs

Maximum Flow: 2574 cfs

Table 2 - Summary of Culvert Flows at Crossing: Godsey

Headwater Elevation (ft)	Total Discharge (cfs)	Godsey Discharge (cfs)	Roadway Discharge (cfs)	Iterations
285.50	100.00	100.00	0.00	1
285.53	347.40	347.40	0.00	1
285.59	594.80	594.80	0.00	1
285.69	842.20	842.20	0.00	1
285.82	1089.60	1089.60	0.00	1
285.98	1337.00	1337.00	0.00	1
286.17	1584.40	1584.40	0.00	1
286.27	1694.00	1694.00	0.00	1
286.66	2079.20	2079.20	0.00	1
286.96	2326.60	2326.60	0.00	1
287.30	2574.00	2574.00	0.00	1
287.30	2574.28	2574.28	0.00	Overtopping

Table 3 - Downstream Channel Rating Curve* (Crossing: Godsey)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	285.50	8.70
347.40	285.50	8.70
594.80	285.50	8.70
842.20	285.50	8.70
1089.60	285.50	8.70
1337.00	285.50	8.70
1584.40	285.50	8.70
1694.00 (design flow)	285.50	8.70
2079.20	285.50	8.70
2326.60	285.50	8.70
2574.00	285.50	8.70

Downstream depth is based on constant tailwater elevation for design flow

Tailwater Channel Data - Godsey

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 285.50 ft

Roadway Data for Crossing: Godsey

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 287.30 ft

Roadway Surface: Paved

Roadway Top Width: 26.50 ft

Water Surface Profile Plot for Culvert: Holman

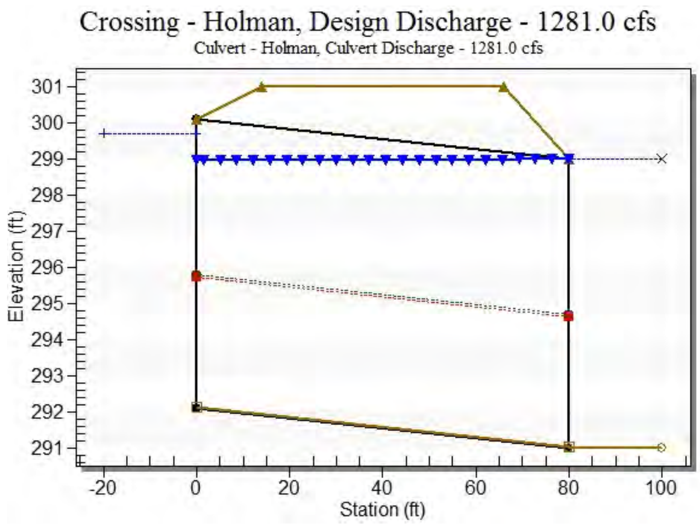


Table 4 - Culvert Summary Table: Holman

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	298.97	0.936	6.866	3-M1t	0.747	0.651	7.962	7.970	0.381	0.000
302.80	302.80	299.01	2.099	6.902	3-M1t	1.481	1.369	7.962	7.970	1.152	0.000
505.60	505.60	299.08	2.954	6.975	3-M1t	2.027	1.948	7.962	7.970	1.924	0.000
708.40	708.40	299.19	3.699	7.084	3-M1t	2.505	2.436	7.962	7.970	2.696	0.000
911.20	911.20	299.34	4.364	7.230	3-M1t	2.950	2.880	7.962	7.970	3.468	0.000
1114.00	1114.00	299.52	5.010	7.413	3-M1t	3.345	3.291	7.962	7.970	4.240	0.000
1281.00	1281.00	299.70	5.542	7.591	3-M1t	3.665	3.609	7.962	7.970	4.876	0.000
1519.60	1519.60	300.00	6.224	7.890	3-M1t	4.068	4.033	7.962	7.970	5.784	0.000
1722.40	1722.40	300.29	6.774	8.184	7-M1t	4.403	4.383	7.962	7.970	6.556	0.000
1925.20	1925.20	300.63	7.324	8.518	1-S1t	4.700	4.720	7.962	7.970	8.030	0.000
2128.00	2128.00	301.00	7.952	8.890	1-S1t	4.998	5.048	7.962	7.970	8.876	0.000

****

Straight Culvert

Inlet Elevation (invert): 292.11 ft, Outlet Elevation (invert): 291.01 ft

Culvert Length: 80.01 ft, Culvert Slope: 0.0138

****

Site Data - Holman

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 292.10 ft

Outlet Station: 80.00 ft

Outlet Elevation: 291.00 ft

Number of Barrels: 3

Culvert Data Summary - Holman

Barrel Shape: Concrete Box

Barrel Span: 11.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.10 in

Barrel Manning's n: 0.0150 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 100 cfs

Design Flow: 1281 cfs

Maximum Flow: 2128 cfs

Table 5 - Summary of Culvert Flows at Crossing: Holman

Headwater Elevation (ft)	Total Discharge (cfs)	Holman Discharge (cfs)	Roadway Discharge (cfs)	Iterations
298.97	100.00	100.00	0.00	1
299.01	302.80	302.80	0.00	1
299.08	505.60	505.60	0.00	1
299.19	708.40	708.40	0.00	1
299.34	911.20	911.20	0.00	1
299.52	1114.00	1114.00	0.00	1
299.70	1281.00	1281.00	0.00	1
300.00	1519.60	1519.60	0.00	1
300.29	1722.40	1722.40	0.00	1
300.63	1925.20	1925.20	0.00	1
301.00	2128.00	2128.00	0.00	1
301.00	2128.37	2128.37	0.00	Overtopping

Table 6 - Downstream Channel Rating Curve* (Crossing: Holman)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	298.97	7.97
302.80	298.97	7.97
505.60	298.97	7.97
708.40	298.97	7.97
911.20	298.97	7.97
1114.00	298.97	7.97
1281.00 (design flow)	298.97	7.97
1519.60	298.97	7.97
1722.40	298.97	7.97
1925.20	298.97	7.97
2128.00	298.97	7.97

***Downstream depth is based on constant tailwater elevation for design flow**

Tailwater Channel Data - Holman

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 298.97 ft

Roadway Data for Crossing: Holman

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 301.00 ft

Roadway Surface: Paved

Roadway Top Width: 52.00 ft

Water Surface Profile Plot for Culvert: MonmthCutoff @ Holman

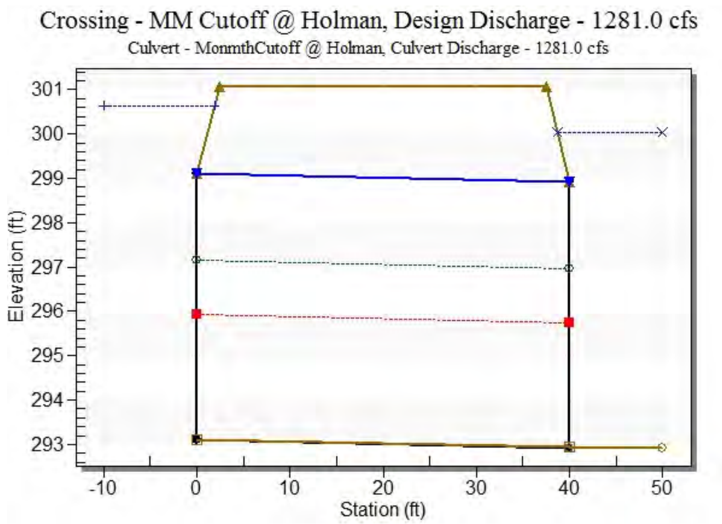


Table 7 - Culvert Summary Table: MonmthCutoff @ Holman

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	300.04	0.745	6.925	4-FFf	0.812	0.502	5.992	7.110	0.382	0.000
258.80	258.80	300.06	1.488	6.946	4-FFf	1.493	0.956	5.992	7.110	0.990	0.000
417.60	417.60	300.10	2.045	6.985	4-FFf	2.015	1.339	5.992	7.110	1.597	0.000
576.40	576.40	300.16	2.536	7.043	4-FFf	2.466	1.653	5.992	7.110	2.205	0.000
735.20	735.20	300.24	2.983	7.119	4-FFf	2.873	1.945	5.992	7.110	2.812	0.000
894.00	894.00	300.33	3.385	7.213	4-FFf	3.246	2.215	5.992	7.110	3.419	0.000
1052.80	1052.80	300.44	3.786	7.326	4-FFf	3.575	2.469	5.992	7.110	4.027	0.000
1211.60	1211.60	300.58	4.188	7.457	4-FFf	3.894	2.712	5.992	7.110	4.634	0.000
1281.00	1281.00	300.64	4.363	7.520	4-FFf	4.024	2.812	5.992	7.110	4.900	0.000
1529.20	1529.20	300.89	4.897	7.775	4-FFf	4.478	3.153	5.992	7.110	5.849	0.000
1688.00	1688.00	301.08	5.239	7.961	4-FFf	4.751	3.367	5.992	7.110	6.456	0.000

****

Straight Culvert

Inlet Elevation (invert): 293.12 ft, Outlet Elevation (invert): 292.94 ft

Culvert Length: 40.00 ft, Culvert Slope: 0.0045

****

Site Data - MonmthCutoff @ Holman

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 293.11 ft

Outlet Station: 40.00 ft

Outlet Elevation: 292.93 ft

Number of Barrels: 4

Culvert Data Summary - MonmthCutoff @ Holman

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.10 in

Barrel Manning's n: 0.0150 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 100 cfs

Design Flow: 1281 cfs

Maximum Flow: 1688 cfs

Table 8 - Summary of Culvert Flows at Crossing: MM Cutoff @ Holman

Headwater Elevation (ft)	Total Discharge (cfs)	MonmthCutoff @ Holman Discharge (cfs)	Roadway Discharge (cfs)	Iterations
300.04	100.00	100.00	0.00	1
300.06	258.80	258.80	0.00	1
300.10	417.60	417.60	0.00	1
300.16	576.40	576.40	0.00	1
300.24	735.20	735.20	0.00	1
300.33	894.00	894.00	0.00	1
300.44	1052.80	1052.80	0.00	1
300.58	1211.60	1211.60	0.00	1
300.64	1281.00	1281.00	0.00	1
300.89	1529.20	1529.20	0.00	1
301.08	1688.00	1688.00	0.00	1
301.08	1688.10	1688.10	0.00	Overtopping

Table 9 - Downstream Channel Rating Curve* (Crossing: MM Cutoff @ Holman)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	300.04	7.11
258.80	300.04	7.11
417.60	300.04	7.11
576.40	300.04	7.11
735.20	300.04	7.11
894.00	300.04	7.11
1052.80	300.04	7.11
1211.60	300.04	7.11
1281.00 (design flow)	300.04	7.11
1529.20	300.04	7.11
1688.00	300.04	7.11

Downstream depth is based on constant tailwater elevation for design flow

Tailwater Channel Data - MM Cutoff @ Holman

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 300.04 ft

Roadway Data for Crossing: MM Cutoff @ Holman

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 301.08 ft

Roadway Surface: Paved

Roadway Top Width: 35.00 ft

Water Surface Profile Plot for Culvert: Uglow

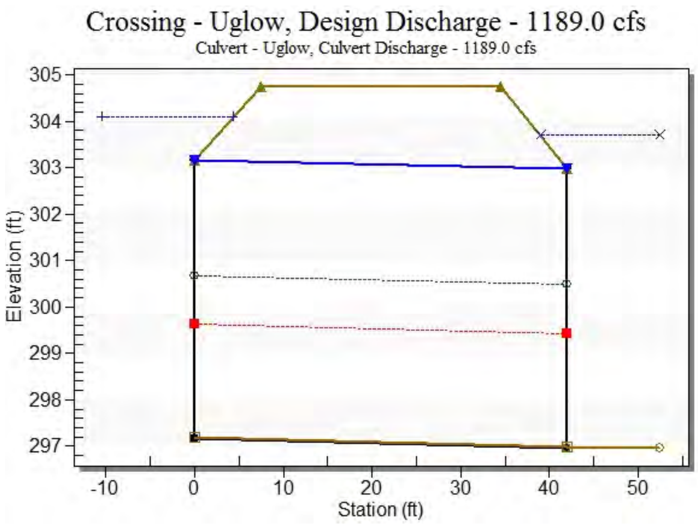


Table 10 - Culvert Summary Table: Uglow

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	303.70	0.660	6.524	4-FFf	0.734	0.463	5.992	6.730	0.334	0.000
284.70	284.70	303.72	1.447	6.544	4-FFf	1.431	0.935	5.992	6.730	0.950	0.000
469.40	469.40	303.76	2.019	6.583	4-FFf	1.961	1.321	5.992	6.730	1.567	0.000
654.10	654.10	303.82	2.519	6.641	4-FFf	2.417	1.643	5.992	6.730	2.183	0.000
838.80	838.80	303.90	2.973	6.718	4-FFf	2.829	1.940	5.992	6.730	2.800	0.000
1023.50	1023.50	303.99	3.382	6.814	4-FFf	3.200	2.214	5.992	6.730	3.416	0.000
1189.00	1189.00	304.09	3.747	6.916	4-FFf	3.500	2.445	5.992	6.730	3.969	0.000
1392.90	1392.90	304.24	4.197	7.064	4-FFf	3.855	2.718	5.992	6.730	4.649	0.000
1577.60	1577.60	304.40	4.568	7.217	4-FFf	4.150	2.951	5.992	6.730	5.266	0.000
1762.30	1762.30	304.57	4.915	7.389	4-FFf	4.438	3.165	5.992	6.730	5.883	0.000
1947.00	1947.00	304.76	5.262	7.580	4-FFf	4.710	3.381	5.992	6.730	6.499	0.000

****

Straight Culvert

Inlet Elevation (invert): 297.18 ft, Outlet Elevation (invert): 296.98 ft

Culvert Length: 42.00 ft, Culvert Slope: 0.0048

****

Site Data - Uglow

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 297.17 ft

Outlet Station: 42.00 ft

Outlet Elevation: 296.97 ft

Number of Barrels: 5

Culvert Data Summary - Uglow

Barrel Shape: Concrete Box

Barrel Span: 11.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.10 in

Barrel Manning's n: 0.0150 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 100 cfs

Design Flow: 1189 cfs

Maximum Flow: 1947 cfs

Table 11 - Summary of Culvert Flows at Crossing: Uglow

Headwater Elevation (ft)	Total Discharge (cfs)	Uglow Discharge (cfs)	Roadway Discharge (cfs)	Iterations
303.70	100.00	100.00	0.00	1
303.72	284.70	284.70	0.00	1
303.76	469.40	469.40	0.00	1
303.82	654.10	654.10	0.00	1
303.90	838.80	838.80	0.00	1
303.99	1023.50	1023.50	0.00	1
304.09	1189.00	1189.00	0.00	1
304.24	1392.90	1392.90	0.00	1
304.40	1577.60	1577.60	0.00	1
304.57	1762.30	1762.30	0.00	1
304.76	1947.00	1947.00	0.00	1
304.76	1947.61	1947.61	0.00	Overtopping

Table 12 - Downstream Channel Rating Curve* (Crossing: Uglow)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	303.70	6.73
284.70	303.70	6.73
469.40	303.70	6.73
654.10	303.70	6.73
838.80	303.70	6.73
1023.50	303.70	6.73
1189.00 (design flow)	303.70	6.73
1392.90	303.70	6.73
1577.60	303.70	6.73
1762.30	303.70	6.73
1947.00	303.70	6.73

Downstream depth is based on constant tailwater elevation for design flow

Tailwater Channel Data - Uglow

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 303.70 ft

Roadway Data for Crossing: Uglow

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 304.76 ft

Roadway Surface: Paved

Roadway Top Width: 27.00 ft

Water Surface Profile Plot for Culvert: WeyCo Culvert

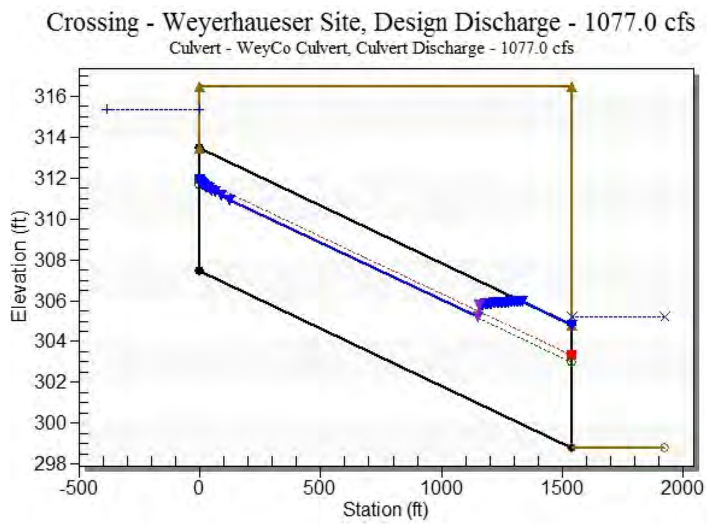


Table 13 - Culvert Summary Table: WeyCo Culvert

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	309.02	1.569	0.0*	1-JS1f	0.815	0.919	6.000	6.420	0.833	0.000
215.30	215.30	310.07	2.617	0.0*	1-JS1f	1.364	1.532	6.000	6.420	1.794	0.000
330.60	330.60	310.92	3.467	0.0*	1-JS1f	1.822	2.040	6.000	6.420	2.755	0.000
445.90	445.90	311.66	4.211	0.0*	1-JS1f	2.239	2.490	6.000	6.420	3.716	0.000
561.20	561.20	312.35	4.896	0.0*	1-JS1f	2.624	2.903	6.000	6.420	4.677	0.000
676.50	676.50	313.00	5.548	0.665	1-JS1f	2.990	3.288	6.000	6.420	5.638	0.000
791.80	791.80	313.64	6.193	1.732	5-JS1f	3.347	3.651	6.000	6.420	6.598	0.000
907.10	907.10	314.30	6.850	2.967	5-JS1f	3.690	3.998	6.000	6.420	7.559	0.000
1022.40	1022.40	314.99	7.535	4.370	5-JS1f	4.025	4.330	6.000	6.420	8.520	0.000
1077.00	1077.00	315.32	7.874	5.092	5-JS1f	4.182	4.482	6.000	6.420	8.975	0.000
1253.00	1253.00	316.50	9.048	7.677	5-JS1f	4.677	4.958	6.000	6.420	10.442	0.000

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Inlet Elevation (invert): 307.45 ft, Outlet Elevation (invert): 298.81 ft

Culvert Length: 1540.02 ft, Culvert Slope: 0.0056

****

Site Data - WeyCo Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 307.45 ft

Outlet Station: 1540.00 ft

Outlet Elevation: 298.81 ft

Number of Barrels: 2

Culvert Data Summary - WeyCo Culvert

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0150

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 100 cfs

Design Flow: 1077 cfs

Maximum Flow: 1253 cfs

Table 14 - Summary of Culvert Flows at Crossing: Weyerhaueser Site

Headwater Elevation (ft)	Total Discharge (cfs)	WeyCo Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
309.02	100.00	100.00	0.00	1
310.07	215.30	215.30	0.00	1
310.92	330.60	330.60	0.00	1
311.66	445.90	445.90	0.00	1
312.35	561.20	561.20	0.00	1
313.00	676.50	676.50	0.00	1
313.64	791.80	791.80	0.00	1
314.30	907.10	907.10	0.00	1
314.99	1022.40	1022.40	0.00	1
315.32	1077.00	1077.00	0.00	1
316.50	1253.00	1253.00	0.00	1
316.50	1253.23	1253.23	0.00	Overtopping

Table 15 - Downstream Channel Rating Curve (Crossing: Weyerhaueser Site)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	305.23	6.42
215.30	305.23	6.42
330.60	305.23	6.42
445.90	305.23	6.42
561.20	305.23	6.42
676.50	305.23	6.42
791.80	305.23	6.42
907.10	305.23	6.42
1022.40	305.23	6.42
1077.00	305.23	6.42
1253.00	305.23	6.42

Tailwater Channel Data - Weyerhaueser Site

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 305.23 ft

Roadway Data for Crossing: Weyerhaueser Site

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 316.50 ft

Roadway Surface: Paved

Roadway Top Width: 1540.00 ft

Worksheet for R1_EndofWeycotoUglow

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00528	ft/ft
Normal Depth	6.00	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	23.50	ft

Results

Discharge	1203.28	ft^3/s
Flow Area	213.00	ft^2
Wetted Perimeter	50.33	ft
Hydraulic Radius	4.23	ft
Top Width	47.50	ft
Critical Depth	3.86	ft
Critical Slope	0.02657	ft/ft
Velocity	5.65	ft/s
Velocity Head	0.50	ft
Specific Energy	6.50	ft
Froude Number	0.47	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	6.92	ft
Length	300.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	6.36	ft
Profile Description	M1	
Profile Headloss	1.02	ft
Downstream Velocity	4.66	ft/s
Upstream Velocity	5.23	ft/s
Normal Depth	6.00	ft
Critical Depth	3.86	ft
Channel Slope	0.00528	ft/ft

GVF Output Data

Critical Slope	0.02657	ft/ft

Worksheet for R2_UglowtoMonmouthCutoff

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00421	ft/ft
Normal Depth	6.63	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	23.50	ft

Results

Discharge		1296.96	ft³/s
Flow Area		243.72	ft²
Wetted Perimeter		53.15	ft
Hydraulic Radius		4.59	ft
Top Width		50.02	ft
Critical Depth		4.04	ft
Critical Slope		0.02628	ft/ft
Velocity		5.32	ft/s
Velocity Head		0.44	ft
Specific Energy		7.07	ft
Froude Number		0.43	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	7.53	ft
Length	860.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth		6.73	ft
Profile Description	M1		
Profile Headloss		2.83	ft
Downstream Velocity		4.47	ft/s
Upstream Velocity		5.21	ft/s
Normal Depth		6.63	ft
Critical Depth		4.04	ft
Channel Slope		0.00421	ft/ft

GVF Output Data

Critical Slope	0.02628	ft/ft

Worksheet for R3_MonmouthCutoffToHolman

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00692	ft/ft
Normal Depth	6.07	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	21.00	ft

Results

Discharge	1289.77	ft^3/s
Flow Area	201.16	ft^2
Wetted Perimeter	48.15	ft
Hydraulic Radius	4.18	ft
Top Width	45.28	ft
Critical Depth	4.25	ft
Critical Slope	0.02621	ft/ft
Velocity	6.41	ft/s
Velocity Head	0.64	ft
Specific Energy	6.71	ft
Froude Number	0.54	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	7.61	ft
Length	120.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	7.11	ft
Profile Description	M1	
Profile Headloss	0.33	ft
Downstream Velocity	4.68	ft/s
Upstream Velocity	5.15	ft/s
Normal Depth	6.07	ft
Critical Depth	4.25	ft
Channel Slope	0.00692	ft/ft

GVF Output Data

Critical Slope	0.02621	ft/ft

Messages

Notes

Worksheet for R4_NF36toNF35

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00359	ft/ft
Normal Depth	8.00	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	15.25	ft

Results

Discharge	1284.12	ft³/s
Flow Area	250.00	ft²
Wetted Perimeter	51.03	ft
Hydraulic Radius	4.90	ft
Top Width	47.25	ft
Critical Depth	4.85	ft
Critical Slope	0.02615	ft/ft
Velocity	5.14	ft/s
Velocity Head	0.41	ft
Specific Energy	8.41	ft
Froude Number	0.39	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	7.91	ft
Length	529.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	7.97	ft
Profile Description	M2	
Profile Headloss	1.96	ft
Downstream Velocity	5.23	ft/s
Upstream Velocity	5.16	ft/s
Normal Depth	8.00	ft
Critical Depth	4.85	ft
Channel Slope	0.00359	ft/ft

Worksheet for R4_NF36toNF35

GVF Output Data

Critical Slope	0.02615	ft/ft

Messages

Notes

Worksheet for R5_NF35to34

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00385	ft/ft
Normal Depth	8.00	ft
Left Side Slope	2.40	ft/ft (H:V)
Right Side Slope	2.40	ft/ft (H:V)
Bottom Width	14.00	ft

Results

Discharge	1389.16	ft³/s
Flow Area	265.60	ft²
Wetted Perimeter	55.60	ft
Hydraulic Radius	4.78	ft
Top Width	52.40	ft
Critical Depth	5.05	ft
Critical Slope	0.02582	ft/ft
Velocity	5.23	ft/s
Velocity Head	0.43	ft
Specific Energy	8.43	ft
Froude Number	0.41	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	7.10	ft
Length	804.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	7.91	ft
Profile Description	M2	
Profile Headloss	3.91	ft
Downstream Velocity	6.30	ft/s
Upstream Velocity	5.32	ft/s
Normal Depth	8.00	ft
Critical Depth	5.05	ft
Channel Slope	0.00385	ft/ft

Worksheet for R5_NF35to34

GVF Output Data

Critical Slope	0.02582	ft/ft

Messages

Notes

Worksheet for R6_TribDivtoGodsey100YEARDESIGNFLOW

Project Description

Friction Method	Manning Formula
Solve For	Bottom Width

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00554	ft/ft
Normal Depth	7.10	ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	1712.49	ft³/s

Results

Bottom Width	16.50	ft
Flow Area	293.59	ft²
Wetted Perimeter	68.58	ft
Hydraulic Radius	4.28	ft
Top Width	66.20	ft
Critical Depth	4.94	ft
Critical Slope	0.02561	ft/ft
Velocity	5.83	ft/s
Velocity Head	0.53	ft
Specific Energy	7.63	ft
Froude Number	0.49	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	7.94	ft
Length	1660.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	7.10	ft
Profile Description	M1	
Profile Headloss	8.36	ft
Downstream Velocity	4.87	ft/s
Upstream Velocity	5.83	ft/s
Normal Depth	7.10	ft
Critical Depth	4.94	ft
Channel Slope	0.00554	ft/ft

Worksheet for R6_TribDivtoGodsey100YEARDESIGNFLOW

GVF Output Data

Critical Slope	0.02561	ft/ft

Messages

Notes

Worksheet for R7_GodseytoGway

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00265	ft/ft
Normal Depth	8.70	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	27.00	ft

Results

Discharge	1922.09	ft³/s
Flow Area	386.28	ft²
Wetted Perimeter	65.91	ft
Hydraulic Radius	5.86	ft
Top Width	61.80	ft
Critical Depth	4.77	ft
Critical Slope	0.02492	ft/ft
Velocity	4.98	ft/s
Velocity Head	0.38	ft
Specific Energy	9.08	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	9.30	ft
Length	3882.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	8.70	ft
Profile Description	M1	
Profile Headloss	9.70	ft
Downstream Velocity	4.53	ft/s
Upstream Velocity	4.97	ft/s
Normal Depth	8.70	ft
Critical Depth	4.77	ft
Channel Slope	0.00265	ft/ft

Worksheet for R7_GodseytoGway

GVF Output Data

Critical Slope	0.02492	ft/ft

Messages

Notes

Monmouth Cutoff Crossing of Tributary

HY-8 Culvert Analysis Report

NORTH FORK ASH CREEK
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Monmouth Cutoff Crossing of Tributary

City of Dallas Stormwater Master Plan

Water Surface Profile Plot for Culvert: MonmthCutoff @ Trib

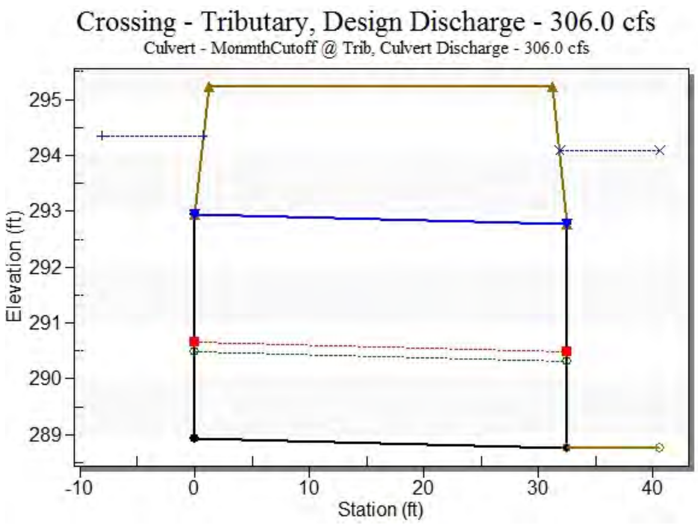


Table 1 - Culvert Summary Table: MonmthCutoff @ Trib

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10.00	10.00	294.08	0.300	5.140	4-FFf	0.118	0.175	4.000	5.310	0.104	0.000
74.10	74.10	294.10	1.139	5.155	4-FFf	0.613	0.666	4.000	5.310	0.772	0.000
138.20	138.20	294.13	1.725	5.192	4-FFf	0.918	1.010	4.000	5.310	1.440	0.000
202.30	202.30	294.19	2.217	5.252	4-FFf	1.178	1.302	4.000	5.310	2.107	0.000
266.40	266.40	294.27	2.650	5.334	4-FFf	1.411	1.564	4.000	5.310	2.775	0.000
306.00	306.00	294.34	2.900	5.396	4-FFf	1.544	1.715	4.000	5.310	3.188	0.000
394.60	394.60	294.51	3.428	5.566	4-FFf	1.828	2.032	4.000	5.310	4.110	0.000
458.70	458.70	294.66	3.796	5.716	4-FFf	2.018	2.247	4.000	5.310	4.778	0.000
522.80	522.80	294.83	4.162	5.888	4-FFf	2.205	2.452	4.000	5.310	5.446	0.000
586.90	586.90	295.02	4.534	6.082	4-FFf	2.382	2.648	4.000	5.310	6.114	0.000
651.00	651.00	295.24	4.920	6.299	4-FFf	2.559	2.838	4.000	5.310	6.781	0.000

****

Straight Culvert

Inlet Elevation (invert): 288.94 ft, Outlet Elevation (invert): 288.77 ft

Culvert Length: 32.50 ft, Culvert Slope: 0.0052

****

Site Data - MonmthCutoff @ Trib

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 288.94 ft

Outlet Station: 32.50 ft

Outlet Elevation: 288.77 ft

Number of Barrels: 2

Culvert Data Summary - MonmthCutoff @ Trib

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 4.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0150

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 10 cfs

Design Flow: 306 cfs

Maximum Flow: 651 cfs

Table 2 - Summary of Culvert Flows at Crossing: Tributary

Headwater Elevation (ft)	Total Discharge (cfs)	MonmthCutoff @ Trib Discharge (cfs)	Roadway Discharge (cfs)	Iterations
294.08	10.00	10.00	0.00	1
294.10	74.10	74.10	0.00	1
294.13	138.20	138.20	0.00	1
294.19	202.30	202.30	0.00	1
294.27	266.40	266.40	0.00	1
294.34	306.00	306.00	0.00	1
294.51	394.60	394.60	0.00	1
294.66	458.70	458.70	0.00	1
294.83	522.80	522.80	0.00	1
295.02	586.90	586.90	0.00	1
295.24	651.00	651.00	0.00	1
295.24	651.15	651.15	0.00	Overtopping

Table 3 - Downstream Channel Rating Curve* (Crossing: Tributary)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
10.00	294.08	5.31
74.10	294.08	5.31
138.20	294.08	5.31
202.30	294.08	5.31
266.40	294.08	5.31
306.00 (design flow)	294.08	5.31
394.60	294.08	5.31
458.70	294.08	5.31
522.80	294.08	5.31
586.90	294.08	5.31
651.00	294.08	5.31

****Downstream depth based on constant tailwater elevation for design flow***

Tailwater Channel Data - Tributary

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 294.08 ft

Roadway Data for Crossing: Tributary

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 295.24 ft

Roadway Surface: Paved

Roadway Top Width: 30.00 ft

Worksheet for TributaryDiversionChannelDESIGN25yearatConfluence

Project Description

Friction Method	Manning Formula	
Solve For	Discharge	

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00189	ft/ft
Normal Depth	4.50	ft
Left Side Slope	3.50	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Bottom Width	7.00	ft

Results

Discharge	306.00	ft^3/s
Flow Area	127.90	ft^2
Wetted Perimeter	50.79	ft
Hydraulic Radius	2.52	ft
Top Width	49.79	ft
Critical Depth	2.40	ft
Critical Slope	0.03270	ft/ft
Velocity	2.39	ft/s
Velocity Head	0.09	ft
Specific Energy	4.59	ft
Froude Number	0.26	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	6.43	ft
Length	840.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	5.30	ft
Profile Description	M1	
Profile Headloss	0.46	ft
Downstream Velocity	1.27	ft/s
Upstream Velocity	1.79	ft/s
Normal Depth	4.50	ft
Critical Depth	2.40	ft
Channel Slope	0.00189	ft/ft

GVF Output Data

Critical Slope	0.03270	ft/ft

Worksheet for TribChannelDESIGN100yeardepthatConfluence

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.00189	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Bottom Width	7.00	ft
Discharge	306.00	ft³/s

Results

Normal Depth	4.58	ft
Flow Area	126.42	ft²
Wetted Perimeter	49.33	ft
Hydraulic Radius	2.56	ft
Top Width	48.21	ft
Critical Depth	2.44	ft
Critical Slope	0.03260	ft/ft
Velocity	2.42	ft/s
Velocity Head	0.09	ft
Specific Energy	4.67	ft
Froude Number	0.26	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	7.54	ft
Length	840.00	ft
Number Of Steps	100	

GVF Output Data

Upstream Depth	6.18	ft
Profile Description	M1	
Profile Headloss	0.23	ft
Downstream Velocity	0.99	ft/s
Upstream Velocity	1.42	ft/s
Normal Depth	4.58	ft
Critical Depth	2.44	ft
Channel Slope	0.00189	ft/ft

Worksheet for TribChannelDESIGN100yeardepthatConfluence

GVF Output Data

Critical Slope	0.03260	ft/ft

Worksheet for TribDivEXISTING

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00189	ft/ft
Discharge	306.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	295.90
0+59	295.30
1+09	294.80
1+62	294.70
1+89	292.90
1+90	290.10
1+93	288.90
2+00	288.80
2+05	290.30
2+21	294.80
2+73	294.70
3+26	293.50
3+79	293.40
4+29	293.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 295.90)	(4+29, 293.00)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for TribDivEXISTING

Results

Normal Depth		5.39	ft
Elevation Range	288.80 to 295.90 ft		
Flow Area		215.43	ft²
Wetted Perimeter		186.95	ft
Hydraulic Radius		1.15	ft
Top Width		183.11	ft
Normal Depth		5.39	ft
Critical Depth		2.85	ft
Critical Slope		0.03225	ft/ft
Velocity		1.42	ft/s
Velocity Head		0.03	ft
Specific Energy		5.43	ft
Froude Number		0.23	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth		6.43	ft
Length		840.00	ft
Number Of Steps		100	

GVF Output Data

Upstream Depth		5.51	ft
Profile Description	M1		
Profile Headloss		0.67	ft
Downstream Velocity		0.63	ft/s
Upstream Velocity		1.29	ft/s
Normal Depth		5.39	ft
Critical Depth		2.85	ft
Channel Slope		0.00189	ft/ft
Critical Slope		0.03225	ft/ft

Appendix C
Hydrologic Analysis Data, Calculations, and Results

Hydrologic_Data

(blue)	Data needs to be computed by an Engineer
(yellow)	Results

Sub_Basin_ID	Major Basin	Area (mi2)	Area (acres)	Existing Weighted CN	Initial Abstraction (in)	Existing Time of Concentration (minutes)	Existing Lag Time (minutes)	Existing Peak Runoff (100 yr)	20-year Weighted CN	Initial Abstraction (in)	20 year Time of Concentration	20-year Lag Time (minutes)	20 year Peak Runoff (100 yr)	Buildout Weighted CN	Initial Abstraction (in)	Buildout Time of Concentration	Buildout Lag Time (minutes)	Buildout year Peak Runoff (100 yr)
Assigned by Engineer	Assigned by Engineer	Calculated from GIS data	GIS Spatial Analysis	Computedby engineer from GIS data adjusted with visual inspection	Calculated by Engineer =0.2*S; S=(1000-10CN)/CN	Computed by Engineers.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS 100-year	Computedby engineer from GIS data adjusted with visual inspection	Calculated by Engineer	Computed by Engineers. Calculations to be documented in excel spreadsheet.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS	Computed from GIS data in .xls	Calculated by Engineer	Computed by Engineers. Calculations to be documented in excel spreadsheet.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS 100-year
A-BW-A1	*Ash Creek Bridlewood*	*2.922*	*1870.0*	*78*	*0.56*	*475*	*285*	*505*	*78*	*0.56*	*475*	*285*	*504.8*	*78*	*0.56*	*475*	*285*	*505*
A-BW-A2	Ash Creek Bridlewood	0.031	19.8	88.08	0.27	10	6	*26*	88.08	0.27	10	6	26	88.08	0.27	10	6	*26*
A-BW-C1	Ash Creek Bridlewood	0.090	57.6	87.35	0.29	18	11	*70*	87.35	0.29	18	11	70	87.35	0.29	18	11	*70*
A-BW-B1	Ash Creek Bridlewood	0.021	13.3	81.95	0.44	44	26	*12*	81.95	0.44	44	26	12	83.38	0.40	16	10	*15*
A-BW-D1	Ash Creek Bridlewood	0.148	94.5	83.61	0.39	48	29	*83*	83.61	0.39	48	29	83	86.52	0.31	29	17	*105*
A-I-A1	Ash Creek Industrial	0.052	33.2	91.65	0.18	30	18	*41*	91.65	0.18	30	18	41	94.29	0.12	12	7	*48*
A-I-A2	Ash Creek Industrial	0.037	23.4	92.75	0.16	32	19	*29*	92.75	0.16	32	19	29	97.06	0.06	11	7	*35*
A-I-B1	Ash Creek Industrial	0.065	41.4	96.47	0.07	22	13	*59*	96.47	0.07	22	13	59	97.26	0.06	22	13	*59*
A-I-B2	Ash Creek Industrial	0.033	21.1	97.55	0.05	28	17	*29*	97.55	0.05	28	17	29	97.55	0.05	28	17	*29*
A-I-C1	Ash Creek Industrial	0.030	19.3	95.77	0.09	20	12	*27*	95.77	0.09	20	12	27	97.52	0.05	20	12	*28*
A-I-C2N	Ash Creek Industrial	0.035	22.3	93.65	0.14	16	10	*31*	93.65	0.14	16	10	31	97.07	0.06	8	5	*34*
A-I-C2S	Ash Creek Industrial	0.094	60.3	75.93	0.63	21	13	*51*	75.93	0.63	21	13	51	76.91	0.60	17	10	*54*
A-I-C3	*Ash Creek Industrial*	*1.466*	*938.1*	*74.31*	*0.69*	*78*	*47*	*282*	*74.31*	*0.69*	*78*	*47*	*282*	*74.33*	*0.69*	*58*	*35*	*282*
A-I-D1	Ash Creek Industrial	0.028	18.2	93.00	0.15	22	13	*24*	93.00	0.15	22	13	24	96.93	0.06	15	9	*26*
A-I-E1	Ash Creek Industrial	0.043	27.7	92.84	0.15	41	25	*32*	92.84	0.15	41	25	32	95.62	0.09	28	17	*37*
A-I-F1	Ash Creek Industrial	0.016	10.0	95.16	0.10	40	24	*12*	95.16	0.10	40	24	12	96.42	0.07	28	17	*14*
A-I-H1	Ash Creek Industrial	0.088	56.6	92.77	0.16	64	38	*56*	92.77	0.16	64	38	56	97.26	0.06	37	22	*72*
A-I-I1	Ash Creek Industrial	0.016	9.9	84.13	0.38	30	18	*11*	84.13	0.38	30	18	11	85.85	0.33	11	6	*13*
A-I-I2	Ash Creek Industrial	0.068	43.7	81.04	0.47	21	13	*44*	81.04	0.47	21	13	44	82.14	0.43	20	12	*46*
A-I-J1	Ash Creek Industrial	0.033	21.3	91.89	0.18	20	12	*28*	91.89	0.18	20	12	28	92.14	0.17	16	9	*29*
A-I-J2	Ash Creek Industrial	0.050	32.0	94.39	0.12	47	28	*37*	94.39	0.12	47	28	37	97.41	0.05	27	16	*44*
A-R-A1	Ash Creek Residential	0.026	16.4	78.35	0.55	43	26	*13*	78.35	0.55	43	26	13	82.55	0.42	42	25	*15*
A-R-B1	Ash Creek Residential	0.042	27.1	78.55	0.55	53	32	*19*	78.55	0.55	53	32	19	83.20	0.40	51	30	*23*
A-R-B3S	Ash Creek Residential	0.051	32.5	81.40	0.46	42	25	*31*	81.40	0.46	42	25	31	84.71	0.36	22	13	*36*
A-R-B2	Ash Creek Residential	0.021	13.5	87.99	0.27	15	9	*17*	87.99	0.27	15	9	17	90.45	0.21	11	7	*18*
A-R-B3N	Ash Creek Residential	0.027	17.3	86.54	0.31	21	13	*20*	86.54	0.31	21	13	20	87.45	0.29	16	10	*21*
A-R-B3C	Ash Creek Residential	0.192	122.6	80.82	0.47	43	26	*103*	80.82	0.47	43	26	103	83.78	0.39	37	22	*119*
A-R-B4N	Ash Creek Residential	0.051	32.8	85.00	0.35	33	20	*34*	85.00	0.35	33	20	34	87.43	0.29	26	15	*38*
A-R-C1	Ash Creek Residential	0.043	27.6	73.63	0.72	31	19	*19*	73.63	0.72	31	19	19	73.65	0.72	23	14	*21*
A-R-D1	Ash Creek Residential	0.054	34.4	84.21	0.38	21	16	*37*	84.21	0.38	21	16	37	88.33	0.26	19	12	*43*
A-R-E1	Ash Creek Residential	0.045	28.5	87.21	0.29	20	16	*33*	87.21	0.29	20	16	33	91.30	0.19	18	11	*38*
A-R-F1	Ash Creek Residential	0.050	32.2	92.23	0.17	17	10	*44*	92.23	0.17	17	10	44	95.21	0.10	11	7	*47*
A-R-G1	Ash Creek Residential	0.093	59.2	89.27	0.24	28	17	*71*	89.27	0.24	28	17	71	90.02	0.22	26	16	*73*
A-R-H1	Ash Creek Residential	*0.530*	*339.0*	*78.00*	*0.56*		*500*	*89*	*78.00*	*0.56*	*0*	*500*	*89*	*78.00*	*0.56*		*500*	*89*
BS-A1	Baskett Slough	0.037	24.0	79.85	0.50	54	33	*18*	81.51	0.45	20	12	24	81.51	0.45	20	12	*24*
BS-B1	Baskett Slough	0.027	17.2	82.11	0.44	13	8	*19*	85.70	0.33	11	7	21	85.70	0.33	11	7	*21*
BS-C1	Baskett Slough	0.099	63.1	81.67	0.45	33	20	*59*	83.79	0.39	23	14	68	83.79	0.39	23	14	*68*
BS-C2	Baskett Slough	0.088	56.2	88.22	0.27	19	12	*70*	91.02	0.20	13	8	77	91.02	0.20	13	8	*77*
D-A1	Douglas Drainage	0.056	36.1	87.92	0.27	16	9	*45*	87.92	0.27	16	9	45	89.91	0.22	15	9	*47*
D-A2E	Douglas Drainage	0.050	32.1	89.28	0.24	24	14	*40*	89.28	0.24	24	14	40	89.28	0.24	24	14	*40*
D-A2W	Douglas Drainage	0.058	37.1	86.64	0.31	32	19	*40*	90.73	0.20	25	15	47	90.73	0.20	25	15	*47*
D-A3	Douglas Drainage	0.070	44.6	90.32	0.21	37	22	*52*	90.32	0.21	37	22	52	90.32	0.21	37	22	*52*
D-A4	Douglas Drainage	0.107	68.5	83.65	0.39	41	24	*64*	83.65	0.39	41	24	64	86.61	0.31	30	18	*75*
D-A5E	Douglas Drainage	0.022	14.3	78.87	0.54	27	16	*13*	78.87	0.54	27	16	13	79.37	0.52	17	10	*14*
D-A5W1	Douglas Drainage	0.029	18.6	80.84	0.47	25	15	*18*	80.84	0.47	25	15	18	80.84	0.47	25	15	*18*
D-A5W2	Douglas Drainage	0.036	22.9	80.84	0.47	27	16	*22*	80.84	0.47	27	16	22	80.84	0.47	27	16	*22*
D-B1	Douglas Drainage	0.093	59.5	88.75	0.25	30	18	*69*	88.75	0.25	30	18	69	90.21	0.22	30	18	*71*
R-B-A1	Rickreall Barberry Node	0.053	34.2	82.03	0.44	67	40	*25*	86.13	0.32	38	23	35	86.13	0.32	38	23	*35*
R-B-B1	Rickreall Barberry Node	0.056	36.0	83.96	0.38	55	33	*30*	89.43	0.24	37	22	40	89.43	0.24	37	22	*40*
R-B-B2	Rickreall Barberry Node	0.190	121.8	79.25	0.52	64	38	*84*	83.27	0.40	39	23	114	83.27	0.40	39	23	*114*
R-B-C1	Rickreall Barberry Node	0.062	39.7	87.50	0.29	74	44	*33*	89.70	0.23	41	25	43	89.70	0.23	41	25	*43*
R-B-C2	Rickreall Barberry Node	0.017	10.9	84.45	0.37	23	14	*12*	84.92	0.36	22	13	12	84.92	0.36	22	13	*12*
R-B-D1	Rickreall Barberry Node	0.014	8.9	85.01	0.35	27	16	*10*	90.17	0.22	12	7	12	90.17	0.22	12	7	*12*
R-B-D2	Rickreall Barberry Node	0.063	40.3	85.89	0.33	37	30	*37*	90.16	0.22	35	21	46	90.16	0.22	35	21	*46*
R-B-D3	Rickreall Barberry Node	0.032	20.8	84.44	0.37	48	29	*19*	89.78	0.23	31	19	24	89.78	0.23	31	19	*24*
R-CBD-A1	Rickreall Central Business District	0.011	7.0	91.73	0.18	13	8	*10*	91.73	0.18	13	8	10	92.49	0.16	13	8	*10*
R-CBD-B1	Rickreall Central Business District	0.064	41.0	94.20	0.12	22	13	*56*	94.20	0.12	22	13	56	94.20	0.12	22	13	*56*
R-CBD-B2	Rickreall Central Business District	0.082	52.8	92.23	0.17	28	17	*66*	92.23	0.17	28	17	66	92.23	0.17	28	17	*66*
R-CBD-B3	Rickreall Central Business District	0.044	28.2	89.34	0.24	27	16	*34*	89.34	0.24	27	16	34	89.34	0.24	27	16	*34*
R-CBD-C1	Rickreall Central Business District	0.036	22.9	96.43	0.07	11	7	*34*	96.43	0.07	11	7	34	96.86	0.06	11	7	*34*
R-CBD-D1	Rickreall Central Business District	0.045	28.6	93.02	0.15	25	15	*38*	93.02	0.15	25	15	38	95.50	0.09	8	5	*42*
R-CBD-E1	Rickreall Central Business District	0.062	39.5	94.82	0.11	19	11	*56*	94.82	0.11	19	11	56	94.82	0.11	19	11	*56*
R-CBD-E2	Rickreall Central Business District	0.055	35.5	94.40	0.12	37	22	*43*	94.40	0.12	37	22	43	94.40	0.12	37	22	*43*

