



# STORMWATER MODELING REPORT WEST DRAW SUBWATERSHED



*Stormwater Pond in Highland Hills*



*Hamlet Park Pond*



*70<sup>th</sup> and Hardwood*

## WEST DRAW SUBWATERSHED SOUTH WASHINGTON WATERSHED DISTRICT

**JULY 2005**

**HDR**

# **STORMWATER MODELING REPORT WEST DRAW SUBWATERSHED**

**SOUTH WASHINGTON  
WATERSHED DISTRICT**



**July 2005**

*Prepared by:*

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**TABLE OF CONTENTS**

**1.0 INTRODUCTION..... 1**

**2.0 SUMMARY OF ACTIVITIES ..... 3**

**2.1 GIS/MODEL DATA DEVELOPMENT..... 4**

**2.2 MODEL HISTORY ..... 4**

**2.3 MODEL ERROR..... 5**

**3.0 PROJECT OVERVIEW ..... 6**

**3.1 INTER-COMMUNITY FLOW EVALUATION..... 6**

**3.2 CRITICAL FLOODING LOCATIONS..... 9**

**3.3 HIGHWAY 61 FLOODING ISSUES ..... 10**

**3.4 DESIGN STANDARD EVALUATION..... 14**

**3.5 ULTIMATE DEVELOPMENT REVIEWS..... 14**

**APPENDIX**

Appendix A List of Development Plans Used to Create the West Draw Model..... 16

Appendix B Detailed Model Output Maps and Table for the West Draw Watershed..... 24

**LIST OF FIGURES**

Figure 1 West Draw Subwatershed Map..... 2

Figure 2 Inter-Community Flow ..... 8

Figure 3 Storage and Ponding Locations ..... 12

Figure 4 Critical Flooding Areas..... 13

**PICTURES**

Picture 1 70<sup>th</sup> and Hardwood..... 9

Picture 2 Hamlet Park Pond ..... 11

**ACRONYMS AND SHORT FORMS**

<b>BMP</b>	Best Management Practices
<b>BRA</b>	Boonestro, Rosene, Anderlik & Associates
<b>CSAH</b>	County State Aid Highway
<b>DNR</b>	Department of Natural Resources
<b>DSS</b>	Decision Support System
<b>DTM</b>	Digital Terrain Model
<b>EOR</b>	Emmons & Olivier Resources, Inc.
<b>GIS</b>	Geographic Information System
<b>GPS</b>	Global Positioning System
<b>LOS</b>	Level of Service
<b>MnDOT</b>	Minnesota Department of Transportation
<b>NGVD</b>	National Geodetic Vertical Datum
<b>SCS</b>	Soil Conservation Service
<b>SWWD</b>	South Washington Watershed District
<b>TH</b>	Trunk Highway
<b>TKDA</b>	Toltz, King, Duvall, Anderson and Associates, Inc.



## 1.0 INTRODUCTION

The South Washington Watershed District (SWWD) initiated a study of the West Draw Subwatershed (Figure 1) to quantify the flood risk and identify potential solutions to minimize flood damage potential. The study was initiated in 2004 at the request of the Cities of Cottage Grove and Woodbury. The West Draw Subwatershed is undergoing active suburban development. The SWWD plan contained inter-community flow values based upon municipal drainage plans. The purpose of the present study was to establish the existing drainage patterns and evaluate the inter-community flow values based upon the as-built condition and currently planned projects. Of particular importance to the communities is inter-community flow between Woodbury and Cottage Grove, required storage volumes to achieve the flow, and the downstream drainage concerns at Hamlet Park Pond (WTG-P2) and Highway 61.