Sub_Basin_ID	Major Basin	Area (mi2)	Area (acres)	Existing Weighted CN	Initial Abstraction (in)	Existing Time of Concentration (minutes)	Existing Lag Time (minutes)	Existing Peak Runoff (100 yr)	20-year Weighted CN	Initial Abstraction (in)	20 year Time of Concentration	20-year Lag Time (minutes)	20 year Peak Runoff (100 yr)	Buildout Weighted CN	Initial Abstraction (in)	Buildout Time of Concentration	Buildout Lag Time (minutes)	Buildout year Peak Runoff (100 yr)
Assigned by Engineer	Assigned by Engineer	Calculated from GIS data	GIS Spatial Analysis	Computedby engineer from GIS data adjusted with visual inspection	Calculated by Engineer =0.2*S; S=(1000-10CN)/CN	Computed by Engineers.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS 100-year	Computedby engineer from GIS data adjusted with visual inspection	Calculated by Engineer	Computed by Engineers. Calculations to be documented in excel spreadsheet.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS	Computed from GIS data in .xls	Calculated by Engineer	Computed by Engineers. Calculations to be documented in excel spreadsheet.	Computed by Engineers based on Time of Concentration (=0.6*Tc)	Peak runoff computed by HMS 100-year
R-CBD-E3	Rickreall Central Business District	0.072	46.3	95.35	0.10	29	17	*61*	95.35	0.10	29	17	61	95.35	0.10	29	17	*61*
R-NE-A1	Rickreall NE	0.047	30.2	88.49	0.26	39	24	*32*	88.49	0.26	39	24	32	89.69	0.23	25	15	*37*
R-NE-B1	Rickreall NE	0.019	12.4	86.37	0.32	83	50	*9*	86.37	0.32	83	50	9	87.26	0.29	36	22	*13*
R-NE-C1	Rickreall NE	0.037	23.5	89.45	0.24	55	33	*23*	89.45	0.24	55	33	23	91.26	0.19	30	18	*29*
R-NE-D1	Rickreall NE	0.064	40.9	86.31	0.32	37	22	*42*	86.31	0.32	37	22	42	88.79	0.25	35	21	*46*
R-NE-E1	Rickreall NE	0.064	40.8	86.67	0.31	64	39	*35*	86.67	0.31	64	39	35	89.73	0.23	25	15	*51*
R-NE-E2	Rickreall NE	0.059	37.9	90.65	0.21	79	48	*33*	90.65	0.21	79	48	33	90.65	0.21	79	48	*33*
R-NE-E3C	Rickreall NE	0.089	57.0	91.37	0.19	26	16	*72*	91.37	0.19	26	16	72	91.97	0.17	25	15	*74*
R-NE-E3E	Rickreall NE	0.042	26.7	81.46	0.46	54	32	*21*	81.46	0.46	54	32	21	83.30	0.40	35	21	*26*
R-NE-E3W	Rickreall NE	0.058	37.0	92.38	0.17	26	16	*48*	92.38	0.17	26	16	48	92.81	0.15	26	15	*49*
R-NE-E4	Rickreall NE	0.069	44.4	89.46	0.24	27	16	*53*	89.46	0.24	27	16	53	91.24	0.19	26	16	*56*
R-NC-A1	Rickreall North Central	0.039	25.1	90.78	0.20	19	11	*33*	90.78	0.20	19	11	33	91.51	0.19	18	11	*33*
R-NC-A2E	Rickreall North Central	0.072	45.9	89.06	0.25	22	13	*57*	89.06	0.25	22	13	57	93.14	0.15	22	13	*62*
R-NC-A2W	Rickreall North Central	0.077	49.5	89.44	0.24	29	18	*58*	89.44	0.24	29	18	58	90.93	0.20	24	14	*63*
R-NC-B1	Rickreall North Central	0.061	39.4	95.42	0.10	16	9	*57*	95.42	0.10	16	9	57	95.81	0.09	16	9	*57*
R-NC-C1	Rickreall North Central	0.046	29.6	87.77	0.28	10	6	*38*	87.77	0.28	10	6	38	89.05	0.25	10	6	*39*
R-NW-A1	Rickreall NW	0.026	16.4	76.13	0.63	32	19	*13*	76.13	0.63	32	19	13	84.29	0.37	20	12	*19*
R-NW-B1	Rickreall NW	0.031	20.0	83.16	0.40	55	33	*17*	83.16	0.40	55	33	17	85.93	0.33	37	22	*20*
R-NW-B2	Rickreall NW	0.049	31.6	89.26	0.24	24	14	*17*	89.26	0.24	24	14	17	89.26	0.24	24	14	*17*
R-NW-C1N	Rickreall NW	0.032	20.5	87.19	0.29	41	25	*21*	89.38	0.24	32	19	24	89.38	0.24	32	19	*24*
R-NW-C1S	Rickreall NW	0.049	31.6	87.19	0.29	41	25	*50*	89.38	0.24	31	18	37	89.38	0.24	31	18	*37*
R-NW-C2E	Rickreall NW	0.061	39.0	84.03	0.38	47	28	*35*	89.09	0.25	26	15	47	89.09	0.25	26	15	*47*
R-NW-C2W	Rickreall NW	0.059	37.5	77.29	0.59	31	19	*31*	77.29	0.59	31	19	31	77.89	0.57	24	14	*34*
R-NW-C3EE	Rickreall NW	0.071	45.6	85.14	0.35	53	32	*40*	89.02	0.25	23	14	56	89.02	0.25	23	14	*56*
R-NW-C3EW	Rickreall NW	1.025	655.9	77.77	0.57	86	52	*381*	77.96	0.57	80	48	394	77.96	0.57	80	48	*394*
R-NW-D1	Rickreall NW	0.023	14.5	88.24	0.27	20	12	*18*	88.24	0.27	20	12	18	89.63	0.23	20	12	*19*
R-NW-E1	Rickreall NW	0.028	17.8	89.18	0.24	29	18	*21*	89.18	0.24	29	18	21	89.18	0.24	29	18	*21*
R-NW-F1	Rickreall NW	0.029	18.4	83.88	0.38	24	14	*20*	83.88	0.38	24	14	20	87.36	0.29	15	9	*23*
R-NW-G1	Rickreall NW	0.036	23.3	87.86	0.28	27	16	*27*	87.86	0.28	27	16	27	87.86	0.28	27	16	*27*
R-NW-H1	Rickreall NW	0.049	31.1	84.08	0.38	29	17	*33*	84.08	0.38	29	17	33	87.48	0.29	20	12	*38*
R-SE-A1	Rickreall SE	0.028	17.6	90.91	0.20	10	6	*25*	90.91	0.20	10	6	25	91.50	0.19	10	6	*25*
R-SE-B1	Rickreall SE	0.024	15.4	91.56	0.18	14	8	*21*	91.56	0.18	14	8	21	92.00	0.17	14	8	*21*
R-SE-C1	Rickreall SE	0.090	57.4	91.28	0.19	32	19	*70*	91.28	0.19	32	19	70	91.28	0.19	32	19	*70*
R-SE-D1	Rickreall SE	0.025	15.8	85.03	0.35	10	6	*19*	85.03	0.35	10	6	19	88.84	0.25	9	6	*21*
R-SE-E1	Rickreall SE	0.088	56.4	88.74	0.25	26	16	*67*	88.74	0.25	26	16	67	90.98	0.20	26	16	*70*
R-SE-F1	Rickreall SE	0.018	11.3	86.32	0.32	63	38	*10*	86.32	0.32	63	38	10	89.42	0.24	28	17	*14*
R-SW-A1	Rickreall SW	0.035	22.6	80.02	0.50	8	5	*23*	80.02	0.50	8	5	23	80.66	0.48	8	5	*24*
R-SW-B1	Rickreall SW	0.069	43.9	87.84	0.28	12	7	*56*	87.84	0.28	12	7	56	89.50	0.23	12	7	*59*
R-SW-B2E	Rickreall SW	0.088	56.3	90.26	0.22	34	20	*66*	90.26	0.22	34	20	66	90.26	0.22	34	20	*66*
R-SW-B2W	Rickreall SW	0.034	21.9	92.20	0.17	16	10	*30*	92.20	0.17	16	10	30	93.23	0.15	11	7	*31*
R-SW-B3	Rickreall SW	0.142	90.8	80.56	0.48	30	18	*84*	80.56	0.48	30	18	84	81.29	0.46	30	18	*86*
R-SW-C1	Rickreall SW	0.030	18.9	88.18	0.27	16	10	*24*	88.18	0.27	16	10	24	88.18	0.27	16	10	*24*
R-UO-A1	Rickreall Uglow-Orchard	0.045	28.8	88.66	0.26	28	17	*34*	88.66	0.26	28	17	34	89.94	0.22	27	16	*35*
R-UO-A2	Rickreall Uglow-Orchard	0.054	34.5	93.04	0.15	21	13	*47*	93.04	0.15	21	13	47	93.46	0.14	21	13	*47*
R-UO-A3	Rickreall Uglow-Orchard	0.055	35.4	95.98	0.08	13	8	*52*	95.98	0.08	13	8	52	96.26	0.08	13	8	*52*
R-UO-A4C	Rickreall Uglow-Orchard	0.022	13.9	90.27	0.22	12	7	*19*	90.27	0.22	12	7	19	90.87	0.20	12	7	*19*
R-UO-A4E	Rickreall Uglow-Orchard	0.056	36.0	89.25	0.24	31	19	*42*	89.25	0.24	31	19	42	90.61	0.21	31	18	*43*
R-UO-A4W	Rickreall Uglow-Orchard	0.039	24.7	93.35	0.14	23	14	*33*	93.35	0.14	23	14	33	93.73	0.13	23	14	*34*
R-UO-A5E	Rickreall Uglow-Orchard	0.065	41.4	91.28	0.19	24	15	*52*	91.28	0.19	24	15	52	91.41	0.19	24	14	*54*
R-UO-A5W	Rickreall Uglow-Orchard	0.042	26.9	91.28	0.19	24	14	*35*	91.28	0.19	24	14	35	91.61	0.18	24	14	*35*
R-UO-A6	Rickreall Uglow-Orchard	0.047	29.8	88.68	0.26	34	20	*34*	88.68	0.26	34	20	34	91.02	0.20	27	16	*38*
R-UO-AB1	Rickreall Uglow-Orchard	0.002	1.3	87.35	0.29	3	2	*2*	87.35	0.29	3	2	2	87.35	0.29	32	19	*2*
R-UO-AB2E	Rickreall Uglow-Orchard	0.021	13.3	89.24	0.24	14	9	*18*	89.24	0.24	14	9	18	89.24	0.24	14	9	*18*
R-UO-AB2W	Rickreall Uglow-Orchard	0.039	24.9	77.47	0.58	21	12	*23*	77.47	0.58	21	12	23	77.47	0.58	20	12	*23*

TIME OF CONCENTRATION CALCULATION SHEET - Existing Condition

			Sheet Flow						Shallow Conc. Flow					Pipe & Channel Flow			Gutters Flow				
Sub Basin	Drainage Area		Length	Surface Description	Manning's Roughness Coeff.	Slope	Travel Time	Travel Time	Length	Slope	Paved, Un-paved, or na	Average Velocity	Travel Time	length	Average Velocity	Travel Time	Street Gutter length	Travel Time	Total length (ft)	Cummulative Time of Concentratio	Lag Time
	A	A	L		*n*	S	T_t	T_t	L	S		$V_{ave.}$	T_t	L	$V_{ave.}$	T_t	L	T_t		T_c	Tlag
	(sq mile)	(ac)	(ft)			(ft/ft)	(hr)	(min)	(ft)	(ft/ft)		(ft/s)	(min)	(ft)	(ft/s)	(min)	(ft)	(min)		(min)	(min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
Ash Creek Bridlewood																					
A-BW-A1	2.922	1870.0									Not Calculated										
A-BW-A2	0.031	19.8	165	Urban Residential	0.080	0.0909	0.089	5.36	448	0.1116	unpaved	5.4	1.4	503	3	2.8		0.0	1116	10	6
A-BW-C1	0.090	57.6	55	Urban Residential	0.080	0.0545	0.045	2.73	190	0.0368	paved	3.9	0.8	2551	3	14.2		0.0	2796	18	11
A-BW-B1	0.021	13.3	250	Forest	0.400	0.04	0.626	37.58	382	0.0393	unpaved	3.2	2.0	765	3	4.3		0.0	1397	44	26
A-BW-D1	0.148	94.5	290	Forest	0.400	0.1552	0.410	24.60	1117	0.1119	unpaved	5.4	3.4	3520	3	19.6		0.0	4927	48	29
Ash Creek Industrial																					
A-I-A1	0.052	33.2	270	Forest	0.400	0.1741	0.370	22.19	645	0.1628	unpaved	6.5	1.6	1105	3	6.1		0.0	2020	30	18
A-I-A2	0.037	23.4	300	Forest	0.400	0.1567	0.420	25.18	525	0.1905	unpaved	7.1	1.2	985	3	5.5		0.0	1810	32	19
A-I-B1	0.065	41.4	145	Industrial Area	0.050	0.0138	0.117	7.05	790	0.0063	paved	1.6	8.2	1227	3	6.8		0.0	2162	22	13
A-I-B2	0.033	21.1	242	Industrial Area	0.050	0.0083	0.217	13.03	835	0.006	paved	1.6	8.9	1135	3	6.3		0.0	2212	28	17
A-I-C1	0.030	19.3	275	Industrial Area	0.050	0.0109	0.215	12.92	285	0.0175	paved	2.7	1.8	980	3	5.4		0.0	1540	20	12
A-I-C2N	0.035	22.3	300	Meadow, Pasture, Range Land	0.150	0.15	0.195	11.69	720	0.0319	unpaved	2.9	4.2	0	3	0.0		0.0	1020	16	10
A-I-C2S	0.094	60.3	190	Meadow, Pasture, Range Land	0.150	0.1579	0.132	7.95	775	0.1161	unpaved	5.5	2.3	2005	3	11.1		0.0	2970	21	13
A-I-C3	1.466	938.1									Not Calculated										
A-I-D1	0.028	18.2	80	Meadow, Pasture, Range Land	0.150	0.025	0.139	8.32	801	0.0062	unpaved	1.3	10.6	633	3	3.5		0.0	1514	22	13
A-I-E1	0.043	27.7	250	Meadow, Pasture, Range Land	0.150	0.012	0.463	27.75	786	0.0089	unpaved	1.5	8.7	803	3	4.5		0.0	1839	41	25
A-I-F1	0.016	10.0	250	Meadow, Pasture, Range Land	0.150	0.008	0.544	32.64	712	0.0056	paved	1.5	7.8	0	3	0.0		0.0	962	40	24
A-I-H1	0.088	56.6	300	Meadow, Pasture, Range Land	0.150	0.0067	0.677	40.62	1200	0.0067	unpaved	1.3	15.3	1377	3	7.7		0.0	2877	64	38
A-I-I1	0.016	9.9	290	Forest	0.400	0.1207	0.453	27.21	229	0.131	unpaved	5.8	0.7	448	3	2.5		0.0	967	30	18
A-I-I2	0.068	43.7	300	Meadow, Pasture, Range Land	0.150	0.1167	0.215	12.93	1200	0.0564	unpaved	3.8	5.2	750	4	3.1		0.0	2250	21	13
A-I-J1	0.033	21.3	95	Urban Residential	0.080	0.0105	0.136	8.16	520	0.0058	unpaved	1.2	7.1	777	3	4.3		0.0	1392	20	12
A-I-J2	0.050	32.0	300	Meadow, Pasture, Range Land	0.150	0.0167	0.469	28.16	1200	0.0058	unpaved	1.2	16.4	500	3	2.8		0.0	2000	47	28
Ash Creek Residential																					
A-R-H1	0.528	338.0									Not Calculated										
A-R-A1	0.026	16.4	300	Rural Residential	0.240	0.0233	0.597	35.85	1100	0.0227	unpaved	2.4	7.6	0	3	0.0	0	0.0	1400	43	26
A-R-B1	0.042	27.1	300	Rural Residential	0.240	0.0167	0.683	41.01	1200	0.0161	unpaved	2.0	9.8	350	3	1.9	0	0.0	1850	53	32
A-R-C1	0.043	27.6	300	Forest	0.400	0.2167	0.369	22.12	1200	0.0667	unpaved	4.2	4.8	750	3	4.2	0	0.0	2250	31	19
A-R-D1	0.054	34.4	300	Meadow, Pasture, Range Land	0.150	0.0833	0.247	14.79	1200	0.0256	unpaved	2.6	7.8	750	3	4.2	0	0.0	2250	27	16
A-R-E1	0.045	28.5	300	Meadow, Pasture, Range Land	0.150	0.0667	0.270	16.17	1200	0.0233	unpaved	2.5	8.2	300	3	1.7	0	0.0	1800	26	16
A-R-F1	0.050	32.2	300	Meadow, Pasture, Range Land	0.150	0.12	0.213	12.78	1100	0.0673	unpaved	4.2	4.4	0	3	0.0	0	0.0	1400	17	10
A-R-G1	0.093	59.2	300	Urban Residential	0.080	0.0667	0.163	9.78	1200	0.025	unpaved	2.5	7.9	1860	3	10.3	0	0.0	3360	28	17
A-R-B3S	0.051	32.5	300	Forest	0.400	0.14	0.439	26.34	1200	0.1042	unpaved	5.2	3.8	2121	3	11.8		0.0	3621	42	25
A-R-B2	0.021	13.5	125	Meadow, Pasture, Range Land	0.150	0.056	0.143	8.61	356	0.0702	unpaved	4.3	1.4	823	3	4.6		0.0	1304	15	9
A-R-B3N	0.027	17.3	220	Meadow, Pasture, Range Land	0.150	0.05	0.236	14.16	1200	0.076	unpaved	4.4	4.5	510	3	2.8		0.0	1930	21	13
A-R-B3C	0.192	122.6	300	Meadow, Pasture, Range Land	0.150	0.1	0.229	13.75	315	0.1429	unpaved	6.1	0.9	5057	3	28.1		0.0	5672	43	26
A-R-B4N	0.051	32.8	300	Meadow, Pasture, Range Land	0.150	0.0833	0.247	14.79	1200	0.025	unpaved	2.5	7.9	1860	3	10.3		0.0	3360	33	20
Baskett Slough																					
BS-A1	0.037	24.0	300	Forest	0.400	0.0333	0.779	46.77	1010	0.0644	unpaved	4.1	4.1	605	3	3.4		0.0	1915	54	33
BS-B1	0.027	17.2	50	Meadow, Pasture, Range Land	0.150	0.04	0.079	4.73	0		unpaved	0.0	0.0	1535	3	8.5		0.0	1585	13	8
BS-C1	0.099	63.1	265	Meadow, Pasture, Range Land	0.150	0.0189	0.404	24.26	460	0.0326	unpaved	2.9	2.6	1172	3	6.5		0.0	1897	33	20
BS-C2	0.088	56.2	130	Meadow, Pasture, Range Land	0.150	0.0385	0.172	10.32	1077	0.0158	unpaved	2.0	8.9	0	3	0.0		0.0	1207	19	12
Forestry Creek																					
F-A1	0.056	36.1	300	Urban Residential	0.080	0.033	0.215	12.91	315	0.0317	unpaved	2.9	1.8	170	3	0.9	0	0.0	785	16	9
F-A2E	0.050	32.1	220	Meadow, Pasture, Range Land	0.150	0.114	0.170	10.19	0		unpaved	0.0	0.0	1800	3	10.0	300	3.3	2320	24	14
F-A2W	0.058	37.1	300	Meadow, Pasture, Range Land	0.150	0.1333	0.204	12.26	1200	0.031	unpaved	2.8	7.1	2200	3	12.2	0	0.0	3700	32	19
F-A3	0.070	44.6	215	Urban Residential	0.080	0.009	0.275	16.47	0		paved	0.0	0.0	3780	3	21.0	0	0.0	3995	37	22
F-A4	0.107	68.5	300	Meadow, Pasture, Range Land	0.150	0.023	0.410	24.61	1200	0.0467	unpaved	3.5	5.8	1880	3	10.4	0	0.0	3380	41	24
F-A5E	0.022	14.3	300	Meadow, Pasture, Range Land	0.150	0.033	0.356	21.34	1180	0.0466	unpaved	3.5	5.7	0	3	0.0	0	0.0	1480	27	16
F-A5W1	0.029	18.6	300	Meadow, Pasture, Range Land	0.150	0.033	0.356	21.34	735	0.0369	unpaved	3.1	4.0	0	3	0.0	0	0.0	1035	25	15

CH2M HILL

City of Dallas Stormwater Master Plan

TIME OF CONCENTRATION CALCULATION SHEET - Existing Condition

Sub Basin	Drainage Area		Sheet Flow						Shallow Conc. Flow					Pipe & Channel Flow			Gutters Flow				
	Drainage Area		Length	Surface Description	Manning's Roughness Coeff.	Slope	Travel Time	Travel Time	Length	Slope	Paved, Un-paved, or na	Average Velocity	Travel Time	length	Average Velocity	Travel Time	Street Gutter length	Travel Time	Total length (ft)	Cummulative Time of Concentratio	Lag Time
	A (sq mile)	A (ac)	L (ft)		*n*	S (ft/ft)	T_t (hr)	T_t (min)	L (ft)	S (ft/ft)		$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	T_t (min)		T_c (min)	Tlag (min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
F-A5W2	0.036	22.9	300	Meadow, Pasture, Range Land	0.150	0.033	0.356	21.34	730	0.0369	unpaved	3.1	3.9	310	3	1.7	0	0.0	1340	27	16
F-B1	0.093	59.5	160	Urban Residential	0.080	0.019	0.164	9.82	0	0	paved or unpav		0.0	3550	3	19.7	0	0.0	3710	30	18
Rickreall Barberry Node																					
R-B-A1	0.053	34.2	300	Rural Residential	0.240	0.0133	0.747	44.84	1200	0.0093	unpaved	1.5	13.0	1598	3	8.9	0	0.0	3098	67	40
R-B-B1	0.056	36.0	300	Meadow, Pasture, Range Land	0.150	0.0067	0.677	40.62	1200	0.0146	unpaved	1.9	10.3	683	3	3.8	0	0.0	2183	55	33
R-B-B2	0.190	121.8	300	Rural Residential	0.240	0.02	0.635	38.13	1200	0.0098	unpaved	1.6	12.6	2380	3	13.2	0	0.0	3880	64	38
R-B-C1	0.062	39.7	300	Rural Residential	0.240	0.01	0.838	50.31	1200	0.0082	unpaved	1.4	13.8	1742	3	9.7	0	0.0	3242	74	44
R-B-C2	0.017	10.9	300	Urban Residential	0.080	0.0167	0.284	17.03	350	0.02	unpaved	2.3	2.6	550	3	3.1	0	0.0	1200	23	14
R-B-D1	0.014	8.9	300	Rural Residential	0.240	0.0567	0.419	25.14	200	0.01	unpaved	1.6	2.1	0	3	0.0	0	0.0	500	27	16
R-B-D2	0.063	40.3	300	Meadow, Pasture, Range Land	0.150	0.0133	0.513	30.79	1150	0.0104	unpaved	1.6	11.7	1250	3	6.9	0	0.0	2700	49	30
R-B-D3	0.032	20.8	300	Meadow, Pasture, Range Land	0.150	0.01	0.576	34.54	1050	0.0067	unpaved	1.3	13.4	0	3	0.0	0	0.0	1350	48	29
Rickreall Central Business District																					
R-CBD-A1	0.011	7.0	300	Urban Residential	0.080	0.0533	0.178	10.69	300	0.0167	unpaved	2.1	2.4	0	3	0.0	0	0.0	600	13	8
R-CBD-B1	0.064	41.0	80	Urban Residential	0.080	0.0125	0.111	6.64	0		paved or unpav		0.0	2400	3	13.3	170	1.9	2650	22	13
R-CBD-B2	0.082	52.8	130	Urban Residential	0.080	0.0154	0.150	9.01	0		paved or unpav		0.0	2575	3	14.3	400	4.4	3105	28	17
R-CBD-B3	0.044	28.2	300	Urban Residential	0.080	0.0167	0.284	17.03	160	0.0188	unpaved	2.2	1.2	1520	3	8.4	0	0.0	1980	27	16
R-CBD-C1	0.036	22.9	80	City Business Area	0.014	0.0125	0.027	1.65	0		paved or unpav		0.0	1240	3	6.9	230	2.6	1550	11	7
R-CBD-D1	0.045	28.6	300	Urban Residential	0.080	0.01	0.348	20.89	630	0.0317	unpaved	2.9	3.7	0	3	0.0	0	0.0	930	25	15
R-CBD-E1	0.062	39.5	130	Pavement and Roofs	0.014	0.0077	0.049	2.95	0		paved or unpav		0.0	2800	3	15.6	0	0.0	2930	19	11
R-CBD-E2	0.055	35.5	300	Urban Residential	0.080	0.01	0.348	20.89	0		paved or unpav		0.0	2370	3	13.2	300	3.3	2970	37	22
R-CBD-E3	0.072	46.3	300	Urban Residential	0.080	0.0333	0.215	12.91	20	0.05	unpaved	3.6	0.1	2680	3	14.9	100	1.1	3100	29	17
Rickreall NE																					
R-NE-A1	0.047	30.2	300	Meadow, Pasture, Range Land	0.150	0.01	0.576	34.54	325	0.0462	unpaved	3.5	1.6	590	3	3.3	0	0.0	1215	39	24
R-NE-B1	0.019	12.4	300	Light Turf	0.240	0.0033	1.301	78.07	780	0.0256	unpaved	2.6	5.1	0	3	0.0	0	0.0	1080	83	50
R-NE-C1	0.037	23.5	300	Light Turf	0.240	0.02	0.635	38.13	1200	0.0112	unpaved	1.7	11.8	840	3	4.7	0	0.0	2340	55	33
R-NE-D1	0.064	40.9	300	Urban Residential	0.080	0.0067	0.409	24.57	430	0.0047	unpaved	1.1	6.6	980	3	5.4	0	0.0	1710	37	22
R-NE-E1	0.064	40.8	300	Forest	0.400	0.0233	0.899	53.94	0		paved or unpav		0.0	1880	3	10.4	0	0.0	2180	64	39
R-NE-E2	0.059	37.9	300	Light Turf	0.240	0.0067	0.986	59.17	900	0.0078	unpaved	1.4	10.6	1700	3	9.4	0	0.0	2900	79	48
R-NE-E3C	0.089	57.0	300	Urban Residential	0.080	0.0333	0.215	12.91	700	0.0214	unpaved	2.3	5.0	1520	3	8.4	0	0.0	2520	26	16
R-NE-E3E	0.042	26.7	300	Light Turf	0.240	0.0333	0.518	31.08	590	0.0169	unpaved	2.1	4.7	0	3	0.0	1610	17.9	2500	54	32
R-NE-E3W	0.058	37.0	300	Urban Residential	0.080	0.0233	0.248	14.88	430	0.0349	unpaved	3.0	2.4	1600	3	8.9	0	0.0	2330	26	16
R-NE-E4	0.069	44.4	300	Urban Residential	0.080	0.05	0.183	10.97	420	0.0357	unpaved	3.0	2.3	2390	3	13.3	0	0.0	3110	27	16
Rickreall North Central																					
R-NC-A1	0.039	25.1	300	Urban Residential	0.080	0.04	0.200	12.00	150	0.0467	unpaved	3.5	0.7	1050	3	5.8	0	0.0	1500	19	11
R-NC-A2E	0.059	37.7	141	Urban Residential	0.080	0.0709	0.087	5.22	151	0.0464	paved	4.4	0.6	2977	3	16.5	0	0.0	3269	22	13
R-NC-A2W	0.080	51.5	290	Meadow, Pasture, Range Land	0.150	0.0862	0.237	14.20	0		unpaved	0.0	0.0	1560	3	8.7	575	6.4	2425	29	18
R-NC-A3	0.032	20.5	230	Urban Residential	0.080	0.0435	0.156	9.38	0		paved	0.0	0.0	2000	3	11.1	0	0.0	2230	20	12
R-NC-B1	0.061	39.4	0	na	0.000			0.00	440	0.0159	paved	2.6	2.9	2279	3	12.7	0	0.0	2719	16	9
R-NC-C1	0.046	29.6	0	na	0.000			0.00	0		paved	0.0	0.0	520	3	2.9	600	6.7	1120	10	6
Rickreall NW																					
R-NW-A1	0.026	16.4	300	Meadow, Pasture, Range Land	0.150	0.0167	0.469	28.16	430	0.0116	unpaved	1.7	4.2	0	3	0.0	0	0.0	730	32	19
R-NW-B1	0.031	20.0	300	Meadow, Pasture, Range Land	0.150	0.0067	0.677	40.62	800	0.01	unpaved	1.6	8.3	1050	3	5.8	0	0.0	2150	55	33
R-NW-B2	0.022	14.2	300	Urban Residential	0.080	0.0133	0.310	18.62	100	0.02	unpaved	2.3	0.7	800	3	4.4	0	0.0	1200	24	14
R-NW-C1	0.076	48.6	300	Meadow, Pasture, Range Land	0.150	0.0233	0.410	24.61	1000	0.03	unpaved	2.8	6.0	1900	3	10.6	0	0.0	3200	41	25
R-NW-C2E	0.061	39.0	230	Forest	0.400	0.0652	0.482	28.91	0		paved or unpav		0.0	3170	3	17.6	0	0.0	3400	47	28
R-NW-C2W	0.059	37.5	300	Meadow, Pasture, Range Land	0.150	0.0667	0.270	16.17	1200	0.0474	unpaved	3.5	5.7	1680	3	9.3	0	0.0	3180	31	19
R-NW-C3EE	0.071	45.6	300	Forest	0.400	0.05	0.663	39.77	1100	0.0727	unpaved	4.3	4.2	1640	3	9.1	0	0.0	3040	53	32
R-NW-C3EW	1.030	659.5	300	Meadow, Pasture, Range Land	0.150	0.0833	0.247	14.79	1200	0.137	unpaved	6.0	3.3	12283	3	68.2	0	0.0	13783	86	52
R-NW-D1	0.023	14.5	100	Urban Residential	0.080	0.01	0.145	8.67	0		paved or unpav		0.0	1200	3	6.7	450	5.0	1750	20	12
R-NW-E1	0.028	17.8	270	Urban Residential	0.080	0.0074	0.361	21.65	0		paved or unpav		0.0	1820	4	7.6	0	0.0	2090	29	18

TIME OF CONCENTRATION CALCULATION SHEET - Existing Condition

Sub Basin	Drainage Area		Sheet Flow						Shallow Conc. Flow					Pipe & Channel Flow			Gutters Flow				
			Length	Surface Description	Manning's Roughness Coeff.	Slope	Travel Time	Travel Time	Length	Slope	Paved, Un-paved, or na	Average Velocity	Travel Time	length	Average Velocity	Travel Time	Street Gutter length	Travel Time	Total length (ft)	Cummulative Time of Concentratio	Lag Time
	A	A	L		*n*	S	T_t	T_t	L	S		$V_{ave.}$	T_t	L	$V_{ave.}$	T_t	L	T_t		T_c	Tlag
	(sq mile)	(ac)	(ft)			(ft/ft)	(hr)	(min)	(ft)	(ft/ft)		(ft/s)	(min)	(ft)	(ft/s)	(min)	(ft)	(min)		(min)	(min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
R-NW-F1	0.029	18.4	300	Meadow, Pasture, Range Land	0.150	0.0367	0.342	20.54	480	0.0208	unpaved	2.3	3.5	0	3	0.0	0	0.0	780	24	14
R-NW-G1	0.036	23.3	100	Urban Residential	0.080	0.02	0.110	6.57	55	0.0182	unpaved	2.2	0.4	2943	3	16.4	323	3.6	3421	27	16
R-NW-H1	0.049	31.1	200	Meadow, Pasture, Range Land	0.150	0.015	0.354	21.23	283	0.0177	unpaved	2.1	2.2	972	3	5.4	0	0.0	1455	29	17
Rickreall SE																					
R-SE-A1	0.028	17.6	155	Pavement and Roofs	0.014	0.0387	0.030	1.78	140	0.0143	paved	2.4	1.0	920	3	5.1	170	1.9	1385	10	6
R-SE-B1	0.024	15.4	120	Pavement and Roofs	0.014	0.0083	0.045	2.68	0		paved or unpav		0.0	1660	3	9.2	170	1.9	1950	14	8
R-SE-C1	0.090	57.4	278	Urban Residential	0.080	0.0108	0.318	19.07	0		paved or unpav		0.0	2350	3	13.1	0	0.0	2628	32	19
R-SE-D1	0.025	15.8	170	Urban Residential	0.080	0.0882	0.093	5.55	100	0.02	unpaved	2.3	0.7	604	3	3.4	0	0.0	874	10	6
R-SE-E1	0.088	56.4	300	Urban Residential	0.080	0.0333	0.215	12.91	0		paved or unpav		0.0	2340	3	13.0	0	0.0	2640	26	16
R-SE-F1	0.018	11.3	300	Light Turf	0.240	0.0067	0.986	59.17	550	0.0218	unpaved	2.4	3.9	0	3	0.0	0	0.0	850	63	38
Rickreall SW																					
R-SW-A1	0.035	22.6	270	Urban Residential	0.080	0.1111	0.122	7.33	491	0.2749	unpaved	8.5	1.0	0	3	0.0		0.0	761	8	5
R-SW-B1	0.069	43.9	115	Urban Residential	0.080	0.0609	0.079	4.71	539	0.0278	unpaved	2.7	3.4	796	3	4.4		0.0	1450	12	7
R-SW-B2E	0.088	56.3	300	Urban Residential	0.080	0.0167	0.284	17.03	375	0.0533	paved	4.7	1.3	2831	3	15.7		0.0	3506	34	20
R-SW-B2W	0.034	21.9	150	Meadow, Pasture, Range Land	0.150	0.0467	0.179	10.71	495	0.0404	unpaved	3.2	2.6	522	3	2.9		0.0	1167	16	10
R-SW-B3	0.142	90.8	255	Urban Residential	0.080	0.1569	0.102	6.10	710	0.0775	unpaved	4.5	2.6	3879	3	21.6		0.0	4844	30	18
R-SW-C1	0.030	18.9	183	Urban Residential	0.080	0.0273	0.157	9.41	351	0.0285	unpaved	2.7	2.2	880	3	4.9		0.0	1414	16	10
Rickreall Uglow-Orchard																					
R-UO-A1	0.045	28.8	300	Urban Residential	0.080	0.0167	0.284	17.03	375	0.008	unpaved	1.4	4.4	1150	3	6.4	0	0.0	1825	28	17
R-UO-A2	0.054	34.5	300	Urban Residential	0.080	0.0233	0.248	14.88	20	0.05	unpaved	3.6	0.1	1090	3	6.1	0	0.0	1410	21	13
R-UO-A3	0.055	35.4	150	Pavement and Roofs	0.014	0.0067	0.058	3.50	0		paved or unpav		0.0	1700	3	9.4	0	0.0	1850	13	8
R-UO-A4C	0.022	13.9	230	Urban Residential	0.080	0.0652	0.133	7.98	0		unpaved	0.0	0.0	765	3	4.3	0	0.0	995	12	7
R-UO-A4E	0.056	36.0	300	Urban Residential	0.080	0.0233	0.248	14.88	320	0.0625	unpaved	4.0	1.3	2680	3	14.9	0	0.0	3300	31	19
R-UO-A4W	0.039	24.7	230	Urban Residential	0.080	0.0217	0.206	12.38	0		paved or unpav		0.0	2000	3	11.1	0	0.0	2230	23	14
R-UO-A5E	0.046	29.7	110	Urban Residential	0.080	0.0909	0.065	3.87	450	0.0778	unpaved	4.5	1.7	1120	3	6.2	330	3.7	2010	15	9
R-UO-A5W	0.042	26.9	300	Urban Residential	0.080	0.0333	0.215	12.91	20	0.05	unpaved	3.6	0.1	2000	3	11.1	0	0.0	2320	24	14
R-UO-A6	0.043	27.3	175	Meadow, Pasture, Range Land	0.150	0.0171	0.301	18.09	0		unpaved	0.0	0.0	2818	3	15.7	0	0.0	2993	34	20
R-UO-AB1	0.002	1.3	100	Light Turf	0.240	0.03	0.224	13.46	0		unpaved	0.0	0.0	175	3	1.0	0	0.0	275	14	9
R-UO-AB2E	0.021	13.3	185	Urban Residential	0.080	0.0432	0.132	7.90	0		paved or unpav		0.0	328	3	1.8	421	4.7	934	14	9
R-UO-AB2W	0.039	24.9	260	Urban Residential	0.080	0.0385	0.181	10.87	859	0.0233	unpaved	2.4	5.8	724	3	4.0	0	0.0	1843	21	12

TIME OF CONCENTRATION CALCULATION SHEET - BUILDOUT CONDITION

			Sheet Flow						Shallow Conc. Flow					Pipe & Channel Flow			Gutters Flow				
Sub Basin	Drainage Area		Length	Surface Description	Manning's Roughness Coeff.	Slope	Travel Time	Travel Time	Length	Slope	Paved, Un-paved, or na	Average Velocity	Travel Time	length	Average Velocity	Travel Time	Street Gutter length	Travel Time	Total length (ft)	Cummulative Time of Concentration	Lag Time
	A (sq mile)	A (ac)	L (ft)		*n*	S (ft/ft)	T_t (hr)	T_t (min)	L (ft)	S (ft/ft)		$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	T_t (min)		T_c (min)	Tlag (min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
Ash Creek Bridlewood																					
A-BW-A1	2.922	1870.0									Not Calculated										
A-BW-A2	0.031	19.8	165	Urban Residential	0.080	0.0909	0.089	5.36	448	0.1116	unpaved	5.4	1.4	503	3	2.8		0.0	1116	10	6
A-BW-C1	0.090	57.6	55	Urban Residential	0.080	0.0545	0.045	2.73	190	0.0368	paved	3.9	0.8	2551	3	14.2		0.0	2796	18	11
A-BW-B1	0.021	13.3	250	Urban Residential	0.080	0.04	0.173	10.37	382	0.0393	paved	4.0	1.6	765	3	4.3		0.0	1397	16	10
A-BW-D1	0.148	94.5	290	Urban Residential	0.080	0.1552	0.113	6.79	1117	0.1119	paved	6.8	2.7	3520	3	19.6		0.0	4927	29	17
Ash Creek Industrial																					
A-I-A1	0.052	33.2	270	Industrial Area	0.050	0.1741	0.070	4.20	645	0.1628	paved	8.2	1.3	1105	3	6.1		0.0	2020	12	7
A-I-A2	0.037	23.4	300	Industrial Area	0.050	0.1567	0.080	4.77	525	0.1905	paved	8.9	1.0	985	3	5.5		0.0	1810	11	7
A-I-B1	0.065	41.4	145	Industrial Area	0.050	0.0138	0.117	7.05	790	0.0063	paved	1.6	8.2	1227	3	6.8		0.0	2162	22	13
A-I-B2	0.033	21.1	242	Industrial Area	0.050	0.0083	0.217	13.03	835	0.006	paved	1.6	8.9	1135	3	6.3		0.0	2212	28	17
A-I-C1	0.030	19.3	275	Industrial Area	0.050	0.0109	0.215	12.92	285	0.0175	paved	2.7	1.8	980	3	5.4		0.0	1540	20	12
A-I-C2N	0.035	22.3	300	Industrial Area	0.050	0.15	0.081	4.86	720	0.0319	paved	3.6	3.3	0	3	0.0		0.0	1020	8	5
A-I-C2S	0.094	60.3	190	Industrial Area	0.050	0.1579	0.055	3.30	775	0.1161	unpaved	5.5	2.3	2005	3	11.1		0.0	2970	17	10
A-I-C3	1.466	938.1									Not Calculated										
A-I-D1	0.028	18.2	80	Industrial Area	0.050	0.025	0.058	3.45	801	0.0062	paved	1.6	8.3	633	3	3.5		0.0	1514	15	9
A-I-E1	0.043	27.7	250	Urban Residential	0.080	0.012	0.280	16.78	786	0.0089	paved	1.9	6.8	803	3	4.5		0.0	1839	28	17
A-I-F1	0.016	10.0	250	Urban Residential	0.080	0.008	0.329	19.74	712	0.0056	paved	1.5	7.8	0	3	0.0		0.0	962	28	17
A-I-H1	0.088	56.6	300	Industrial Area	0.050	0.0067	0.281	16.87	1200	0.0067	paved	1.7	12.1	1377	3	7.7		0.0	2877	37	22
A-I-I1	0.016	9.9	290	Urban Residential	0.080	0.1207	0.125	7.51	229	0.131	paved	7.4	0.5	448	3	2.5		0.0	967	11	6
A-I-I2	0.068	43.7	300	Urban Residential	0.150	0.1167	0.215	12.93	1200	0.0564	paved	4.8	4.1	750	4	3.1		0.0	2250	20	12
A-I-J1	0.033	21.3	95	Industrial Area	0.050	0.0105	0.093	5.60	520	0.0058	paved	1.5	5.6	777	3	4.3		0.0	1392	16	9
A-I-J2	0.050	32.0	300	Industrial Area	0.050	0.0167	0.195	11.69	1200	0.0058	paved	1.5	12.9	500	3	2.8		0.0	2000	27	16
Ash Creek Residential																					
A-R-A1	0.026	16.4	300	Rural Residential	0.240	0.0233	0.597	35.85	1100	0.0227	paved	3.1	6.0	0	3	0.0	0	0.0	1400	42	25
A-R-B1	0.042	27.1	300	Rural Residential	0.240	0.0167	0.683	41.01	1200	0.0161	paved	2.6	7.8	350	3	1.9	0	0.0	1850	51	30
A-R-C1	0.043	27.6	300	Rural Residential	0.240	0.2167	0.245	14.70	1200	0.0667	paved	5.3	3.8	750	3	4.2	0	0.0	2250	23	14
A-R-D1	0.054	34.4	300	Urban Residential	0.080	0.0833	0.149	8.95	1200	0.0256	paved	3.3	6.2	750	3	4.2	0	0.0	2250	19	12
A-R-E1	0.045	28.5	300	Urban Residential	0.080	0.0667	0.163	9.78	1200	0.0233	paved	3.1	6.5	300	3	1.7	0	0.0	1800	18	11
A-R-F1	0.050	32.2	300	Urban Residential	0.080	0.12	0.129	7.73	1100	0.0673	paved	5.3	3.5	0	3	0.0	0	0.0	1400	11	7
A-R-G1	0.093	59.2	300	Urban Residential	0.080	0.0667	0.163	9.78	1200	0.025	paved	3.2	6.2	1860	3	10.3	0	0.0	3360	26	16
A-R-B3S	0.051	32.5	300	Urban Residential	0.080	0.14	0.121	7.27	1200	0.1042	paved	6.6	3.0	2121	3	11.8		0.0	3621	22	13
A-R-B2	0.021	13.5	125	Urban Residential	0.080	0.056	0.087	5.21	356	0.0702	paved	5.4	1.1	823	3	4.6		0.0	1304	11	7
A-R-B3N	0.027	17.3	220	Urban Residential	0.080	0.05	0.143	8.56	1200	0.076	unpaved	4.4	4.5	510	3	2.8		0.0	1930	16	10
A-R-B3C	0.192	122.6	300	Urban Residential	0.080	0.1	0.139	8.32	315	0.1429	paved	7.7	0.7	5057	3	28.1		0.0	5672	37	22
A-R-B4N	0.051	32.8	300	Urban Residential	0.080	0.0833	0.149	8.95	1200	0.025	paved	3.2	6.2	1860	3	10.3		0.0	3360	26	15
Baskett Slough																					
BS-A1	0.037	24.0	300	Urban Residential	0.080	0.0333	0.215	12.91	1010	0.0644	paved	5.2	3.3	605	3	3.4		0.0	1915	20	12
BS-B1	0.027	17.2	50	Urban Residential	0.080	0.04	0.048	2.86	0		paved	0.0	0.0	1535	3	8.5		0.0	1585	11	7
BS-C1	0.099	63.1	265	Urban Residential	0.080	0.0189	0.245	14.67	460	0.0326	paved	3.7	2.1	1172	3	6.5		0.0	1897	23	14
BS-C2	0.088	56.2	130	Urban Residential	0.080	0.0385	0.104	6.24	1077	0.0158	paved	2.5	7.0	0	3	0.0		0.0	1207	13	8
Forestry Creek																					
F-A1	0.056	36.1	300	Urban Residential	0.080	0.033	0.215	12.91	315	0.0317	paved	3.6	1.4	170	3	0.9	0	0.0	785	15	9
F-A2E	0.050	32.1	220	Meadow, Pasture, Range Land	0.150	0.1136	0.170	10.19	0		unpaved	0.0	0.0	1800	3	10.0	300	3.3	2320	24	14
F-A2W	0.058	37.1	300	Urban Residential	0.080	0.1333	0.124	7.41	1200	0.031	paved	3.6	5.6	2200	3	12.2	0	0.0	3700	25	15
F-A3	0.070	44.6	215	Urban Residential	0.080	0.0093	0.275	16.47	0		paved	0.0	0.0	3780	3	21.0	0	0.0	3995	37	22
F-A4	0.107	68.5	300	Urban Residential	0.080	0.023	0.248	14.88	1200	0.0467	paved	4.4	4.6	1880	3	10.4	0	0.0	3380	30	18
F-A5E	0.022	14.3	300	Urban Residential	0.080	0.033	0.215	12.91	1180	0.0466	paved	4.4	4.5	0	3	0.0	0	0.0	1480	17	10