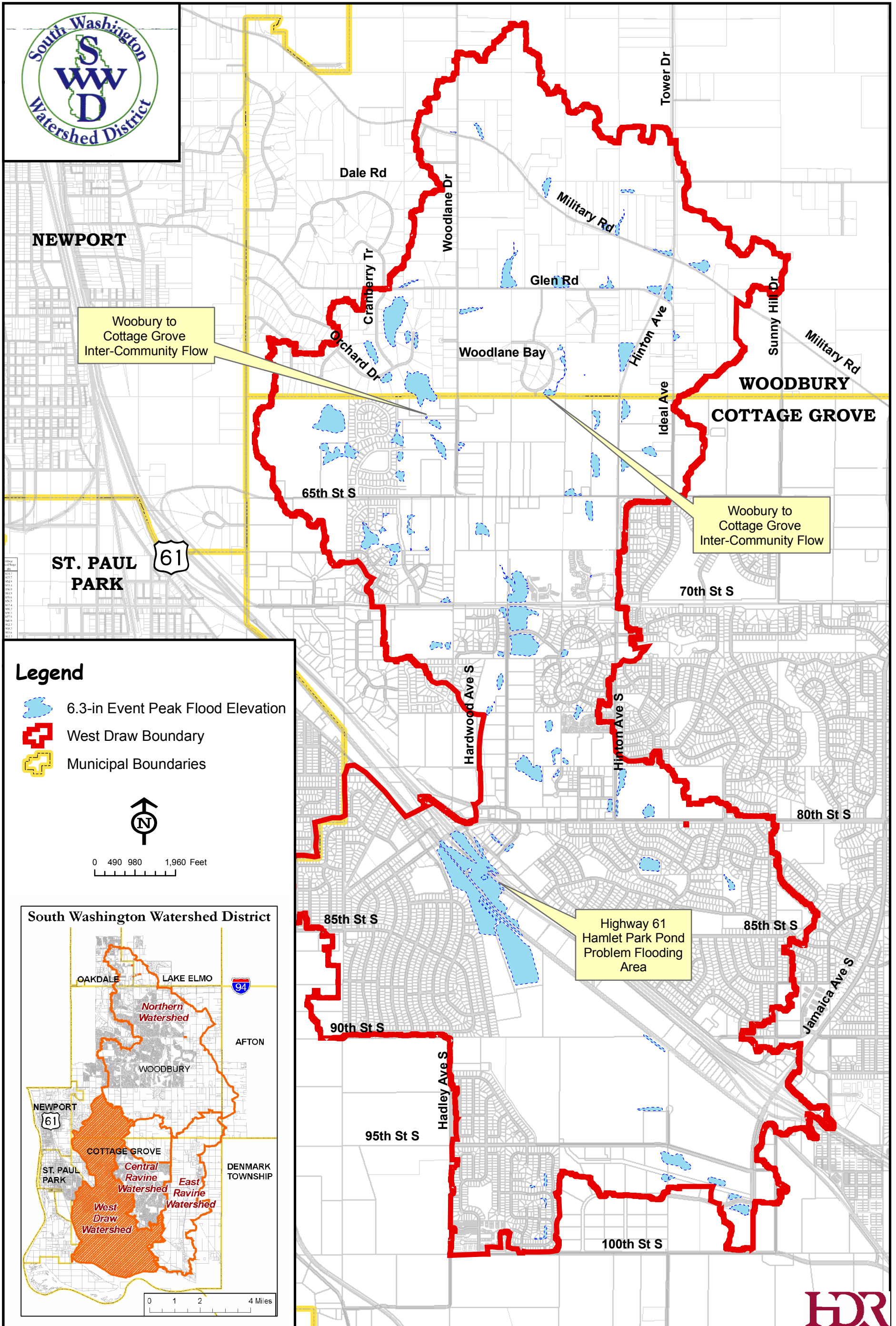


Figure 1- Overview Map, West Draw Subwatershed, South Washington Watershed District, Washington County, MN.



## 2.0 SUMMARY OF ACTIVITIES

The analysis of the current hydrologic and hydraulic conditions for the West Draw Subwatershed consisted of the following:

- Creating a Geographic Information System-based (GIS) hydrologic/hydraulic model of the West Draw Subwatershed using input data such as existing as-built information, year 2000 Washington County 2-foot topography/aerial photography National Geodetic Vertical Datum of 1929 (NGVD), year 2003 Farm Service Agency (FSA) 1-meter aerial photography, detailed structure surveys, information provided by the communities, and grading plans for developments.
- Identifying subwatersheds that have a significant hydrologic/hydraulic contribution to the West Draw Drainage System.
- Identifying locations where flooding poses a potential hazard to homes and property.
- Preparation of report.