TIME OF CONCENTRATION CALCULATION SHEET - BUILDOUT CONDITION

Sub Basin	Drainage Area		Sheet Flow						Shallow Conc. Flow					Pipe & Channel Flow			Gutters Flow				
			Length	Surface Description	Manning's Roughness Coeff.	Slope	Travel Time	Travel Time	Length	Slope	Paved, Un-paved, or na	Average Velocity	Travel Time	length	Average Velocity	Travel Time	Street Gutter length	Travel Time	Total length (ft)	Cummulative Time of Concentration	Lag Time
	A (sq mile)	A (ac)	L (ft)		n	S (ft/ft)	T_t (hr)	T_t (min)	L (ft)	S (ft/ft)		$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	T_t (min)		T_c (min)	Tlag (min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
F-A5W1	0.065	41.5	300	Meadow, Pasture, Range Land	0.150	0.0333	0.356	21.34	735	0.0369	unpaved	3.1	4.0	0	3	0.0	0	0.0	1035	25	15
F-A5W2	0.065	41.5	300	Meadow, Pasture, Range Land	0.150	0.0333	0.356	21.34	730	0.0369	unpaved	3.1	3.9	310	3	1.7	0	0.0	1340	27	16
F-B1	0.093	59.5	160	Urban Residential	0.080	0.019	0.164	9.82	0	0	paved or unpav		0.0	3550	3	19.7	0	0.0	3710	30	18
Rickreall Barberry Node																					
R-B-A1	0.053	34.2	300	Urban Residential	0.080	0.0133	0.310	18.62	1200	0.0093	paved	2.0	10.2	1598	3	8.9	0	0.0	3098	38	23
R-B-B1	0.056	36.0	300	Urban Residential	0.080	0.0067	0.409	24.57	1200	0.0146	paved	2.5	8.2	683	3	3.8	0	0.0	2183	37	22
R-B-B2	0.190	121.8	300	Urban Residential	0.080	0.02	0.264	15.83	1200	0.0098	paved	2.0	10.0	2380	3	13.2	0	0.0	3880	39	23
R-B-C1	0.062	39.7	300	Urban Residential	0.080	0.01	0.348	20.89	1200	0.0082	paved	1.8	10.9	1742	3	9.7	0	0.0	3242	41	25
R-B-C2	0.017	10.9	300	Urban Residential	0.080	0.0167	0.284	17.03	350	0.02	paved	2.9	2.0	550	3	3.1	0	0.0	1200	22	13
R-B-D1	0.014	8.9	300	Urban Residential	0.080	0.0567	0.174	10.44	200	0.01	paved	2.0	1.6	0	3	0.0	0	0.0	500	12	7
R-B-D2	0.063	40.3	300	Urban Residential	0.080	0.0133	0.310	18.62	1150	0.0104	paved	2.1	9.3	1250	3	6.9	0	0.0	2700	35	21
R-B-D3	0.032	20.8	300	Urban Residential	0.080	0.01	0.348	20.89	1050	0.0067	paved	1.7	10.6	0	3	0.0	0	0.0	1350	31	19
Rickreall Central Business District																					
R-CBD-A1	0.011	7.0	300	Urban Residential	0.080	0.0533	0.178	10.69	300	0.0167	paved	2.6	1.9	0	3	0.0	0	0.0	600	13	8
R-CBD-B1	0.064	41.0	80	Urban Residential	0.080	0.0125	0.111	6.64	0		paved or unpav		0.0	2400	3	13.3	170	1.9	2650	22	13
R-CBD-B2	0.082	52.8	130	Urban Residential	0.080	0.0154	0.150	9.01	0		paved or unpav		0.0	2575	3	14.3	400	4.4	3105	28	17
R-CBD-B3	0.044	28.2	300	Urban Residential	0.080	0.0167	0.284	17.03	160	0.0188	unpaved	2.2	1.2	1520	3	8.4	0	0.0	1980	27	16
R-CBD-C1	0.036	22.9	80	City Business Area	0.014	0.0125	0.027	1.65	0		paved or unpav		0.0	1240	3	6.9	230	2.6	1550	11	7
R-CBD-D1	0.045	28.6	300	City Business Area	0.014	0.01	0.086	5.18	630	0.0317	paved	3.6	2.9	0	3	0.0	0	0.0	930	8	5
R-CBD-E1	0.062	39.5	130	Pavement and Roofs	0.014	0.0077	0.049	2.95	0		paved or unpav		0.0	2800	3	15.6	0	0.0	2930	19	11
R-CBD-E2	0.055	35.5	300	Urban Residential	0.080	0.01	0.348	20.89	0		paved or unpav		0.0	2370	3	13.2	300	3.3	2970	37	22
R-CBD-E3	0.072	46.3	300	Urban Residential	0.080	0.0333	0.215	12.91	20	0.05	unpaved	3.6	0.1	2680	3	14.9	100	1.1	3100	29	17
Rickreall NE																					
R-NE-A1	0.047	30.2	300	Urban Residential	0.080	0.01	0.348	20.89	325	0.0462	paved	4.4	1.2	590	3	3.3	0	0.0	1215	25	15
R-NE-B1	0.019	12.4	300	Urban Residential	0.080	0.0033	0.540	32.42	780	0.0256	paved	3.3	4.0	0	3	0.0	0	0.0	1080	36	22
R-NE-C1	0.037	23.5	300	Urban Residential	0.080	0.02	0.264	15.83	1200	0.0112	paved	2.1	9.3	840	3	4.7	0	0.0	2340	30	18
R-NE-D1	0.064	40.9	300	Urban Residential	0.080	0.0067	0.409	24.57	430	0.0047	paved	1.4	5.2	980	3	5.4	0	0.0	1710	35	21
R-NE-E1	0.064	40.8	300	Urban Residential	0.080	0.0233	0.248	14.88	0		paved or unpav		0.0	1880	3	10.4	0	0.0	2180	25	15
R-NE-E2	0.059	37.9	300	Light Turf	0.240	0.0067	0.986	59.17	900	0.0078	unpaved	1.4	10.6	1700	3	9.4	0	0.0	2900	79	48
R-NE-E3C	0.089	57.0	300	Urban Residential	0.080	0.0333	0.215	12.91	700	0.0214	paved	3.0	3.9	1520	3	8.4	0	0.0	2520	25	15
R-NE-E3E	0.042	26.7	300	Urban Residential	0.080	0.0333	0.215	12.91	590	0.0169	paved	2.6	3.7	0	3	0.0	1610	17.9	2500	35	21
R-NE-E3W	0.058	37.0	300	Urban Residential	0.080	0.0233	0.248	14.88	430	0.0349	paved	3.8	1.9	1600	3	8.9	0	0.0	2330	26	15
R-NE-E4	0.069	44.4	300	Urban Residential	0.080	0.05	0.183	10.97	420	0.0357	paved	3.8	1.8	2390	3	13.3	0	0.0	3110	26	16
Rickreall North Central																					
R-NC-A1	0.039	25.1	300	Urban Residential	0.080	0.04	0.200	12.00	150	0.0467	paved	4.4	0.6	1050	3	5.8	0	0.0	1500	18	11
R-NC-A2E	0.059	37.7	141	Urban Residential	0.080	0.0709	0.087	5.22	151	0.0464	paved	4.4	0.6	2977	3	16.5	0	0.0	3269	22	13
R-NC-A2W	0.080	51.5	290	Urban Residential	0.080	0.0862	0.143	8.59	0		unpaved	0.0	0.0	1560	3	8.7	575	6.4	2425	24	14
R-NC-A3	0.032	20.5	230	Urban Residential	0.080	0.0435	0.156	9.38	0		paved	0.0	0.0	2000	3	11.1	0	0.0	2230	20	12
R-NC-B1	0.061	39.4	0	na	0.000			0.00	440	0.0159	paved	2.6	2.9	2279	3	12.7	0	0.0	2719	16	9
R-NC-C1	0.046	29.6	0	na	0.000			0.00	0		paved	0.0	0.0	520	3	2.9	600	6.7	1120	10	6
Rickreall NW																					
R-NW-A1	0.026	16.4	300	Urban Residential	0.080	0.0167	0.284	17.03	430	0.0116	paved	2.2	3.3	0	3	0.0	0	0.0	730	20	12
R-NW-B1	0.031	20.0	300	Urban Residential	0.080	0.0067	0.409	24.57	800	0.01	paved	2.0	6.6	1050	3	5.8	0	0.0	2150	37	22
R-NW-B2	0.022	14.2	300	Urban Residential	0.080	0.0133	0.310	18.62	100	0.02	unpaved	2.3	0.7	800	3	4.4	0	0.0	1200	24	14
R-NW-C1N	0.032	20.5	300	Meadow, Pasture, Range Land	0.150	0.0233	0.410	24.61	1025	0.0293	unpaved	2.7	6.2	135	3	0.8	0	0.0	1460	32	19
R-NW-C1S	0.049	31.6	300	Urban Residential	0.080	0.0233	0.248	14.88	0		paved	0.0	0.0	1035	3	5.8	900	10.0	2235	31	18
R-NW-C2E	0.061	39.0	230	Urban Residential	0.080	0.0652	0.133	7.98	0		paved	0.0	0.0	3170	3	17.6	0	0.0	3400	26	15
R-NW-C2W	0.059	37.5	300	Urban Residential	0.080	0.0667	0.163	9.78	1200	0.0474	paved	4.4	4.5	1680	3	9.3	0	0.0	3180	24	14

CH2M HILL

City of Dallas Stormwater Master Plan

TIME OF CONCENTRATION CALCULATION SHEET - BUILDOUT CONDITION

Sub Basin	Drainage Area		Sheet Flow Length	Sheet Flow Surface Description	Sheet Flow Manning's Roughness Coeff.	Sheet Flow Slope	Sheet Flow Travel Time	Sheet Flow Travel Time	Shallow Conc. Flow Length	Shallow Conc. Flow Slope	Shallow Conc. Flow Paved, Un-paved, or na	Shallow Conc. Flow Average Velocity	Shallow Conc. Flow Travel Time	Pipe & Channel Flow length	Pipe & Channel Flow Average Velocity	Pipe & Channel Flow Travel Time	Gutters Flow Street Gutter length	Gutters Flow Travel Time	Total length (ft)	Cummulative Time of Concentration	Lag Time
	A (sq mile)	A (ac)	L (ft)		*n*	S (ft/ft)	T_t (hr)	T_t (min)	L (ft)	S (ft/ft)		$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	$V_{ave.}$ (ft/s)	T_t (min)	L (ft)	T_t (min)		T_c (min)	Tlag (min)
1	3	4	2		3	4		5	6	7		8	9	10	12	13	14	16	17	18	
R-NW-C3EE	0.071	45.6	300	Urban Residential	0.080	0.05	0.183	10.97	1100	0.0727	paved	5.5	3.3	1640	3	9.1	0	0.0	3040	23	14
R-NW-C3EW	1.025	655.9	300	Urban Residential	0.080	0.0833	0.149	8.95	1200	0.137	paved	7.5	2.7	12283	3	68.2	0	0.0	13783	80	48
R-NW-D1	0.023	14.5	100	Urban Residential	0.080	0.01	0.145	8.67	0		paved or unpav		0.0	1200	3	6.7	450	5.0	1750	20	12
R-NW-E1	0.028	17.8	270	Urban Residential	0.080	0.0074	0.361	21.65	0		paved or unpav		0.0	1820	4	7.6	0	0.0	2090	29	18
R-NW-F1	0.029	18.4	300	Urban Residential	0.080	0.0367	0.207	12.42	480	0.0208	paved	2.9	2.7	0	3	0.0	0	0.0	780	15	9
R-NW-G1	0.036	23.3	100	Urban Residential	0.080	0.02	0.110	6.57	55	0.0182	unpaved	2.2	0.4	2943	3	16.4	323	3.6	3421	27	16
R-NW-H1	0.049	31.1	200	Urban Residential	0.080	0.015	0.214	12.84	283	0.0177	paved	2.7	1.7	972	3	5.4	0	0.0	1455	20	12
Rickreall SE																					
R-SE-A1	0.028	17.6	155	Pavement and Roofs	0.014	0.0387	0.030	1.78	140	0.0143	paved	2.4	1.0	920	3	5.1	170	1.9	1385	10	6
R-SE-B1	0.024	15.4	120	Pavement and Roofs	0.014	0.0083	0.045	2.68	0		paved or unpav		0.0	1660	3	9.2	170	1.9	1950	14	8
R-SE-C1	0.090	57.4	278	Urban Residential	0.080	0.0108	0.318	19.07	0		paved or unpav		0.0	2350	3	13.1	0	0.0	2628	32	19
R-SE-D1	0.025	15.8	170	Urban Residential	0.080	0.0882	0.093	5.55	100	0.02	paved	2.9	0.6	604	3	3.4	0	0.0	874	9	6
R-SE-E1	0.088	56.4	300	Urban Residential	0.080	0.0333	0.215	12.91	0		paved or unpav		0.0	2340	3	13.0	0	0.0	2640	26	16
R-SE-F1	0.018	11.3	300	Urban Residential	0.080	0.0067	0.409	24.57	550	0.0218	paved	3.0	3.1	0	3	0.0	0	0.0	850	28	17
Rickreall SW																					
R-SW-A1	0.035	22.6	270	Urban Residential	0.080	0.1111	0.122	7.33	491	0.2749	paved	10.7	0.8	0	3	0.0		0.0	761	8	5
R-SW-B1	0.069	43.9	115	Urban Residential	0.080	0.0609	0.079	4.71	539	0.0278	paved	3.4	2.7	796	3	4.4		0.0	1450	12	7
R-SW-B2E	0.088	56.3	300	Urban Residential	0.080	0.0167	0.284	17.03	375	0.0533	paved	4.7	1.3	2831	3	15.7		0.0	3506	34	20
R-SW-B2W	0.034	21.9	150	Urban Residential	0.080	0.0467	0.108	6.48	495	0.0404	paved	4.1	2.0	522	3	2.9		0.0	1167	11	7
R-SW-B3	0.142	90.8	255	Urban Residential	0.080	0.1569	0.102	6.10	710	0.0775	paved	5.7	2.1	3879	3	21.6		0.0	4844	30	18
R-SW-C1	0.030	18.9	183	Urban Residential	0.080	0.0273	0.157	9.41	351	0.0285	unpaved	2.7	2.2	880	3	4.9		0.0	1414	16	10
Rickreall Uglow-Orchard																					
R-UO-A1	0.045	28.8	300	Urban Residential	0.080	0.0167	0.284	17.03	375	0.008	paved	1.8	3.4	1150	3	6.4	0	0.0	1825	27	16
R-UO-A2	0.054	34.5	300	Urban Residential	0.080	0.0233	0.248	14.88	20	0.05	paved	4.5	0.1	1090	3	6.1	0	0.0	1410	21	13
R-UO-A3	0.055	35.4	150	Pavement and Roofs	0.014	0.0067	0.058	3.50	0		paved	0.0	0.0	1700	3	9.4	0	0.0	1850	13	8
R-UO-A4C	0.022	13.9	230	Urban Residential	0.080	0.0652	0.133	7.98	0		paved	0.0	0.0	765	3	4.3	0	0.0	995	12	7
R-UO-A4E	0.056	36.0	300	Urban Residential	0.080	0.0233	0.248	14.88	320	0.0625	paved	5.1	1.0	2680	3	14.9	0	0.0	3300	31	18
R-UO-A4W	0.039	24.7	230	Urban Residential	0.080	0.0217	0.206	12.38	0		paved	0.0	0.0	2000	3	11.1	0	0.0	2230	23	14
R-UO-A5E	0.046	29.7	300	Urban Residential	0.080	0.0333	0.215	12.91	450	0.0778	paved	5.7	1.3	1120	3	6.2	330	3.7	2200	24	14
R-UO-A5W	0.042	26.9	300	Urban Residential	0.080	0.0333	0.215	12.91	20	0.05	paved	4.5	0.1	2000	3	11.1	0	0.0	2320	24	14
R-UO-A6	0.043	27.3	175	Urban Residential	0.080	0.0171	0.182	10.94	0		paved	0.0	0.0	2818	3	15.7	0	0.0	2993	27	16
R-UO-AB1	0.002	1.3	300	Light Turf	0.240	0.0333	0.518	31.08	180	0.0278	unpaved	2.7	1.1	0	3	0.0	0	0.0	480	32	19
R-UO-AB2E	0.021	13.3	185	Urban Residential	0.080	0.0432	0.132	7.90	0		paved or unpav		0.0	328	3	1.8	421	4.7	934	14	9
R-UO-AB2W	0.039	24.9	260	Urban Residential	0.080	0.0385	0.181	10.87	859	0.0233	Paved	3.1	4.6	724	3	4.0	0	0.0	1843	20	12

PROJECT: Dallas Stormwater Master Plan **DATE:** 10/1/2014

PROJECT #: 496541 **REGION:** **2B**

BASIN DESCRIPTION Tributary basin upstream of Bridlewood crossing

INPUT

Variable	value	units	Description	Source
Area =	**2.9219**	*sq mi*	*Drainage Area, in square miles*	measured from USGS 7.5 minute quad map
Slope =	**5.6**	*degrees*	*Mean watershed slope, in degrees*	measured from USGS 7.5 minute quad map
I24-2 =	**3.1**	*in*	*Precipitation Intensity for a 2-year 24-hour event, in inches*	taken from NOAA Isopoluvial Map

Region 1

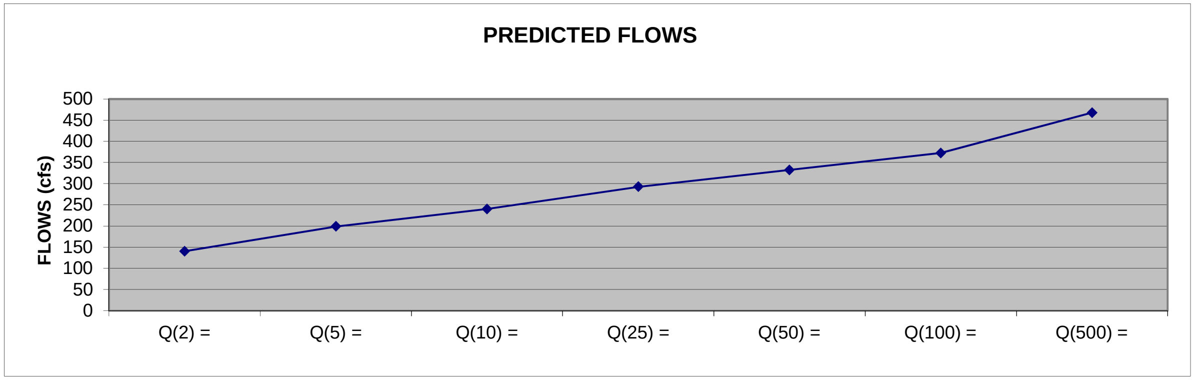
CALCULATIONS *For estimating peak discharge for ungaged watersheds in Region 2B, western interior with mean elevation less than 3,000 ft (SIR 2005-5116)*

Discharge	Constant	Area	A Exp	Slope	Slope Exp	I24-2	I24-2 Exp
cfs	-	*sq mi*	-	*deg*	-	*in*	-
Q(2) =	9.136	**2.921875**	0.9004	**5.6**	0.4695	**3.1**	0.8481
Q(5) =	14.540	**2.921875**	0.9042	**5.6**	0.4735	**3.1**	0.7355
Q(10) =	18.490	**2.921875**	0.9064	**5.6**	0.4688	**3.1**	0.6937
Q(25) =	23.720	**2.921875**	0.9086	**5.6**	0.4615	**3.1**	0.6578
Q(50) =	27.750	**2.921875**	0.9101	**5.6**	0.4559	**3.1**	0.6390
Q(100) =	31.850	**2.921875**	0.9114	**5.6**	0.4501	**3.1**	0.6252
Q(500) =	41.720	**2.921875**	0.9141	**5.6**	0.4365	**3.1**	0.6059

OUTPUT

Discharge (n) year recurrance interval	- 1 Standard Error	Flow	+ 1 Standard Error	Percent Standard Error
	cfs	*cfs*	*cfs*	*%*
Q(2) =	96	**141**	185	31.9
Q(5) =	136	**199**	262	31.6
Q(10) =	163	**240**	317	32.0
Q(25) =	196	**293**	390	33.0
Q(50) =	220	**333**	446	34.0
Q(100) =	242	**373**	503	35.0
Q(500) =	292	**468**	645	37.7

$$Q(2) = 9.136\ Area^{0.9004}\ Slope^{0.4695}\ I24-2^{0.8481}$$
$$Q(5) = 14.54\ Area^{0.9042}\ Slope^{0.4735}\ I24-2^{0.7355}$$
$$Q(10) = 18.49\ Area^{0.9064}\ Slope^{0.4688}\ I24-2^{0.6937}$$
$$Q(25) = 23.72\ Area^{0.9086}\ Slope^{0.4615}\ I24-2^{0.6578}$$
$$Q(50) = 27.75\ Area^{0.9101}\ Slope^{0.4559}\ I24-2^{0.6390}$$
$$Q(100) = 31.85\ Area^{0.9114}\ Slope^{0.4501}\ I24-2^{0.6252}$$
$$Q(500) = 41.72\ Area^{0.9141}\ Slope^{0.4365}\ I24-2^{0.6059}$$



PROJECT: Dallas Stormwater Master Plan **DATE:** 10/1/2014
PROJECT #: 496541 **REGION:** **2B**

BASIN DESCRIPTI(Tributary to N. Fork Ash Creek upstream of Weyerhaeuser.

INPUT

Variable	value	units	Description	Source
Area =	**0.5297**	*sq mi*	*Drainage Area, in square miles*	measured from USGS 7.5 minute quad map
Slope =	**3.55**	*degrees*	*Mean watershed slope, in degrees*	measured from USGS 7.5 minute quad map
I24-2 =	**3.1**	*in*	*Precipitation Intensity for a 2-year 24-hour event, in inches*	taken from NOAA Isopoluvial Map

Region 1

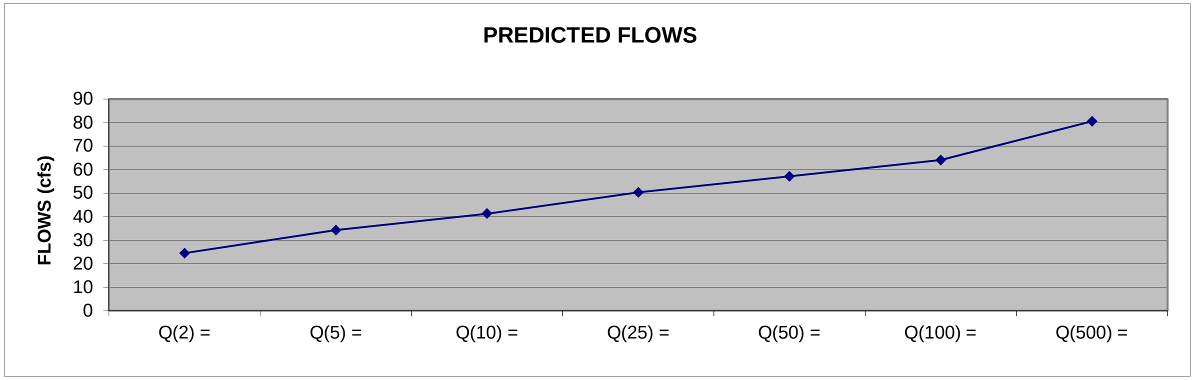
CALCULATIONS *For estimating peak discharge for ungaged watersheds in Region 2B, western interior with mean elevation less than 3,000 ft (SIR 2005-5116)*

Discharge	Constant	Area	A Exp	Slope	Slope Exp	I24-2	I24-2 Exp
cfs	-	*sq mi*	-	*deg*	-	*in*	-
Q(2) =	9.136	**0.529688**	0.9004	**3.55**	0.4695	**3.1**	0.8481
Q(5) =	14.540	**0.529688**	0.9042	**3.55**	0.4735	**3.1**	0.7355
Q(10) =	18.490	**0.529688**	0.9064	**3.55**	0.4688	**3.1**	0.6937
Q(25) =	23.720	**0.529688**	0.9086	**3.55**	0.4615	**3.1**	0.6578
Q(50) =	27.750	**0.529688**	0.9101	**3.55**	0.4559	**3.1**	0.6390
Q(100) =	31.850	**0.529688**	0.9114	**3.55**	0.4501	**3.1**	0.6252
Q(500) =	41.720	**0.529688**	0.9141	**3.55**	0.4365	**3.1**	0.6059

OUTPUT

Discharge (n) year recurrance interval	- 1 Standard Error	Flow	+ 1 Standard Error	Percent Standard Error
	cfs	*cfs*	*cfs*	*%*
Q(2) =	17	**24**	32	31.9
Q(5) =	23	**34**	45	31.6
Q(10) =	28	**41**	54	32.0
Q(25) =	34	**50**	67	33.0
Q(50) =	38	**57**	77	34.0
Q(100) =	42	**64**	86	35.0
Q(500) =	50	**81**	111	37.7

$$Q(2) = 9.136\ Area^{0.9004}\ Slope^{0.4695}\ I24-2^{0.8481}$$
$$Q(5) = 14.54\ Area^{0.9042}\ Slope^{0.4735}\ I24-2^{0.7355}$$
$$Q(10) = 18.49\ Area^{0.9064}\ Slope^{0.4688}\ I24-2^{0.6937}$$
$$Q(25) = 23.72\ Area^{0.9086}\ Slope^{0.4615}\ I24-2^{0.6578}$$
$$Q(50) = 27.75\ Area^{0.9101}\ Slope^{0.4559}\ I24-2^{0.6390}$$
$$Q(100) = 31.85\ Area^{0.9114}\ Slope^{0.4501}\ I24-2^{0.6252}$$
$$Q(500) = 41.72\ Area^{0.9141}\ Slope^{0.4365}\ I24-2^{0.6059}$$



PROJECT: Dallas Stormwater Master Plan
PROJECT #: 496541

DATE: 10/1/2014
REGION: **2B**

BASIN DESCRIPTION Mistletoe Road tributary basin

INPUT

Variable	value	units	Description	Source
Area =	**1.4656**	*sq mi*	*Drainage Area, in square miles*	measured from USGS 7.5 minute quad map
Slope =	**6.5**	*degrees*	*Mean watershed slope, in degrees*	measured from USGS 7.5 minute quad map
I24-2 =	**3.1**	*in*	*Precipitation Intensity for a 2-year 24-hour event, in inches*	taken from NOAA Isopoluvial Map

Region 1

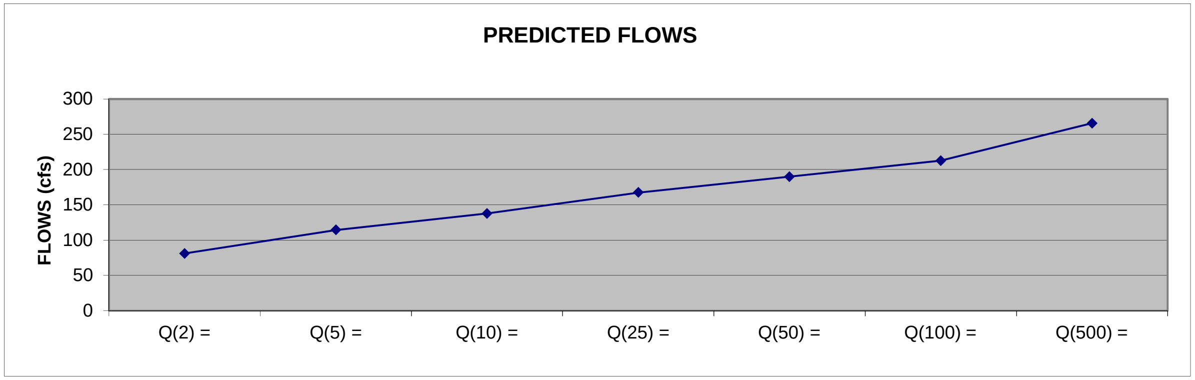
CALCULATIONS *For estimating peak discharge for ungaged watersheds in Region 2B, western interior with mean elevation less than 3,000 ft (SIR 2005-5116)*

Discharge	Constant	Area	A Exp	Slope	Slope Exp	I24-2	I24-2 Exp
cfs	-	*sq mi*	-	*deg*	-	*in*	-
Q(2) =	9.136	**1.465625**	0.9004	**6.5**	0.4695	**3.1**	0.8481
Q(5) =	14.540	**1.465625**	0.9042	**6.5**	0.4735	**3.1**	0.7355
Q(10) =	18.490	**1.465625**	0.9064	**6.5**	0.4688	**3.1**	0.6937
Q(25) =	23.720	**1.465625**	0.9086	**6.5**	0.4615	**3.1**	0.6578
Q(50) =	27.750	**1.465625**	0.9101	**6.5**	0.4559	**3.1**	0.6390
Q(100) =	31.850	**1.465625**	0.9114	**6.5**	0.4501	**3.1**	0.6252
Q(500) =	41.720	**1.465625**	0.9141	**6.5**	0.4365	**3.1**	0.6059

OUTPUT

Discharge (n) year recurrance interval	- 1 Standard Error	Flow	+ 1 Standard Error	Percent Standard Error
	cfs	*cfs*	*cfs*	*%*
Q(2) =	55	**81**	107	31.9
Q(5) =	78	**115**	151	31.6
Q(10) =	94	**138**	182	32.0
Q(25) =	112	**168**	223	33.0
Q(50) =	125	**190**	255	34.0
Q(100) =	138	**213**	287	35.0
Q(500) =	166	**266**	366	37.7

$$Q(2) = 9.136\, Area^{0.9004}\, Slope^{0.4695}\, I24-2^{0.8481}$$
$$Q(5) = 14.54\, Area^{0.9042}\, Slope^{0.4735}\, I24-2^{0.7355}$$
$$Q(10) = 18.49\, Area^{0.9064}\, Slope^{0.4688}\, I24-2^{0.6937}$$
$$Q(25) = 23.72\, Area^{0.9086}\, Slope^{0.4615}\, I24-2^{0.6578}$$
$$Q(50) = 27.75\, Area^{0.9101}\, Slope^{0.4559}\, I24-2^{0.6390}$$
$$Q(100) = 31.85\, Area^{0.9114}\, Slope^{0.4501}\, I24-2^{0.6252}$$
$$Q(500) = 41.72\, Area^{0.9141}\, Slope^{0.4365}\, I24-2^{0.6059}$$



Appendix D
Cost Estimate Report

Basis of Estimate

City of Dallas, Oregon Storm Water Master Plan

Prepared for

City of Dallas
Dallas, Oregon

December 2014

CH2MHILL®

1100 NE Circle Blvd Suite 300
Corvallis, OR 97330
US
(541) 752-4271
Fax (541) 752-0276

Contents

Acronyms and Abbreviations

AACEI	Association for the Advancement of Cost Engineering International
CY	Cubic Yard
EA	Each
GC	General Conditions or General Contractor
LF	Linear Foot
NTP	Notice to Proceed
RCP	Reinforced Concrete Pipe
SF	Square Foot
VE	Value Engineering

SECTION 1

Executive Summary

1.1 Project Overview

The following cost estimates are to provide the City of Dallas with approximate costs for pipe replacements, culvert replacements, channel modifications, and water quality facilities.

TABLE NUMBER 1.1
Project Overview

Estimate Classification:	Class 4
Requested By:	Emily Callaway/PDX
Estimated By:	Tom Jones/CVO
Estimate Date	December 10, 2014

1.2 Overall Costs

This executive summary provides an overview of the Cost Estimate. Reliance on this information is advised to be in consideration of the full context of this report.

The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, final project costs, implementation schedule and other variable factors. As a result, the final project costs will vary from the estimate presented herein. The following is a summary breakdown of the cost (rounded to the nearest $1,000).

TABLE NUMBER 1.2
Overall Costs

	Low Range [-30%]	Estimated Costs [a]	High Range [+50%]
West Ellendale @ Wyatt	$267,000	**$381,000**	$572,000
Douglas System	$407,000	**$581,000**	$872,000
Cemetery	$71,000	**$101,000**	$152,000
Rickreall Uglow/Orchard	$1,124,000	**$1,605,000**	$2,408,000
Kings Valley Highway at Bridlewood	$92,000	**$131,000**	$197,000
Weyerhaeuser to G-Way Ranch	$7,323,000	**$10,461,000**	$15,692,000
Hunter Street	$113,000	**$161,000**	$242,000
Growth Node – Wyatt	$589,000	**$842,000**	$1,263,000
Growth Node – La Creole	$599,000	**$855,000**	$1,283,000
Growth Node - Barberry	$823,000	**$1,176,000**	$1,764,000

[a] See Appendix A for cost estimate details

SECTION 2

Estimate Information

2.1 Purpose of Estimate

The purpose of this estimate of construction costs is to establish the Engineer's opinion of probable construction costs for the preliminary level of design development.

2.2 Client

These cost estimates are for the City of Dallas, located in Polk County, Oregon.

2.3 General Scope

This project consists of the following areas of improvement:

- West Ellendale @ Wyatt
  - 5' x 6' Box Culvert – 65LF
  - Clear and Replant Channel – 1,600LF
  - Regrade Channel – 115LF
- Douglas System
  - Install 42" Diameter RCP Pipe – 250LF
  - Replace Existing Pipe with 48" Diameter RCP Pipe – 578LF
  - Replace Existing Outfall with Bioswale – 150LF
- Cemetery
  - Northern 3'x4' Box Culvert
  - Southern 2'x4' Box Culvert
  - Driveway 2'x4' Box Culvert
- Rickreall Uglow/Orchard System
  - Replace 15" Culvert with 24" Diameter RCP Culvert – 85LF
  - Dual 54" Diameter RCP – Parking Lot – 230LF
  - Replace Box Culvert w/ Dual 42" Diameter RCP at Ellendale – 150LF
  - Replace Existing 36" with 42" RCP – Ellendale to Apartments – 610LF
  - New 42" Diameter RCP Parallel to Existing 42" – Apartments to Hankel St. – 600LF
  - New 36" Diameter RCP Install Parallel to Existing 48" to Outfall – 900LF
  - Kings Valley Highway Biofiltration Swale – 180LF
  - Uglow Outfall Biofiltration Swale – 150LF
- Kings Valley Highway at Bridlewood
  - Two 6'x8' Box Culvert
- Weyerhaeuser to G-Way Ranch
  - Former Weyerhaeuser Property – 2 parallel 6'x10' Box Culvert
  - Channel Modifications – Reach 1 (Former Weyerhaeuser to Uglow)
  - Uglow Street – 5 Parallel 6'x5' Box Culvert
  - Channel Modifications – Reach 2 (Uglow to Monmouth Cutoff)
  - Monmouth Cutoff West of Holman – New Bridge
  - Channel Modifications – Reach 3 (Monmouth Cutoff to Holman)
  - Holman Street – 3 Parallel 8'x11' Box Culvert
  - Channel Modifications – Reach 4 (Holman to Tributary Upstream)
  - Channel Modifications – Reach 5 (Tributary Upstream and Tributary Downstream)
  - Channel Modifications – Reach 6 (Tributary Downstream to Godsey)
  - Godsey Street – New Bridge

- Channel Modifications – Reach 7 (Godsey to G-Way)
  - Monmouth Cutoff Tributary – Clear Existing Culverts
  - Channel Modifications – Reach T1 (Tributary Channel)
- Hunter Street
  - Install New 48” Culvert
- Growth Node – Wyatt
  - Western Trunkline, 24”
  - Eastern Trunkline, 24”
- Growth Node – La Creole
  - Northern Trunkline, 36”
  - Southern Trunkline, 30”
- Growth Node – Barberry
  - Western Trunkline, 36”
  - Eastern Trunkline, 42”

2.4 Estimate Classification

This cost estimate prepared is considered a Feasibility or Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). Refer to Appendix B for more definition.

Project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding. Our estimate is based on material, equipment, and labor pricing as of October 2014.

This Cost Estimate is based on the use of conceptual and stochastic costs and detailed items using separate Labor, Materials and Equipment costs. The estimate uses parametric costs where design information or details are insufficient to allow a detailed item method. Quotations, allowances, and other costs are as described in Section 3.

SECTION 3

Basis of Estimate

3.1 Basis Documents

The cost estimate is based upon the follow project documents:

- CH2M HILL Preliminary Design sketches and report November 2014

3.2 Estimate Methodology

This cost estimate is considered a bottom rolled up type estimate with cost items and breakdown of Labor, Materials and Equipment.

For the development of this cost estimate, there may be systems that have yet to be defined enough on which to base a scope of work for estimating purposes. CH2M HILL estimating provides parametric costing based on a unit of measurement (i.e. cost per square foot or cost per unit). The cost is assigned per unit and typically is developed by averaging similar projects and analysis of historic costs. Using this approach, CH2M HILL parametric estimators strive to generate a basic system design fitting the parameters of the structure and its proposed function.

Finally, pricing is geographically adjusted to reflect local labor and material rates and job site conditions and requirements. As the design process progresses and the details have increased the parametric costing can be replaced with a detailed takeoff and estimated accordingly.

3.3 Key Assumptions

The following is a list of the Key Assumptions on how the estimator interprets how the project will be constructed:

- West Ellendale @ Wyatt
  - 5’ x 6’ Box Culvert – 65LF
    - Excavation will require shoring and well point dewatering
    - Stream will need to be bypassed during construction of Box Culvert
    - Asphalt thickness is assumed to be 9”
    - A manhole access will need to be installed where existing storm drains intersect new box culvert
    - Traffic Control will need to be provided. (18 days included)
  - Clear and Replant Channel – 1,600LF
    - Stream will need to be bypassed during construction
      - Sand bag cofferdam and single submersible pump will be sufficient
    - Existing trees to remain in place
    - Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded to existing contours.
    - Channel will be reseeded with a grass mix and mulch.
  - Regrade Channel – 115LF
    - An area of the existing channel needs to be regraded to make the channel a continuous slope.
    - Assumed 170cy of excavation will be required. (20ft wide x 2ft deep x 115lf)
      - Excess material will be hauled off site.

- Douglas System
  - Replace Existing Pipe with 42” Diameter RCP Pipe – 250LF
    - Existing storm drain will be removed and replaced with new 42” RCP pipe.
    - Work will be done within roadway (assumed 4” pavement thickness).
    - Work will require the removal and replacement of existing manholes
      - 96” Manhole (approximately 10’ depth) – 2 each
    - Assumed contractor can use trench boxes for shoring
    - Traffic Control will need to be provided. (8 days included)
    - Assumed Storm Drain is dry during construction. No water management required.
  - Replace Existing Pipe with 48” Diameter RCP Pipe – 578LF
    - Existing storm drain will be removed and replaced with new 48” RCP pipe.
    - Portion of work will be done within roadway (assumed 4” pavement thickness).
    - Portion of work will be done outside of roadway on a variety of surface (Surface Replacement Allowance included in estimate).
    - Work will require the removal and replacement of existing manhole
      - 120” Manhole (approximately 10’ depth) – 3 each
    - New 5’ x 8’ Junction Box will need to be installed where existing storm drains intersect new storm drain
    - Assumed contractor can use trench boxes for shoring
    - Traffic Control will need to be provided for roadway work. (10 days included)
    - Assumed Storm Drain is dry during construction. No water management required.
  - Replace Existing Outfall with Bioswale – 150LF
    - Existing Outfall storm drain will be removed – 150LF
    - Bioswale area is 1,050SY (150LF x 63ft wide)
    - Assumed average excavation depth of 3.5ft.
    - Bioswale will be graded then seeded with grass seed mix and mulch
    - Assumed Outfall is dry during construction. No water management required.
- Cemetery
  - Northern 3’ x 4’ Box Culvert – 58LF
    - Replacement of existing storm drain and installation of new 3’ x 4’ Box Culvert.
    - Work to be done crossing Kings Valley Highway Road
      - Assumed 3 days of traffic control
    - Pavement is assumed to be 9” thickness to be removed and replaced (8’ trench width)
    - Assumed contractor can use trench boxes for shoring
    - Assumed that ditches will be dry during construction. No water management required.
  - Southern 2’ x 4’ Box Culvert – 58LF
    - Replacement of existing storm drain and installation of new 3’ x 4’ Box Culvert.
    - Work to be done crossing Kings Valley Highway Road
      - Assumed 3 days of traffic control
    - Pavement is assumed to be 9” thickness to be removed and replaced (8’ trench width)
    - Assumed contractor can use trench boxes for shoring
    - Assumed that ditches will be dry during construction. No water management required.
  - Driveway 2’ x 4’ Box Culvert – 35LF
    - Assumes installation of new 2’ x 4’ Box Culvert
    - Work includes new area catch basin on South side of driveway.
    - Work to be done crossing Cemetery driveway

            - Pavement is assumed to be 4” thickness to be removed and replaced (8’ trench width)
            - Assumed contractor can use trench boxes for shoring
            - Assumed that ditches will be dry during construction. No water management required.

- Rickreall Uglow/Orchard System
    - Replace 15” Culvert with 24” Diameter RCP Culvert – 85LF
        - Existing culvert will be removed and replaced with new 24” RCP pipe
            - New standard Flared End Sections will be installed on the upstream and downstream ends.
        - Work crosses Fairhaven Ln
            - Assumed 3 days of Traffic Control
        - Assumed 4” pavement section of asphalt to be removed and replaced
        - Assumed concrete sidewalk on each side of road to be removed and replaced
        - Assumed contractor can use trench boxes for shoring
        - Assumed that ditches will be dry during construction. No water management required.
    - Dual 54” Diameter RCP – Parking Lot – 230LF
        - Assumes replacement of existing single storm drain and installation of new dual 54” RCP storm drain.
        - Work to be done within the Papa Murphy’s parking lot on the East side of the building
        - Pavement is assumed to be 4” thickness to be removed and replaced (12’ trench width)
        - Assumed contractor can use trench boxes for shoring
        - Assumed that storm drain will be dry during construction. No water management required.
    - Replace Box Culvert w/ Dual 42” Diameter RCP at Ellendale – 150LF
        - Assumes replacement of existing Box Culvert and installation of new dual 42” RCP storm drain.
        - Work to be done crossing E. Ellendale Road
            - Assumed 10 days of traffic control
        - Pavement is assumed to be 9” thickness to be removed and replaced (12’ trench width)
        - Assumed contractor can use trench boxes for shoring
        - 5’ x 8’ Junction Box on North end of E. Ellendale will be installed.
        - Assumed concrete sidewalk on each side of road to be removed and replaced
        - Assumed that storm drain will be dry during construction. No water management required.
    - Replace Existing 36” with 42” RCP – Ellendale to Apartments – 610LF
        - Assumes replacement of existing single storm drain and installation of new 42” RCP storm drain.
        - Work will require the removal and replacement of existing manholes
            - 84” Manhole (approximately 10’ depth) – 5 each
        - Work to be done within the Phoenix Counseling Center West parking lot to easement near apartments towards the South.
        - Work will be done outside of roadway on a variety of surface (Surface Replacement Allowance included in estimate).
        - Assumed contractor can use trench boxes for shoring

        - Assumed that storm drain will be dry during construction. No water management required.
    - New 42” Diameter RCP Parallel to Existing 42” – Apartments to Hankel St. – 600LF
        - Assumes installation of new 42” RCP storm drain parallel to existing 42” storm drain.
        - Work will require the removal and replacement of existing manholes
            - 84” Manhole (approximately 10’ depth) – 2 each
        - Work to be done within the easement North of Hankel St.
        - Work will be done outside of roadway on a variety of surface (Surface Replacement Allowance included in estimate).
        - Assumed contractor can use trench boxes for shoring
        - Assumed that storm drain will be dry during construction. No water management required.
    - New 36” Diameter RCP Install Parallel to Existing 48” to Outfall – 900LF
        - Assumes installation of new 36” RCP storm drain parallel to existing 42” storm drain.
        - Work will be done within roadway (assumed 4” pavement thickness).
        - Assumed concrete sidewalk on North side of Hankel St. to be removed and replaced
        - Work will require the removal and replacement of existing manholes
            - 84” Manhole (approximately 10’ depth) – 3 each
        - Traffic Control will need to be provided. (24 days included)
        - Assumed that storm drain will be dry during construction. No water management required.
    - Kings Valley Highway Biofiltration Swale – 180LF
        - Existing Outfall storm drain will be removed – 180LF
        - Bioswale area is 1,200SY (180LF x 60ft wide)
        - Assumed average excavation depth of 1.25ft.
        - Bioswale will be graded then seeded with grass seed mix and mulch
        - Allowance for retrofit of the existing flow splitting manhole
        - Assumed Outfall is dry during construction. No water management required.
    - Uglow Outfall Biofiltration Swale – 150LF
        - Existing Outfall storm drain will be removed – 180LF
        - Bioswale area is 333.33SY (150LF x 20ft wide)
        - Assumed average excavation depth of 1ft.
        - Bioswale will be graded then seeded with grass seed mix and mulch
        - Allowance for retrofit of the existing flow splitting manhole
        - Assumed Outfall is dry during construction. No water management required.
- Kings Valley Highway at Bridlewood
    - Two 6’x8’ Box Culvert – 37 LF
        - Assumes replacement of existing storm drain and installation of new 6’ x 8’ Box Culvert.
        - Work to be done crossing Kings Valley Highway Road
            - Assumed 10 days of traffic control
        - Pavement is assumed to be 9” thickness to be removed and replaced (8’ trench width)
        - Assumed contractor can use trench boxes for shoring
        - Assumed that ditches will be dry during construction. No water management required.
- Weyerhaeuser to G-Way Ranch
    - Former Weyerhaeuser Property – 2 parallel 6’x10’ Box Culvert
        - Assumes replacement of existing storm drain and installation of new parallel 6’x10’ Box Culvert storm drain.

- Work to be done within the former Weyerhaeuser Property.
      - Work will require the demolition and removal of a variety of surfaces (Surface Removal/Replacement Allowance included in estimate).
      - Assumed contractor can use trench boxes for shoring
      - Stream will need to be bypassed during construction
        - Sand bag cofferdam and single submersible pump will be sufficient
  - Channel Modifications – Reach 1 (Former Weyerhaeuser to Uglow)
      - Stream will need to be bypassed during construction
        - Sand bag cofferdam and single submersible pump will be sufficient
      - Existing trees to remain in place
      - Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
      - Channel will be reseeded with a grass mix and mulch.
      - An area of the existing channel needs to be excavated to make the channel wider.
      - Assumed 1,425.51cy of excavation will be required. (124.16sf x 310lf)
        - Excess material will be hauled off site.
  - Uglow Street – 5 Parallel 6’x5’ Box Culvert
      - Assumes replacement of existing storm drain and installation of 5 new 6’ x 5’ Box Culverts.
      - Work to be done crossing Uglow Street
        - Assumed 21 days of traffic control
      - Pavement is assumed to be 4” thickness to be removed and replaced (45’ trench width)
      - Stream will need to be bypassed and construction area dewatered with well points during construction of Box Culvert
      - Assumed contractor can use Sheet Piles for shoring
  - Channel Modifications – Reach 2 (Uglow to Monmouth Cutoff)
      - Stream will need to be bypassed during construction
        - Sand bag cofferdam and single submersible pump will be sufficient
      - Existing trees to remain in place
      - Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
      - Channel will be reseeded with a grass mix and mulch.
      - An area of the existing channel needs to be excavated to make the channel wider.
      - Assumed 3,954.72cy of excavation will be required. (124.16sf x 860lf)
        - Excess material will be hauled off site.
  - Monmouth Cutoff West of Holman – New Bridge
      - Assumes replacement of existing storm drain and installation of new precast bridge structure.
      - Work to be done crossing Monmouth Cutoff
        - Assumed 18 days of traffic control
      - Pavement is assumed to be 4” thickness to be removed and replaced (68’ trench width)
      - Stream will need to be bypassed and construction area dewatered with well points during construction of Bridge
      - Assumed contractor can use Sheet Piles for shoring
  - Channel Modifications – Reach 3 (Monmouth Cutoff to Holman)
      - Stream will need to be bypassed during construction
        - Sand bag cofferdam and single submersible pump will be sufficient

- Gabions will be removed on one side of channel and replaced after channel is widened.
- Channel slopes and bottoms will be cleared of vegetation, and regraded.
- Channel will be reseeded with a grass mix and mulch.
- An area of the existing channel needs to be excavated to make the channel wider.
- Assumed 346.66cy of excavation will be required. (78sf x 120lf)
  - Excess material will be hauled off site.

o Holman Street – 3 Parallel 8'x11' Box Culvert
- Assumes replacement of existing storm drain and installation of 3 new 8' x 11' Box Culverts.
- Work to be done crossing Holman Street
  - Assumed 24 days of traffic control
- Pavement is assumed to be 4" thickness to be removed and replaced (57' trench width)
- Stream will need to be bypassed and construction area dewatered with well points during construction of Box Culvert
- Assumed contractor can use Sheet Piles for shoring

o Channel Modifications – Reach 4 (Holman to Tributary Upstream)
- Stream will need to be bypassed during construction
  - Sand bag cofferdam and single submersible pump will be sufficient
- Existing trees to remain in place
- Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
- Channel will be reseeded with a grass mix and mulch.
- An area of the existing channel needs to be excavated to make the channel wider.
- Assumed 2,381.67cy of excavation will be required. (121.56sf x 529lf)
  - Excess material will be hauled off site.

o Channel Modifications – Reach 5 (Tributary Upstream and Tributary Downstream)
- Stream will need to be bypassed during construction
  - Sand bag cofferdam and single submersible pump will be sufficient
- Existing trees to remain in place
- Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
- Channel will be reseeded with a grass mix and mulch.
- An area of the existing channel needs to be excavated to make the channel wider.
- Assumed 2,381.67cy of excavation will be required. (121.56sf x 529lf)
  - Excess material will be hauled off site.

o Channel Modifications – Reach 6 (Tributary Downstream to Godsey)
- Stream will need to be bypassed during construction
  - Sand bag cofferdam and single submersible pump will be sufficient
- Existing trees to remain in place
- Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
- Channel will be reseeded with a grass mix and mulch.
- An area of the existing channel needs to be excavated to make the channel wider.
- Assumed 788.21cy of excavation will be required. (26.47sf x 804lf)
  - Excess material will be hauled off site.
- Assumed 841.52cy import of fill material to raise channel top of slope. (28.27sf x 804lf)

o Godsey Street – New Bridge

- Assumes replacement of existing storm drain and installation of new precast bridge structure.
- Work to be done crossing Godsey Street
  - Assumed 14 days of traffic control
- Pavement is assumed to be 4" thickness to be removed and replaced (64' trench width)
- Stream will need to be bypassed and construction area dewatered with well points during construction of Bridge
- Assumed contractor can use Sheet Piles for shoring

- Channel Modifications – Reach 7 (Godsey to G-Way)
  - Stream will need to be bypassed during construction
    - Sand bag cofferdam and single submersible pump will be sufficient
  - Existing trees to remain in place
  - Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
  - Channel will be reseeded with a grass mix and mulch.
  - An area of the existing channel needs to be excavated to make the channel wider.
  - Assumed 21,162.65cy of excavation will be required. (147.19sf x 3882lf)
    - Excess material will be hauled off site.
  - Assumed 362.32cy import of fill material to raise channel top of slope. (2.52sf x 3882lf)
- Monmouth Cutoff Tributary – Clear Existing Culverts
  - Allowance for a site clearing crew 3 days to clean out and remove debris from existing culvert.
- Channel Modifications – Reach T1 (Tributary Channel)
  - Stream will need to be bypassed during construction
    - Sand bag cofferdam and single submersible pump will be sufficient
  - Existing trees to remain in place
  - Channel slopes and bottoms will be cleared of vegetation (excluding trees), and regraded.
  - Channel will be reseeded with a grass mix and mulch.
  - An area of the existing channel needs to be excavated to make the channel wider.
  - Assumed 161.47cy of excavation will be required. (8.40sf x 840lf)
    - Excess material will be hauled off site.

- Hunter Street
  - Install New 48" Culvert
    - Existing Culvert will be capped and abandoned in place.
    - Portion of work will be done within roadway (assumed 4" pavement thickness).
    - Portion of work will be done outside of roadway on a variety of surface (Surface Replacement Allowance included in estimate).
    - Work will require the installation of a new manholes
      - 120" Manhole (approximately 10' depth) – 2 each
    - Assumed contractor can use trench boxes for shoring
    - Assumed Storm Drain is dry during construction. No water management required.
- Growth Node – Wyatt
  - Western Trunkline, 24"
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25')
    - Installation of 24" N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10' trench depth. (assumed 1 1/2 : 1 open trench)

- o Eastern Trunkline, 24”
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25’)
    - Installation of 24” N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10’ trench depth. (assumed 1 1/2 : 1 open trench)
- Growth Node – La Creole
  - o Northern Trunkline, 36”
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25’)
    - Installation of 36” N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10’ trench depth. (assumed 1 1/2 : 1 open trench)
  - o Southern Trunkline, 30”
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25’)
    - Installation of 30” N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10’ trench depth. (assumed 1 1/2 : 1 open trench)
- Growth Node – Barberry
  - o Western Trunkline, 36”
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25’)
    - Installation of 36” N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10’ trench depth. (assumed 1 1/2 : 1 open trench)
  - o Eastern Trunkline, 42”
    - Work will require the clearing and replanting of the pipe alignment. (Assumed approximate width of 25’)
    - Installation of 42” N-20 (corrugated HDPE) Storm Pipe.
    - Assumed average 10’ trench depth. (assumed 1 1/2 : 1 open trench)

3.4 Allowances

The estimate includes allowances for known work that is not sufficiently detailed at this time:

- Surfacing Demolition Allowance - $125/cy
- Surfacing Replacement Allowance - $3/sf
- Sheet Pile Shoring Alowance - $25/sf exposed face
- Precast Bridge Structure - $100/sf

3.5 Exclusions

The cost estimate excludes the following costs:

- Excavation and Disposal of hazardous material
- Rock Excavation
- Non-construction or soft costs for design, services during construction, land, legal and owner administration costs
- Material Adjustment allowances above and beyond what is included at the time of the cost estimate.

3.6 Project Delivery and Methodology

It is assumed that this project will be procured using the traditional Design/Bid/Build method. The general contractor will contract directly with the owner.

The estimate is based on the assumption the work will be done on a competitive bid basis and the contractor will have a reasonable amount of time to complete the work. All contractors are equal, with a reasonable project schedule, no overtime, constructed as under a single contract, no liquidated damages.

3.7 Labor, Material, Subcontracts and Other Direct Costs

3.7.1 Labor

The estimate has been adjusted for local area labor rates, based upon 2014 national rates.

Labor unit prices reflect a burdened rate, including: workers compensation, unemployment taxes, Fringe Benefits, and medical insurance.

3.7.2 Material

Materials pricing is national average as determined by RS Means or other data sources. Quotes on certain items may have been obtained and included in this estimate. Many quotes given for engineering estimates are budgetary and may not reflect actual contractor pricing.

3.7.3 Subcontracts

It is assumed that General Contractors will subcontract a portion of the work. Items listed in the cost estimate as subcontractor includes all anticipated markups that a general contractor would receive.

3.7.4 Construction Equipment

Equipment items listed in this cost estimate are for the construction equipment necessary for the installation of the work. Equipment rates in this estimate are assumed to be 75% of 2014 Blue Book value. This is to account for contractor owned equipment or discounted rental equipment.

3.8 Markups, Taxes, and Other Indirect Costs

The following typical contractor markups were applied to the cost estimate:

TABLE NUMBER 3.8
Markups, Taxes, and Other Indirect Costs

Item	Unit	Comments
General Conditions	7.00%	
Home Office Overhead	10.00%	
Profit	5.00%	
Mobilization	3.00%	
Builder's Risk & General Liability	1.00%	
Payment & Performance Bonds	1.16%	
Contingency	20.00%	
Escalation	5.00%	
Taxes	0.00%	This project is considered Tax Exempt.

3.9 Escalation Costs

A 5% escalation factor was used in this estimate to account for inflation. It is undetermined when actual construction will begin. This factor allows for 18 months from estimate date to the midpoint of construction.

This CH2M HILL escalation forecast is based upon economic data from Global Insight, Inc. and the United States Bureau of Labor Statistics.

3.10 Market Conditions

During volatile economic conditions, an estimate may have a Market Conditions amount applied. This adjustment is done to account for the current volatility in the construction market and/or the location of a project.

However, based on the current construction market, and the location of the work proposed in this estimate, a Market Conditions adjustment was not applied.

3.11 Cost Resources

The following is a list of the various cost resources used in the development of the cost estimate:

- R.S. Means 2014 Data
- CH2M HILL Historical Data
- Vendor Quotes where available
- Estimator Judgment

3.12 Disclaimer

The opinions of cost (estimates) shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. The recent increases or decreases in material pricing may have a significant impact which is not predictable and careful review or consideration must be used in evaluation of material prices. As a result, the final project costs will vary from the opinions of cost presented herein. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Appendix A:
Cost Estimate

Detail Report

Job Size:
Duration:

Project: W. Ellendale @ Wyatt
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**5' x 6' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	130.00 lf	2.0	81	47	-	47	-	1.34 /lf	175	292
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	390.00 lf	3.5	145	47	-	85	-	0.71 /lf	277	463
			Asphalt Demolition and Loading	24.00 cy	1.0	40	-	-	35	-	3.11 /cy	75	125
			Remove Asphalt Pavement	**145.00 SY**	**6.4**	**266**	**94**		**167**		**3.63 /SY**	**526**	**879**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	20.00 lf	3.5	159	-	-	147	-	15.28 /lf	306	510
			Demo Existing Storm Sewer	**20.00 LF**	**3.5**	**159**			**147**		**15.28 /LF**	**306**	**510**
			02-01 Demolition	**1.00 LS**	**9.9**	**424**	**94**		**314**		**832.03 /LS**	**832**	**1,389**
			02.0 Existing Conditions	**1.00 LS**	**9.9**	**424**	**94**		**314**		**832.03 /LS**	**832**	**1,389**
	31.0		**Site/Civil**										
		31-16	**Earthworks, Sheeting/Shoring**										
			Shoring										
			Shoring, sheet pile, subcontracted	1,300.00 sf	169.0		-	32,500	-	-	25.00 /sf	32,500	54,272
			Shoring	**1,300.00 SF**	**169.0**			**32,500**			**25.00 /SF**	**32,500**	**54,272**
			31-16 Earthworks, Sheeting/Shoring	**1,300.00 SF**	**169.0**			**32,500**			**25.00 /SF**	**32,500**	**54,272**
		31-19	**Dewatering and Bypass Pumping**										
			Dewatering or Bypass Channel Pumping										
			Dewatering Wellpoints, Complete System, Mob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering Wellpoints, Complete System, Install	1.00 day	48.0	1,994	-	-	1,677	-	3,670.78 /day	3,671	6,130
			Dewatering Wellpoints, Complete System, Rental, First Month	1.00 mo		-	-	-	10,000	-	10,000.00 /mo	10,000	16,699
			Dewatering Wellpoints, Complete System, Operation - Labor to maintain / check pumps/ fuel and lube	0.50 mo	45.0	1,768	-	-	222	-	3,979.50 /mo	1,990	3,323
			Fuel for generator	0.50 mo		-	-	-	-	4,500	9,000.00 /mo	4,500	7,515
			Dewatering Wellpoints, Complete System, Removal	1.00 day	48.0	1,994	-	-	1,462	-	3,456.09 /day	3,456	5,771
			Dewatering Wellpoints, Complete System, Demob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering or Bypass Channel Pumping	**15.00 DAY**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**1,907.78 /DAY**	**28,617**	**47,787**
			31-19 Dewatering and Bypass Pumping	**1.00 LS**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**28,616.62 /LS**	**28,617**	**47,787**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	145.00 sy	2.2	95	2,153	-	216	-	17.00 /sy	2,464	4,115
			Prepare and roll sub-base, small areas to 2500 S.Y.	145.00 sy	2.3	100	-	-	243	-	2.37 /sy	343	573
			Asphaltic paving, roadway wearing course, 3" thick	145.00 sy	2.9	118	1,660	-	287	-	14.24 /sy	2,065	3,449
			Asphaltic paving, replacement over trench, 6" thick	145.00 sy	126.6	5,187	3,263	-	4,505	-	89.34 /sy	12,954	21,632
			Replace Pavement	**145.00 SY**	**134.0**	**5,501**	**7,076**		**5,250**		**122.94 /SY**	**17,827**	**29,769**
			31-40 Paving	**145.00 SY**	**134.0**	**5,501**	**7,076**		**5,250**		**122.94 /SY**	**17,827**	**29,769**
			31.0 Site/Civil	**1.00 LS**	**492.0**	**11,257**	**7,076**	**37,500**	**18,611**	**4,500**	**78,943.44 /LS**	**78,943**	**131,829**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			5'x6' Precast Box Culvert										
			Traffic Control, Labor per Day	18.00 day	288.0	10,802	-	-	-	-	600.10 /day	10,802	18,038
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	350.00 cy	4.6	197	-	-	514	-	2.03 /cy	711	1,187
			Bedding, crushed stone 1/2" to 3/4"	50.00 cy	3.0	130	1,250	-	226	-	32.11 /cy	1,606	2,681
			Compaction, vibratory plate, 8" lifts, common fill	350.00 cy	14.0	525	-	-	87	-	1.75 /cy	612	1,023
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	500.00 cy	84.0	3,585	-	-	7,140	-	21.45 /cy	10,725	17,910
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	150.00 cy	5.0	188	-	-	409	-	3.99 /cy	598	998
			Public Storm Utility Drainage Piping, concrete, box culvert, precast, base price, 8' long, 6' x 5', excludes excavation or backfill	65.00 lf	113.8	5,316	33,410	-	7,603	-	712.76 /lf	46,329	77,366
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	2.00 ea	3.5	164	1,660	-	234	-	1,028.76 /ea	2,058	3,436
			5'x6' Precast Box Culvert	**65.00 LF**	**515.8**	**20,906**	**36,320**		**16,214**		**1,129.85 /LF**	**73,440**	**122,639**
			Manhole Access to Box Culvert										
			Manholes, precast, 4' inside dia, 4' deep	1.00 ea	6.0	281	440	-	282	-	1,002.69 /ea	1,003	1,674
			Precast Base, 4'	1.00 ea	3.0	141	370	-	141	-	651.34 /ea	651	1,088
			Grade Ring, 4'	1.00 ea	1.0	47	25	-	47	-	118.78 /ea	119	198
			Frame & Cover, 4'	1.00 ea	2.0	94	225	-	94	-	412.56 /ea	413	689
			Manhole Access to Box Culvert	**1.00 EA**	**12.0**	**562**	**1,060**		**563**		**2,185.37 /EA**	**2,185**	**3,649**

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			33-00 Yard Piping	65.00 LF	527.8	21,469	37,380		16,777		1,163.47 /LF	75,626	126,288
			33.0 Buried Piping	65.00 LF	527.8	21,469	37,380		16,777		1,163.47 /LF	75,626	126,288
			001 5' x 6' Box Culvert	**65.00 LF**	**1,029.7**	**33,150**	**44,550**	**37,500**	**35,702**	**4,500**	**2,390.79 /LF**	**155,401**	**259,507**
002			**Clear & Replant Channel**										
	31.0		Site/Civil										
		31-20	Earthworks, Site										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	1.50 acre	15.0	630	-	-	785	-	943.01 /acre	1,415	2,362
			Rough Site Grading, Small Crew	7,111.11 sy	94.8	4,266	-	-	7,020	-	1.59 /sy	11,286	18,846
			Finish grading lagoon bottoms	64.00 msf	256.0	10,698	-	-	24,150	-	544.51 /msf	34,849	58,194
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	600.00 cy	24.0	904	-	-	1,965	-	4.78 /cy	2,869	4,792
			Permanent Seed and Mulch	1.50 acre	9.0		-	2,250	-	-	1,500.00 /acre	2,250	3,757
			Clear & Replant Channel	**1,600.00 LF**	**398.8**	**16,498**		**2,250**	**33,920**		**32.92 /LF**	**52,668**	**87,952**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			31-20 Earthworks, Site	1.00 LS	496.8	21,004	1,250	2,250	45,482		69,985.56 /LS	69,986	116,870
			31.0 Site/Civil	1.00 LS	496.8	21,004	1,250	2,250	45,482		69,985.56 /LS	69,986	116,870
			002 Clear & Replant Channel	**1,600.00 LF**	**496.8**	**21,004**	**1,250**	**2,250**	**45,482**		**43.74 /LF**	**69,986**	**116,870**
003			**Regrade Channel**										
	31.0		Site/Civil										
		31-20	Earthworks, Site										
			Regrade Channel										
			Rough Site Grading, Small Crew	511.11 sy	6.8	307	-	-	505	-	1.59 /sy	811	1,355
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	170.00 cy	13.6	580	-	-	578	-	6.81 /cy	1,158	1,935
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	170.00 cy	6.8	256	-	-	557	-	4.78 /cy	813	1,358
			Regrade Channel	**115.00 LF**	**27.2**	**1,143**			**1,639**		**24.20 /LF**	**2,783**	**4,647**
			31-20 Earthworks, Site	1.00 LS	27.2	1,143			1,639		2,782.62 /LS	2,783	4,647
			31.0 Site/Civil	1.00 LS	27.2	1,143			1,639		2,782.62 /LS	2,783	4,647
			003 Regrade Channel	**115.00 LF**	**27.2**	**1,143**			**1,639**		**24.20 /LF**	**2,783**	**4,647**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	55,296		1,553.730 I		14.51%
Material	45,800				12.02%
Subcontract	39,750				10.43%
Equipment	82,823		1,169.126 I		21.74%
Other	4,500				1.18%
Total Before Markups	**228,169**	**228,169**			59.88
Project Staff & Home Office OH	22,817			10.000 %	5.99%
Total Overhead	**22,817**	**250,986**			5.99
General Conditions	17,569			7.000 %	4.61%
Total General Conditions	**17,569**	**268,555**			4.61
Profit on Previous Subtotal	13,428			5.000 %	3.52%
Total Profit	**13,428**	**281,983**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**281,983**			
Mobilization/Demobilization	11,431			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	3,810			1.000 %	1.00%
Payment & Performance Bonds	4,420			1.160 %	1.16%
Total Bonds and Insurances	**19,661**	**301,644**			5.16
Contingency - %	60,329			20.000 %	15.83%
Total Contingency	**60,329**	**361,973**			15.83
Escalation on Estimate Total	19,051			5.000 %	5.00%
Total Escalation	**19,051**	**381,024**			5.00
Construction Total		**381,024**			

Job Size:
Duration:

Detail Report

Project: Douglas System
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Install 42" Diameter Pipe**										
	02.0		Existing Conditions										
		02-01	Demolition										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	260.00 lf	3.9	161	94	-	94	-	1.34 /lf	349	583
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	260.00 lf	2.3	97	31	-	57	-	0.71 /lf	185	308
			Asphalt Demolition and Loading	13.00 cy	0.5	21	-	-	19	-	3.11 /cy	40	68
			Remove Asphalt Pavement	**115.00 SY**	**6.8**	**280**	**125**		**170**		**5.00 /SY**	**574**	**959**
			Existing Manhole Demolition										
			Manhole Demolition and Loading, 10' Deep	1.00 ea	17.5	793	-	-	735	-	1,528.21 /ea	1,528	2,552
			Existing Manhole Demolition	**3.00 EA**	**17.5**	**793**			**735**		**509.40 /EA**	**1,528**	**2,552**
			02-01 Demolition	1.00 LS	24.3	1,072	125		905		2,102.70 /LS	2,103	3,511
			02.0 Existing Conditions	1.00 LS	24.3	1,072	125		905		2,102.70 /LS	2,103	3,511
	31.0		Site/Civil										
		31-35	Site Landscaping										
			Surfacing Replacement Allowance										
			Surfacing Replacement Allowance	2,400.00 sf	7.2		-	7,200	-	-	3.00 /sf	7,200	12,023
			Surfacing Replacement Allowance	**2,400.00 SF**	**7.2**			**7,200**			**3.00 /SF**	**7,200**	**12,023**
			31-35 Site Landscaping	1.00 LS	7.2			7,200			7,200.00 /LS	7,200	12,023
		31-40	Paving										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	115.00 sy	1.7	75	1,708	-	171	-	17.00 /sy	1,955	3,264
			Prepare and roll sub-base, small areas to 2500 S.Y.	115.00 sy	1.8	80	-	-	192	-	2.37 /sy	272	454
			Asphaltic paving, replacement over trench, 4" thick	115.00 sy	78.9	3,233	1,633	-	2,807	-	66.72 /sy	7,673	12,813
			Replace Pavement	**115.00 SY**	**82.5**	**3,388**	**3,341**		**3,171**		**86.08 /SY**	**9,900**	**16,531**
			31-40 Paving	115.00 SY	82.5	3,388	3,341		3,171		86.08 /SY	9,900	16,531
			31.0 Site/Civil	1.00 LS	89.7	3,388	3,341	7,200	3,171		17,099.56 /LS	17,100	28,555
	33.0		Buried Piping										
		33-00	Yard Piping										
			42" RCP Pipe										
			Traffic Control, Labor per Day	8.00 day	128.0	4,801	-	-	-	-	600.10 /day	4,801	8,017
			Trench Box, 8' x 24' x 10'	1.09 mo		-	-	-	2,500	-	2,300.00 /mo	2,500	4,175
			Excav. pipe trench, w/ trench box, for > 30" pipe	623.79 CY	13.7	586	-	-	2,885	-	5.56 /CY	3,470	5,795
			Backfill / Compact @ pipe zone, for 30" & larger pipe	240.12 cy	30.5	1,256	-	-	2,470	-	15.52 /cy	3,725	6,221
			Backfill / Compact above pipe zone, for 30" & larger pipe	345.56 cy	10.4	478	-	-	738	-	3.52 /cy	1,216	2,030
			Pipe zone material	240.12 cy		-	6,723	-	-	-	28.00 /cy	6,723	11,227
			Pipe bedding material	64.75 cy		-	1,813	-	-	-	28.00 /cy	1,813	3,027
			Haul spoils, offsite, up to 10 miles	304.87 cy		-	-	3,049	-	-	10.00 /cy	3,049	5,091
			42" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	250.00 LF	43.8	2,045	20,070	-	2,924	-	100.16 /LF	25,039	41,813
			Grout joint, ID or OD, 42"	31.52 ea	31.5	1,387	630	-	-	-	64.00 /ea	2,017	3,369
			42" RCP Pipe	**250.00 LF**	**257.9**	**10,552**	**29,237**	**3,049**	**11,517**		**217.42 /LF**	**54,354**	**90,766**
			33-00 Yard Piping	250.00 LF	257.9	10,552	29,237	3,049	11,517		217.42 /LF	54,354	90,766
		33-15	Yard Structures										
			96" Manholes										
			Manholes, precast, 8' inside dia, 10' deep	2.00 ea	24.0	1,124	8,900	-	1,126	-	5,575.37 /ea	11,151	18,621
			Cast-in-Place Base, 8'	2.00 ea	6.0	281	3,600	-	282	-	2,081.35 /ea	4,163	6,951
			Grade Ring, 8'	2.00 ea	2.0	94	50	-	94	-	118.78 /ea	238	397
			Frame & Cover, 8'	2.00 ea	4.0	187	450	-	188	-	412.56 /ea	825	1,378
			Grout Invert, 8'	2.00 ea	6.0	281	300	-	282	-	431.34 /ea	863	1,441
			96" Manholes	**2.00 EA**	**42.0**	**1,968**	**13,300**		**1,971**		**8,619.39 /EA**	**17,239**	**28,787**
			33-15 Yard Structures	2.00 EA	42.0	1,968	13,300		1,971		8,619.39 /EA	17,239	28,787
			33.0 Buried Piping	250.00 LF	299.9	12,519	42,537	3,049	13,488		286.37 /LF	71,592	119,553
			001 Install 42" Diameter Pipe	**250.00 LF**	**413.8**	**16,979**	**46,002**	**10,249**	**17,565**		**363.18 /LF**	**90,795**	**151,620**
002			**Replace Existing Pipe w/ 48" Diameter Pipe**										
	02.0		Existing Conditions										
		02-01	Demolition										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	460.00 lf	6.9	285	166	-	167	-	1.34 /lf	618	1,032
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	460.00 lf	4.1	171	55	-	100	-	0.71 /lf	327	546
			Asphalt Demolition and Loading	23.00 cy	0.9	38	-	-	34	-	3.11 /cy	72	120

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Remove Asphalt Pavement	205.00 SY	12.0	495	221		301		4.96 /SY	1,016	1,697
			Existing Storm Sewer Demolition										
			Storm Sewer Pipe Demolition and Loading, 10' Deep	578.00 lf	161.8	7,332	-	-	6,801	-	24.45 /lf	14,133	23,601
			Existing Storm Sewer Demolition	578.00 LF	161.8	7,332			6,801		24.45 /LF	14,133	23,601
			Existing Manhole Demolition										
			Manhole Demolition and Loading, 10' Deep	2.00 ea	35.0	1,586	-	-	1,471	-	1,528.20 /ea	3,056	5,104
			Existing Manhole Demolition	2.00 EA	35.0	1,586			1,471		1,528.20 /EA	3,056	5,104
			02-01 Demolition	1.00 LS	208.8	9,412	221		8,573		18,205.61 /LS	18,206	30,402
			02.0 Existing Conditions	1.00 LS	208.8	9,412	221		8,573		18,205.61 /LS	18,206	30,402
	31.0		Site/Civil										
		31-35	Site Landscaping										
			Surfacing Replacement Allowance										
			Surfacing Replacement Allowance	6,360.00 sf	19.1		-	19,080	-	-	3.00 /sf	19,080	31,862
			Surfacing Replacement Allowance	6,360.00 SF	19.1			19,080			3.00 /SF	19,080	31,862
			31-35 Site Landscaping	1.00 LS	19.1			19,080			19,080.00 /LS	19,080	31,862
		31-40	Paving										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	205.00 sy	3.1	135	3,044	-	305	-	17.00 /sy	3,484	5,818
			Prepare and roll sub-base, small areas to 2500 S.Y.	205.00 sy	3.3	142	-	-	343	-	2.37 /sy	485	810
			Asphaltic paving, replacement over trench, 4" thick	205.00 sy	140.6	5,763	2,911	-	5,004	-	66.72 /sy	13,678	22,841
			Replace Pavement	205.00 SY	147.0	6,039	5,955		5,653		86.08 /SY	17,647	29,469
			31-40 Paving	205.00 SY	147.0	6,039	5,955		5,653		86.08 /SY	17,647	29,469
			31.0 Site/Civil	1.00 LS	166.1	6,039	5,955	19,080	5,653		36,727.07 /LS	36,727	61,331
	33.0		Buried Piping										
		33-00	Yard Piping										
			48" RCP Pipe										
			Traffic Control, Labor per Day	10.00 day	160.0	6,001	-	-	-	-	600.10 /day	6,001	10,021
			Trench Box, 8' x 24' x 10'	2.51 mo		-	-	-	5,780	-	2,300.00 /mo	5,780	9,652
			Excav. pipe trench, w/ trench box, for > 30" pipe	1,442.11 CY	31.7	1,354	-	-	6,669	-	5.56 /CY	8,023	13,398
			Backfill / Compact @ pipe zone, for 30" & larger pipe	555.12 cy	70.5	2,903	-	-	5,709	-	15.52 /cy	8,612	14,382
			Backfill / Compact above pipe zone, for 30" & larger pipe	798.88 cy	24.0	1,104	-	-	1,706	-	3.52 /cy	2,811	4,693
			Pipe zone material	555.12 cy		-	15,543	-	-	-	28.00 /cy	15,543	25,956
			Pipe bedding material	149.69 cy		-	4,191	-	-	-	28.00 /cy	4,191	6,999
			Haul spoils, offsite, up to 10 miles	704.81 cy		-	-	7,048	-	-	10.00 /cy	7,048	11,770
			48" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	578.00 LF	121.4	5,673	55,586	-	7,099	-	118.27 /LF	68,358	114,152
			Grout joint, ID or OD, 48"	73.00 ea	73.0	3,212	1,606	-	-	-	66.00 /ea	4,818	8,046
			48" RCP Pipe	578.00 LF	480.6	20,247	76,927	7,048	26,964		226.97 /LF	131,186	219,070
			33-00 Yard Piping	578.00 LF	480.6	20,247	76,927	7,048	26,964		226.97 /LF	131,186	219,070
		33-15	Yard Structures										
			120" Manhole										
			Manholes, precast, 10' inside dia, 10' deep	3.00 ea	36.0	1,686	19,500	-	1,690	-	7,625.37 /ea	22,876	38,201
			Cast-in-Place Base, 10'	3.00 ea	9.0	422	8,400	-	422	-	3,081.34 /ea	9,244	15,437
			Grade Ring, 10'	3.00 ea	3.0	141	75	-	141	-	118.78 /ea	356	595
			Frame & Cover, 10'	3.00 ea	6.0	281	675	-	282	-	412.56 /ea	1,238	2,067
			Grout Invert, 10'	3.00 ea	10.5	492	600	-	493	-	528.23 /ea	1,585	2,646
			120" Manhole	3.00 EA	64.5	3,022	29,250		3,027		11,766.28 /EA	35,299	58,946
			5'x8' Junction Box										
			5'x8' Junction Box	1.00 ea	36.0	1,453	8,000	-	571	-	10,023.63 /ea	10,024	16,739
			5'x8' Junction Box	1.00 EA	36.0	1,453	8,000		571		10,023.63 /EA	10,024	16,739
			33-15 Yard Structures	3.00 EA	100.5	4,475	37,250		3,598		15,107.49 /EA	45,322	75,685
			33.0 Buried Piping	578.00 LF	581.1	24,722	114,177	7,048	30,562		305.38 /LF	176,508	294,754
			002 Replace Existing Pipe w/ 48" Diameter Pipe	578.00 LF	955.9	40,173	120,353	26,128	44,787		400.42 /LF	231,441	386,487
003			Replace Existing Outfall w/ Biofiltration Swale										
	02.0		Existing Conditions										
		02-01	Demolition										
			Existing Storm Sewer Demolition										
			Storm Sewer Pipe Demolition and Loading, 10' Deep	150.00 lf	42.0	1,903	-	-	1,765	-	24.45 /lf	3,668	6,125
			Existing Storm Sewer Demolition	150.00 LF	42.0	1,903			1,765		24.45 /LF	3,668	6,125

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			02-01 Demolition	**1.00 LS**	**42.0**	**1,903**			**1,765**		**3,667.68 /LS**	**3,668**	**6,125**
			02.0 Existing Conditions	**1.00 LS**	**42.0**	**1,903**			**1,765**		**3,667.68 /LS**	**3,668**	**6,125**
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Excavate Bioswale										
			Rough Site Grading, Small Crew	1,050.00 sy	14.0	630	-	-	1,037	-	1.59 /sy	1,666	2,783
			Finish grading lagoon bottoms	9.50 msf	38.0	1,588	-	-	3,585	-	544.51 /msf	5,173	8,638
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	1,300.00 cy	104.0	4,439	-	-	4,420	-	6.81 /cy	8,859	14,793
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	1,300.00 cy	52.0	1,960	-	-	4,257	-	4.78 /cy	6,217	10,382
			Permanent Seed and Mulch	0.21 acre	1.3		-	315	-	-	1,500.00 /acre	315	526
			Excavate Bioswale	**150.00 LF**	**209.3**	**8,616**		**315**	**13,299**		**148.20 /LF**	**22,230**	**37,122**
			31-20 Earthworks, Site	**1.00 LS**	**209.3**	**8,616**		**315**	**13,299**		**22,230.04 /LS**	**22,230**	**37,122**
			31.0 Site/Civil	**1.00 LS**	**209.3**	**8,616**		**315**	**13,299**		**22,230.04 /LS**	**22,230**	**37,122**
			003 Replace Existing Outfall w/ Biofiltration Swale	**150.00 LF**	**251.3**	**10,519**		**315**	**15,064**		**172.65 /LF**	**25,898**	**43,247**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	67,671		1,620.971 I		11.64%
Material	166,355				28.62%
Subcontract	36,692				6.31%
Equipment	77,416		1,644.710 I		13.32%
Other					
Total Before Markups	**348,134**	**348,134**			59.88
Project Staff & Home Office OH	34,813			10.000 %	5.99%
Total Overhead	**34,813**	**382,947**			5.99
General Conditions	26,806			7.000 %	4.61%
Total General Conditions	**26,806**	**409,753**			4.61
Profit on Previous Subtotal	20,488			5.000 %	3.52%
Total Profit	**20,488**	**430,241**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**430,241**			
Mobilization/Demobilization	17,441			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	5,814			1.000 %	1.00%
Payment & Performance Bonds	6,744			1.160 %	1.16%
Total Bonds and Insurances	**29,999**	**460,240**			5.16
Contingency - %	92,048			20.000 %	15.83%
Total Contingency	**92,048**	**552,288**			15.83
Escalation on Estimate Total	29,068			5.000 %	5.00%
Total Escalation	**29,068**	**581,356**			5.00
Construction Total		**581,356**			

CH2MHILL

Job Size:
Duration:

Detail Report

Project: Cemetery
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Northern 3'x4' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	80.00 lf	1.2	50	29	-	29	-	1.34 /lf	108	180
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	480.00 lf	4.3	179	58	-	105	-	0.71 /lf	341	569
			Asphalt Demolition and Loading	9.00 cy	0.4	15	-	-	13	-	3.11 /cy	28	47
			Remove Asphalt Pavement	**36.00 SY**	**5.9**	**243**	**86**		**147**		**13.23 /SY**	**476**	**796**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	58.00 lf	10.2	460	-	-	427	-	15.28 /lf	886	1,480
			Demo Existing Storm Sewer	**58.00 LF**	**10.2**	**460**			**427**		**15.28 /LF**	**886**	**1,480**
			02-01 Demolition	**1.00 LS**	**16.0**	**703**	**86**		**573**		**1,362.78 /LS**	**1,363**	**2,276**
			02.0 Existing Conditions	**1.00 LS**	**16.0**	**703**	**86**		**573**		**1,362.78 /LS**	**1,363**	**2,276**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	36.00 sy	0.5	24	535	-	54	-	17.00 /sy	612	1,022
			Prepare and roll sub-base, small areas to 2500 S.Y.	36.00 sy	0.6	25	-	-	60	-	2.36 /sy	85	142
			Asphaltic paving, roadway wearing course, 3" thick	36.00 sy	0.7	29	412	-	71	-	14.24 /sy	513	856
			Asphaltic paving, replacement over trench, 6" thick	36.00 sy	31.4	1,288	810	-	1,118	-	89.34 /sy	3,216	5,371
			Replace Pavement	**36.00 SY**	**33.3**	**1,366**	**1,757**		**1,303**		**122.94 /SY**	**4,426**	**7,391**
			31-40 Paving	**36.00 SY**	**33.3**	**1,366**	**1,757**		**1,303**		**122.94 /SY**	**4,426**	**7,391**
			31.0 Site/Civil	**1.00 LS**	**33.3**	**1,366**	**1,757**		**1,303**		**4,425.97 /LS**	**4,426**	**7,391**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			3'x4' Precast Box Culvert										
			Traffic Control, Labor per Day	3.00 day	48.0	1,800	-	-	-	-	600.10 /day	1,800	3,006
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	70.00 cy	0.9	39	-	-	103	-	2.03 /cy	142	237
			Bedding, crushed stone 1/2" to 3/4"	10.00 cy	0.6	26	250	-	45	-	32.11 /cy	321	536
			Compaction, vibratory plate, 8" lifts, common fill	70.00 cy	2.8	105	-	-	17	-	1.75 /cy	122	205
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	105.00 cy	17.6	753	-	-	1,499	-	21.45 /cy	2,252	3,761
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	35.00 cy	1.2	44	-	-	96	-	3.99 /cy	139	233
			Public Storm Utility Drainage Piping, concrete, box culvert, cast in place, 3' x 4', excludes excavation or backfill	58.00 lf	21.8	1,019	11,600	-	1,021	-	235.17 /lf	13,640	22,777
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	2.00 ea	6.0	281	1,000	-	282	-	781.35 /ea	1,563	2,610
			3'x4' Precast Box Culvert	**58.00 LF**	**98.9**	**4,067**	**12,850**		**3,063**		**344.49 /LF**	**19,980**	**33,365**
			33-00 Yard Piping	**58.00 LF**	**98.9**	**4,067**	**12,850**		**3,063**		**344.49 /LF**	**19,980**	**33,365**
			33.0 Buried Piping	**58.00 LF**	**98.9**	**4,067**	**12,850**		**3,063**		**344.49 /LF**	**19,980**	**33,365**
			001 Northern 3'x4' Box Culvert	**58.00 LF**	**148.2**	**6,136**	**14,693**		**4,940**		**444.29 /LF**	**25,769**	**43,032**
002			**Southern 2'x4' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	80.00 lf	1.2	50	29	-	29	-	1.34 /lf	108	180
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	480.00 lf	4.3	179	58	-	105	-	0.71 /lf	341	569
			Asphalt Demolition and Loading	9.00 cy	0.4	15	-	-	13	-	3.11 /cy	28	47
			Remove Asphalt Pavement	**36.00 SY**	**5.9**	**243**	**86**		**147**		**13.23 /SY**	**476**	**796**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	58.00 lf	10.2	460	-	-	427	-	15.28 /lf	886	1,480
			Demo Existing Storm Sewer	**58.00 LF**	**10.2**	**460**			**427**		**15.28 /LF**	**886**	**1,480**
			02-01 Demolition	**1.00 LS**	**16.0**	**703**	**86**		**573**		**1,362.78 /LS**	**1,363**	**2,276**
			02.0 Existing Conditions	**1.00 LS**	**16.0**	**703**	**86**		**573**		**1,362.78 /LS**	**1,363**	**2,276**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	36.00 sy	0.5	24	535	-	54	-	17.00 /sy	612	1,022
			Prepare and roll sub-base, small areas to 2500 S.Y.	36.00 sy	0.6	25	-	-	60	-	2.36 /sy	85	142
			Asphaltic paving, roadway wearing course, 3" thick	36.00 sy	0.7	29	412	-	71	-	14.24 /sy	513	856
			Asphaltic paving, replacement over trench, 6" thick	36.00 sy	31.4	1,288	810	-	1,118	-	89.34 /sy	3,216	5,371