The base model for the West Draw Subwatershed was created using existing as-built information, the 2000 Washington County 2-foot topography, 2003 FSA aerial photography, and field site specific elevation and location surveys conducted by a professional surveyor. A complete GIS database was generated to track the source data and create a metadata file. A complete copy of all source data used in the analysis is available from the SWWD.

The SWWD chose to utilize the hydrologic and hydraulic model XP-SWMM version number 9.5 to develop the hydrologic and hydraulic information necessary for this report. The non-linear reservoir method in XP-SWMM was used to estimate the runoff hydrographs from the land surface. These resultant hydrographs were then routed through the drainage system's network of ponds, pipes and channels using the EXTRAN block of XP-SWMM. A complete list of modeling parameters is provided in the "Engineer's Report for the Central Draw Project and Flood Storage Area Maps, June 2002" (June 2002 Engineer's Report).



## 2.1 GIS/MODEL DATA DEVELOPMENT

Data related to hydraulic structures was collected by HDR Engineering, Inc (HDR) between October 2004 and March 2005. All available as-built information was collected from the City of Cottage Grove and Woodbury. Gaps in the as-built information were determined and supplemented with site visits by HDR and a survey by Foltz, Freeman, Erickson, Inc. (FFE). In instances where as-built information was not available or where there were areas with complicated outlet structures, digital photos were taken for subsequent inclusion in the GIS Database as supporting documentation. The following summarizes the data sources for the West Draw modeling effort:

- Foltz, Freeman, Erickson, Inc., Total Stations/Global Positioning System (GPS) Survey, February 2005.
- Minnesota Department of Transportation (Mn/DOT) Project 8205-65 (—T.H. 61) Plan Sheets, May, 1985.
- Minnesota Department of Transportation (Mn/DOT) Project 82-613-07 (Washington County CSAH 13) Plan Sheets, March, 2003.
- Development Plan Sheets Throughout West Draw Area (Appendix A)
- 2000 Washington County 2-foot Contour Maps.
- 2003 FSA 1-Meter Color Aerial Photography.
- Bonestroo, Rosene Anderlik, and Associates WD-P19 and WD-P30 Hydrologic Study, HydroCAD Model , 2/25/04.
- City of Cottage Grove Surface Water Management Plan, Surface Water System, Map 1, 6/15/2000.

## 2.2 MODEL HISTORY

The existing condition was newly created for this project. The following is a list of major activities and steps taken during the model construction process.

- Evaluated the model provided by the City of Cottage Grove.
- Setup a model background in GIS.



- Created DTM based on the 2-ft topographic information.
- Used special analyst and ArcHydro to develop initial watershed boundaries.
- Collected from Cottage Grove city offices copies of all storm sewer as-builts within the West Draw Subwatershed and added them to the database.
- Performed a field visit to verify structures and the drainage patterns.
- Checked and refined watershed boundaries and made adjustments based on field visits and information on new developments.
- Developed the infrastructure data base including pipes, structures, and storage locations.

In all instances the 24-hour, 100-year, 6.3-inch precipitation event was used by HDR as the Design Storm based on the Huff and Angel rainfall data utilized in the June 2002 Engineer's Report.

### **2.3 MODEL ERROR**

The overall continuity error of the final model is 10.1 acre-feet (ac-ft) net gain of water. This represents 8.2 percent of the total inflow to the model. The error occurs due to calculation errors at landlocked basins. Many of the landlocked basins and storage nodes experience periods of zero outflow prior to the water surface elevation reaching the outlet elevation. During this period a continuity error accumulates for each time step, contributing a major portion of the overall continuity error. For the purposes of this analysis, overall model continuity error is considered reasonable per accepted engineering practices.



### 3.0 PROJECT OVERVIEW

The West Draw stormwater model study analyzed the rate, volume and timing of stormwater discharges into and through the West Draw Drainage system from its tributaries. The project addressed the following issues:

- Evaluation of the inter-community flow situation: timing, rate and volume
- Identification of existing critical storage areas in both communities
- Evaluation of existing design standards to determine their adequacy for future growth
- Confirmation and evaluation of flooding issues at Hwy 61
- Identification of other critical locations in the watershed in terms of flooding potential
- Creation of a management tool for evaluating the impact of new developments and the ultimate development of a stormwater management plan
- Maps showing detailed modeling results are presenting in Appendix B

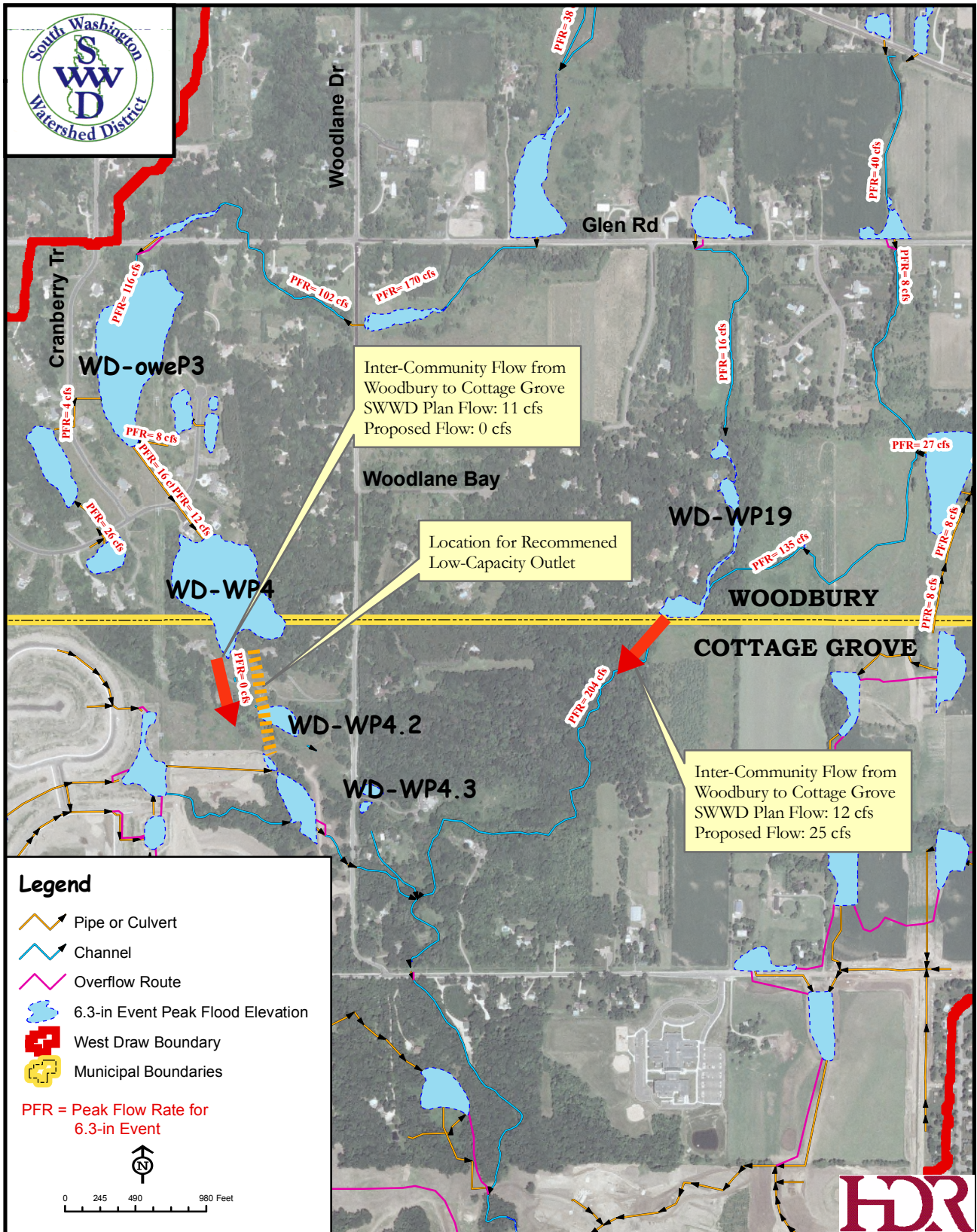
#### 3.1 INTER-COMMUNITY FLOW EVALUATION