Detail Report

Job Size:
Duration:

Project: Cemetery
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Replace Pavement	**36.00 SY**	**33.3**	**1,366**	**1,757**		**1,303**		**122.94 /SY**	**4,426**	**7,391**
			31-40 Paving	**36.00 SY**	**33.3**	**1,366**	**1,757**		**1,303**		**122.94 /SY**	**4,426**	**7,391**
			31.0 Site/Civil	**1.00 LS**	**33.3**	**1,366**	**1,757**		**1,303**		**4,425.97 /LS**	**4,426**	**7,391**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			2'x4' Box Culvert										
			Traffic Control, Labor per Day	3.00 day	48.0	1,800	-	-	-	-	600.10 /day	1,800	3,006
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	80.00 cy	1.0	45	-	-	117	-	2.03 /cy	162	271
			Bedding, crushed stone 1/2" to 3/4"	10.00 cy	0.6	26	250	-	45	-	32.11 /cy	321	536
			Compaction, vibratory plate, 8" lifts, common fill	80.00 cy	3.2	120	-	-	20	-	1.75 /cy	140	234
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	105.00 cy	17.6	753	-	-	1,499	-	21.45 /cy	2,252	3,761
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	25.00 cy	0.8	31	-	-	68	-	3.99 /cy	100	166
			Public Storm Utility Drainage Piping, concrete, box culvert, cast in place, 2' x 4', excludes excavation or backfill	58.00 lf	21.8	1,019	8,700	-	1,021	-	185.17 /lf	10,740	17,934
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	2.00 ea	6.0	244	800	-	276	-	660.24 /ea	1,320	2,205
			2'x4' Box Culvert	**58.00 LF**	**99.1**	**4,038**	**9,750**		**3,047**		**290.28 /LF**	**16,836**	**28,115**
			33-00 Yard Piping	**58.00 LF**	**99.1**	**4,038**	**9,750**		**3,047**		**290.28 /LF**	**16,836**	**28,115**
			33.0 Buried Piping	**58.00 LF**	**99.1**	**4,038**	**9,750**		**3,047**		**290.28 /LF**	**16,836**	**28,115**
			002 Southern 2'x4' Box Culvert	**58.00 LF**	**148.4**	**6,107**	**11,593**		**4,924**		**390.08 /LF**	**22,625**	**37,781**
003			**Driveway 2'x4' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	40.00 lf	0.6	25	14	-	15	-	1.34 /lf	54	90
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	40.00 lf	0.4	15	5	-	9	-	0.71 /lf	28	47
			Asphalt Demolition and Loading	2.00 cy	0.1	3	-	-	3	-	3.11 /cy	6	10
			Remove Asphalt Pavement	**18.00 SY**	**1.0**	**43**	**19**		**26**		**4.91 /SY**	**88**	**148**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	35.00 lf	6.1	277	-	-	257	-	15.28 /lf	535	893
			Demo Existing Storm Sewer	**35.00 LF**	**6.1**	**277**			**257**		**15.28 /LF**	**535**	**893**
			02-01 Demolition	**1.00 LS**	**7.2**	**320**	**19**		**284**		**623.23 /LS**	**623**	**1,041**
			02.0 Existing Conditions	**1.00 LS**	**7.2**	**320**	**19**		**284**		**623.23 /LS**	**623**	**1,041**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	18.00 sy	0.3	12	267	-	27	-	17.00 /sy	306	511
			Prepare and roll sub-base, small areas to 2500 S.Y.	18.00 sy	0.3	12	-	-	30	-	2.37 /sy	43	71
			Asphaltic paving, replacement over trench, 4" thick	18.00 sy	12.3	506	256	-	439	-	66.72 /sy	1,201	2,006
			Replace Pavement	**18.00 SY**	**12.9**	**530**	**523**		**496**		**86.08 /SY**	**1,550**	**2,588**
			31-40 Paving	**18.00 SY**	**12.9**	**530**	**523**		**496**		**86.08 /SY**	**1,550**	**2,588**
			31.0 Site/Civil	**1.00 LS**	**12.9**	**530**	**523**		**496**		**1,549.50 /LS**	**1,550**	**2,588**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			2'x4' Box Culvert										
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	47.00 cy	0.6	26	-	-	69	-	2.03 /cy	95	159
			Bedding, crushed stone 1/2" to 3/4"	5.00 cy	0.3	13	125	-	23	-	32.11 /cy	161	268
			Compaction, vibratory plate, 8" lifts, common fill	47.00 cy	1.9	71	-	-	12	-	1.75 /cy	82	137
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	62.00 cy	10.4	445	-	-	885	-	21.45 /cy	1,330	2,221
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	15.00 cy	0.5	19	-	-	41	-	3.99 /cy	60	100
			Public Storm Utility Drainage Piping, concrete, box culvert, cast in place, 2' x 4', excludes excavation or backfill	35.00 lf	13.1	615	5,250	-	616	-	185.17 /lf	6,481	10,823
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	1.00 ea	3.0	122	400	-	138	-	660.24 /ea	660	1,103
			2'x4' Box Culvert	**35.00 LF**	**29.8**	**1,310**	**5,775**		**1,784**		**253.40 /LF**	**8,869**	**14,811**
			33-00 Yard Piping	**35.00 LF**	**29.8**	**1,310**	**5,775**		**1,784**		**253.40 /LF**	**8,869**	**14,811**
		33-15	**Yard Structures**										
			Catch Basin										
			Catch Basins, precast, 4' inside dia, 6' deep	1.00 ea	6.0	281	360	-	282	-	922.69 /ea	923	1,541

Job Size:
Duration:

Detail Report

Project: Cemetery
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Catch Basin	**1.00 EA**	**6.0**	**281**	**360**		**282**		**922.69 /EA**	**923**	**1,541**
			33-15 Yard Structures	**1.00 EA**	**6.0**	**281**	**360**		**282**		**922.69 /EA**	**923**	**1,541**
			33.0 Buried Piping	**35.00 LF**	**35.8**	**1,591**	**6,135**		**2,065**		**279.76 /LF**	**9,792**	**16,351**
			003 Driveway 2'x4' Box Culvert	**35.00 LF**	**55.9**	**2,442**	**6,677**		**2,845**		**341.84 /LF**	**11,964**	**19,980**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	14,685		352.421 I		14.57%
Material	32,964				32.70%
Subcontract					
Equipment	12,709		236.776 I		12.61%
Other					
Total Before Markups	**60,358**	**60,358**			59.88
Project Staff & Home Office OH	6,036			10.000 %	5.99%
Total Overhead	**6,036**	**66,394**			5.99
General Conditions	4,648			7.000 %	4.61%
Total General Conditions	**4,648**	**71,042**			4.61
Profit on Previous Subtotal	3,552			5.000 %	3.52%
Total Profit	**3,552**	**74,594**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**74,594**			
Mobilization/Demobilization	3,024			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	1,008			1.000 %	1.00%
Payment & Performance Bonds	1,169			1.160 %	1.16%
Total Bonds and Insurances	**5,201**	**79,795**			5.16
Contingency - %	15,959			20.000 %	15.83%
Total Contingency	**15,959**	**95,754**			15.83
Escalation on Estimate Total	5,040			5.000 %	5.00%
Total Escalation	**5,040**	**100,794**			5.00
Construction Total		**100,794**			

CH2MHILL

Job Size:
Duration:

Detail Report

Project: RickreallUglowOrchard Sys
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 03 - 12/05/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Replace 15" Culvert w/ 24" Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	80.00 lf	1.2	50	29	-	29	-	1.34 /lf	108	180
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	80.00 lf	0.7	30	10	-	17	-	0.71 /lf	57	95
			Asphalt Demolition and Loading	2.00 cy	0.1	3	-	-	3	-	3.11 /cy	6	10
			Remove Asphalt Pavement	**145.00 SY**	**2.0**	**83**	**38**		**49**		**1.18 /SY**	**171**	**285**
			Remove Sidewalk										
			Saw cutting, conc slabs, plain, up to 3" deep	24.00 lf	0.4	15	4	-	9	-	1.16 /lf	28	47
			Saw cutting, conc slabs, plain, each addit inch of depth over 3"	24.00 lf	0.1	5	1	-	3	-	0.39 /lf	9	16
			Concrete Sidewalk Demolition and Loading	1.00 cy	0.0	2	-	-	1	-	3.11 /cy	3	5
			Remove Sidewalk	**72.00 SF**	**0.5**	**22**	**6**		**13**		**0.56 /SF**	**40**	**67**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	100.00 lf	17.5	793	-	-	735	-	15.28 /lf	1,528	2,552
			Demo Existing Storm Sewer	**100.00 LF**	**17.5**	**793**			**735**		**15.28 /LF**	**1,528**	**2,552**
			02-01 Demolition	**1.00 LS**	**20.0**	**897**	**44**		**798**		**1,739.08 /LS**	**1,739**	**2,904**
			02.0 Existing Conditions	**1.00 LS**	**20.0**	**897**	**44**		**798**		**1,739.08 /LS**	**1,739**	**2,904**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	22.00 sy	0.3	14	327	-	33	-	17.00 /sy	374	624
			Prepare and roll sub-base, small areas to 2500 S.Y.	22.00 sy	0.4	15	-	-	37	-	2.37 /sy	52	87
			Asphaltic paving, replacement over trench, 6" thick	22.00 sy	19.2	787	495	-	683	-	89.34 /sy	1,965	3,282
			Replace Pavement	**22.00 SY**	**19.9**	**817**	**822**		**753**		**108.70 /SY**	**2,391**	**3,993**
			Replace Sidewalk										
			Sidewalks, conc, 3000 PSI, CIP w/ 6x6 mesh, broom fin, no base, 4" T	72.00 sf	2.9	123	119	-	-	-	3.36 /sf	242	404
			Sidewalks, bank run gravel base, 4" thick, add	72.00 sf	0.7	28	37	-	4	-	0.97 /sf	69	116
			Replace Sidewalk	**72.00 SF**	**3.6**	**152**	**156**		**4**		**4.33 /SF**	**312**	**520**
			31-40 Paving	**22.00 SY**	**23.5**	**968**	**977**		**758**		**122.86 /SY**	**2,703**	**4,514**
			31.0 Site/Civil	**1.00 LS**	**23.5**	**968**	**977**		**758**		**2,703.00 /LS**	**2,703**	**4,514**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			24" RCP Culvert										
			Traffic Control, Labor per Day	3.00 day	48.0	1,800	-	-	-	-	600.10 /day	1,800	3,006
			Bedding Stone, Material Only	6.29 tn		-	88	-	-	-	14.00 /tn	88	147
			24" pipe, RCP, Class III B & S, excav/bkfill included, 0-8'	85.00 LF	31.9	1,493	2,490	-	1,496	-	64.46 /LF	5,479	9,149
			24" flared end, RCP, B & S	2.00 ea	6.0	281	930	-	282	-	746.35 /ea	1,493	2,493
			Grout joint, ID or OD, 24"	11.00 ea	8.3	363	88	-	-	-	41.00 /ea	451	753
			24" RCP Culvert	**85.00 LF**	**94.1**	**3,938**	**3,596**		**1,778**		**109.54 /LF**	**9,311**	**15,548**
			33-00 Yard Piping	**85.00 LF**	**94.1**	**3,938**	**3,596**		**1,778**		**109.54 /LF**	**9,311**	**15,548**
			33.0 Buried Piping	**85.00 LF**	**94.1**	**3,938**	**3,596**		**1,778**		**109.54 /LF**	**9,311**	**15,548**
			001 Replace 15" Culvert w/ 24" Culvert	**85.00 LF**	**137.6**	**5,803**	**4,617**		**3,333**		**161.80 /LF**	**13,753**	**22,966**
002			**Dual 54" RCP in Parking Lot**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	460.00 lf	6.9	285	166	-	167	-	1.34 /lf	618	1,032
			Asphalt Demolition and Loading	34.00 cy	1.4	56	-	-	50	-	3.11 /cy	106	177
			Remove Asphalt Pavement	**307.00 SY**	**8.3**	**342**	**166**		**217**		**2.36 /SY**	**724**	**1,209**
			Existing Storm Sewer Demolition										
			Storm Sewer Pipe Demolition and Loading, 10' Deep	230.00 lf	64.4	2,917	-	-	2,706	-	24.45 /lf	5,624	9,391
			Existing Storm Sewer Demolition	**230.00 LF**	**64.4**	**2,917**			**2,706**		**24.45 /LF**	**5,624**	**9,391**
			02-01 Demolition	**1.00 LS**	**72.7**	**3,259**	**166**		**2,923**		**6,347.74 /LS**	**6,348**	**10,600**
			02.0 Existing Conditions	**1.00 LS**	**72.7**	**3,259**	**166**		**2,923**		**6,347.74 /LS**	**6,348**	**10,600**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	307.00 sy	4.6	201	4,559	-	457	-	17.00 /sy	5,218	8,713

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Replace Pavement										
			Prepare and roll sub-base, small areas to 2500 S.Y.	307.00 sy	4.9	212	-	-	514	-	2.37 /sy	726	1,212
			Asphaltic paving, replacement over trench, 4" thick	307.00 sy	210.6	8,630	4,359	-	7,494	-	66.72 /sy	20,484	34,206
			Replace Pavement	**307.00 SY**	**220.1**	**9,044**	**8,918**		**8,465**		**86.08 /SY**	**26,428**	**44,132**
			31-40 Paving	**307.00 SY**	**220.1**	**9,044**	**8,918**		**8,465**		**86.08 /SY**	**26,428**	**44,132**
			31.0 Site/Civil	**1.00 LS**	**220.1**	**9,044**	**8,918**		**8,465**		**26,427.55 /LS**	**26,428**	**44,132**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			54" RCP Pipe										
			Trench Box, 8' x 24' x 10'	2.00 mo		-	-	-	4,600	-	2,300.00 /mo	4,600	7,682
			Excav. pipe trench, w/ trench box, for > 30" pipe	1,147.72 CY	25.2	1,078	-	-	5,308	-	5.56 /CY	6,385	10,663
			Backfill / Compact @ pipe zone, for 30" & larger pipe	441.80 cy	56.1	2,310	-	-	4,544	-	15.52 /cy	6,854	11,446
			Backfill / Compact above pipe zone, for 30" & larger pipe	635.80 cy	19.1	879	-	-	1,358	-	3.52 /cy	2,237	3,735
			Pipe zone material	441.80 cy		-	12,370	-	-	-	28.00 /cy	12,370	20,658
			Pipe bedding material	119.13 cy		-	3,336	-	-	-	28.00 /cy	3,336	5,570
			Haul spoils, offsite, up to 10 miles	560.93 cy		-	-	5,609	-	-	10.00 /cy	5,609	9,367
			54" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	460.00 LF	119.6	5,590	51,962	-	6,609	-	139.48 /LF	64,160	107,142
			Grout joint, ID or OD, 54"	58.00 ea	58.0	2,114	2,320	-	-	-	76.44 /ea	4,434	7,404
			54" RCP Pipe	**460.00 LF**	**278.0**	**11,970**	**69,988**	**5,609**	**22,418**		**239.10 /LF**	**109,986**	**183,667**
			33-00 Yard Piping	**230.00 LF**	**278.0**	**11,970**	**69,988**	**5,609**	**22,418**		**478.20 /LF**	**109,986**	**183,667**
			33.0 Buried Piping	**230.00 LF**	**278.0**	**11,970**	**69,988**	**5,609**	**22,418**		**478.20 /LF**	**109,986**	**183,667**
			002 Dual 54" RCP in Parking Lot	**230.00 LF**	**570.8**	**24,273**	**79,072**	**5,609**	**33,807**		**620.70 /LF**	**142,761**	**238,399**
003			**Replace Box Culvert w/ Dual 42" RCP @ Ellendale**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	90.00 lf	1.4	56	32	-	33	-	1.34 /lf	121	202
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	540.00 lf	4.9	201	65	-	118	-	0.71 /lf	384	640
			Asphalt Demolition and Loading	19.00 cy	0.8	31	-	-	28	-	3.11 /cy	59	99
			Remove Asphalt Pavement	**75.00 SY**	**7.0**	**288**	**97**		**178**		**7.52 /SY**	**564**	**941**
			Remove Sidewalk										
			Saw cutting, conc slabs, plain, up to 3" deep	32.00 lf	0.5	20	6	-	12	-	1.16 /lf	37	62
			Saw cutting, conc slabs, plain, each addit inch of depth over 3"	32.00 lf	0.2	7	2	-	4	-	0.39 /lf	12	21
			Concrete Sidewalk Demolition and Loading	3.00 cy	0.1	5	-	-	4	-	3.11 /cy	9	16
			Remove Sidewalk	**240.00 SF**	**0.8**	**31**	**8**		**20**		**0.25 /SF**	**59**	**99**
			Demo Existing Storm Sewer										
			Selective demolition, box culvert, precast, 8' x 6' x 3' to 8' x 8' x 8', excludes excavation	150.00 lf	24.0	976	-	-	1,106	-	13.88 /lf	2,082	3,477
			Demo Existing Storm Sewer	**150.00 LF**	**24.0**	**976**			**1,106**		**13.88 /LF**	**2,082**	**3,477**
			02-01 Demolition	**1.00 LS**	**31.7**	**1,296**	**105**		**1,304**		**2,704.62 /LS**	**2,705**	**4,517**
			02.0 Existing Conditions	**1.00 LS**	**31.7**	**1,296**	**105**		**1,304**		**2,704.62 /LS**	**2,705**	**4,517**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	75.00 sy	1.1	49	1,114	-	112	-	17.00 /sy	1,275	2,129
			Prepare and roll sub-base, small areas to 2500 S.Y.	75.00 sy	1.2	52	-	-	125	-	2.37 /sy	177	296
			Asphaltic paving, replacement over trench, 4" thick	75.00 sy	51.5	2,108	1,065	-	1,831	-	66.72 /sy	5,004	8,357
			Asphaltic paving, replacement over trench, 6" thick	75.00 sy	65.5	2,683	1,688	-	2,330	-	89.34 /sy	6,700	11,189
			Replace Pavement	**75.00 SY**	**119.3**	**4,892**	**3,866**		**4,398**		**175.42 /SY**	**13,157**	**21,971**
			Replace Sidewalk										
			Sidewalks, conc, 3000 PSI, CIP w/ 6x6 mesh, broom fin, no base, 4" T	240.00 sf	9.6	411	396	-	-	-	3.36 /sf	807	1,348
			Sidewalks, bank run gravel base, 4" thick, add	240.00 sf	2.4	94	122	-	15	-	0.97 /sf	232	387
			Replace Sidewalk	**240.00 SF**	**12.0**	**505**	**518**		**15**		**4.33 /SF**	**1,039**	**1,734**
			31-40 Paving	**75.00 SY**	**131.3**	**5,398**	**4,385**		**4,413**		**189.27 /SY**	**14,195**	**23,705**
			31.0 Site/Civil	**1.00 LS**	**131.3**	**5,398**	**4,385**		**4,413**		**14,195.36 /LS**	**14,195**	**23,705**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			54" RCP Pipe										
			Traffic Control, Labor per Day	10.00 day	160.0	6,001	-	-	-	-	600.10 /day	6,001	10,021

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			54" RCP Pipe										
			Trench Box, 8' x 24' x 10'	2.00 mo		-	-	-	4,600	-	2,300.00 /mo	4,600	7,682
			Excav. pipe trench, w/ trench box, for > 30" pipe	933.18 CY	20.5	876	-	-	4,316	-	5.56 /CY	5,192	8,670
			Backfill / Compact @ pipe zone, for 30" & larger pipe	374.38 cy	47.5	1,958	-	-	3,850	-	15.52 /cy	5,808	9,699
			Backfill / Compact above pipe zone, for 30" & larger pipe	516.96 cy	15.5	715	-	-	1,104	-	3.52 /cy	1,819	3,037
			Pipe zone material	374.38 cy		-	10,483	-	-	-	28.00 /cy	10,483	17,505
			Pipe bedding material	96.85 cy		-	2,712	-	-	-	28.00 /cy	2,712	4,529
			Haul spoils, offsite, up to 10 miles	471.23 cy		-	-	4,712	-	-	10.00 /cy	4,712	7,869
			42" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	300.00 LF	52.5	2,454	24,084	-	3,509	-	100.16 /LF	30,047	50,176
			Grout joint, ID or OD, 42"	38.00 ea	38.0	1,672	760	-	-	-	64.00 /ea	2,432	4,061
			54" RCP Pipe	**150.00 LF**	**334.1**	**13,675**	**38,038**	**4,712**	**17,379**		**492.04 /LF**	**73,805**	**123,249**
			33-00 Yard Piping	**150.00 LF**	**334.1**	**13,675**	**38,038**	**4,712**	**17,379**		**492.04 /LF**	**73,805**	**123,249**
		33-15	**Yard Structures**										
			5'x8' Junction Box										
			5'x8' Junction Box	1.00 ea	36.0	1,453	8,000	-	571	-	10,023.63 /ea	10,024	16,739
			5'x8' Junction Box	**1.00 EA**	**36.0**	**1,453**	**8,000**		**571**		**10,023.63 /EA**	**10,024**	**16,739**
			33-15 Yard Structures	**1.00 EA**	**36.0**	**1,453**	**8,000**		**571**		**10,023.63 /EA**	**10,024**	**16,739**
			33.0 Buried Piping	**150.00 LF**	**370.1**	**15,128**	**46,038**	**4,712**	**17,950**		**558.86 /LF**	**83,829**	**139,987**
			003 Replace Box Culvert w/ Dual 42" RCP @ Ellendale	**150.00 LF**	**533.1**	**21,822**	**50,528**	**4,712**	**23,667**		**671.53 /LF**	**100,729**	**168,209**
004			**Replace Existing 36" with 42" to Apartments**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Site Demoliton										
			Site Surface Demoliton Allowance	150.00 cy		-		18,750	-	-	125.00 /cy	18,750	31,311
			Site Demoliton	**12,200.00 SF**				**18,750**			**1.54 /SF**	**18,750**	**31,311**
			Demo Existing Storm Sewer										
			Manhole Demolition and Loading, 10' Deep	5.00 ea	87.5	3,964	-	-	3,677	-	1,528.20 /ea	7,641	12,760
			Storm Sewer Pipe Demolition and Loading, 6' Deep	610.00 lf	106.8	4,836	-	-	4,486	-	15.28 /lf	9,322	15,567
			Demo Existing Storm Sewer	**610.00 LF**	**194.3**	**8,800**			**8,163**		**27.81 /LF**	**16,963**	**28,327**
			02-01 Demolition	**1.00 LS**	**194.3**	**8,800**		**18,750**	**8,163**		**35,713.03 /LS**	**35,713**	**59,638**
			02.0 Existing Conditions	**1.00 LS**	**194.3**	**8,800**		**18,750**	**8,163**		**35,713.03 /LS**	**35,713**	**59,638**
	31.0		**Site/Civil**										
		31-35	**Site Landscaping**										
			Surface Replacement										
			Surfacing Replacement Allowance	12,200.00 sf	36.6		-	36,600	-	-	3.00 /sf	36,600	61,119
			Surface Replacement	**12,200.00 SF**	**36.6**			**36,600**			**3.00 /SF**	**36,600**	**61,119**
			31-35 Site Landscaping	**1.00 LS**	**36.6**			**36,600**			**36,600.00 /LS**	**36,600**	**61,119**
			31.0 Site/Civil	**1.00 LS**	**36.6**			**36,600**			**36,600.00 /LS**	**36,600**	**61,119**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			54" RCP Pipe										
			Trench Box, 8' x 24' x 10'	2.00 mo		-	-	-	4,600	-	2,300.00 /mo	4,600	7,682
			Excav. pipe trench, w/ trench box, for > 30" pipe	1,520.73 CY	33.5	1,428	-	-	7,033	-	5.56 /CY	8,461	14,129
			Backfill / Compact @ pipe zone, for 30" & larger pipe	585.39 cy	74.3	3,061	-	-	6,021	-	15.52 /cy	9,082	15,166
			Backfill / Compact above pipe zone, for 30" & larger pipe	842.44 cy	25.3	1,164	-	-	1,799	-	3.52 /cy	2,964	4,949
			Pipe zone material	585.39 cy		-	16,391	-	-	-	28.00 /cy	16,391	27,371
			Pipe bedding material	157.85 cy		-	4,420	-	-	-	28.00 /cy	4,420	7,381
			Haul spoils, offsite, up to 10 miles	743.23 cy		-	-	7,432	-	-	10.00 /cy	7,432	12,411
			42" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	610.00 LF	106.8	4,989	48,971	-	7,135	-	100.16 /LF	61,095	102,024
			Grout joint, ID or OD, 42"	77.00 ea	77.0	3,388	1,540	-	-	-	64.00 /ea	4,928	8,229
			54" RCP Pipe	**610.00 LF**	**316.8**	**14,031**	**71,321**	**7,432**	**26,588**		**195.69 /LF**	**119,372**	**199,342**
			33-00 Yard Piping	**610.00 LF**	**316.8**	**14,031**	**71,321**	**7,432**	**26,588**		**195.69 /LF**	**119,372**	**199,342**
		33-15	**Yard Structures**										
			84" Manholes										
			Manholes, precast, 7' inside dia, 10' deep	5.00 ea	60.0	2,811	17,500	-	2,816	-	4,625.37 /ea	23,127	38,620
			Cast-in-Place Base, 7'	5.00 ea	15.0	703	7,000	-	704	-	1,681.34 /ea	8,407	14,039
			Grade Ring, 7'	10.00 ea	10.0	468	250	-	469	-	118.78 /ea	1,188	1,984
			Frame & Cover, 7'	5.00 ea	10.0	468	1,125	-	469	-	412.56 /ea	2,063	3,445
			Grout Invert, 7'	5.00 ea	12.5	586	500	-	587	-	334.45 /ea	1,672	2,793

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			84" Manholes	**5.00 EA**	**107.5**	**5,036**	**26,375**		**5,045**		**7,291.28 /EA**	**36,456**	**60,879**
			33-15 Yard Structures	**5.00 EA**	**107.5**	**5,036**	**26,375**		**5,045**		**7,291.28 /EA**	**36,456**	**60,879**
			33.0 Buried Piping	**610.00 LF**	**424.3**	**19,067**	**97,696**	**7,432**	**31,633**		**255.46 /LF**	**155,829**	**260,221**
			004 Replace Existing 36" with 42" to Apartments	**610.00 LF**	**655.2**	**27,867**	**97,696**	**62,782**	**39,797**		**374.00 /LF**	**228,142**	**380,978**
005			**New 42" Parallel to Existing 42"**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Site Demoliton										
			Site Surface Demoliton Allowance	150.00 cy		-		18,750	-	-	125.00 /cy	18,750	31,311
			Site Demoliton	**12,000.00 SF**				**18,750**			**1.56 /SF**	**18,750**	**31,311**
			02-01 Demolition	**1.00 LS**				**18,750**			**18,750.00 /LS**	**18,750**	**31,311**
			02.0 Existing Conditions	**1.00 LS**				**18,750**			**18,750.00 /LS**	**18,750**	**31,311**
	31.0		**Site/Civil**										
		31-35	**Site Landscaping**										
			Surface Replacement										
			Surfacing Replacement Allowance	12,000.00 sf	36.0		-	36,000	-	-	3.00 /sf	36,000	60,117
			Surface Replacement	**12,000.00 SF**	**36.0**			**36,000**			**3.00 /SF**	**36,000**	**60,117**
			31-35 Site Landscaping	**1.00 LS**	**36.0**			**36,000**			**36,000.00 /LS**	**36,000**	**60,117**
			31.0 Site/Civil	**1.00 LS**	**36.0**			**36,000**			**36,000.00 /LS**	**36,000**	**60,117**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			54" RCP Pipe										
			Trench Box, 8' x 24' x 10'	2.60 mo		-	-	-	5,973	-	2,300.00 /mo	5,973	9,975
			Excav. pipe trench, w/ trench box, for > 30" pipe	1,490.32 CY	32.8	1,399	-	-	6,892	-	5.56 /CY	8,291	13,846
			Backfill / Compact @ pipe zone, for 30" & larger pipe	573.68 cy	72.9	3,000	-	-	5,900	-	15.52 /cy	8,900	14,863
			Backfill / Compact above pipe zone, for 30" & larger pipe	825.59 cy	24.8	1,141	-	-	1,763	-	3.52 /cy	2,905	4,850
			Pipe zone material	573.68 cy		-	16,063	-	-	-	28.00 /cy	16,063	26,824
			Pipe bedding material	154.69 cy		-	4,331	-	-	-	28.00 /cy	4,331	7,233
			Haul spoils, offsite, up to 10 miles	728.37 cy		-	-	7,284	-	-	10.00 /cy	7,284	12,163
			42" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	600.00 LF	105.0	4,907	48,168	-	7,018	-	100.16 /LF	60,094	100,351
			Grout joint, ID or OD, 42"	75.00 ea	75.0	3,300	1,500	-	-	-	64.00 /ea	4,800	8,016
			54" RCP Pipe	**600.00 LF**	**310.4**	**13,748**	**70,062**	**7,284**	**27,547**		**197.74 /LF**	**118,641**	**198,121**
			33-00 Yard Piping	**600.00 LF**	**310.4**	**13,748**	**70,062**	**7,284**	**27,547**		**197.74 /LF**	**118,641**	**198,121**
		33-15	**Yard Structures**										
			84" Manholes										
			Manholes, precast, 7' inside dia, 10' deep	2.00 ea	24.0	1,124	7,000	-	1,126	-	4,625.37 /ea	9,251	15,448
			Cast-in-Place Base, 7'	2.00 ea	6.0	281	2,800	-	282	-	1,681.35 /ea	3,363	5,615
			Grade Ring, 7'	2.00 ea	2.0	94	50	-	94	-	118.78 /ea	238	397
			Frame & Cover, 7'	2.00 ea	4.0	187	450	-	188	-	412.56 /ea	825	1,378
			Grout Invert, 7'	2.00 ea	5.0	234	200	-	235	-	334.45 /ea	669	1,117
			84" Manholes	**2.00 EA**	**41.0**	**1,921**	**10,500**		**1,924**		**7,172.50 /EA**	**14,345**	**23,955**
			33-15 Yard Structures	**2.00 EA**	**41.0**	**1,921**	**10,500**		**1,924**		**7,172.50 /EA**	**14,345**	**23,955**
			33.0 Buried Piping	**600.00 LF**	**351.4**	**15,669**	**80,562**	**7,284**	**29,471**		**221.64 /LF**	**132,986**	**222,076**
			005 New 42" Parallel to Existing 42"	**600.00 LF**	**387.4**	**15,669**	**80,562**	**62,034**	**29,471**		**312.89 /LF**	**187,736**	**313,504**
006			**New 36" Installed Parallel to Existing 48" to Outfall**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	1,800.00 lf	27.0	1,117	648	-	654	-	1.34 /lf	2,419	4,039
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	1,800.00 lf	16.2	670	216	-	392	-	0.71 /lf	1,278	2,135
			Asphalt Demolition and Loading	66.00 cy	2.6	109	-	-	96	-	3.11 /cy	205	343
			Remove Asphalt Pavement	**600.00 SY**	**45.8**	**1,896**	**864**		**1,142**		**6.50 /SY**	**3,903**	**6,517**
			Remove Sidewalk										
			Saw cutting, conc slabs, plain, up to 3" deep	10.00 lf	0.2	6	2	-	4	-	1.16 /lf	12	19
			Saw cutting, conc slabs, plain, each addit inch of depth over 3"	10.00 lf	0.1	2	1	-	1	-	0.39 /lf	4	6
			Concrete Sidewalk Demolition and Loading	1.00 cy	0.0	2	-	-	1	-	3.11 /cy	3	5
			Remove Sidewalk	**60.00 SF**	**0.2**	**10**	**2**		**6**		**0.31 /SF**	**19**	**31**

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			02-01 Demolition	**1.00 LS**	**46.1**	**1,906**	**866**		**1,149**		**3,921.14 /LS**	**3,921**	**6,548**
			02.0 Existing Conditions	**1.00 LS**	**46.1**	**1,906**	**866**		**1,149**		**3,921.14 /LS**	**3,921**	**6,548**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	600.00 sy	9.0	394	8,910	-	894	-	17.00 /sy	10,198	17,030
			Prepare and roll sub-base, small areas to 2500 S.Y.	600.00 sy	9.6	415	-	-	1,004	-	2.37 /sy	1,419	2,369
			Asphaltic paving, replacement over trench, 4" thick	600.00 sy	411.6	16,867	8,520	-	14,647	-	66.72 /sy	40,033	66,852
			Replace Pavement	**600.00 SY**	**430.2**	**17,675**	**17,430**		**16,545**		**86.08 /SY**	**51,650**	**86,251**
			Replace Sidewalk										
			Sidewalks, conc, 3000 PSI, CIP w/ 6x6 mesh, broom fin, no base, 4" T	60.00 sf	2.4	103	99	-	-	-	3.36 /sf	202	337
			Sidewalks, bank run gravel base, 4" thick, add	60.00 sf	0.6	24	31	-	4	-	0.97 /sf	58	97
			Replace Sidewalk	**60.00 SF**	**3.0**	**126**	**130**		**4**		**4.33 /SF**	**260**	**434**
			31-40 Paving	**600.00 SY**	**433.2**	**17,801**	**17,560**		**16,549**		**86.52 /SY**	**51,910**	**86,685**
			31.0 Site/Civil	**1.00 LS**	**433.2**	**17,801**	**17,560**		**16,549**		**51,909.60 /LS**	**51,910**	**86,685**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			36" RCP Pipe										
			Traffic Control, Labor per Day	24.00 day	384.0	14,402	-	-	-	-	600.10 /day	14,402	24,051
			Trench Box, 8' x 24' x 10'	3.90 mo		-	-	-	8,961	-	2,300.00 /mo	8,961	14,964
			Excav. pipe trench, w/ trench box, for > 30" pipe	2,235.47 CY	49.2	2,099	-	-	10,338	-	5.56 /CY	12,437	20,769
			Backfill / Compact @ pipe zone, for 30" & larger pipe	860.52 cy	109.3	4,500	-	-	8,850	-	15.52 /cy	13,351	22,294
			Backfill / Compact above pipe zone, for 30" & larger pipe	1,238.38 cy	37.2	1,712	-	-	2,645	-	3.52 /cy	4,357	7,276
			Pipe zone material	860.52 cy		-	24,094	-	-	-	28.00 /cy	24,094	40,236
			Pipe bedding material	232.04 cy		-	6,497	-	-	-	28.00 /cy	6,497	10,849
			Haul spoils, offsite, up to 10 miles	1,092.55 cy		-	-	10,926	-	-	10.00 /cy	10,926	18,245
			36" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	900.00 LF	135.0	6,309	55,305	-	7,895	-	77.23 /LF	69,510	116,076
			Grout joint, ID or OD, 36"	113.00 ea	84.8	3,729	1,356	-	-	-	45.00 /ea	5,085	8,492
			36" RCP Pipe	**900.00 LF**	**799.4**	**32,752**	**87,252**	**10,926**	**38,690**		**188.47 /LF**	**169,619**	**283,250**
			33-00 Yard Piping	**900.00 LF**	**799.4**	**32,752**	**87,252**	**10,926**	**38,690**		**188.47 /LF**	**169,619**	**283,250**
		33-15	**Yard Structures**										
			84" Manholes										
			Manholes, precast, 7' inside dia, 10' deep	3.00 ea	36.0	1,686	10,500	-	1,690	-	4,625.37 /ea	13,876	23,172
			Cast-in-Place Base, 7'	3.00 ea	9.0	422	4,200	-	422	-	1,681.34 /ea	5,044	8,423
			Grade Ring, 7'	3.00 ea	3.0	141	75	-	141	-	118.78 /ea	356	595
			Frame & Cover, 7'	3.00 ea	6.0	281	675	-	282	-	412.56 /ea	1,238	2,067
			Grout Invert, 7'	3.00 ea	7.5	351	300	-	352	-	334.45 /ea	1,003	1,676
			84" Manholes	**3.00 EA**	**61.5**	**2,881**	**15,750**		**2,886**		**7,172.50 /EA**	**21,518**	**35,932**
			33-15 Yard Structures	**3.00 EA**	**61.5**	**2,881**	**15,750**		**2,886**		**7,172.50 /EA**	**21,518**	**35,932**
			33.0 Buried Piping	**900.00 LF**	**860.9**	**35,633**	**103,002**	**10,926**	**41,576**		**212.37 /LF**	**191,137**	**319,183**
			006 New 36" Installed Parallel to Existing 48" to Outfall	**900.00 LF**	**1,340.1**	**55,340**	**121,428**	**10,926**	**59,273**		**274.41 /LF**	**246,968**	**412,416**
007			**Kings Valley Highway Biofiltration Swale**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Existing Storm Sewer Demolition										
			Storm Sewer Pipe Demolition and Loading, 10' Deep	180.00 lf	50.4	2,283	-	-	2,118	-	24.45 /lf	4,401	7,350
			Existing Storm Sewer Demolition	**180.00 LF**	**50.4**	**2,283**			**2,118**		**24.45 /LF**	**4,401**	**7,350**
			02-01 Demolition	**1.00 LS**	**50.4**	**2,283**			**2,118**		**4,401.22 /LS**	**4,401**	**7,350**
			02.0 Existing Conditions	**1.00 LS**	**50.4**	**2,283**			**2,118**		**4,401.22 /LS**	**4,401**	**7,350**
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Excavate Bioswale										
			Rough Site Grading, Small Crew	1,200.00 sy	16.0	720	-	-	1,185	-	1.59 /sy	1,904	3,180
			Finish grading lagoon bottoms	10.80 msf	43.2	1,805	-	-	4,075	-	544.51 /msf	5,881	9,820
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	500.00 cy	40.0	1,707	-	-	1,700	-	6.81 /cy	3,407	5,690
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	500.00 cy	20.0	754	-	-	1,637	-	4.78 /cy	2,391	3,993
			Permanent Seed and Mulch	0.25 acre	1.5		-	375	-	-	1,500.00 /acre	375	626

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Excavate Bioswale	**180.00 LF**	**120.7**	**4,986**		**375**	**8,597**		**77.55 /LF**	**13,959**	**23,310**
			Retrofit Flow Splitting Manhole										
			Retrofit Flow Splitting Manhole Allowance	1.00 ea	120.0	4,843	1,000	-	1,902	-	7,745.44 /ea	7,745	12,934
			Retrofit Flow Splitting Manhole	**1.00 EA**	**120.0**	**4,843**	**1,000**		**1,902**		**7,745.44 /EA**	**7,745**	**12,934**
			31-20 Earthworks, Site	**1.00 LS**	**240.7**	**9,830**	**1,000**	**375**	**10,499**		**21,703.98 /LS**	**21,704**	**36,244**
			31.0 Site/Civil	**1.00 LS**	**240.7**	**9,830**	**1,000**	**375**	**10,499**		**21,703.98 /LS**	**21,704**	**36,244**
			007 Kings Valley Highway Biofiltration Swale	**180.00 LF**	**291.1**	**12,113**	**1,000**	**375**	**12,617**		**145.03 /LF**	**26,105**	**43,594**
008			**Uglow Outfall Biofiltration Swale**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Existing Storm Sewer Demolition										
			Storm Sewer Pipe Demolition and Loading, 10' Deep	150.00 lf	42.0	1,903	-	-	1,765	-	24.45 /lf	3,668	6,125
			Existing Storm Sewer Demolition	**1.00 LF**	**42.0**	**1,903**			**1,765**		**3,667.68 /LF**	**3,668**	**6,125**
			02-01 Demolition	**1.00 LS**	**42.0**	**1,903**			**1,765**		**3,667.68 /LS**	**3,668**	**6,125**
			02.0 Existing Conditions	**1.00 LS**	**42.0**	**1,903**			**1,765**		**3,667.68 /LS**	**3,668**	**6,125**
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Excavate Bioswale										
			Rough Site Grading, Small Crew	333.33 sy	4.4	200	-	-	329	-	1.59 /sy	529	883
			Finish grading lagoon bottoms	3.00 msf	12.0	501	-	-	1,132	-	544.51 /msf	1,634	2,728
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	105.00 cy	8.4	359	-	-	357	-	6.81 /cy	716	1,195
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	105.00 cy	4.2	158	-	-	344	-	4.78 /cy	502	839
			Permanent Seed and Mulch	0.07 acre	0.4		-	105	-	-	1,500.00 /acre	105	175
			Excavate Bioswale	**150.00 LF**	**29.5**	**1,218**		**105**	**2,162**		**23.24 /LF**	**3,485**	**5,820**
			Retrofit Flow Splitting Manhole										
			Retrofit Flow Splitting Manhole Allowance	1.00 ea	120.0	4,843	1,000	-	1,902	-	7,745.44 /ea	7,745	12,934
			Retrofit Flow Splitting Manhole	**1.00 EA**	**120.0**	**4,843**	**1,000**		**1,902**		**7,745.44 /EA**	**7,745**	**12,934**
			31-20 Earthworks, Site	**1.00 LS**	**149.5**	**6,062**	**1,000**	**105**	**4,064**		**11,230.64 /LS**	**11,231**	**18,754**
			31.0 Site/Civil	**1.00 LS**	**149.5**	**6,062**	**1,000**	**105**	**4,064**		**11,230.64 /LS**	**11,231**	**18,754**
			008 Uglow Outfall Biofiltration Swale	**150.00 LF**	**191.5**	**7,964**	**1,000**	**105**	**5,829**		**99.32 /LF**	**14,898**	**24,879**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	170,850		4,106.805 I		10.65%
Material	435,904				27.16%
Subcontract	146,543				9.13%
Equipment	207,794		4,899.402 I		12.95%
Other					
Total Before Markups	**961,091**	**961,091**			59.88
Project Staff & Home Office OH	96,109			10.000 %	5.99%
Total Overhead	**96,109**	**1,057,200**			5.99
General Conditions	74,004			7.000 %	4.61%
Total General Conditions	**74,004**	**1,131,204**			4.61
Profit on Previous Subtotal	56,560			5.000 %	3.52%
Total Profit	**56,560**	**1,187,764**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**1,187,764**			
Mobilization/Demobilization	48,148			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	16,049			1.000 %	1.00%
Payment & Performance Bonds	18,617			1.160 %	1.16%
Total Bonds and Insurances	**82,814**	**1,270,578**			5.16
Contingency - %	254,116			20.000 %	15.83%
Total Contingency	**254,116**	**1,524,694**			15.83
Escalation on Estimate Total	80,247			5.000 %	5.00%
Total Escalation	**80,247**	**1,604,941**			5.00
Construction Total		**1,604,941**			