The SWWD Plan identified inter-community flow at two locations, as shown in Table VI-1 contained in the SWWD plan. The total flow amounted to a maximum inter-community flow of 23 cfs from Woodbury into Cottage Grove for a 6-inch 24-hour 100-year event. The respective flow values and hydrographs were used by Cottage Grove as the basis of the design for their trunk storm sewer system. Therefore, one aspect of this project was to evaluate the inter-community flow values and the impact of a change of those values on each community's drainage system. The modeling results show that the west tributary of the West Draw in Woodbury has sufficient storage volume to completely retain the 6.3-inch 100-year event without discharging stormwater into the Cottage Grove system. The critical storage areas and structures in this area are basins WD-oweP3 and WD-WP4 (Figure 2). An important assumption that was made in the analysis is that basin WD-WP4 begins the storm with 171.5 ac-ft of storage available below its normal outlet. This assumption was based upon several factors. These include eyewitness accounts by property owners regarding the lack of water observed in the



storage area, the type of vegetation growing in the location indicating that it is not a wetland, soil conditions, and observations of a lack of water by Woodbury public works staff. Woodbury staff have concurred with this assumption and are satisfied that the west tributary of the West Draw can be managed as a zero discharge system during the design event. Given the landlocked nature of this system, a low capacity gated gravity outlet or pump system is recommended to be included in the SWWD plan from basin WD-WP4 to WD-WP4-2, to allow for drawdown between storm events, provided capacity is available in the downstream system.

In the community drainage plans, the west tributary and east tributary discharges occurred over nearly the same time frames. Therefore, the communities agreed to allocate the 11 cfs, previously allocated to the west tributary, to the east tributary flows. Under existing conditions, the modeling predicts over 200 cfs discharging from Woodbury to Cottage Grove in the east tributary. The ultimate condition flow from the east tributary into Cottage Grove would need to be restricted to 25 cfs in order to match the design of the Cottage Grove system. The modeling confirmed that the transfer of peak flow capacity is within the design assumptions of the downstream City of Cottage Grove drainage system. In order to accomplish a 25 cfs discharge at the City boundary, Woodbury will need to establish approximately 40 ac-ft of additional storage in the east tributary near the location of where the flow crosses the city boundary. The City of Woodbury will be responsible for determining the exact location and nature the proposed storage locations. It should be noted that until the storage and control structures are implemented, there is a short-term risk of higher than assumed discharges entering the downstream Cottage Grove drainage system.



**Figure 2- Location of Inter-Community Flow between Woodbury and Cottage Grove, West Draw Subwatershed, South Washington Watershed District, Washington County, MN.**



### 3.2 CRITICAL FLOODING LOCATIONS

The storage locations consisting of natural depressions and constructed stormwater ponds within the West Draw Watershed are shown in Figure 3. Figure 4 shows a closer view of some of the critical flooding areas and storage opportunities within the West Draw Watershed. As expected, most of the urban streets in Cottage Grove within the watershed have overland flow as the 6.3 inch event overwhelms the existing storm sewer system.

As with many of the stormwater ponds installed within residential developments, the ponds proposed within the Pinecroft development cannot attenuate the 6.3-inch 24-hour event. Hence the model results indicate that the ponds overtop and flow into the County State Aid Highway (CSAH) 13 MnDOT pond. The MnDOT pond then overtops causing an overflow of 86 cfs which can potentially flood the existing residential streets downstream. (Figure 4). This overflow, as shown in Figure 4, ultimately ends up at the regional pond (WD-P32.1) north of 70<sup>th</sup> street. This pond is connected to two subsequent ponds that the model shows is operating at maximum capacity during the peak period of the storm. Pond WD-P36.1 overflows along Hardwood Avenue into the wide ditch on the east side of the road. Similarly, the storm water pond associated with the Auburn Woods area has a flashy overflow of about 50-cfs during the event.

**PICTURE 1  
70<sup>TH</sup> AND HARDWOOD**





Based on modeling results, this roadside ditch has additional capacity for storage along with pond WD-P38.3 which is further south along the system, which can be used to alleviate the critical flooding locations discussed above. Also, there are multiple locations within the Woodbury section of the West Draw Watershed that have potential capacity to store additional water. Use of this storage capacity is previously discussed in the Inter-Community Flow section of this report.

The flooding at Hamlet Park Pond and Highway 61 is discussed in the next section.

### **3.3 HIGHWAY 61 FLOODING ISSUES**

A major portion of the West Draw Watershed flows through Cottage Grove and crosses Hwy 61 at the 80<sup>th</sup> Street intersection. The pipe crossing HWY 61 is a 62- to 72-inch concrete pipe outletting into Hamlet Park Pond (Picture 2).

The peak elevation at Hamlet Park Pond reaches 788 ft, for the 6.3-inch event, which causes back flow in the 72-inch pipe and reduces maximum capacity to 60 cfs. The initial backflow and the reduction in flow capacity result in approximately 1.5 ft of flooding at the low point of the highway. The low point of Hwy 61 is 786.5 ft. The flooding extends along a significant section of the highway. As the existing 30-inch outlet to Hamlet Park Pond does not draw down the pond rapidly, the highway remains flooded for approximately 10 days.

The model was also run to simulate a 5.9-inch 24-hour event. The peak elevation at Hamlet Park Pond is similar at 788 ft, but the duration of flooding reduces to eight days. The highway flooding remains similar to the 6.3-inch event with a reduction in duration of flooding.