Detail Report

CH2MHILL

Job Size:	Project: Bridlewood System	Estimator: T Jones
Duration:	Project No.: 496541	Revision / Date: 02 - 11/20/2014
	Design Stage: Preliminary Design	Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Two 6'x8' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	74.00 lf	1.1	46	27	-	27	-	1.34 /lf	99	166
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	444.00 lf	4.0	165	53	-	97	-	0.71 /lf	315	527
			Asphalt Demolition and Loading	42.00 cy	1.7	69	-	-	61	-	3.11 /cy	131	218
			Remove Asphalt Pavement	**166.67 SY**	**6.8**	**281**	**80**		**185**		**3.27 /SY**	**546**	**911**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	72.00 lf	12.6	571	-	-	530	-	15.28 /lf	1,100	1,837
			Demo Existing Storm Sewer	**72.00 LF**	**12.6**	**571**			**530**		**15.28 /LF**	**1,100**	**1,837**
			02-01 Demolition	**1.00 LS**	**19.4**	**851**	**80**		**715**		**1,645.85 /LS**	**1,646**	**2,748**
			02.0 Existing Conditions	**1.00 LS**	**19.4**	**851**	**80**		**715**		**1,645.85 /LS**	**1,646**	**2,748**
	31.0		**Site/Civil**										
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	166.67 sy	2.5	109	2,475	-	248	-	17.00 /sy	2,833	4,731
			Prepare and roll sub-base, small areas to 2500 S.Y.	166.67 sy	2.7	115	-	-	279	-	2.37 /sy	394	658
			Asphaltic paving, replacement over trench, 4" thick	166.67 sy	114.3	4,685	2,367	-	4,069	-	66.72 /sy	11,121	18,571
			Asphaltic paving, replacement over trench, 6" thick	166.67 sy	145.5	5,962	3,750	-	5,178	-	89.34 /sy	14,890	24,865
			Replace Pavement	**166.67 SY**	**265.0**	**10,872**	**8,592**		**9,774**		**175.42 /SY**	**29,238**	**48,825**
			31-40 Paving	**36.00 SY**	**265.0**	**10,872**	**8,592**		**9,774**		**812.16 /SY**	**29,238**	**48,825**
			31.0 Site/Civil	**1.00 LS**	**265.0**	**10,872**	**8,592**		**9,774**		**29,237.71 /LS**	**29,238**	**48,825**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			6'x8' Precast Box Culvert										
			Traffic Control, Labor per Day	10.00 day	160.0	6,001	-	-	-	-	600.10 /day	6,001	10,021
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	380.00 cy	4.9	214	-	-	558	-	2.03 /cy	772	1,288
			Bedding, crushed stone 1/2" to 3/4"	20.00 cy	1.2	52	500	-	90	-	32.11 /cy	642	1,072
			Compaction, vibratory plate, 8" lifts, common fill	380.00 cy	15.2	570	-	-	95	-	1.75 /cy	665	1,110
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	530.00 cy	89.0	3,800	-	-	7,568	-	21.45 /cy	11,369	18,985
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	130.00 cy	4.3	163	-	-	355	-	3.99 /cy	518	865
			Public Storm Utility Drainage Piping, concrete, box culvert, precast, base price, 8' long, 6' x 8', excludes excavation or backfill	74.00 lf	28.4	1,156	23,680	-	1,309	-	353.31 /lf	26,145	43,660
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	2.00 ea	6.0	281	1,000	-	282	-	781.35 /ea	1,563	2,610
			6'x8' Precast Box Culvert	**74.00 LF**	**309.1**	**12,237**	**25,180**		**10,257**		**644.25 /LF**	**47,674**	**79,612**
			33-00 Yard Piping	**74.00 LF**	**309.1**	**12,237**	**25,180**		**10,257**		**644.25 /LF**	**47,674**	**79,612**
			33.0 Buried Piping	**74.00 LF**	**309.1**	**12,237**	**25,180**		**10,257**		**644.25 /LF**	**47,674**	**79,612**
			001 Two 6'x8' Box Culvert	**37.00 LF**	**593.5**	**23,961**	**33,852**		**20,745**		**2,123.18 /LF**	**78,558**	**131,185**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	23,961		593.521 I		18.26%
Material	33,852				25.80%
Subcontract					
Equipment	20,745		403.369 I		15.81%
Other					
Total Before Markups	**78,558**	**78,558**			59.88
Project Staff & Home Office OH	7,856			10.000 %	5.99%
Total Overhead	**7,856**	**86,414**			5.99
General Conditions	6,049			7.000 %	4.61%
Total General Conditions	**6,049**	**92,463**			4.61
Profit on Previous Subtotal	4,623			5.000 %	3.52%
Total Profit	**4,623**	**97,086**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**97,086**			
Mobilization/Demobilization	3,936			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	1,312			1.000 %	1.00%
Payment & Performance Bonds	1,522			1.160 %	1.16%
Total Bonds and Insurances	**6,770**	**103,856**			5.16
Contingency - %	20,771			20.000 %	15.83%
Total Contingency	**20,771**	**124,627**			15.83
Escalation on Estimate Total	6,559			5.000 %	5.00%
Total Escalation	**6,559**	**131,186**			5.00
Construction Total		**131,186**			

Job Size:
Duration:

Detail Report

Project: Ashcreek
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 03 - 12/05/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Former Weyerhaeuser Property - 2 Parallel 6'x10' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Site Demoliton										
			Site Surface Demoliton Allowance	1,140.00 cy		-		142,500	-	-	125.00 /cy	142,500	237,963
			Site Demoliton	**61,600.00 SF**				**142,500**			**2.31 /SF**	**142,500**	**237,963**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	1,540.00 lf	269.5	12,209	-	-	11,325	-	15.28 /lf	23,534	39,300
			Demo Existing Storm Sewer	**1,540.00 LF**	**269.5**	**12,209**			**11,325**		**15.28 /LF**	**23,534**	**39,300**
			02-01 Demolition	**1.00 LS**	**269.5**	**12,209**		**142,500**	**11,325**		**166,034.28 /LS**	**166,034**	**277,263**
			02.0 Existing Conditions	**1.00 LS**	**269.5**	**12,209**		**142,500**	**11,325**		**166,034.28 /LS**	**166,034**	**277,263**
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	40.0	1,680	400		2,092	-	4,172.04 /ls	4,172	6,967
			Bypass Pumping, Set-up Pumps	4.00 ea	64.0	3,068	2,000	-	1,386	-	1,613.35 /ea	6,453	10,777
			Bypass Pumping, Install Suction Piping	4.00 ea	32.0	1,534	600	-	693	-	706.68 /ea	2,827	4,720
			Bypass Pumping, Install Discharge Piping	4.00 ea	96.0	4,602	2,000	-	2,079	-	2,170.03 /ea	8,680	14,495
			Bypass Pumping, System Operation	14.00 week	280.0	12,490		-	70,000	-	5,892.14 /week	82,490	137,751
			Management of Channel Water	**1.00 LS**	**512.0**	**23,373**	**5,000**		**76,249**		**104,622.23 /LS**	**104,622**	**174,710**
			31-20 Earthworks, Site	**1.00 LS**	**512.0**	**23,373**	**5,000**		**76,249**		**104,622.23 /LS**	**104,622**	**174,710**
		31-35	**Site Landscaping**										
			Surface Replacement										
			Surfacing Replacement Allowance	61,600.00 sf	184.8		-	184,800	-	-	3.00 /sf	184,800	308,601
			Surface Replacement	**61,600.00 SF**	**184.8**			**184,800**			**3.00 /SF**	**184,800**	**308,601**
			31-35 Site Landscaping	**1.41 AC**	**184.8**			**184,800**			**131,063.83 /AC**	**184,800**	**308,601**
			31.0 Site/Civil	**1.00 LS**	**696.8**	**23,373**	**5,000**	**184,800**	**76,249**		**289,422.23 /LS**	**289,422**	**483,311**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			6'x10' Box Culvert										
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	10,266.67 cy	133.5	5,768	-	-	15,077	-	2.03 /cy	20,845	34,810
			Bedding, crushed stone 1/2" to 3/4"	1,140.74 cy	68.4	2,958	28,519	-	5,155	-	32.11 /cy	36,631	61,171
			Compaction, vibratory plate, 8" lifts, common fill	10,266.67 cy	410.7	15,402	-	-	2,563	-	1.75 /cy	17,965	30,001
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	17,111.11 cy	2,874.7	122,691	-	-	244,350	-	21.45 /cy	367,040	612,927
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	5,703.70 cy	190.1	7,165	-	-	15,566	-	3.99 /cy	22,731	37,959
			Public Storm Utility Drainage Piping, concrete, box culvert, precast, base price, 8' long, 6' x 10', excludes excavation or backfill	3,080.00 lf	1,182.7	48,115	2,864,400	-	54,480	-	963.31 /lf	2,966,995	4,954,637
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	4.00 ea	12.0	562	4,000	-	563	-	1,281.34 /ea	5,125	8,559
			6'x10' Box Culvert	**3,080.00 LF**	**4,872.1**	**202,662**	**2,896,919**		**337,754**		**1,116.02 /LF**	**3,437,334**	**5,740,063**
			33-00 Yard Piping	**3,080.00 LF**	**4,872.1**	**202,662**	**2,896,919**		**337,754**		**1,116.02 /LF**	**3,437,334**	**5,740,063**
			33.0 Buried Piping	**3,080.00 LF**	**4,872.1**	**202,662**	**2,896,919**		**337,754**		**1,116.02 /LF**	**3,437,334**	**5,740,063**
			001 Former Weyerhaeuser Property - 2 Parallel 6'x10' Box Culvert	**1,540.00 LF**	**5,838.4**	**238,244**	**2,901,919**	**327,300**	**425,328**		**2,527.79 /LF**	**3,892,791**	**6,500,638**
002			**Channel Modifications - Reach 1 (Former Weyerhaeuser to Uglow)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	0.48 acre	4.8	202	-	-	251	-	943.02 /acre	453	756
			Rough Site Grading, Small Crew	2,342.22 sy	31.2	1,405	-	-	2,312	-	1.59 /sy	3,717	6,208
			Finish grading lagoon bottoms	21.08 msf	84.3	3,524	-	-	7,955	-	544.51 /msf	11,478	19,168
			Permanent Seed and Mulch	0.48 acre	2.9		-	720	-	-	1,500.00 /acre	720	1,202
			Clear & Replant Channel	**310.00 LF**	**123.2**	**5,130**		**720**	**10,518**		**52.80 /LF**	**16,368**	**27,333**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Management of Channel Water										
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	1,425.54 cy	114.0	4,867	-	-	4,847	-	6.81 /cy	9,714	16,222
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	1,425.54 cy	57.0	2,149	-	-	4,669	-	4.78 /cy	6,817	11,385
			Regrade Channel	**310.00 LF**	**171.1**	**7,016**			**9,515**		**53.33 /LF**	**16,532**	**27,607**
			31-20 Earthworks, Site	**1.00 LS**	**392.3**	**16,652**	**1,250**	**720**	**31,596**		**50,217.12 /LS**	**50,217**	**83,858**
			31.0 Site/Civil	**1.00 LS**	**392.3**	**16,652**	**1,250**	**720**	**31,596**		**50,217.12 /LS**	**50,217**	**83,858**
			002 Channel Modifications - Reach 1 (Former Weyerhaeuser to Uglow)	**310.00 LF**	**392.3**	**16,652**	**1,250**	**720**	**31,596**		**161.99 /LF**	**50,217**	**83,858**
003			**Uglow Street - 5 Parallel 6'x5' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	80.00 lf	1.2	50	29	-	29	-	1.34 /lf	108	179
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	80.00 lf	0.7	30	10	-	17	-	0.71 /lf	57	95
			Asphalt Demolition and Loading	17.11 cy	0.7	28	-	-	25	-	3.11 /cy	53	89
			Remove Asphalt Pavement	**155.55 SY**	**2.6**	**108**	**38**		**71**		**1.40 /SY**	**218**	**363**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	42.00 lf	7.4	333	-	-	309	-	15.28 /lf	642	1,072
			Demo Existing Storm Sewer	**42.00 LF**	**7.4**	**333**			**309**		**15.28 /LF**	**642**	**1,072**
			02-01 Demolition	**1.00 LS**	**10.0**	**441**	**38**		**380**		**859.43 /LS**	**859**	**1,435**
			02.0 Existing Conditions	**1.00 LS**	**10.0**	**441**	**38**		**380**		**859.43 /LS**	**859**	**1,435**
	31.0		**Site/Civil**										
		31-16	**Earthworks, Sheeting/Shoring**										
			Shoring										
			Shoring, sheet pile, subcontracted	840.00 sf	109.2		-	21,000	-	-	25.00 /sf	21,000	35,068
			Shoring	**840.00 SF**	**109.2**			**21,000**			**25.00 /SF**	**21,000**	**35,068**
			31-16 Earthworks, Sheeting/Shoring	**840.00 SF**	**109.2**			**21,000**			**25.00 /SF**	**21,000**	**35,068**
		31-19	**Dewatering and Bypass Pumping**										
			Dewatering or Bypass Channel Pumping										
			Dewatering Wellpoints, Complete System, Mob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering Wellpoints, Complete System, Install	1.00 day	48.0	1,994	-	-	1,677	-	3,670.78 /day	3,671	6,130
			Dewatering Wellpoints, Complete System, Rental, First Month	1.00 mo		-	-	-	10,000	-	10,000.00 /mo	10,000	16,699
			Dewatering Wellpoints, Complete System, Operation - Labor to maintain / check pumps/ fuel and lube	0.50 mo	45.0	1,768	-	-	222	-	3,979.50 /mo	1,990	3,323
			Fuel for generator	0.50 mo		-	-	-	-	4,500	9,000.00 /mo	4,500	7,515
			Dewatering Wellpoints, Complete System, Removal	1.00 day	48.0	1,994	-	-	1,462	-	3,456.09 /day	3,456	5,771
			Dewatering Wellpoints, Complete System, Demob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering or Bypass Channel Pumping	**15.00 DAY**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**1,907.78 /DAY**	**28,617**	**47,787**
			31-19 Dewatering and Bypass Pumping	**1.00 LS**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**28,616.62 /LS**	**28,617**	**47,787**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	155.55 sy	2.3	102	2,310	-	232	-	17.00 /sy	2,644	4,415
			Prepare and roll sub-base, small areas to 2500 S.Y.	155.55 sy	2.5	108	-	-	260	-	2.37 /sy	368	614
			Asphaltic paving, replacement over trench, 6" thick	155.55 sy	135.8	5,565	3,500	-	4,832	-	89.34 /sy	13,897	23,206
			Replace Pavement	**155.55 SY**	**140.6**	**5,774**	**5,810**		**5,324**		**108.70 /SY**	**16,908**	**28,236**
			31-40 Paving	**155.55 SY**	**140.6**	**5,774**	**5,810**		**5,324**		**108.70 /SY**	**16,908**	**28,236**
			31.0 Site/Civil	**1.00 LS**	**438.8**	**11,530**	**5,810**	**26,000**	**18,685**	**4,500**	**66,524.98 /LS**	**66,525**	**111,091**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			6'x5' Box Culvert										
			Traffic Control, Labor per Day	21.00 day	336.0	12,602	-	-	-	-	600.10 /day	12,602	21,044
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	311.11 cy	4.0	175	-	-	457	-	2.03 /cy	632	1,055
			Bedding, crushed stone 1/2" to 3/4"	38.88 cy	2.3	101	972	-	176	-	32.11 /cy	1,249	2,085
			Compaction, vibratory plate, 8" lifts, common fill	311.11 cy	12.4	467	-	-	78	-	1.75 /cy	544	909
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	544.44 cy	91.5	3,904	-	-	7,775	-	21.45 /cy	11,678	19,502

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			6'x5' Box Culvert										
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	233.33 cy	7.8	293	-	-	637	-	3.99 /cy	930	1,553
			Public Storm Utility Drainage Piping, concrete, box culvert, precast, base price, 8' long, 6' x 5', excludes excavation or backfill	210.00 lf	367.5	17,175	107,940	-	24,564	-	712.76 /lf	149,679	249,952
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	10.00 ea	17.5	818	8,300	-	1,170	-	1,028.76 /ea	10,288	17,179
			6'x5' Box Culvert	**210.00 LF**	**839.1**	**35,535**	**117,212**		**34,855**		**893.34 /LF**	**187,602**	**313,280**
			33-00 Yard Piping	**210.00 LF**	**839.1**	**35,535**	**117,212**		**34,855**		**893.34 /LF**	**187,602**	**313,280**
			33.0 Buried Piping	**210.00 LF**	**839.1**	**35,535**	**117,212**		**34,855**		**893.34 /LF**	**187,602**	**313,280**
			003 Uglow Street - 5 Parallel 6'x5' Box Culvert	**42.00 LF**	**1,287.8**	**47,505**	**123,060**	**26,000**	**53,921**	**4,500**	**6,071.10 /LF**	**254,986**	**425,806**
004			**Channel Modifications - Reach 2 (Uglow to Monmouth Cutoff)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	1.32 acre	13.2	554	-	-	690	-	943.01 /acre	1,245	2,079
			Rough Site Grading, Small Crew	6,426.11 sy	85.7	3,855	-	-	6,344	-	1.59 /sy	10,199	17,031
			Finish grading lagoon bottoms	57.84 msf	231.4	9,669	-	-	21,826	-	544.51 /msf	31,494	52,593
			Permanent Seed and Mulch	1.32 acre	7.9		-	1,980	-	-	1,500.00 /acre	1,980	3,306
			Clear & Replant Channel	**860.00 LF**	**338.2**	**14,078**		**1,980**	**28,860**		**52.23 /LF**	**44,918**	**75,009**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	3,954.72 cy	316.4	13,503	-	-	13,446	-	6.81 /cy	26,949	45,003
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	3,954.72 cy	158.2	5,961	-	-	12,952	-	4.78 /cy	18,913	31,583
			Regrade Channel	**860.00 LF**	**474.6**	**19,464**			**26,398**		**53.33 /LF**	**45,862**	**76,586**
			31-20 Earthworks, Site	**1.00 LS**	**910.7**	**38,047**	**1,250**	**1,980**	**66,820**		**108,097.02 /LS**	**108,097**	**180,513**
			31.0 Site/Civil	**1.00 LS**	**910.7**	**38,047**	**1,250**	**1,980**	**66,820**		**108,097.02 /LS**	**108,097**	**180,513**
			004 Channel Modifications - Reach 2 (Uglow to Monmouth Cutoff)	**860.00 LF**	**910.7**	**38,047**	**1,250**	**1,980**	**66,820**		**125.69 /LF**	**108,097**	**180,513**
005			**Monmouth Cutoff West of Holman - New Bridge**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	80.00 lf	1.2	50	29	-	29	-	1.34 /lf	108	180
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	80.00 lf	0.7	30	10	-	17	-	0.71 /lf	57	95
			Asphalt Demolition and Loading	29.33 cy	1.2	48	-	-	43	-	3.11 /cy	91	152
			Remove Asphalt Pavement	**266.66 SY**	**3.1**	**128**	**38**		**89**		**0.96 /SY**	**256**	**427**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	40.00 lf	7.0	317	-	-	294	-	15.28 /lf	611	1,021
			Demo Existing Storm Sewer	**40.00 LF**	**7.0**	**317**			**294**		**15.28 /LF**	**611**	**1,021**
			02-01 Demolition	**1.00 LS**	**10.1**	**445**	**38**		**384**		**866.92 /LS**	**867**	**1,448**
			02.0 Existing Conditions	**1.00 LS**	**10.1**	**445**	**38**		**384**		**866.92 /LS**	**867**	**1,448**
	03.0		**Concrete Work**										
		03-10	**Cast-In-Place Concrete Work**										
			New Bridge Structure										
			Traffic Control, Labor per Day	18.00 day	288.0	10,802	-	-	-	-	600.10 /day	10,802	18,038
			Bridges, precast concrete, complete in place, 100' span	2,400.00 sf	726.5		240,000	-		-	100.00 /sf	240,000	400,780
			New Bridge Structure	**1.00 LS**	**1,014.5**	**10,802**	**240,000**				**250,801.73 /LS**	**250,802**	**418,818**
			03-10 Cast-In-Place Concrete Work	**1.00 LS**	**1,014.5**	**10,802**	**240,000**				**250,801.73 /LS**	**250,802**	**418,818**
			03.0 Concrete Work	**1.00 LS**	**1,014.5**	**10,802**	**240,000**				**250,801.73 /LS**	**250,802**	**418,818**
	31.0		**Site/Civil**										
		31-16	**Earthworks, Sheeting/Shoring**										

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Shoring										
			Shoring, sheet pile, subcontracted	800.00 sf	104.0		-	20,000	-	-	25.00 /sf	20,000	33,398
			Shoring	**800.00 SF**	**104.0**			**20,000**			**25.00 /SF**	**20,000**	**33,398**
			31-16 Earthworks, Sheeting/Shoring	**800.00 SF**	**104.0**			**20,000**			**25.00 /SF**	**20,000**	**33,398**
		31-19	**Dewatering and Bypass Pumping**										
			Dewatering or Bypass Channel Pumping										
			Dewatering Wellpoints, Complete System, Mob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering Wellpoints, Complete System, Install	1.00 day	48.0	1,994	-	-	1,677	-	3,670.78 /day	3,671	6,130
			Dewatering Wellpoints, Complete System, Rental, First Month	1.00 mo		-	-	-	10,000	-	10,000.00 /mo	10,000	16,699
			Dewatering Wellpoints, Complete System, Operation - Labor to maintain / check pumps/ fuel and lube	0.50 mo	45.0	1,768	-	-	222	-	3,979.50 /mo	1,990	3,323
			Fuel for generator	0.50 mo		-	-	-	-	4,500	9,000.00 /mo	4,500	7,515
			Dewatering Wellpoints, Complete System, Removal	1.00 day	48.0	1,994	-	-	1,462	-	3,456.09 /day	3,456	5,771
			Dewatering Wellpoints, Complete System, Demob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering or Bypass Channel Pumping	**15.00 DAY**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**1,907.78 /DAY**	**28,617**	**47,787**
			31-19 Dewatering and Bypass Pumping	**1.00 LS**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**28,616.62 /LS**	**28,617**	**47,787**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	266.66 sy	4.0	175	3,960	-	397	-	17.00 /sy	4,532	7,569
			Prepare and roll sub-base, small areas to 2500 S.Y.	266.66 sy	4.3	184	-	-	446	-	2.37 /sy	631	1,053
			Asphaltic paving, replacement over trench, 6" thick	266.66 sy	232.8	9,539	6,000	-	8,284	-	89.34 /sy	23,823	39,783
			Replace Pavement	**266.66 SY**	**241.1**	**9,899**	**9,960**		**9,128**		**108.70 /SY**	**28,986**	**48,404**
			31-40 Paving	**266.66 SY**	**241.1**	**9,899**	**9,960**		**9,128**		**108.70 /SY**	**28,986**	**48,404**
			31.0 Site/Civil	**1.00 LS**	**534.1**	**15,655**	**9,960**	**25,000**	**22,488**	**4,500**	**77,602.70 /LS**	**77,603**	**129,590**
			005 Monmouth Cutoff West of Holman - New Bridge	**40.00 LF**	**1,558.6**	**26,901**	**249,998**	**25,000**	**22,872**	**4,500**	**8,231.78 /LF**	**329,271**	**549,856**
006			**Channel Modifications - Reach 3 (Monmouth Cutoff to Holman)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Rough Site Grading, Small Crew	920.00 sy	12.3	552	-	-	908	-	1.59 /sy	1,460	2,438
			Finish grading lagoon bottoms	8.28 msf	33.1	1,384	-	-	3,124	-	544.51 /msf	4,509	7,529
			Selective demolition, retaining walls, stone filled gabions, 6' x 3' x 1'	140.00 ea	46.1	1,855	-	-	929	-	19.89 /ea	2,785	4,650
			Gabion retaining walls, stone filled gabions, stone delivered, galvanized, 3' wide, 6' long, 1' high, excludes excavation	140.00 ea	69.4	2,791	14,840	-	1,398	-	135.92 /ea	19,029	31,777
			Clear & Replant Channel	**120.00 LF**	**160.9**	**6,582**	**14,840**		**6,360**		**231.52 /LF**	**27,782**	**46,394**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	346.66 cy	27.7	1,184	-	-	1,179	-	6.81 /cy	2,362	3,945
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	346.66 cy	13.9	523	-	-	1,135	-	4.78 /cy	1,658	2,768
			Regrade Channel	**120.00 LF**	**41.6**	**1,706**			**2,314**		**33.50 /LF**	**4,020**	**6,713**
			31-20 Earthworks, Site	**1.00 LS**	**300.5**	**12,793**	**16,090**		**20,236**		**49,119.75 /LS**	**49,120**	**82,026**
			31.0 Site/Civil	**1.00 LS**	**300.5**	**12,793**	**16,090**		**20,236**		**49,119.75 /LS**	**49,120**	**82,026**
			006 Channel Modifications - Reach 3 (Monmouth Cutoff to Holman)	**120.00 LF**	**300.5**	**12,793**	**16,090**		**20,236**		**409.33 /LF**	**49,120**	**82,026**
007			**Holman Street - 3 Parallel 8'x11' Box Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	110.00 lf	1.7	68	40	-	40	-	1.34 /lf	148	247
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	110.00 lf	1.0	41	13	-	24	-	0.71 /lf	78	130

CH2MHILL

Job Size:

Duration:

Detail Report

Project: Ashcreek

Project No.: 496541

Design Stage: Preliminary Design

Estimator: T Jones

Revision / Date: 03 - 12/05/2014

Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Remove Asphalt Pavement										
			Asphalt Demolition and Loading	30.25 cy	1.2	50	-	-	44	-	3.11 /cy	94	157
			Remove Asphalt Pavement	**275.00 SY**	**3.9**	**159**	**53**		**108**		**1.16 /SY**	**320**	**535**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	80.00 lf	14.0	634	-	-	588	-	15.28 /lf	1,223	2,042
			Demo Existing Storm Sewer	**80.00 LF**	**14.0**	**634**			**588**		**15.28 /LF**	**1,223**	**2,042**
			02-01 Demolition	**1.00 LS**	**17.9**	**793**	**53**		**696**		**1,542.67 /LS**	**1,543**	**2,576**
			02.0 Existing Conditions	**1.00 LS**	**17.9**	**793**	**53**		**696**		**1,542.67 /LS**	**1,543**	**2,576**
	31.0		**Site/Civil**										
		31-16	**Earthworks, Sheeting/Shoring**										
			Shoring										
			Shoring, sheet pile, subcontracted	1,920.00 sf	249.6	0	-	48,000	-	-	25.00 /sf	48,000	80,156
			Shoring	**1,920.00 SF**	**249.6**			**48,000**			**25.00 /SF**	**48,000**	**80,156**
			31-16 Earthworks, Sheeting/Shoring	**1,920.00 SF**	**249.6**			**48,000**			**25.00 /SF**	**48,000**	**80,156**
		31-19	**Dewatering and Bypass Pumping**										
			Dewatering or Bypass Channel Pumping										
			Dewatering Wellpoints, Complete System, Mob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering Wellpoints, Complete System, Install	1.00 day	48.0	1,994	-	-	1,677	-	3,670.78 /day	3,671	6,130
			Dewatering Wellpoints, Complete System, Rental, First Month	1.00 mo		-	-	-	10,000	-	10,000.00 /mo	10,000	16,699
			Dewatering Wellpoints, Complete System, Operation - Labor to maintain / check pumps/ fuel and lube	0.50 mo	45.0	1,768	-	-	222	-	3,979.50 /mo	1,990	3,323
			Fuel for generator	0.50 mo		-	-	-	-	4,500	9,000.00 /mo	4,500	7,515
			Dewatering Wellpoints, Complete System, Removal	1.00 day	48.0	1,994	-	-	1,462	-	3,456.09 /day	3,456	5,771
			Dewatering Wellpoints, Complete System, Demob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering or Bypass Channel Pumping	**15.00 DAY**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**1,907.78 /DAY**	**28,617**	**47,787**
			31-19 Dewatering and Bypass Pumping	**1.00 LS**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**28,616.62 /LS**	**28,617**	**47,787**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	275.00 sy	4.1	180	4,084	-	410	-	17.00 /sy	4,674	7,805
			Prepare and roll sub-base, small areas to 2500 S.Y.	275.00 sy	4.4	190	-	-	460	-	2.37 /sy	650	1,086
			Asphaltic paving, replacement over trench, 6" thick	275.00 sy	240.1	9,838	6,188	-	8,543	-	89.34 /sy	24,568	41,027
			Replace Pavement	**275.00 SY**	**248.6**	**10,208**	**10,271**		**9,413**		**108.70 /SY**	**29,893**	**49,918**
			31-40 Paving	**275.00 SY**	**248.6**	**10,208**	**10,271**		**9,413**		**108.70 /SY**	**29,893**	**49,918**
			31.0 Site/Civil	**1.00 LS**	**687.2**	**15,964**	**10,271**	**53,000**	**22,774**	**4,500**	**106,509.26 /LS**	**106,509**	**177,862**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			8'x11' Box Culvert										
			Traffic Control, Labor per Day	24.00 day	384.0	14,402	-	-	-	-	600.10 /day	14,402	24,051
			Backfill, dozer backfill, trench, up to 300' haul, no compaction	817.78 cy	10.6	459	-	-	1,201	-	2.03 /cy	1,660	2,773
			Bedding, crushed stone 1/2" to 3/4"	97.77 cy	5.9	254	2,444	-	442	-	32.11 /cy	3,140	5,243
			Compaction, vibratory plate, 8" lifts, common fill	817.78 cy	32.7	1,227	-	-	204	-	1.75 /cy	1,431	2,390
			Excav, Struct, clay/till/blasted rock, hyd backhoe, 1 CY bkt	1,600.00 cy	268.8	11,472	-	-	22,848	-	21.45 /cy	34,321	57,313
			Haul Excess Spoils Off-Site, 12 yd capacity, 2.5 miles RT	782.22 cy	26.1	983	-	-	2,135	-	3.99 /cy	3,117	5,206
			Public Storm Utility Drainage Piping, concrete, box culvert, precast, base price, 8' long, 8' x 11', excludes excavation or backfill	240.00 lf	115.2	4,687	264,000	-	5,307	-	1,141.64 /lf	273,993	457,546
			Public Storm Utility Drainage Piping, precast concrete, box culvert, sloped or skewed end, excludes excavation or backfill, add	6.00 ea	18.0	843	6,000	-	845	-	1,281.34 /ea	7,688	12,838
			8'x11' Box Culvert	**240.00 LF**	**861.3**	**34,327**	**272,444**		**32,981**		**1,415.64 /LF**	**339,752**	**567,358**
			33-00 Yard Piping	**240.00 LF**	**861.3**	**34,327**	**272,444**		**32,981**		**1,415.64 /LF**	**339,752**	**567,358**
			33.0 Buried Piping	**240.00 LF**	**861.3**	**34,327**	**272,444**		**32,981**		**1,415.64 /LF**	**339,752**	**567,358**
			007 Holman Street - 3 Parallel 8'x11' Box Culvert	**80.00 LF**	**1,566.3**	**51,085**	**282,768**	**53,000**	**56,451**	**4,500**	**5,597.56 /LF**	**447,804**	**747,796**
008			**Channel Modifications - Reach 4 (Holman to Tributary Upstream)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	0.88 acre	8.8	370	-	-	460	-	943.01 /acre	830	1,386
			Rough Site Grading, Small Crew	4,290.77 sy	57.2	2,574	-	-	4,236	-	1.59 /sy	6,810	11,372
			Finish grading lagoon bottoms	38.62 msf	154.5	6,456	-	-	14,573	-	544.51 /msf	21,029	35,117
			Permanent Seed and Mulch	0.88 acre	5.3		-	1,320	-	-	1,500.00 /acre	1,320	2,204

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Clear & Replant Channel	**529.00 LF**	**225.8**	**9,399**		**1,320**	**19,269**		**56.69 /LF**	**29,988**	**50,078**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	2,381.67 cy	190.5	8,132	-	-	8,098	-	6.81 /cy	16,230	27,102
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	2,381.67 cy	95.3	3,590	-	-	7,800	-	4.78 /cy	11,390	19,020
			Regrade Channel	**529.00 LF**	**285.8**	**11,722**			**15,898**		**52.21 /LF**	**27,620**	**46,123**
			31-20 Earthworks, Site	**1.00 LS**	**609.6**	**25,626**	**1,250**	**1,320**	**46,729**		**74,925.46 /LS**	**74,925**	**125,119**
			31.0 Site/Civil	**1.00 LS**	**609.6**	**25,626**	**1,250**	**1,320**	**46,729**		**74,925.46 /LS**	**74,925**	**125,119**
			008 Channel Modifications - Reach 4 (Holman to Tributary Upstream)	**529.00 LF**	**609.6**	**25,626**	**1,250**	**1,320**	**46,729**		**141.64 /LF**	**74,925**	**125,119**
009			**Channel Modifications - Reach 5 (Tributary Upstream to Tributary Downs**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	1.55 acre	15.5	651	-	-	811	-	943.01 /acre	1,462	2,441
			Rough Site Grading, Small Crew	7,504.00 sy	100.1	4,502	-	-	7,408	-	1.59 /sy	11,909	19,888
			Finish grading lagoon bottoms	67.54 msf	270.2	11,290	-	-	25,486	-	544.51 /msf	36,776	61,413
			Permanent Seed and Mulch	1.55 acre	9.3		-	2,325	-	-	1,500.00 /acre	2,325	3,883
			Clear & Replant Channel	**804.00 LF**	**395.0**	**16,442**		**2,325**	**33,705**		**65.26 /LF**	**52,472**	**87,624**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	788.21 cy	63.1	2,691	-	-	2,680	-	6.81 /cy	5,371	8,969
			Import Fill - Medium Crew	841.52 cy	84.2	3,592	25,246	-	3,577	-	38.52 /cy	32,414	54,128
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	788.21 cy	31.5	1,188	-	-	2,581	-	4.78 /cy	3,770	6,295
			Regrade Channel	**804.00 LF**	**178.7**	**7,471**	**25,246**		**8,838**		**51.69 /LF**	**41,554**	**69,392**
			31-20 Earthworks, Site	**1.00 LS**	**671.8**	**28,418**	**26,496**	**2,325**	**54,105**		**111,343.75 /LS**	**111,344**	**185,935**
			31.0 Site/Civil	**1.00 LS**	**671.8**	**28,418**	**26,496**	**2,325**	**54,105**		**111,343.75 /LS**	**111,344**	**185,935**
			009 Channel Modifications - Reach 5 (Tributary Upstream to Tributary Downs	**804.00 LF**	**671.8**	**28,418**	**26,496**	**2,325**	**54,105**		**138.49 /LF**	**111,344**	**185,935**
010			**Channel Modifications - Reach 6 (Tributary Downstream to Godsey)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	3.16 acre	31.6	1,327	-	-	1,653	-	943.01 /acre	2,980	4,976
			Rough Site Grading, Small Crew	15,308.88 sy	204.1	9,184	-	-	15,113	-	1.59 /sy	24,296	40,573
			Finish grading lagoon bottoms	137.78 msf	551.1	23,031	-	-	51,991	-	544.51 /msf	75,022	125,281
			Permanent Seed and Mulch	3.16 acre	19.0		-	4,740	-	-	1,500.00 /acre	4,740	7,915
			Clear & Replant Channel	**1,660.00 LF**	**805.8**	**33,542**		**4,740**	**68,756**		**64.48 /LF**	**107,038**	**178,745**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Management of Channel Water										
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	647.40 cy	51.8	2,210	-	-	2,201	-	6.81 /cy	4,412	7,367
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	647.40 cy	25.9	976	-	-	2,120	-	4.78 /cy	3,096	5,170
			Regrade Channel	**1,660.00 LF**	**77.7**	**3,186**			**4,321**		**4.52 /LF**	**7,508**	**12,537**
			31-20 Earthworks, Site	**1.00 LS**	**981.5**	**41,233**	**1,250**	**4,740**	**84,640**		**131,863.46 /LS**	**131,863**	**220,201**
			31.0 Site/Civil	**1.00 LS**	**981.5**	**41,233**	**1,250**	**4,740**	**84,640**		**131,863.46 /LS**	**131,863**	**220,201**
			010 Channel Modifications - Reach 6 (Tributary Downstream to Godsey)	**1,660.00 LF**	**981.5**	**41,233**	**1,250**	**4,740**	**84,640**		**79.44 /LF**	**131,863**	**220,201**
011			**Godsey Street - New Bridge**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	60.00 lf	0.9	37	22	-	22	-	1.34 /lf	81	135
			Saw cutting, asphalt, after 3" deep; each addl inch of depth	60.00 lf	0.5	22	7	-	13	-	0.71 /lf	43	71
			Asphalt Demolition and Loading	14.67 cy	0.6	24	-	-	21	-	3.11 /cy	46	76
			Remove Asphalt Pavement	**133.33 SY**	**2.0**	**84**	**29**		**56**		**1.27 /SY**	**169**	**282**
			Demo Existing Storm Sewer										
			Storm Sewer Pipe Demolition and Loading, 6' Deep	30.00 lf	5.3	238	-	-	221	-	15.28 /lf	458	766
			Demo Existing Storm Sewer	**30.00 LF**	**5.3**	**238**			**221**		**15.28 /LF**	**458**	**766**
			02-01 Demolition	**1.00 LS**	**7.3**	**322**	**29**		**277**		**627.37 /LS**	**627**	**1,048**
			02.0 Existing Conditions	**1.00 LS**	**7.3**	**322**	**29**		**277**		**627.37 /LS**	**627**	**1,048**
	03.0		**Concrete Work**										
		03-10	**Cast-In-Place Concrete Work**										
			New Bridge Structure										
			Traffic Control, Labor per Day	18.00 day	288.0	10,802	-	-	-	-	600.10 /day	10,802	18,038
			Bridges, precast concrete, complete in place, 100' span	1,200.00 sf	363.2		120,000	-		-	100.00 /sf	120,000	200,390
			New Bridge Structure	**1.00 LS**	**651.2**	**10,802**	**120,000**				**130,801.73 /LS**	**130,802**	**218,428**
			03-10 Cast-In-Place Concrete Work	**1.00 LS**	**651.2**	**10,802**	**120,000**				**130,801.73 /LS**	**130,802**	**218,428**
			03.0 Concrete Work	**1.00 LS**	**651.2**	**10,802**	**120,000**				**130,801.73 /LS**	**130,802**	**218,428**
	31.0		**Site/Civil**										
		31-16	**Earthworks, Sheeting/Shoring**										
			Shoring										
			Shoring, sheet pile, subcontracted	720.00 sf	93.6		-	18,000	-	-	25.00 /sf	18,000	30,059
			Shoring	**720.00 SF**	**93.6**			**18,000**			**25.00 /SF**	**18,000**	**30,059**
			31-16 Earthworks, Sheeting/Shoring	**720.00 SF**	**93.6**			**18,000**			**25.00 /SF**	**18,000**	**30,059**
		31-19	**Dewatering and Bypass Pumping**										
			Dewatering or Bypass Channel Pumping										
			Dewatering Wellpoints, Complete System, Mob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering Wellpoints, Complete System, Install	1.00 day	48.0	1,994	-	-	1,677	-	3,670.78 /day	3,671	6,130
			Dewatering Wellpoints, Complete System, Rental, First Month	1.00 mo		-	-	-	10,000	-	10,000.00 /mo	10,000	16,699
			Dewatering Wellpoints, Complete System, Operation - Labor to maintain / check pumps/ fuel and lube	0.50 mo	45.0	1,768	-	-	222	-	3,979.50 /mo	1,990	3,323
			Fuel for generator	0.50 mo		-	-	-	-	4,500	9,000.00 /mo	4,500	7,515
			Dewatering Wellpoints, Complete System, Removal	1.00 day	48.0	1,994	-	-	1,462	-	3,456.09 /day	3,456	5,771
			Dewatering Wellpoints, Complete System, Demob	1.00 ea	24.0		-	2,500	-	-	2,500.00 /ea	2,500	4,175
			Dewatering or Bypass Channel Pumping	**15.00 DAY**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**1,907.78 /DAY**	**28,617**	**47,787**
			31-19 Dewatering and Bypass Pumping	**1.00 LS**	**189.0**	**5,756**		**5,000**	**13,361**	**4,500**	**28,616.62 /LS**	**28,617**	**47,787**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	133.33 sy	2.0	87	1,980	-	199	-	17.00 /sy	2,266	3,784
			Prepare and roll sub-base, small areas to 2500 S.Y.	133.33 sy	2.1	92	-	-	223	-	2.37 /sy	315	526
			Asphaltic paving, replacement over trench, 6" thick	133.33 sy	116.4	4,770	3,000	-	4,142	-	89.34 /sy	11,912	19,891
			Replace Pavement	**133.33 SY**	**120.5**	**4,949**	**4,980**		**4,564**		**108.70 /SY**	**14,493**	**24,202**
			31-40 Paving	**133.33 SY**	**120.5**	**4,949**	**4,980**		**4,564**		**108.70 /SY**	**14,493**	**24,202**

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			31.0 Site/Civil	**1.00 LS**	**403.1**	**10,705**	**4,980**	**23,000**	**17,924**	**4,500**	**61,109.66 /LS**	**61,110**	**102,048**
			011 Godsey Street - New Bridge	**30.00 LF**	**1,061.6**	**21,829**	**125,009**	**23,000**	**18,201**	**4,500**	**6,417.96 /LF**	**192,539**	**321,524**
012			**Channel Modifications - Reach 7 (Godsey to G-Way)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	7.93 acre	79.3	3,330	-	-	4,148	-	943.01 /acre	7,478	12,488
			Rough Site Grading, Small Crew	38,388.66 sy	511.8	23,029	-	-	37,896	-	1.59 /sy	60,925	101,740
			Finish grading lagoon bottoms	345.50 msf	1,382.0	57,754	-	-	130,374	-	544.51 /msf	188,128	314,157
			Permanent Seed and Mulch	7.93 acre	47.6		-	11,895	-	-	1,500.00 /acre	11,895	19,864
			Clear & Replant Channel	**3,882.00 LF**	**2,020.7**	**84,113**		**11,895**	**172,418**		**69.15 /LF**	**268,426**	**448,249**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	21,162.65 cy	1,693.0	72,257	-	-	71,954	-	6.81 /cy	144,211	240,820
			Import Fill - Medium Crew	362.32 cy	36.2	1,546	10,870	-	1,540	-	38.52 /cy	13,956	23,305
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	21,162.65 cy	846.5	31,901	-	-	69,307	-	4.78 /cy	101,207	169,008
			Regrade Channel	**3,882.00 LF**	**2,575.8**	**105,704**	**10,870**		**142,801**		**66.82 /LF**	**259,374**	**433,133**
			31-20 Earthworks, Site	**1.00 LS**	**4,694.5**	**194,322**	**12,120**	**11,895**	**326,781**		**545,117.13 /LS**	**545,117**	**910,300**
			31.0 Site/Civil	**1.00 LS**	**4,694.5**	**194,322**	**12,120**	**11,895**	**326,781**		**545,117.13 /LS**	**545,117**	**910,300**
			012 Channel Modifications - Reach 7 (Godsey to G-Way)	**3,882.00 LF**	**4,694.5**	**194,322**	**12,120**	**11,895**	**326,781**		**140.42 /LF**	**545,117**	**910,300**
013			**Monmouth Cutoff Tributary - Clear Existing Culverts**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Demo Existing Storm Sewer										
			Clear Existing Culvert	33.00 lf	120.0	5,040	-	-	6,276	-	342.91 /lf	11,316	18,897
			Demo Existing Storm Sewer	**33.00 LF**	**120.0**	**5,040**			**6,276**		**342.91 /LF**	**11,316**	**18,897**
			02-01 Demolition	**1.00 LS**	**120.0**	**5,040**			**6,276**		**11,316.08 /LS**	**11,316**	**18,897**
			02.0 Existing Conditions	**1.00 LS**	**120.0**	**5,040**			**6,276**		**11,316.08 /LS**	**11,316**	**18,897**
			013 Monmouth Cutoff Tributary - Clear Existing Culverts	**33.00 LF**	**120.0**	**5,040**			**6,276**		**342.91 /LF**	**11,316**	**18,897**
014			**Channel Modifications - Reach T1 (Tributary Channel)**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Channel										
			Clearing, heavy overgrowth of weeds and shrubs	1.35 acre	13.5	567	-	-	706	-	943.01 /acre	1,273	2,126
			Rough Site Grading, Small Crew	6,533.33 sy	87.1	3,919	-	-	6,450	-	1.59 /sy	10,369	17,315
			Finish grading lagoon bottoms	58.80 msf	235.2	9,829	-	-	22,188	-	544.51 /msf	32,017	53,466
			Permanent Seed and Mulch	1.35 acre	8.1		-	2,025	-	-	1,500.00 /acre	2,025	3,382
			Clear & Replant Channel	**840.00 LF**	**343.9**	**14,315**		**2,025**	**29,344**		**54.39 /LF**	**45,684**	**76,288**
			Management of Channel Water										
			Sand Bag Coffer Allowance	1.00 ls	10.0	420	100		523	-	1,043.01 /ls	1,043	1,742
			Bypass Pumping, Set-up Pumps	1.00 ea	16.0	767	500	-	346	-	1,613.35 /ea	1,613	2,694
			Bypass Pumping, Install Suction Piping	1.00 ea	8.0	383	150	-	173	-	706.67 /ea	707	1,180
			Bypass Pumping, Install Discharge Piping	1.00 ea	24.0	1,150	500	-	520	-	2,170.03 /ea	2,170	3,624
			Bypass Pumping, System Operation	2.00 week	40.0	1,784		-	10,000	-	5,892.14 /week	11,784	19,679

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
			Management of Channel Water	**1.00 LS**	**98.0**	**4,505**	**1,250**		**11,562**		**17,317.34 /LS**	**17,317**	**28,919**
			Regrade Channel										
			Excav, bulk bank, common earth, excavator, crawler, 1 CY cap.= 25 CY/hr	161.47 cy	12.9	551	-	-	549	-	6.81 /cy	1,100	1,837
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	161.47 cy	6.5	243	-	-	529	-	4.78 /cy	772	1,290
			Regrade Channel	**840.00 LF**	**19.4**	**795**			**1,078**		**2.23 /LF**	**1,873**	**3,127**
			31-20 Earthworks, Site	**1.00 LS**	**461.3**	**19,615**	**1,250**	**2,025**	**41,984**		**64,873.80 /LS**	**64,874**	**108,334**
			31.0 Site/Civil	**1.00 LS**	**461.3**	**19,615**	**1,250**	**2,025**	**41,984**		**64,873.80 /LS**	**64,874**	**108,334**
			014 Channel Modifications - Reach T1 (Tributary Channel)	**840.00 LF**	**461.3**	**19,615**	**1,250**	**2,025**	**41,984**		**77.23 /LF**	**64,874**	**108,334**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	767,310		20,454.919 I		7.34%
Material	3,743,709				35.79%
Subcontract	479,305				4.58%
Equipment	1,255,940		15,290.190 I		12.01%
Other	18,000				0.17%
Total Before Markups	**6,264,264**	**6,264,264**			59.88
Project Staff & Home Office OH	626,426			10.000 %	5.99%
Total Overhead	**626,426**	**6,890,690**			5.99
General Conditions	482,348			7.000 %	4.61%
Total General Conditions	**482,348**	**7,373,038**			4.61
Profit on Previous Subtotal	368,652			5.000 %	3.52%
Total Profit	**368,652**	**7,741,690**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**7,741,690**			
Mobilization/Demobilization	313,824			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	104,608			1.000 %	1.00%
Payment & Performance Bonds	121,345			1.160 %	1.16%
Total Bonds and Insurances	**539,777**	**8,281,467**			5.16
Contingency - %	1,656,294			20.000 %	15.83%
Total Contingency	**1,656,294**	**9,937,761**			15.83
Escalation on Estimate Total	523,040			5.000 %	5.00%
Total Escalation	**523,040**	**10,460,801**			5.00
Construction Total		**10,460,801**			

Detail Report

Job Size:
Duration:

Project: Hunter System
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 02 - 11/20/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Install New 48" Culvert**										
	02.0		**Existing Conditions**										
		02-01	**Demolition**										
			Remove Asphalt Pavement										
			Saw cutting, asphalt, up to 3" deep	160.00 lf	2.4	99	58	-	58	-	1.34 /lf	215	359
			Asphaltic Demolition and Loading	9.00 cy	0.4	15	-	-	13	-	3.11 /cy	28	47
			Remove Asphalt Pavement	**107.00 SY**	**2.8**	**114**	**58**		**71**		**2.27 /SY**	**243**	**406**
			Existing Storm Sewer Demolition										
			48" Cap on existing Culvert	2.00 ea	10.5	491	1,000	-	702	-	1,096.28 /ea	2,193	3,661
			Grout joint, ID or OD, 48"	2.00 ea	2.0	88	44	-	-	-	66.00 /ea	132	220
			Existing Storm Sewer Demolition	**1.00 LS**	**12.5**	**579**	**1,044**		**702**		**2,324.55 /LS**	**2,325**	**3,882**
			02-01 Demolition	**1.00 LS**	**15.3**	**693**	**1,102**		**773**		**2,567.56 /LS**	**2,568**	**4,288**
			02.0 Existing Conditions	**1.00 LS**	**15.3**	**693**	**1,102**		**773**		**2,567.56 /LS**	**2,568**	**4,288**
	31.0		**Site/Civil**										
		31-35	**Site Landscaping**										
			Surfacing Replacement Allowance										
			Surfacing Replacement Allowance	2,900.00 sf	8.7		-	8,700	-	-	3.00 /sf	8,700	14,528
			Surfacing Replacement Allowance	**2,900.00 SF**	**8.7**			**8,700**			**3.00 /SF**	**8,700**	**14,528**
			31-35 Site Landscaping	**1.00 LS**	**8.7**			**8,700**			**8,700.00 /LS**	**8,700**	**14,528**
		31-40	**Paving**										
			Replace Pavement										
			Parking lot base course, crushed 3/4" stone, compacted to 12" deep	107.00 sy	1.6	70	1,589	-	159	-	17.00 /sy	1,819	3,037
			Prepare and roll sub-base, small areas to 2500 S.Y.	107.00 sy	1.7	74	-	-	179	-	2.37 /sy	253	423
			Asphaltic paving, replacement over trench, 4" thick	107.00 sy	73.4	3,008	1,519	-	2,612	-	66.72 /sy	7,139	11,922
			Replace Pavement	**107.00 SY**	**76.7**	**3,152**	**3,108**		**2,950**		**86.08 /SY**	**9,211**	**15,381**
			31-40 Paving	**115.00 SY**	**76.7**	**3,152**	**3,108**		**2,950**		**80.10 /SY**	**9,211**	**15,381**
			31.0 Site/Civil	**1.00 LS**	**85.4**	**3,152**	**3,108**	**8,700**	**2,950**		**17,910.91 /LS**	**17,911**	**29,910**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			48" RCP Pipe										
			Trench Box, 8' x 24' x 10'	1.00 mo		-	-	-	2,300	-	2,300.00 /mo	2,300	3,841
			Excav. pipe trench, w/ trench box, for > 30" pipe	562.61 CY	12.4	528	-	-	2,602	-	5.56 /CY	3,130	5,227
			Backfill / Compact @ pipe zone, for 30" & larger pipe	216.57 cy	27.5	1,133	-	-	2,227	-	15.52 /cy	3,360	5,611
			Backfill / Compact above pipe zone, for 30" & larger pipe	311.67 cy	9.4	431	-	-	666	-	3.52 /cy	1,096	1,831
			Pipe zone material	216.57 cy		-	6,064	-	-	-	28.00 /cy	6,064	10,126
			Pipe bedding material	58.40 cy		-	1,635	-	-	-	28.00 /cy	1,635	2,731
			Haul spoils, offsite, up to 10 miles	274.97 cy		-	-	2,750	-	-	10.00 /cy	2,750	4,592
			48" pipe, RCP, Class III B & S, excav/bkfill not included, 8'-15'	225.00 LF	47.3	2,208	21,638	-	2,763	-	118.27 /LF	26,610	44,436
			48" flared end, RCP, B & S	1.00 ea	5.3	245	3,045	-	351	-	3,641.27 /ea	3,641	6,081
			Grout joint, ID or OD, 48"	29.00 ea	29.0	1,276	638	-	-	-	66.00 /ea	1,914	3,196
			48" RCP Pipe	**225.00 LF**	**130.7**	**5,821**	**33,020**	**2,750**	**10,909**		**233.34 /LF**	**52,500**	**87,671**
			33-00 Yard Piping	**225.00 LF**	**130.7**	**5,821**	**33,020**	**2,750**	**10,909**		**233.34 /LF**	**52,500**	**87,671**
		33-15	**Yard Structures**										
			120" Manhole										
			Manholes, precast, 10' inside dia, 10' deep	2.00 ea	24.0	1,124	13,000	-	1,126	-	7,625.37 /ea	15,251	25,467
			Cast-in-Place Base, 10'	2.00 ea	6.0	281	5,600	-	282	-	3,081.35 /ea	6,163	10,291
			Grade Ring, 10'	2.00 ea	2.0	94	50	-	94	-	118.78 /ea	238	397
			Frame & Cover, 10'	2.00 ea	4.0	187	450	-	188	-	412.56 /ea	825	1,378
			Grout Invert, 10'	2.00 ea	7.0	328	400	-	329	-	528.23 /ea	1,056	1,764
			120" Manhole	**2.00 EA**	**43.0**	**2,014**	**19,500**		**2,018**		**11,766.28 /EA**	**23,533**	**39,297**
			33-15 Yard Structures	**2.00 EA**	**43.0**	**2,014**	**19,500**		**2,018**		**11,766.28 /EA**	**23,533**	**39,297**
			33.0 Buried Piping	**225.00 LF**	**173.7**	**7,836**	**52,520**	**2,750**	**12,927**		**337.93 /LF**	**76,033**	**126,969**
			001 Install New 48" Culvert	**225.00 LF**	**274.4**	**11,681**	**56,730**	**11,450**	**16,651**		**428.94 /LF**	**96,512**	**161,166**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	11,681		274.411		7.25%
Material	56,730				35.20%
Subcontract	11,450				7.10%
Equipment	16,651		410.147		10.33%
Other					
Total Before Markups	**96,512**	**96,512**			59.88
Project Staff & Home Office OH	9,651			10.000 %	5.99%
Total Overhead	**9,651**	**106,163**			5.99
General Conditions	7,431			7.000 %	4.61%
Total General Conditions	**7,431**	**113,594**			4.61
Profit on Previous Subtotal	5,680			5.000 %	3.52%
Total Profit	**5,680**	**119,274**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**119,274**			
Mobilization/Demobilization	4,835			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	1,612			1.000 %	1.00%
Payment & Performance Bonds	1,870			1.160 %	1.16%
Total Bonds and Insurances	**8,317**	**127,591**			5.16
Contingency - %	25,518			20.000 %	15.83%
Total Contingency	**25,518**	**153,109**			15.83
Escalation on Estimate Total	8,058			5.000 %	5.00%
Total Escalation	**8,058**	**161,167**			5.00
Construction Total		**161,167**			

Detail Report

Job Size:
Duration:

Project: Growth Node - Wyatt
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 01 - 12/10/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Western Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.25 acre	12.5	525	-	-	654	-	943.02 /acre	1,179	1,968
			Rough Site Grading, Small Crew	6,500.00 sy	86.7	3,899	-	-	6,417	-	1.59 /sy	10,316	17,227
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	540.00 cy	21.6	814	-	-	1,768	-	4.78 /cy	2,582	4,313
			Permanent Seed and Mulch	1.25 acre	7.5		-	1,875	-	-	1,500.00 /acre	1,875	3,131
			Clear & Replant Pipe Alignment	**2,340.00 LF**	**128.3**	**5,238**		**1,875**	**8,839**		**6.82 /LF**	**15,952**	**26,639**
			31-20 Earthworks, Site	**1.00 LS**	**128.3**	**5,238**		**1,875**	**8,839**		**15,952.16 /LS**	**15,952**	**26,639**
			31.0 Site/Civil	**1.00 LS**	**128.3**	**5,238**		**1,875**	**8,839**		**15,952.16 /LS**	**15,952**	**26,639**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			24" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	18,366.17 CY	532.6	22,732	-	-	48,733	-	3.89 /CY	71,465	119,340
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	2,762.10 cy	367.4	15,127	-	-	17,290	-	11.74 /cy	32,417	54,134
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	17,062.99 cy	494.8	22,799	-	-	31,916	-	3.21 /cy	54,714	91,369
			Pipe bedding material	207.31 cy		-	5,805	-	-	-	28.00 /cy	5,805	9,693
			Haul spoils, onsite	2,969.41 cy		-	-	8,908	-	-	3.00 /cy	8,908	14,876
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 24" diameter, excludes excavation or backfill	2,340.00 lf	262.1	11,203	43,290	-	1,334	-	23.86 /lf	55,827	93,227
			24" N-20 Storm Sewer Pipe	**2,340.00 LF**	**1,656.9**	**71,861**	**49,095**	**8,908**	**99,272**		**97.92 /LF**	**229,136**	**382,639**
			33-00 Yard Piping	**2,340.00 LF**	**1,656.9**	**71,861**	**49,095**	**8,908**	**99,272**		**97.92 /LF**	**229,136**	**382,639**
			33.0 Buried Piping	**2,340.00 LF**	**1,656.9**	**71,861**	**49,095**	**8,908**	**99,272**		**97.92 /LF**	**229,136**	**382,639**
			001 Western Trunkline	**2,340.00 LF**	**1,785.2**	**77,099**	**49,095**	**10,783**	**108,111**		**104.74 /LF**	**245,089**	**409,278**
002			**Eastern Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.32 acre	13.2	554	-	-	690	-	943.01 /acre	1,245	2,079
			Rough Site Grading, Small Crew	6,875.55 sy	91.7	4,125	-	-	6,787	-	1.59 /sy	10,912	18,222
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	571.73 cy	22.9	862	-	-	1,872	-	4.78 /cy	2,734	4,566
			Permanent Seed and Mulch	1.32 acre	7.9		-	1,980	-	-	1,500.00 /acre	1,980	3,306
			Clear & Replant Pipe Alignment	**2,475.00 LF**	**135.7**	**5,541**		**1,980**	**9,350**		**6.82 /LF**	**16,871**	**28,173**
			31-20 Earthworks, Site	**1.00 LS**	**135.7**	**5,541**		**1,980**	**9,350**		**16,870.90 /LS**	**16,871**	**28,173**
			31.0 Site/Civil	**1.00 LS**	**135.7**	**5,541**		**1,980**	**9,350**		**16,870.90 /LS**	**16,871**	**28,173**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			24" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	19,426.28 CY	563.4	24,044	-	-	51,545	-	3.89 /CY	75,590	126,228
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	2,920.50 cy	388.4	15,995	-	-	18,282	-	11.74 /cy	34,276	57,239
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	18,047.70 cy	523.4	24,114	-	-	33,758	-	3.21 /cy	57,872	96,642
			Pipe bedding material	220.28 cy		-	6,168	-	-	-	28.00 /cy	6,168	10,300
			Haul spoils, onsite	3,140.78 cy		-	-	9,422	-	-	3.00 /cy	9,422	15,735
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 24" diameter, excludes excavation or backfill	2,475.00 lf	277.2	11,849	45,788	-	1,411	-	23.86 /lf	59,048	98,605
			24" N-20 Storm Sewer Pipe	**2,475.00 LF**	**1,752.4**	**76,003**	**51,955**	**9,422**	**104,996**		**97.93 /LF**	**242,376**	**404,748**
			33-00 Yard Piping	**2,475.00 LF**	**1,752.4**	**76,003**	**51,955**	**9,422**	**104,996**		**97.93 /LF**	**242,376**	**404,748**
			33.0 Buried Piping	**2,475.00 LF**	**1,752.4**	**76,003**	**51,955**	**9,422**	**104,996**		**97.93 /LF**	**242,376**	**404,748**
			002 Eastern Trunkline	**2,475.00 LF**	**1,888.0**	**81,543**	**51,955**	**11,402**	**114,346**		**104.75 /LF**	**259,247**	**432,921**

Detail Report

Project: Growth Node - Wyatt
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 01 - 12/10/2014
Estimate Class: Class 4

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	158,643		3,673.187 I		18.84%
Material	101,050				12.00%
Subcontract	22,186				2.63%
Equipment	222,457		3,190.387 I		26.41%
Other					
Total Before Markups	**504,336**	**504,336**			59.88
Project Staff & Home Office OH	50,434			10.000 %	5.99%
Total Overhead	**50,434**	**554,770**			5.99
General Conditions	38,834			7.000 %	4.61%
Total General Conditions	**38,834**	**593,604**			4.61
Profit on Previous Subtotal	29,680			5.000 %	3.52%
Total Profit	**29,680**	**623,284**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**623,284**			
Mobilization/Demobilization	25,266			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	8,422			1.000 %	1.00%
Payment & Performance Bonds	9,770			1.160 %	1.16%
Total Bonds and Insurances	**43,458**	**666,742**			5.16
Contingency - %	133,348			20.000 %	15.83%
Total Contingency	**133,348**	**800,090**			15.83
Escalation on Estimate Total	42,110			5.000 %	5.00%
Total Escalation	**42,110**	**842,200**			5.00
Construction Total		**842,200**			

Detail Report

Project: Growth Node - La Creole
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 01 - 12/10/2014
Estimate Class: Class 4

Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Northern Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.04 acre	10.4	437	-	-	544	-	943.01 /acre	981	1,638
			Rough Site Grading, Small Crew	5,444.44 sy	72.6	3,266	-	-	5,375	-	1.59 /sy	8,641	14,429
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	452.30 cy	18.1	682	-	-	1,481	-	4.78 /cy	2,163	3,612
			Permanent Seed and Mulch	1.04 acre	6.2		-	1,560	-	-	1,500.00 /acre	1,560	2,605
			Clear & Replant Pipe Alignment	**1,960.00 LF**	**107.3**	**4,385**		**1,560**	**7,400**		**6.81 /LF**	**13,344**	**22,284**
			31-20 Earthworks, Site	**1.00 LS**	**107.3**	**4,385**		**1,560**	**7,400**		**13,344.45 /LS**	**13,344**	**22,284**
			31.0 Site/Civil	**1.00 LS**	**107.3**	**4,385**		**1,560**	**7,400**		**13,344.45 /LS**	**13,344**	**22,284**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			36" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	15,384.04 CY	446.1	19,041	-	-	40,820	-	3.89 /CY	59,861	99,963
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	2,312.80 cy	307.6	12,666	-	-	14,478	-	11.74 /cy	27,144	45,328
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	14,292.32 cy	414.5	19,097	-	-	26,733	-	3.21 /cy	45,830	76,532
			Pipe bedding material	174.44 cy		-	4,884	-	-	-	28.00 /cy	4,884	8,156
			Haul spoils, onsite	2,487.24 cy		-	-	7,462	-	-	3.00 /cy	7,462	12,460
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 36" diameter, excludes excavation or backfill	1,960.00 lf	304.9	13,033	63,700	-	1,552	-	39.94 /lf	78,285	130,730
			36" N-20 Storm Sewer Pipe	**1,960.00 LF**	**1,473.1**	**63,838**	**68,584**	**7,462**	**83,582**		**114.01 /LF**	**223,466**	**373,170**
			33-00 Yard Piping	**1,960.00 LF**	**1,473.1**	**63,838**	**68,584**	**7,462**	**83,582**		**114.01 /LF**	**223,466**	**373,170**
			33.0 Buried Piping	**1,960.00 LF**	**1,473.1**	**63,838**	**68,584**	**7,462**	**83,582**		**114.01 /LF**	**223,466**	**373,170**
			001 Northern Trunkline	**1,960.00 LF**	**1,580.4**	**68,222**	**68,584**	**9,022**	**90,982**		**120.82 /LF**	**236,811**	**395,454**
002			**Southern Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.31 acre	13.1	550	-	-	685	-	943.01 /acre	1,235	2,063
			Rough Site Grading, Small Crew	6,861.11 sy	91.5	4,116	-	-	6,773	-	1.59 /sy	10,889	18,184
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	570.00 cy	22.8	859	-	-	1,867	-	4.78 /cy	2,726	4,552
			Permanent Seed and Mulch	1.31 acre	7.9		-	1,965	-	-	1,500.00 /acre	1,965	3,281
			Clear & Replant Pipe Alignment	**2,470.00 LF**	**135.2**	**5,525**		**1,965**	**9,325**		**6.81 /LF**	**16,815**	**28,080**
			31-20 Earthworks, Site	**1.00 LS**	**135.2**	**5,525**		**1,965**	**9,325**		**16,815.30 /LS**	**16,815**	**28,080**
			31.0 Site/Civil	**1.00 LS**	**135.2**	**5,525**		**1,965**	**9,325**		**16,815.30 /LS**	**16,815**	**28,080**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			30" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	19,387.03 CY	562.2	23,996	-	-	51,441	-	3.89 /CY	75,437	125,973
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	2,914.60 cy	387.6	15,962	-	-	18,245	-	11.74 /cy	34,207	57,123
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	18,011.24 cy	522.3	24,066	-	-	33,690	-	3.21 /cy	57,755	96,446
			Pipe bedding material	219.83 cy		-	6,155	-	-	-	28.00 /cy	6,155	10,279
			Haul spoils, onsite	3,134.43 cy		-	-	9,403	-	-	3.00 /cy	9,403	15,703
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 30" diameter, excludes excavation or backfill	2,470.00 lf	345.8	14,782	59,280	-	1,760	-	30.70 /lf	75,822	126,617
			30" N-20 Storm Sewer Pipe	**2,470.00 LF**	**1,818.0**	**78,806**	**65,435**	**9,403**	**105,136**		**104.77 /LF**	**258,780**	**432,141**
			33-00 Yard Piping	**2,470.00 LF**	**1,818.0**	**78,806**	**65,435**	**9,403**	**105,136**		**104.77 /LF**	**258,780**	**432,141**
			33.0 Buried Piping	**2,470.00 LF**	**1,818.0**	**78,806**	**65,435**	**9,403**	**105,136**		**104.77 /LF**	**258,780**	**432,141**
			002 Southern Trunkline	**2,470.00 LF**	**1,953.2**	**84,331**	**65,435**	**11,368**	**114,461**		**111.58 /LF**	**275,595**	**460,221**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	152,553		3,533.672 I		17.83%
Material	134,020				15.66%
Subcontract	20,390				2.38%
Equipment	205,443		2,957.126 I		24.01%
Other					
Total Before Markups	**512,406**	**512,406**			59.88
Project Staff & Home Office OH	51,241			10.000 %	5.99%
Total Overhead	**51,241**	**563,647**			5.99
General Conditions	39,455			7.000 %	4.61%
Total General Conditions	**39,455**	**603,102**			4.61
Profit on Previous Subtotal	30,155			5.000 %	3.52%
Total Profit	**30,155**	**633,257**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**633,257**			
Mobilization/Demobilization	25,670			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	8,557			1.000 %	1.00%
Payment & Performance Bonds	9,926			1.160 %	1.16%
Total Bonds and Insurances	**44,153**	**677,410**			5.16
Contingency - %	135,482			20.000 %	15.83%
Total Contingency	**135,482**	**812,892**			15.83
Escalation on Estimate Total	42,784			5.000 %	5.00%
Total Escalation	**42,784**	**855,676**			5.00
Construction Total		**855,676**			

CH2MHILL

Job Size:
Duration:

Detail Report

Project: Growth Node - Barberry
Project No.: 496541
Design Stage: Preliminary Design

Estimator: T Jones
Revision / Date: 01 - 12/10/2014
Estimate Class: Class 4

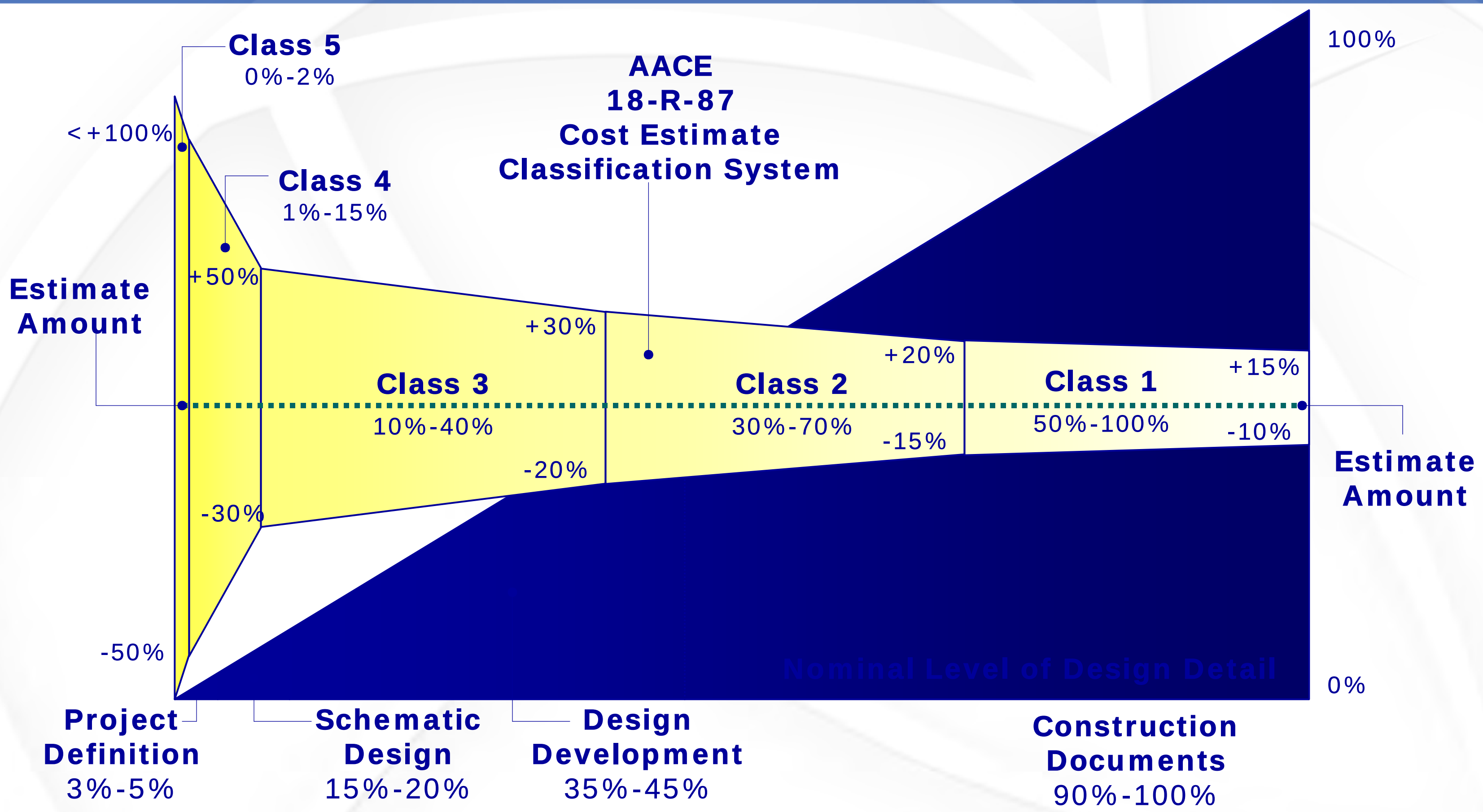
Bid Item	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
001			**Western Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.10 acre	11.0	462	-	-	575	-	943.01 /acre	1,037	1,732
			Rough Site Grading, Small Crew	5,775.46 sy	77.0	3,465	-	-	5,701	-	1.59 /sy	9,166	15,307
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	481.28 cy	19.3	725	-	-	1,576	-	4.78 /cy	2,302	3,844
			Permanent Seed and Mulch	1.10 acre	6.6		-	1,650	-	-	1,500.00 /acre	1,650	2,755
			Clear & Replant Pipe Alignment	**2,080.00 LF**	**113.9**	**4,652**		**1,650**	**7,853**		**6.81 /LF**	**14,155**	**23,638**
			31-20 Earthworks, Site	**1.00 LS**	**113.9**	**4,652**		**1,650**	**7,853**		**14,154.98 /LS**	**14,155**	**23,638**
			31.0 Site/Civil	**1.00 LS**	**113.9**	**4,652**		**1,650**	**7,853**		**14,154.98 /LS**	**14,155**	**23,638**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			36" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	16,325.92 CY	473.5	20,207	-	-	43,319	-	3.89 /CY	63,526	106,083
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	2,454.40 cy	326.4	13,442	-	-	15,364	-	11.74 /cy	28,806	48,104
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	15,167.36 cy	439.9	20,266	-	-	28,370	-	3.21 /cy	48,636	81,218
			Pipe bedding material	185.12 cy		-	5,183	-	-	-	28.00 /cy	5,183	8,656
			Haul spoils, onsite	2,639.52 cy		-	-	7,919	-	-	3.00 /cy	7,919	13,223
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 36" diameter, excludes excavation or backfill	2,080.00 lf	323.6	13,831	67,600	-	1,647	-	39.94 /lf	83,078	138,734
			36" N-20 Storm Sewer Pipe	**2,080.00 LF**	**1,563.3**	**67,746**	**72,783**	**7,919**	**88,700**		**114.01 /LF**	**237,148**	**396,017**
			33-00 Yard Piping	**2,080.00 LF**	**1,563.3**	**67,746**	**72,783**	**7,919**	**88,700**		**114.01 /LF**	**237,148**	**396,017**
			33.0 Buried Piping	**2,080.00 LF**	**1,563.3**	**67,746**	**72,783**	**7,919**	**88,700**		**114.01 /LF**	**237,148**	**396,017**
			001 Western Trunkline	**2,080.00 LF**	**1,677.2**	**72,398**	**72,783**	**9,569**	**96,553**		**120.82 /LF**	**251,303**	**419,655**
002			**Eastern Trunkline**										
	31.0		**Site/Civil**										
		31-20	**Earthworks, Site**										
			Clear & Replant Pipe Alignment										
			Clearing, heavy overgrowth of weeds and shrubs	1.81 acre	18.1	760	-	-	947	-	943.01 /acre	1,707	2,850
			Rough Site Grading, Small Crew	9,520.15 sy	126.9	5,711	-	-	9,398	-	1.59 /sy	15,109	25,231
			Haul Excess Spoils Off-Site, 12 yd capacity, 5 miles RT	793.64 cy	31.7	1,196	-	-	2,599	-	4.78 /cy	3,795	6,338
			Permanent Seed and Mulch	1.81 acre	10.9		-	2,715	-	-	1,500.00 /acre	2,715	4,534
			Clear & Replant Pipe Alignment	**3,430.00 LF**	**187.6**	**7,667**		**2,715**	**12,944**		**6.80 /LF**	**23,326**	**38,953**
			31-20 Earthworks, Site	**1.00 LS**	**187.6**	**7,667**		**2,715**	**12,944**		**23,326.39 /LS**	**23,326**	**38,953**
			31.0 Site/Civil	**1.00 LS**	**187.6**	**7,667**		**2,715**	**12,944**		**23,326.39 /LS**	**23,326**	**38,953**
	33.0		**Buried Piping**										
		33-00	**Yard Piping**										
			42" N-20 Storm Sewer Pipe										
			Excav. pipe trench, open, w/ 1 1/2 : 1 side slopes, for 4" - 24" pipe	26,922.07 CY	780.7	33,322	-	-	71,435	-	3.89 /CY	104,757	174,935
			Backfill / Compact @ pipe zone, for 4" thru 24" pipe	4,047.40 cy	538.3	22,166	-	-	25,336	-	11.74 /cy	47,502	79,325
			Backfill / Compact above pipe zone, for 4" thru 24" pipe	25,011.56 cy	725.3	33,419	-	-	46,783	-	3.21 /cy	80,203	133,932
			Pipe bedding material	305.27 cy		-	8,548	-	-	-	28.00 /cy	8,548	14,274
			Haul spoils, onsite	4,352.67 cy		-	-	13,058	-	-	3.00 /cy	13,058	21,806
			Public Sanitary Utility Sewerage Piping, piping HDPE Corrugated Type S with watertight gaskets, 42" diameter, excludes excavation or backfill	3,430.00 lf	548.8	23,460	149,205	-	2,794	-	51.15 /lf	175,458	293,001
			42" N-20 Storm Sewer Pipe	**3,430.00 LF**	**2,593.2**	**112,367**	**157,753**	**13,058**	**146,348**		**125.23 /LF**	**429,525**	**717,271**
			33-00 Yard Piping	**3,430.00 LF**	**2,593.2**	**112,367**	**157,753**	**13,058**	**146,348**		**125.23 /LF**	**429,525**	**717,271**
			33.0 Buried Piping	**3,430.00 LF**	**2,593.2**	**112,367**	**157,753**	**13,058**	**146,348**		**125.23 /LF**	**429,525**	**717,271**
			002 Eastern Trunkline	**3,430.00 LF**	**2,780.8**	**120,034**	**157,753**	**15,773**	**159,291**		**132.03 /LF**	**452,851**	**756,224**

Estimate Totals

Construction Costs	Amount	Totals	Hours	Rate	% of Total
Labor	192,433		4,457.982 I		16.36%
Material	230,536				19.61%
Subcontract	25,342				2.16%
Equipment	255,844		3,686.965 I		21.76%
Other					
Total Before Markups	**704,155**	**704,155**			59.88
Project Staff & Home Office OH	70,415			10.000 %	5.99%
Total Overhead	**70,415**	**774,570**			5.99
General Conditions	54,220			7.000 %	4.61%
Total General Conditions	**54,220**	**828,790**			4.61
Profit on Previous Subtotal	41,439			5.000 %	3.52%
Total Profit	**41,439**	**870,229**			3.52
Contractor MU on OFCI Equip					
Total MU on OFCI Equip		**870,229**			
Mobilization/Demobilization	35,276			3.000 %	3.00%
Blder's Risk & Gen Liab Ins -%	11,759			1.000 %	1.00%
Payment & Performance Bonds	13,640			1.160 %	1.16%
Total Bonds and Insurances	**60,675**	**930,904**			5.16
Contingency - %	186,181			20.000 %	15.83%
Total Contingency	**186,181**	**1,117,085**			15.83
Escalation on Estimate Total	58,794			5.000 %	5.00%
Total Escalation	**58,794**	**1,175,879**			5.00
Construction Total		**1,175,879**			

Appendix B: AACEI Classification

AACE – Classification System



Construction Cost Estimate Accuracy Ranges

CH2MHILL

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
LEVEL OF PROJECT DEFINITION Expressed as a % of complete definition	**0% to 2%**	**1% to 15%**	**10% to 40%**	**30% to 70%**	**50% to 100%**
END USAGE Typical Purpose of Estimate	**Concept Screening**	**Study or Feasibility**	**Budget Authorization, or Control**	**Control or Bid / Tender**	**Check Estimate or Bid / Tender**
METHODOLOGY Typical estimating method	**Capacity Factored, Parametric Models, Judgment, or Analogy**	**Equipment Factored or Parametric Models**	**Semi-Detailed Unit Costs with Assembly Level Line Items**	**Detailed Unit Cost with Forced Detailed Take-Off**	**Detailed Unit Cost with Detailed Take-Off**
EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	**L: -20% to -50%** / **H: +30% to +100%**	**L: -15% to -30%** / **H: +20% to +50%**	**L: -10% to -20%** / **H: +10% to +30%**	**L: -5% to -15%** / **H: +5% to +20%**	**L: -3% to -10%** / **H: +3% to +15%**
PREPARATION EFFORT Typical degree of effort relative to least cost index of 1 [b]	**1**	**2 to 4**	**3 to 10**	**4 to 20**	**5 to 100**
REFINED CLASS DEFINITION	Class 5 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with very little effort expended - sometimes requiring less than 1 hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.	Class 4 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems and preliminary engineered process and utility equipment lists. Level of Project Definition Required: 1% to 15% of full project definition.	Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineering process and utility equipment lists. Level Of Project Definition Required: 10% to 40% of full project definition.	Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: Process flow diagrams, utility flow diagrams, piping and instrument flow diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.	Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. Level for Project Definition Required: 50% to 100% of full project definition.
END USAGE DEFINED	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimate" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control.	Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs an resources will now be monitored for variation to the budget, and form a part of the change/variation control program.	Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual coasts and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution.
ESTIMATING METHODS USED	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.	Class 4 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.	Class 3 estimates usually involve more deterministic estimating methods that stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.	Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detailed takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods.	Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities.
EXPECTED ACCURACY RANGE	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.
EFFORT TO PREPARE (for US$20MM project):	As little as 1 hour or less to prepare to perhaps more than 200 hours, depending on the project and the estimating methodology used.	Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.	Typically, as little as 150 hours or less to perhaps more than 1500 hours, depending on the project and the estimating methodology used.	Typically, as little as 300 hours or less to perhaps more than 3000 hours, depending on the project and the estimating methodology used. Bid Estimates typically require more effort than estimates used for funding or control purposes	Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimate typically require more effort than estimates used for funding or control purposes.
ANSI Standard Reference Z94.2-1989 name; Alternate Estimate Names, Terms, Expressions, Synonyms:	Order of Magnitude Estimate; Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of thumb.	Budget Estimate; Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.	Budget Estimate; Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate.	Definitive Estimate; Detailed Control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.	Definitive Estimate; Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Estimate Input Checklist and Maturity Index	Class 5	Class 4	Class 3	Class 2	Class 1
GENERAL PROJECT DATA					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production / Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined

ENGINEERING DELIVERABLES:	Class 5	Class 4	Class 3	Class 2	Class 1
Block Flow Diagrams	Started / Preliminary	Preliminary / Complete	Complete	Complete	Complete
Plot Plans		Started	Preliminary / Complete	Complete	Complete
Process Flow Diagrams (PFDs)		Started / Preliminary	Preliminary / Complete	Complete	Complete
Utility Flow Diagrams (UFDs)		Started / Preliminary	Preliminary / Complete	Complete	Complete
Piping & Instrument Diagrams (P&IDS)		Started	Preliminary / Complete	Complete	Complete
Heat and Material Balances		Started	Preliminary / Complete	Complete	Complete
Process Equipment List		Started / Preliminary	Preliminary / Complete	Complete	Complete
Utility Equipment List		Started / Preliminary	Preliminary / Complete	Complete	Complete
Electrical One Line Drawings		Started / Preliminary	Preliminary / Complete	Complete	Complete
Specifications and Datasheets		Started	Preliminary / Complete	Complete	Complete
General Equipment Arrangement Drawings		Started	Preliminary / Complete	Complete	Complete
Spare Parts Lists			Started / Preliminary	Preliminary	Complete
Architectural Details / Schedules		Started	Preliminary / Complete	Complete	Complete
Structural Details		Started	Preliminary / Complete	Complete	Complete
Mechanical Discipline Drawings			Started	Preliminary	Preliminary / Complete
Electrical Discipline Drawings			Started	Preliminary	Preliminary / Complete
System Discipline Drawings			Started	Preliminary	Preliminary / Complete
Civil/Site Discipline Drawings			Started	Preliminary	Preliminary / Complete
Demolition Details		Started	Preliminary / Complete	Complete	Complete

Appendix E
Stormwater Rate Model

APPENDIX E

Dallas Stormwater Management Rate Model

Introduction

Stormwater management (SWM) utilities are authorized by Oregon statute as enterprise funds within a City's budget structure. They are defined as being financially self-sufficient and can be designed to furnish a comprehensive set of services related to stormwater quantity and quality management. Services that SWM utilities provide include not only the construction and maintenance of facilities necessary to control flooding and improve the character of surface runoff, but also implementation of BMPs designed to address nonpoint source pollution.

SWM utilities are also a well-established, efficient, and feasible financing option that provides a dedicated revenue source for stormwater management. A SWM utility operates similarly to water or sewer utilities, which are funded through service fees and administered separately from the general tax fund, ensuring stable and adequate funding for these public services. Generally, there are three major advantages of SWM utilities over funds generated through property tax revenues: (1) increased stability and predictability, (2) greater equity, and (3) the opportunity for incorporating incentives for implementation of onsite stormwater management. Most SWM utilities in Oregon generate revenues based on fees, and the basis for those fees is impervious area. The amount of impervious surface on a property is the single most important factor affecting the amount of water flowing off a property, how quickly that water flows off a property, and the amount of pollution picked up by the water from that property. Because of this, basing stormwater utility fees on the impervious area on a property is one of the most common methods used to determine stormwater utility fees in Oregon and the nation.

For this rate study effort, it was assumed that a Dallas SWM utility fee would be applied to customers based on an "equivalent residential units" (ERU) approach. Under this structure, single-family homes are counted as one ERU and, on average, contain 3,200 square feet of impervious area. All non-single-family residential customers are charged based on their measured impervious area for each developed property, which is then divided by the ERU value of 3,200 square feet of impervious surface. This determines the total number of ERUs billed to that non single-family residential customer.

The technical analysis contained in this master plan produced operations, maintenance, and capital improvement program activities and costs. This financial review assesses the impact of these costs on the City's SWM utility rates and SDCs. A funding model simulates the fiscal management of the SWM utility and accommodates the following conditions:

- A 20-year forecast horizon (the current start year is fiscal year 2014–15)
- A Capital Projects Fund where capital improvement projects are budgeted
- A Stormwater SDC Fund where system development charges are budgeted
- An Operating Fund where revenues and expenses are budgeted
- Issuing and servicing debt to fund capital improvements
- Rate-making based on the revenue requirements for the utility during each forecast year

The Stormwater SDC Fund receives revenues collected from the City's SDCs and, when required, transfers money to the Stormwater Capital Projects Fund to pay for that portion of the construction budget that includes oversizing to serve growth. Historically, annual revenues from SDCs have been very modest (e.g., $42,235 was collected in fiscal year 2012–13, and the City is estimating receipts for fiscal year 2013–14 at $30,000).

The base case forecast for the capital financing plan assumes the City will bond up to $5 million worth of projects in 5-year design and construction cycles, starting in fiscal year 2019. Cash in the Stormwater SDC

Fund is transferred to the Stormwater Capital Projects fund to buy down those borrowing requirements on SDC eligible projects.

This master plan has concluded the City needs to fund approximately $38 million worth of SWM infrastructure reconditioning, replacement, and expansion projects over the 20-year planning horizon. To fund this level of costs, it became clear that significant use of debt will be required to:

- Deliver completed projects in a timely and economically efficient manner
- Keep user rates manageable and predictable

With these issues in mind, the base case capital projects financing plan assumes the City will not do one project at a time, and bond for each individual project identified in this master plan. Rather, a phased capital funding strategy has been adopted with the benefit of City staff input. This strategy assumes future capital projects will be prioritized in 5-year development packages valued at $5 million for each package. Over the 20-year forecast, this implies funding for $20 million worth of projects; not enough to fund the entire master plan capital projects list, but a very significant start toward achievement of that goal.

All operating revenues (i.e., rates, fees, interest income, etc.) flow into the Operating Fund, and all costs of operations, maintenance, and debt service flow out of this fund. Since the City currently does not manage a SWM enterprise operating fund, one was created in the model to test planning assumptions. A pro forma SWM utility budget has been prepared (in fiscal year 2014–15 dollars) that accounts for the operations and maintenance cost estimates that have been developed throughout this master planning effort.

The principal resources for the SWM Operating Fund are working capital, expressed as beginning fund balance and SWM rate revenues. For this modeling effort, the project team assumed the City will provide $500,000 of working capital to "kick start" the SWM Operating Fund via a cash transfer from the Sewer Operating Fund. The Sewer Operating Fund currently has an unencumbered fund balance of approximately $2 million.

The City complies with Oregon budget law, and categorizes expenses in its enterprise funds within the following budget categories:

- **Personnel Services**. The personnel services budget category captures the cost of salaries, overtime, and fringe benefits. The plan calls for a starting staffing plan of 3.0 FTEs, expanding over a 20-year period to up to 7.0 FTEs, to accommodate implementation of TMDL and MS4 permitting requirements.
- **Materials and Services.** This budget category captures the day to day costs of operating and maintaining the SWM program, with the exception of direct labor expenses. For modeling purposes, the project team analyzed the historical expenditure patterns of the City's water and sewer utilities to see if relationships could be made between materials and services expenditures and direct labor expenditures. This relationship is fairly common in the municipal utility industry, and in the case of Dallas, that ratio for both water and sewer services was roughly 45 percent. For rate modeling purposes, the project team extended this cost relationship to the SWM utility and budgeted $56,000 for materials and supplies in the SWM Operating Fund for a starting point. This figure was arrived at through consultation with City staff.
- **Professional Services**. An additional line item in the materials and services budget category was added to the forecast for professional services. After consulting with City staff, it was felt a small annual budget appropriation of $25,000 (in 2015 dollars) should be added to the base case budget to account for on-call engineering services, GIS, and outside technical support starting in 2017.
- **Capital Outlays**. The preponderance of the capital funding activity for the SWM utility takes place in the SWM Capital Projects Fund. However, a small, but very beneficial amount of capital outlays happens in the SWM Operating Fund. Capitalized costs for small works, tools, and minor capital equipment are incurred in the day to day operations of a stormwater utility. The project team has included a starting budget for these capitalized costs at $20,000.