**PICTURE 2  
HAMLET PARK POND**



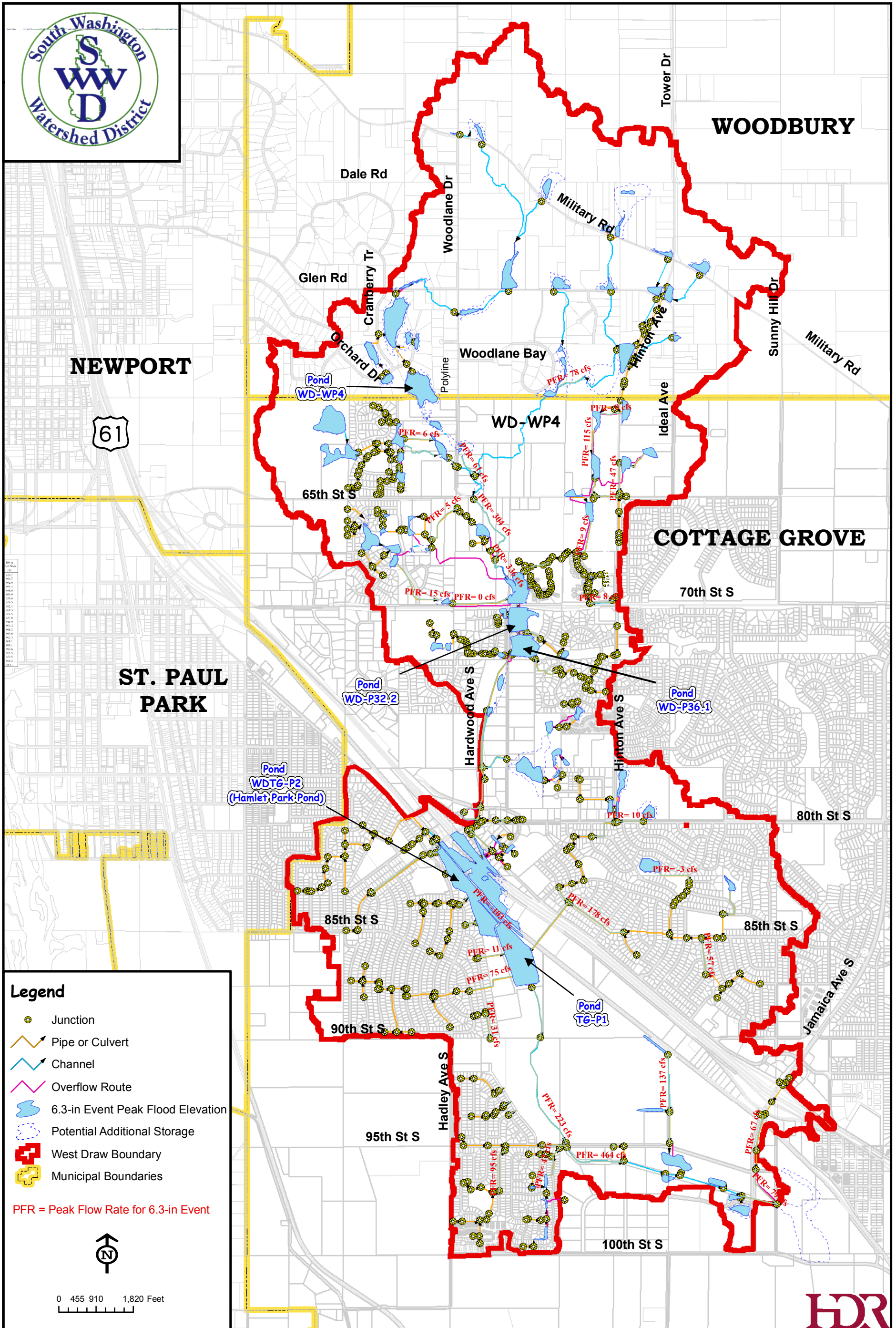


Figure 3- Flooding Areas Versus Storage Capacity, West Draw Subwatershed, South Washington Watershed District, Washington County, MN.