- **Transfers to Other Funds**. In Dallas, the General Fund provides services to the enterprise utilities in the form of payroll management, insurance, franchise fees, and supervision. The water and sewer funds transfer approximately 20 percent of their respective gross rate revenues to the General Fund in payment for these services. In consultation with City staff, it was agreed for the rate study to assume a new SWM utility would only transfer 15 percent of gross rate revenues to the General fund for overhead services.
- **Debt Service**. Principal and interest payment on future revenue bond issuances are captured in this budget category, and become a requirement of SWM rates.

The impact of these revenue and expenditure assumptions on the pro forma cash flows in the SWM Operating Fund are shown in Table E-1.

TABLE E-1
Analysis of Stormwater Operating Fund Cash Flow
City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Resources:						
Beginning Fund Balance	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Revenues:						
Stormwater service charges	$190,000	$283,049	$403,799	$418,093	$889,554	$905,031
Stormwater hookup fees	-	-	-	-	-	-
Investment income	-	$2,700	$2,700	$2,700	$2,700	$2,700
Miscellaneous	-	-	-	-	-	-
Subtotal revenues	$190,000	$285,749	$406,499	$420,793	$892,254	$907,731
Total Resources	**$690,000**	**$785,749**	**$906,499**	**$920,793**	**$1,392,254**	**$1,407,731**
Requirements:						
Expenditures:						
Personnel Services:						
Salaries	$50,150	$91,396	$132,642	$135,958	$139,357	$142,840
Overtime	-	-	-	-	-	-
Fringe benefits	$34,850	$63,466	$92,082	$97,606	$103,463	$109,671
Total personnel services	$85,000	$154,862	$224,723	$233,564	$242,819	$252,511
Materials and Services:						
Materials and supplies	$56,000	$78,563	$101,125	$104,159	$107,284	$110,502
DEQ permits	-	-	-	-	-	-
Vehicle/equipment expense	-	-	-	-	-	-
Repairs and maintenance	-	-	-	-	-	-
Material Disposal	-	-	-	-	-	-
Tools	-	-	-	-	-	-
Telecommunications	-	-	-	-	-	-
HVAC, energy and lighting	-	-	-	-	-	-
Computer services	-	-	-	-	-	-
Insurance	-	-	-	-	-	-
Professional services			$25,000	$25,750	$26,523	$27,318
Employee development	-	-	-	-	-	-
Safety equipment and training	-	-	-	-	-	-
Travel and education	-	-	-	-	-	-
Materials and services - base line	$56,000	$78,563	$126,125	$129,909	$133,806	$137,821
Capital outlays - small works	$20,000	$17,500	$15,000	$15,450	$15,914	$16,391
Transfers to other funds - OUT						
General Fund	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Community Development Fund	-	-	-	-	-	-
Stormwater Capital Projects Fund - reserve for future projects	-	-	-	-	-	-
Stormwater Capital Projects Fund - overheads	-	-	-	-	-	-

TABLE E-1

Analysis of Stormwater Operating Fund Cash Flow

City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Subtotal transfers to other funds	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Debt service:						
Oregon DEQ Revolving Loan	-	-	-	-	-	-
Revenue bonds	-	-			$456,589	$456,589
Subtotal debt service	-	-			$456,589	$456,589
Contingencies/Designations	$83,000					
Total fund expenditures	$273,000	$285,749	$406,499	$420,793	$892,254	$907,731
Unappropriated ending fund balance	$417,000	$500,000	$500,000	$500,000	$500,000	$500,000
Total Requirements	**$690,000**	**$785,749**	**$906,499**	**$920,793**	**$1,392,254**	**$1,407,731**

This SWM rate analysis assumes service charges reflect a rationale that those who contribute runoff to the stormwater system should proportionately contribute to the costs of providing services. This approach is now regarded by most administrators and the courts as an appropriate technique for financing stormwater programs. A basic assumption in this rate analysis is that services will continue to be billed on the basis of impervious surface. For single family residential property owners, the average amount of impervious area on a developed residential lot is assumed to be 3,200 square feet. This value provides the basis for and equates to one ERU. Non-residential property owners are billed based on their measured impervious area divided by 3,200, which is then multiplied by the rate per ERU. Table E-2 shows the rate forecast per ERU over the forecast horizon.

TABLE E-2

Projection of Stormwater Operating Fund Revenue Requirements and Derivation of Monthly Rates per ERU

City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Gross revenues required from rates:						
Operations and maintenance expense:						
Personal services	$85,000	$154,862	$224,723	$233,564	$242,819	$252,511
Materials and services	$56,000	$78,563	$126,125	$129,909	$133,806	$137,821
Operating fund capital outlays - small works	$20,000	$17,500	$15,000	$15,450	$15,914	$16,391
Transfers to other funds	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Debt service	-	-	-	-	$456,589	$456,589
(Use)/Replacement of Operating Fund balance	-	-	-	-	-	-
Subtotal gross revenues required from rates	$190,000	$285,749	$406,499	$420,793	$892,254	$907,731
Revenue offsets to cost of service:						
Intergovernmental	-	-	-	-	-	-
Investment income	-	$2,700	$2,700	$2,700	$2,700	$2,700
Miscellaneous	-	-	-	-	-	-
Subtotal revenue offsets to cost of service	-	$2,700	$2,700	$2,700	$2,700	$2,700
Net revenues required from rates	$190,000	$283,049	$403,799	$418,093	$889,554	$905,031
Forecasted billable retail ERUs	6,100	6,900	7,650	7,688	7,726	7,765
Monthly rate based on revenue requirements	$2.59	$3.42	$4.40	$4.53	$9.59	$ 9.71

TABLE E-2
Projection of Stormwater Operating Fund Revenue Requirements and Derivation of Monthly Rates per ERU
City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	2016	2017	2018	2019	2020

For the budget year 2015, the rate analysis indicates a monthly SWM fee of $2.59 per ERU will be required to fund the program. That rate more than triples to $9.59 per ERU in fiscal year 2019 as the City embarks on the master plan capital improvement program.

Stormwater Rate Model Overview

The technical analysis contained in this master plan produced operations, maintenance, and capital improvement program activities and costs. This financial review assesses the impact of these costs on the City's SWM utility rates and SDCs. A funding model was developed as an electronic-spreadsheet-based (Excel) work product. This model simulates the fiscal management of the SWM utility and accommodates the following conditions:

- A 20-year forecast horizon (the current start year is fiscal year 2014–15)
- A Capital Projects Fund where capital improvement projects are budgeted
- A Stormwater SDC Fund where SDCs are budgeted
- An Operating Fund where revenues and expenses are budgeted
- Issuing and servicing debt to fund capital improvements
- Rate-making based on the revenue requirements for the utility during each forecast year

The model then calculates monthly user charges (rates) based on variable inputs for inflation, operating costs, customer base (i.e., number of ERUs) and capital improvements (either cash or debt funded). The model is designed as a single workbook with integrated spreadsheets that provide toggles for various input assumptions. These are summarized in Table E-3.

TABLE E-3
Model Dependent Variables
City of Dallas Stormwater Master Plan

Dependent Variable	User Inputs Required	Purpose
Financing assumptions	Type of debt financing to be used, term of indenture, interest rates, etc. In Dallas' case, the debt is through revenue bonds.	Debt sizing and servicing
Capital improvement projects and schedule	Project cost, description, year of implementation, CIP inflation rate.	CIP costing
Operating revenues and expenses	Start year budgeted revenues and expenses by line item, billable ERUs, general cost inflation index, projected growth in ERU (as a percent).	Cash flow and income statement for the utility
ERUs	Growth in ERUs through the planning period.	Forecast of estimating billable ERUs

Financial Planning Assumptions

Key modeling assumptions are as follows:

- 20-year revenue bonding at an interest rate of 4.5 percent

- A coverage factor of 1.25 times maximum annual debt service
- Level debt service
- An Operating Fund balance at no less than $500,000
- ERU growth of 0.50 percent per year
- Cost escalation generally at 3 percent with the exception of 2.5 percent for salaries, and 6 percent for fringe benefits

Model Outputs and Reports

The model has a series of standard reports which include:

- **Schedule of financing assumptions.** This report itemizes the user inputs that are required by the model to create debt issuances and bond proceeds that will be used to pay for capital improvements. It is always assumed that debt proceeds are only used to pay for capital improvement projects and related coverage, issuance, and reserve funding requirements. This disallows use of bond proceeds to fund the cost of operations and maintenance expenses. These costs are assumed to be funded through user charges (rates).

- **Debt sizing and servicing report**. This report itemizes the calculated amount of annual debt service for each forecast year. The analysis is based on the level of capital improvement spending in any forecast year and the revenue bond debt funding costs including principal, interest, coverage, and reserve funding requirements.

- **Listing of capital projects and construction fund activity**. This report itemizes the scheduled capital improvement projects over the planning period. The model adjusts project costs for the effects of inflation as future projects are scheduled for implementation. This report also tracks the activity within the capital projects fund for transfers, interest earnings on fund balance, and beginning and ending fund balances.

- **Schedule of revenue requirements and monthly rates**. The rate-making results are displayed in this report. The model uses two tests to solve for rates. The first is for the sufficiency of cash flows to fund operations and debt service. The second is a test of bonded debt coverage requirements. After solving for each of these tests in each forecast year, the model calculates a user charge that will be sufficient to fund the more stringent test.

- **Statement of revenues and expenses**. This report calculates the results of operations for each forecast year prior to rate adjustments. Based on a start-year level of operating revenues and expenses, the model forecasts the net utility income if revenues and expenses are incurred as projected based on inflation assumptions and customer base growth.

- **Debt service worksheet; revenue bonds.** This worksheet shows the debt servicing for revenue bonds by year and by issuance. The model assumes level debt service for all revenue bonds that are issued over the forecast horizon. The purpose of this report is to show the total debt service in any year, but also to see how much of the total service consists of interest and principal repayment.

Economic and Planning Assumptions for Dallas

The model assigns independent inflation factors for various categories of costs. The cost categories that have been developed are consistent with the chart of accounts currently used by the City for budgeting and financial reporting purposes. All of the inflation factors that have been inputted into the model have been vetted by City finance staff. These are noted in Table E-4.

TABLE E-4

Summary of Assumptions

City of Dallas Stormwater Master Plan

Fiscal Year Ended June 30 ...	2015	2016	2017	2018	2019	2020
Inflation Forecast:						
Personal services						
Salaries	Budget	2.50%	2.50%	2.50%	2.50%	2.50%
Overtime	Budget	2.50%	2.50%	2.50%	2.50%	2.50%
Fringe benefits	Budget	6.00%	6.00%	6.00%	6.00%	6.00%
Materials and services						
Materials and supplies	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
DEQ permits	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Vehicle/equipment expense	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Repairs and maintenance	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Material disposal	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Tools	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Telecommunications	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
HVAC, energy and lighting	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Computer services	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Insurance	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Professional services	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Employee development	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Safety equipment and training	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Travel and education	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Capital outlays	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Transfers to other funds	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Revenue Growth Forecast:						
Intergovernmental	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Transfers from other funds	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Investment income	Budget	0.54%	0.54%	0.54%	0.54%	0.54%
Miscellaneous	Budget	3.00%	3.00%	3.00%	3.00%	3.00%
Growth customer base	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Unit SWM SDC	$957	$1,141	$1,141	$1,141	$1,141	$1,141
ERU forecast:						
Estimated ERUs beginning	-	-	-	7,650	7,688	7,726
Annual additions	-	-	-	38	38	39
Estimated ERUs ending	6,100	6,900	7,650	7,688	7,726	7,765

System Development Charge Assumptions and Forecasted Cash Flows

The Stormwater SDC Fund receives revenues collected from the City's SDCs and, when required, transfers money to the Stormwater Capital Projects Fund to pay for that portion of the construction budget that includes oversizing to serve growth. Historically, annual revenues from SDCs have been very modest (e.g., $42,235 was collected in fiscal year 2012–13, and the City is estimating receipts for fiscal year 2013–14 at $30,000).

For this rate modeling effort, the project team has assumed the City's current SWM SDC of $957 per ERU will increase to $986 per ERU during the forecast horizon. If that assumption changes, up or down, the resulting change will be materially affected. For forecasting purposes, based on 0.50 percent per year growth, annual SDC revenues are expected to be about $40,000 per year (consistent with the City's current estimate for fiscal year 2013–14).

The base case forecast for the capital financing plan assumes the City will bond up to $5 million worth of projects in 5-year design and construction cycles, starting in fiscal year 2017. Cash in the Stormwater SDC Fund is transferred to the Stormwater Capital Projects fund to buy down those borrowing requirements on SDC eligible projects. The forecasted cash flows of the Stormwater SDC Fund are shown in Table E-1, above.

As the data in Table E-1 show, the City already accounts for stormwater SDC separately. Based on this accounting, the City is estimating an ending fund balance for this fiscal year (2014–15) of $114,027. Assuming a capital project funding need in fiscal year 2019, this balance and any future SDC receipts up to that date are reserved. Then, in fiscal year 2019, the model transfers all available SDC funds to the Stormwater Capital Projects Fund. As discussed above, the amount of stormwater SDCs available to support capacity-expanding projects is only a fraction of the total $5 million of projects that are planned to be funded from revenue bond proceeds.

Master Plan Capital Projects Financing Strategy

This master plan has concluded the City needs to fund approximately $38 million worth of SWM infrastructure reconditioning, replacement, and expansion projects over the 20-year planning horizon. To fund this level of costs, it became clear that significant use of debt will be required to:

- Deliver completed projects in a timely and economically efficient manner
- Keep user rates manageable and predictable

With these issues in mind, the base case capital projects financing plan assumes the City will not do one project at a time, and bond for each individual project identified in this master plan. Rather, a phased capital funding strategy has been adopted with the benefit of City staff input. This strategy assumes future capital projects will be prioritized in 5-year development packages valued at $5 million for each package. Over the 20-year forecast, this implies funding for $20 million worth of projects; not enough to fund the entire master plan capital projects list, but a very significant start toward achievement of that goal. Table E-5 lays out the cash flow implications of this funding strategy relative to the Stormwater Capital Projects Fund.

TABLE E-5

Analysis of Stormwater Capital Projects Fund Cash Flow

City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	2016	2017	2018	2019	2020
Resources:						
Beginning Fund Balance	-	-	-	-	-	$456,589
Revenues:	-	-	-			
Intergovernmental	-	-	-	-	-	-

TABLE E-5

Analysis of Stormwater Capital Projects Fund Cash Flow

City of Dallas Stormwater Master Plan

Investment income	-	-	-	-	-	$2,466
Contributions	-	-	-	-	-	-
Subtotal revenues	-	-	-	-	-	$2,466
Transfers from other funds - IN:						
Stormwater Operating Fund	-	-	-	-	-	-
Stormwater SDC Fund	-	-	-	-	$204,249	-
Subtotal transfers IN	-	-	-	-	$204,249	-
Bond proceeds:			-			
Interfund loans - General Fund	-	-	-	-	-	-
New revenue bonds - reserve requirement	-	-	-	-	$456,589	-
New revenue bonds - project funding	-	-	-	-	$5,423,295	-
Subtotal bond proceeds	-	-	-	-	$5,879,884	-
Total Resources	**-**	**-**	**-**	**-**	**$6,084,133**	**$459,054**
Requirements:						
Expenditures:						
Capital projects	-	-	-	-	$5,627,544	-
Transfers to other funds - OUT:			-			
General Fund	-	-	-	-	-	-
Community Development Fund	-	-	-	-	-	-
Subtotal transfers to other funds - OUT	-	-	-	-	-	-
Contingency	-	-	-	-	-	-
New revenue bonds - reserve requirement	-	-	-	-	$456,589	$456,589
Unappropriated ending fund balance	-	-	-	-		$2,466
Total Requirements	**-**	**-**	**-**	**-**	**$6,084,133**	**$459,054**

The key fiscal 2019 cash flow components shown in Table E-5 are inflows of stormwater SDCs in support of construction, revenue bond proceeds to fund the reserve account, and revenue bond proceeds to fund the balance of design and construction costs. These types of cash flows will repeat in forecast years 2024, 2029, and 2034.

Operations and Maintenance Funding Strategy

The financial heart and soul of a SWM utility, or any utility for that matter is the Operating Fund. All operating revenues (i.e., rates, fees, interest income, etc.) flow into this fund, and all costs of operations, maintenance, and debt service flow out of this fund. Since the City currently does not manage a SWM enterprise operating fund, we have created one in the model to test planning assumptions. A pro forma SWM utility budget has been prepared (in fiscal year 2014–15 dollars) that accounts for the operations and maintenance cost estimates that have been developed throughout this master planning effort.

Operating Fund Resources

The principal resources for the SWM Operating Fund are working capital, expressed as beginning fund balance and SWM rate revenues. For this modeling effort, the project team assumed the City will provide $500,000 of working capital to “kick start” the SWM Operating Fund via a cash transfer from the Sewer Operating Fund. The Sewer Operating Fund currently has an unencumbered fund balance of approximately $2 million. SWM rate revenue requirements will be solved for based on the operating needs of the utility, and carried forward in the forecast model.

Operating Fund Requirements

The City complies with Oregon budget law, and categorizes expenses in its enterprise funds within the following budget categories:

- **Personnel Services.** As the title implies, the personnel services budget category captures the cost of salaries, overtime, and fringe benefits. During the master planning effort, a SWM utility staffing plan was developed. That plan was crafted to achieve the goals of the Dallas TMDL Plan and the anticipated requirements of a future NPDES MS4 Phase II permit. It should be noted, this staffing complement would have to be achieved over a 20-year period. The plan called for the placing of 7.0 FTEs on the SWM utility payroll. This plan was modeled based on the City's current position control roster and cost structure. Based on midpoint of salary ranges and benefits afforded to full time employees, the total cost of that plan in 2015 dollars came to $521,641. The plan and resulting costs were reviewed with City staff, and were reduced to a total 2015 cost of $85,000. This modified cost became the starting point for the total personnel services budget in the SWM Operating Fund financial forecast.
- **Materials and Services.** This budget category captures the day to day costs of operating and maintaining the SWM program, with the exception of direct labor expenses. For modeling purposes, the project team analyzed the historical expenditure patterns of the City's water and sewer utilities to see if relationships could be made between materials and services expenditures and direct labor expenditures. This relationship is fairly common in the municipal utility industry, and in the case of Dallas, that ratio for both water and sewer services was roughly 45 percent. In other words, for every dollar that is spent on direct labor and benefits, 45¢ is expected to be spent on materials and supplies. For rate modeling purposes, the project team extended this cost relationship to the SWM utility and budgeted $56,000 for materials and supplies in the SWM Operating Fund for a starting point. This figure was arrived at through consultation with City staff.
- **Professional Services.** An additional line item in the materials and services budget category was added to the forecast for professional services. After consulting with City staff, it was felt a small annual budget appropriation of $25,000 (in 2015 dollars) should be added to the base case budget to account for on-call engineering services, GIS, and outside technical support starting in 2017.
- **Capital Outlays.** The preponderance of the capital funding activity for the SWM utility takes place in the SWM Capital Projects Fund (discussed in detail above). However, a small, but very beneficial amount of capital outlay happens in the SWM Operating Fund. Capitalized costs for small works, tools, and minor capital equipment are incurred in the day to day operations of a stormwater utility. The project team has included a starting budget for these capitalized costs at $20,000.
- **Transfers to Other Funds**. In Dallas, the General Fund provides services to the enterprise utilities in the form of payroll management, insurance, franchise fees, and supervision. The water and sewer funds transfer approximately 20 percent of their respective gross rate revenues to the General Fund in payment for these services. In consultation with City staff, it was agreed for the rate study to assume a new SWM utility would only transfer 15 percent of gross rate revenues to the General fund for overhead services. For the start year forecast, this amounted to $29,000. If this assumption changes, forecast results will change in a material way.
- **Debt Service**. Principal and interest payment on future revenue bond issuances are captured in this budget category, and become a requirement of SWM rates.

The impact of these revenue and expenditure assumptions on the pro forma cash flows in the SWM Operating fund are shown in Table E-6.

Analysis of Stormwater Management Revenue Requirements

This task calculates the revenue needed from rates. It is driven by utility cash flow or income requirements, constraints of bond covenants and specific fiscal policies related to the development, operation and maintenance of a “stand alone” SWM management utility. Based on cost and planning information discussed above, and shared with City Staff, the following forecast, displayed in Table E-7, of future stormwater revenue requirements was developed.

TABLE E-6

Analysis of Stormwater Operating Fund Cash Flow

City of Dallas Stormwater Master Plan

	Budget	Forecast				
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Resources:						
Beginning Fund Balance	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Revenues:						
Stormwater service charges	$190,000	$283,049	$403,799	$418,093	$889,554	$905,031
Stormwater hookup fees	-	-	-	-	-	-
Investment income	-	$2,700	$2,700	$2,700	$2,700	$2,700
Miscellaneous	-	-	-	-	-	-
Subtotal revenues	$190,000	$285,749	$406,499	$420,793	$892,254	$907,731
Total Resources	**$690,000**	**$785,749**	**$906,499**	**$920,793**	**$1,392,254**	**$1,407,731**
Requirements:						
Expenditures:						
Personnel Services:						
Salaries	$50,150	$91,396	$132,642	$135,958	$139,357	$142,840
Overtime	-	-	-	-	-	-
Fringe benefits	$34,850	$63,466	$92,082	$97,606	$103,463	$109,671
Total personnel services	$85,000	$154,862	$224,723	$233,564	$242,819	$252,511
Materials and Services:						
Materials and supplies	$56,000	$78,563	$101,125	$104,159	$107,284	$110,502
DEQ permits	-	-	-	-	-	-
Vehicle/equipment expense	-	-	-	-	-	-
Repairs and maintenance	-	-	-	-	-	-
Material Disposal	-	-	-	-	-	-
Tools	-	-	-	-	-	-
Telecommunications	-	-	-	-	-	-
HVAC, energy and lighting	-	-	-	-	-	-
Computer services	-	-	-	-	-	-
Insurance	-	-	-	-	-	-
Professional services			$25,000	$25,750	$26,523	$27,318
Employee development	-	-	-	-	-	-
Safety equipment and training	-	-	-	-	-	-
Travel and education	-	-	-	-	-	-
Materials and services - base line	$56,000	$78,563	$126,125	$129,909	$133,806	$137,821
Capital outlays - small works	$20,000	$17,500	$15,000	$15,450	$15,914	$16,391
Transfers to other funds - OUT						
General Fund	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Community Development Fund	-	-	-	-	-	-
Stormwater Capital Projects Fund - reserve for future projects	-	-	-	-	-	-
Stormwater Capital Projects Fund - overheads	-	-	-	-	-	-
Subtotal transfers to other funds	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Debt service:						
Oregon DEQ Revolving Loan	-	-	-	-	-	-
Revenue bonds	-	-			$456,589	$456,589
Subtotal debt service	-	-			$456,589	$456,589
Contingencies/Designations	$83,000					
Total fund expenditures	$273,000	$285,749	$406,499	$420,793	$892,254	$907,731
Unappropriated ending fund balance	$417,000	$500,000	$500,000	$500,000	$500,000	$500,000
Total Requirements	**$690,000**	**$785,749**	**$906,499**	**$920,793**	**$1,392,254**	**$1,407,731**

TABLE E-7

Projection of Stormwater Operating Fund Revenue Requirements

City of Dallas Stormwater Master Plan

Line Item Description	Budget 2015	Forecast 2016	2017	2018	2019	2020
Projection of Cash Flow:						
Revenues:						
Stormwater service charges	$190,000	$190,000	$283,049	$403,799	$418,093	$958,979
Stormwater hookup fees	-	-	-	-	-	-
Investment income	-	$2,700	$2,700	$2,700	$2,700	$2,700
Miscellaneous	-	-	-	-	-	-
Subtotal revenues	$190,000	$192,700	$285,749	$406,499	$420,793	$961,679
Expenditures:						
Operations and maintenance	$161,000	$250,924	$365,849	$378,923	$392,539	$406,723
Transfers to Other Funds	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Debt service	-	-	-	-	$456,589	$456,589
Use of Operating Fund balance	-	-	-	-	-	-
Subtotal expenditures	$190,000	$285,749	$406,499	$420,793	$892,254	$907,731
Net Cash	-	($93,049)	($120,749)	($14,294)	($471,461)	$53,949
Net Deficiency/(Surplus)	-	$93,049	$120,749	$14,294	$471,461	($53,949)
Test of Coverage Requirement:						
Operating Revenues:						
Stormwater service charges	$190,000	$190,000	$283,049	$403,799	$418,093	$958,979
Stormwater hookup fees	-	-	-	-	-	-
System Development Charges	$40,000	-	-	$43,643	$43,860	$44,077
Transfers (To) From Rate Stabilization Account	-	-	-	-	-	-
Total Operating Revenues	$230,000	$190,000	$283,049	$447,442	$461,953	$1,003,056
Operating Expenses:						
Operations & Maintenance Expense	$161,000	$250,924	$365,849	$378,923	$392,539	$406,723
Transfers to Other Funds	$29,000	$34,825	$40,650	$41,870	$43,126	$44,419
Total Operating Expenses	$190,000	$285,749	$406,499	$420,793	$435,665	$451,142
Net Operating Income	$40,000	($95,749)	($123,449)	$26,649	$26,288	$551,914
Nonoperating Income (Expense):						
Interest Income:						
Stormwater Operating Fund	-	$2,700	$2,700	$2,700	$2,700	$2,700
Stormwater Capital Projects Fund	-	-	-	-	-	$2,466
Stormwater SDC Fund	-	$616	$619	$622	$861	-
Other Nonoperating Income (expense)						
Miscellaneous	-	-	-	-	-	-
Total Nonoperating Income	-	$3,316	$3,319	$3,322	$3,561	$5,166
Total Net Revenues Available for Debt Service	$40,000	($92,434)	($120,130)	$29,971	$29,849	$557,080
Debt Service:						
Senior Lien Parity Obligations:						
Oregon DEQ Revolving Loan	-	-	-	-	-	-
New revenue bonds	-	-	-	-	$456,589	$456,589
Total Senior Lien Parity Obligations	-	-	-	-	$456,589	$456,589
Senior Lien Parity Obligations Coverage Recognized	NA	NA	NA	NA	0.07	1.22
Senior Lien Parity Obligations Coverage Required	1.25	1.25	1.25	1.25	1.25	1.25
Senior Lien Coverage Deficiency	-	-	-	-	$540,887	$13,656
Net Deficiency/(Surplus)	-	-	-	-	$540,887	$13,656
Projection of Revenue Sufficiency:						
Maximum Deficiency	-	$93,049	$120,749	$14,294	$540,887	$13,656
Percent Increase Required Over Current Rate Revenues	**0.00%**	**48.97%**	**42.66%**	**3.54%**	**129.37%**	**1.42%**
Stormwater rates reconciliation:						
Revenues recognized from current rates	$190,000	$190,000	$283,049	$403,799	$418,093	$958,979
Add revenues from rate increase	-	$93,049	$120,749	$14,294	$540,887	$13,656
Total revenues recognized from rate increase	$190,000	$283,049	$403,799	$418,093	$958,979	$972,636

Stormwater Management Rate Analysis

This SWM rate analysis assumes service charges reflect a rationale that those who contribute runoff to the stormwater system should proportionately contribute to the costs of providing services. This approach is now regarded by most administrators and the courts as an appropriate technique for financing stormwater programs. A basic assumption in this rate analysis is that services will continue to be billed on the basis of impervious surface. For single family residential property owners, the average amount of impervious area on a developed residential lot is assumed to be 3,200 square feet. This value provides the basis for and equates to one ERU. Non-residential property owners are billed based on their measured impervious area divided by 3,200, which is then multiplied by the rate per ERU. The base case forecast has assumed the percentage change in revenue requirements in any forecast year will be applied to the prior year’s rate to arrive at that year’s calculated rate per ERU. Table E-2, above, shows the rate forecast per ERU over the forecast horizon.

For the budget year 2015, the rate analysis indicates a monthly SWM fee of $2.59 per ERU will be required to fund the program. That rate more than triples to $9.59 per ERU in fiscal year 2019 as the City embarks on the master plan capital improvement program.

In the beginning of this section, it was pointed out that single family residential customers are currently paying about $2.57 per month for SWM services via their monthly sanitary sewer bill. If this monthly rate component were removed from the monthly sanitary sewer bill and transferred to the new monthly SWM bill, the forecasted monthly start year rate is effectively the same (i.e., $2.59 per ERU).

Stormwater Management Service Charge Credits

Implementation of a stormwater funding structure requires policy direction regarding whether specific classifications of property or uses of such property will qualify for service charge exemption or credit. The amount of a property's service charge must be linked to its proportionate share of stormwater program costs. Issues of equity or legal defensibility arise when exemption or credit policies move away from this utility rate-making premise. Service charges must be fair and reasonable and bear a substantial relationship to the cost of providing services and facilities.

Many basic policy decisions revolve around "who pays" when a stormwater service charge is applied to individual properties. The ERU approach is based on impervious area and would, therefore, exempt undeveloped properties which, by definition, do not have impervious area. If truly undeveloped, i.e., left in its natural state, it is difficult to include undeveloped land in a rate structure based on impervious area and contribution of runoff factors.

Most stormwater service charge structures do not consider property ownership in establishing rates. Instead, charges are based on property conditions/improvements that affect runoff in some manner. One exception is publicly owned properties where a variety of policies have been implemented. Some utilities apply stormwater service charges to public properties in the same manner as private properties. Others do not charge public properties because it is believed that the process only takes money from one City fund and transfers it to another. However, the method most often employed is to bill all public owned facilities (schools, city buildings, etc.) but exempt publicly owned streets. The logic supporting the exemption for streets is that they are designed and operated as part of the City's stormwater conveyance system.

Another question in the stormwater rate is exemption or reduction of the charge based on social issues of low income or elderly. No general rule has been set that enables service charge reductions based solely on ability to pay or age, making this issue one established by local policy. The stormwater charge should be consistent with the City's other rate structures.

The issue of tax-exempt properties being excluded from the service charge is legally straightforward. For the sake of maintaining consistency with legal requirements of service charges, the stormwater fee should be applied to properties owned by churches, non-profit agencies and others having tax exempt status.

Most stormwater utilities do provide for credits against service charges to recognize the effects of onsite detention, water quality mitigation, or other means of stormwater control. The proposed stormwater rate is related to each property's contribution of runoff to the system. The objective of a service charge credit system is to provide incentives for developers to meet or exceed stormwater quantity/quality requirements. The level of credit should reflect the reduced effect of a property with onsite controls compared with the effect of a similar property lacking this mitigation. The amount of reduction is a function of the service charge rate structure. Under the impervious surface approach, the credit results in a reduction of the equivalent units attributable to the property.

The next question is how much of the service charge should be made available for credit. The case for making the entire charge available for credit assumes that if the site totally retains stormwater runoff, that customer is not being served by any of the programs or services offered by the utility. However, because access to the property is available during storm events and those stormwater utility activities such as water quality management, channel maintenance, regulatory compliance, and public information continue to benefit all the City's customers, it is questionable whether any property is left totally unserved by the program. Based on this logic, it is generally accepted that some level of the fee remain in place regardless of the onsite facility constructed by the customer. The level of credit available is then a function of allocating program costs to "base" versus "use" factors. Base can be defined as program costs that are largely unaffected by stormwater flows. These typically include water quality management, regulatory compliance, and billing/administration. Use costs are those that are related to stormwater flow and may include budget categories such as maintenance and some capital improvements.

A final consideration deals with the calculation of the credit itself. There are a number of variations all of which revolve around the desired level of simplicity, equity, and administrative ease. At its simplest, a service charge credit is calculated as a percentage reduction based on the type of facility. A detention facility equals a certain percentage reduction; a retention facility another percentage; sumps another percentage. A higher level of accuracy is achieved when the calculation is based on a case by case comparison of pre- and post-development flows from the site.

A credit procedure does provide the City with the mechanism to establish rate incentives for upsizing or providing levels of treatment that go beyond the requirements established for the stormwater program. The City should consider enacting a credit resolution that specifically lays out the calculations of how the oversizing or other stormwater improvements on the property are translated into a reduction of the rate.

Appendix F
System Development Charge Methodology

APPENDIX F

System Development Charge Methodology

Introduction

For this SDC update, the City established a number of objectives:

- Review the basis for the SDCs to ensure a consistent methodology.
- Develop a reimbursement element of the SDC.
- Consider possible revisions to the structure or basis of the charge that might improve equity or proportionality to demand.

Resolution No. 3053 established the Stormwater SDC for the City. The intent of the City through this stormwater SDC is to ensure that each project contained in the stormwater master plan be evaluated in order to determine whether, or to what extent, each project is eligible to be included in the SDC cost base. The evaluation of these stormwater projects for SDC eligibility employed the following guidelines:

ORS 223 Requirements:

1. Capital improvements mean the facilities or assets used for stormwater management. This definition DOES NOT ALLOW costs for operation or routine maintenance of the improvements.
2. The SDC improvement fee shall consider the cost of projected capital improvements needed to increase the capacity of the stormwater system to accommodate future growth.
3. An increase in system capacity is established if a capital improvement increases the "level of performance or service" provided by existing facilities or provides new facilities in order to accommodate anticipated growth.

Under this approach, the following rules were followed:

1. Repair costs are not included.
2. Replacement costs will not be included unless the replacement includes an upsizing of stormwater system capacity.
3. Costs will not be included that bring deficient systems up to established standards.

For the purpose of this study, service charges and SDCs are based on measured impervious area. The average amount of impervious area on a single family residential developed lot within the City is set at 3,200 square feet. This equates to one ERU. Both rates and SDCs are calculated as a function of ERUs, meaning that each property's fee is calculated as follows: measured impervious surface/3,200 square feet = number of ERUs. The number of ERUs is then multiplied by the unit rate to determine the service charge or SDC amount.

The number of ERUs currently connected to the City's system is estimated to be 7,573, as established through master plan hydrologic modeling. Based on growth projections of 0.50 percent per year, the total number of ERUs within the UGB at the end of the forecast period will be 8,367. This reflects growth of 794 ERUs.

In developing an analysis of the improvement portion of the fee, each project in the City's capital improvement plan was reviewed for capacity expanding properties. Table F-1 shows the water quantity and quality improvements identified through the stormwater master plan project and allocates these costs proportionally by including the total stormwater customer base in the allocation. The project team concluded this approach was appropriate because the inventory of projects that have been identified serves both existing and future customers in proportion to their respective contributions to flows.

TABLE F-1

2014 Stormwater SDC Allocation of Stormwater Capital Improvement Projects to Existing and Future Customers

City of Dallas Stormwater Master Plan

Master Plan Project Description	Estimated Cost of Improvement in 2014 Dollars	Funding Source for Projects				
		Existing and Future Dallas Customers	**ODOT and/or Polk County**	**HBRR***	**Flood Control District**	**Developer Contributions or LIDs**
West Ellendale at Wyatt	$495,000	$495,000	-	-	-	-
Douglas Drainage	$755,000	$755,000	-	-	-	-
Kings Valley Highway/Highway 223 at the Cemetery	$131,000	$131,000	-	-	-	-
Rickreall Uglow/Orchard	$2,348,000	$2,348,000	-	-	-	-
Kings Valley Highway/Highway 223 at Bridlewood	$170,000	-	$170,000	-	-	-
North Fork Ash Creek	$10,000,000	$3,967,880	-	$833,572	$434,949	$4,763,600
Hunter Street	$209,000	$209,000	-	-	-	-
Growth Node: Wyatt	$896,000	$80,640	-	-	-	$815,360
Growth Node: La Creole	$1,112,000	$100,080	-	-	-	$1,011,920
Growth Node: Barberry	$1,308,000	$117,720	-	-	-	$1,190,280
Total	$17,424,000	$8,204,320	$170,000	$833,572	$434,949	$7,781,160

Total costs to be funded by current and future Dallas customers: **$8,204,320**

Estimated existing and future Equivalent Residential Units (ERUs): **8,367**

Calculated Storm Drainage Improvement Fee SDC per ERU: **$981**

*Highway Bridge Replacement and Rehabilitation Program; Section 144 of Title 23 USC; US DOT Federal Highway Administration.

The City requested that a reimbursement element of the stormwater SDC also be evaluated as part of this project. Based on the City's fixed asset schedule, the costs for existing stormwater facilities were identified. From this base all developer contributions and grant funded improvements were subtracted from that total as contributed capital not eligible for SDC reimbursement. No attempt was made to allocate specific assets to growth. Rather, the overall stormwater system assets (less contributed capital) provide capacity to new connections, the cost of which has been paid by the City and its ratepayers. These costs should be proportionately shared by new connections to the system. Therefore, the book value of stormwater system assets (less contributed capital and less depreciation) of $40,473 is divided by the total ERUs in the system (current and future) of 8,367 to derive the reimbursement SDC of $5. Table F-2 summarizes the elements of the proposed stormwater SDC.

TABLE F-2

Proposed Schedule of Stormwater Service Development Charges

City of Dallas Stormwater Master Plan

	$/ERU
Reimbursement	$5
Improvement	$981
Total	$986

Methodology

This update of Dallas' system development charges (SDC) for stormwater was done in conjunction with completion of the stormwater master plan. As part of this update process, issues related to the current stormwater SDC structure were addressed through the City's Finance and Public Works Departments. These groups, working with the CH2M HILL project team, established the proposed direction on the structure and calculation of the draft stormwater SDCs.

For this SDC update, the City established a number of objectives:

- Review the basis for the SDCs to ensure a consistent methodology
- Develop a reimbursement element of the SDC
- Consider possible revisions to the structure or basis of the charge that might improve equity or proportionality to demand

The City's current stormwater SDC is $957 per ERU. This SDC was established in 2004 via Resolution No. 3053. The sole basis for the SDC is future project costs allocated to growth, which in 2004 was valued at $4,605,000. The total cost of the growth/oversizing improvement cost was divided by the 2004 forecast of added impervious area from future urban development. That calculation was achieved by comparing 2004 estimated impervious area to land use and available acreage contained in the City's 1998 Comprehensive Plan (Tables 2.9 and 3.7). The acreage was adjusted by subtracting land developed between December 1998 and May 2004. Industrial impervious area from the 2004 UGB expansion that was pending at the time was added to the inventory. The calculated amount of the improvement fee SDC came to $8,697 per impervious acre. A cost per living unit (ERU) was calculated for residential customers based on Table 3.5 of the 1998 Comprehensive Plan. The SDC for commercial and industrial customers was calculated based on measured impervious area. The methodology for calculating the City's current SWM SDC is shown in Table F-3.

TABLE F-3
Methodology for Calculating City's Current SWM SDC
City of Dallas Stormwater Master Plan

	1998 Comp Plan Total Acres	(-) Developed Acreage as of May 2004	(+) 2004 UGB Expansion Acreage	(=) 2004 Acreage Available for Development	Runoff Coefficient (% Impervious)	Inventory of Future Impervious Area	Cost of Upsizing for Future Stormwater Projects	Upsizing Cost per Future Impervious Acre
Forecast of Future Impervious Area:								
Land Use Designation:								
Single Family Residential	1,104	205	-	899	40%	360		
Multi-Family Residential	24	5	-	19	70%	13		
Commercial/ Industrial	192	8	77	261	60%	157		
Total	1,320	218	77	1,179		530	$4,605,000	$8,697

	Inventory of Future Impervious Area	Cost of Upsizing for Future Stormwater Projects	Upsizing Cost per Future Impervious Acre	Net Upsizing Cost per Future Impervious Acre	Dwelling Units per Acre (per 1998 Comp Plan)	Improvement Fee SDC Per Dwelling Unit (ERU)
Forecast of Future Impervious Area:						

TABLE F-3

Methodology for Calculating City's Current SWM SDC

City of Dallas Stormwater Master Plan

Land Use Designation:						
Single Family Residential	360		$8,697	$3,479	4.3	812
Multi-Family Residential	13		$8,697	$6,088	14.3	427
Commercial/ Industrial	157		$8,697	$5,218	-	
Total	530	$4,605,000	$8,697			

The City requested that a reimbursement element of the stormwater SDC also be evaluated as part of this project. Based on the City's fixed asset schedule, the costs for existing stormwater facilities were identified. From this base, all developer contributions and grant funded improvements were subtracted from that total as contributed capital not eligible for SDC reimbursement. No attempt was made to allocate specific assets to growth. Rather, the overall stormwater system assets (less contributed capital) provide capacity to new connections, the cost of which has been paid by the City and its ratepayers. These costs should be proportionately shared by new connections to the system. Therefore, the book value of stormwater system assets (less contributed capital and less depreciation) of $40,473 is divided by the total ERUs in the system (current and future) of 8,367 to derive the reimbursement SDC of $5. Table F-2 above summarizes the elements of the proposed stormwater SDC.

Statutory Requirements

Resolution No. 3053 established the Stormwater SDC for the City. The intent of the City through this stormwater SDC is to ensure that each project contained in the stormwater master plan be evaluated in order to determine whether or to what extent each project is eligible to be included in the SDC cost base. The evaluation of these stormwater projects for SDC eligibility employed the following guidelines:

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13.1.1.1 System Development Charge Structure

Under ORS 223.297-.314, there are two elements to an SDC: reimbursement fee and improvement fee. These are described separately below.

The reimbursement fee considers the cost of existing facilities, prior contributions by existing users of those facilities, the value of the unused/available capacity, and generally accepted rate-making principles. The objective is that "future system users contribute no more than an equitable share to the cost of existing facilities." The calculation of the reimbursement fee is based on the original cost of stormwater system facilities identified in the City's fixed asset schedule. An original cost base better reflects the fact that most stormwater infrastructure is not mechanical in nature and prone to the same level of depreciation as are water and sewer systems. Any outstanding principal on debt for these facilities has been removed to more accurately reflect the actual investment made by the City and its stormwater customers. Accordingly, any grant-funded facility costs were also removed from the reimbursement fee calculation. The calculations used to arrive at the stormwater reimbursement fee SDC are shown in Table F-3.

TABLE F-3
2014 Stormwater SDC Reimbursement Fee Calculations
Financial Data as of Fiscal Year Ended June 30, 2014
City of Dallas Stormwater Master Plan

	Item	Value
Utility Plant-in-Service (original cost):*		
160	Land	-
162	Infrastructure	$44,476
164	Machinery and equipment	-
165	Auto & trucks	-
176	Construction Work-in-Progress	-
	Total Utility Plant-in-Service	$44,476
Accumulated depreciation*		
160	Land	-
162	Infrastructure	$4,003
164	Machinery and equipment	-
165	Auto & trucks	-
176	Construction Work-in-Progress	-
	Total accumulated depreciation	$4,003
Book value of culinary storm drainage utility plant-in-service @ June 30, 2011		40,473
Eliminating entries:		
	Principal outstanding on bonds, notes, and loans payable	-
	Developer Contributions	-
	Grants, net of amortization	-
	Total eliminating entries	-
Net basis in utility plant-in-service available to serve future customers		$40,473
Estimated existing and future Equivalent Residential Units (ERUs)		8,367

TABLE F-3
2014 Stormwater SDC Reimbursement Fee Calculations
Financial Data as of Fiscal Year Ended June 30, 2014
City of Dallas Stormwater Master Plan

Item	Value
Calculated reimbursement fee - $/ERU	$5

*Source: Dallas records.

The improvement fee is based on the cost of planned future facilities that expand the stormwater system's capacity or increase its level of performance to accommodate growth. In developing an analysis of the improvement portion of the fee, each project in the City's capital improvement plan was reviewed for capacity expanding properties. Table F-1 above shows the water quantity and quality improvements identified through the stormwater master plan project and allocates these costs proportionally by including the total stormwater customer base in the allocation. The project team concluded that this approach was appropriate because the inventory of projects that have been identified serve both existing and future customers in proportion to their respective contributions to flows.