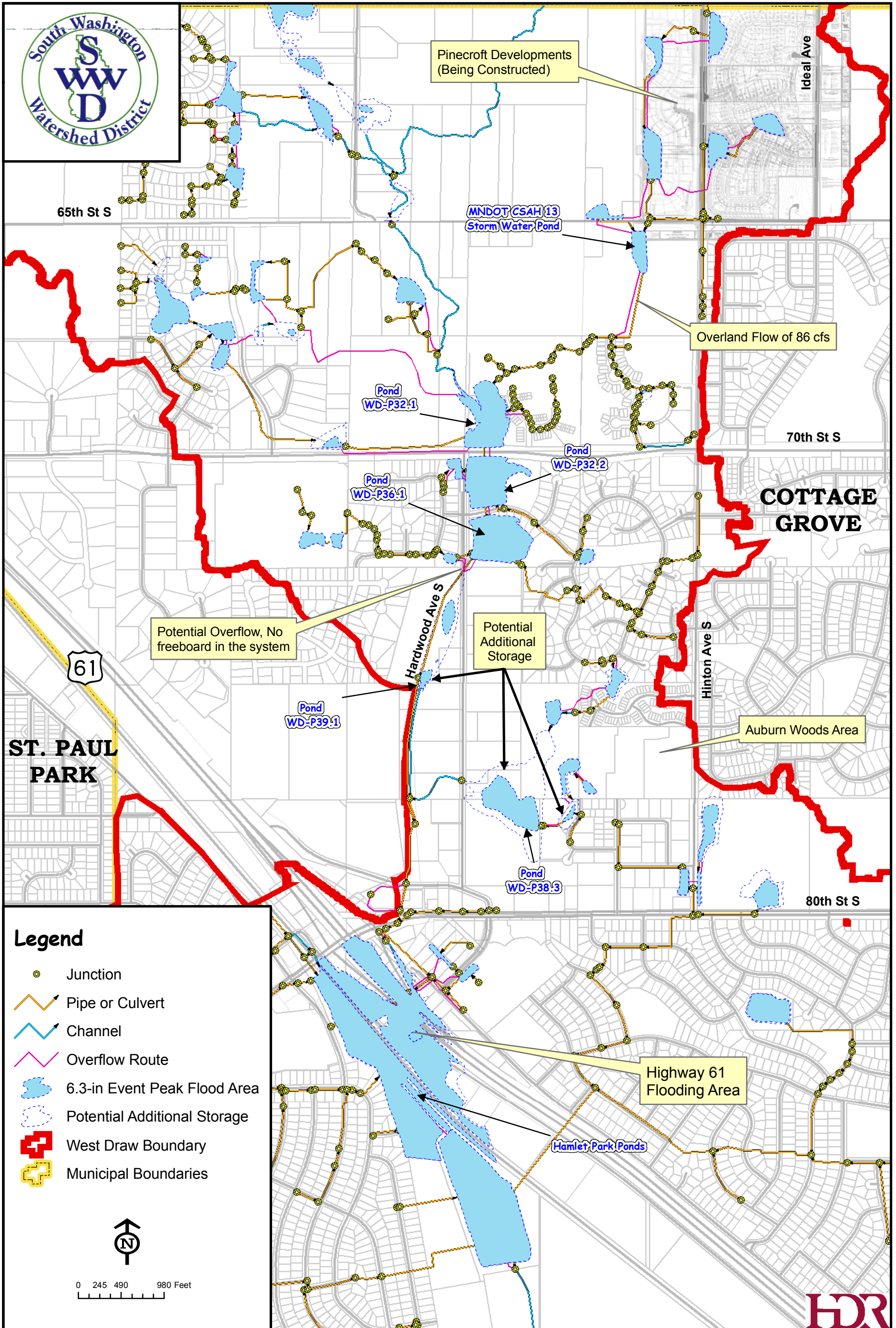


Figure 4- Critical Flooding Areas, West Draw Subwatershed, South Washington Watershed District, Washington County, MN.



### **3.4 DESIGN STANDARD EVALUATION**

The West Draw's Drainage system has been constructed by following a coordinated stormwater management plan between the cities of Woodbury and Cottage Grove. The majority of the system functions as intended and achieves a level of services that is customary for suburban systems. Areas of concern are identified in Section 3.2 and Section 3.3. Recommendations for review and construction of the ultimate development system are discussed in Section 3.5.

### **3.5 ULTIMATE DEVELOPMENT REVIEWS**

The SWWD has conducted detailed stormwater modeling of the majority of the SWWD Drainage systems. As found in the West Draw, the majority of the drainage system functions as intended and the flood risk is low.

The original stormwater planning conducted by Cottage Grove and Woodbury utilized graphical and mass balance methods that seem to have under predicted the impact of peak flow, volume and timing at storage locations along major trunk lines in the drainage system. The benefit of XP-SWMM modeling has been the identification of critical locations prior to ultimate development which provides opportunity to adjust the community drainage plans and design standards.

HDR recommends that as new developments or regional ponding is developed that it be incorporated in the SWWD's model for the purpose of optimizing the design. This application of the model has proved beneficial in the Wilmes Subwatershed. The principal issue in the West Draw is to closely evaluate the timing and volume of the runoff. Other than the potential for flooding at Hwy 61 and Hamlet Park Pond, there does not appear to be any significant corrective actions required for the West Draw Watershed. HDR would recommend further evaluation of the opportunities and benefits of utilizing the potential additional storage identified in Figure 4.



**APPENDIX A  
LIST OF DEVELOPMENT PLANS  
USED TO CREATE THE WEST DRAW MODEL**



**LIST OF DEVELOPMENT PLANS  
USED TO CREATE THE WEST DRAW MODEL**

Title	Project #	Designer/Engineer	Stamp Date
<b>1994 - 95TH STREET SOUTH, PHASE 2</b>	4831? M.S.A.P. 180- 111-02 Section #20 95005 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	8/14/95
<b>AUBURN WOODS UTILITIES IMPROVEMENTS PROJECT 1994</b>	48326 Section #8 94001 Reg. No. 22785	Bonestroo Rosene Anderlik & Associates	5/25/94
<b>CANADIAN PACIFIC RAILWAY</b>	Commission No. 1194701	TKDA	3/10/00
<b>COTTAGE GROVE ESTATES UTILITY AND STREET IMPROVEMENTS 1989</b>	48228 Section #20 89022 Reg. No. 6971	Bonestroo Rosene Anderlik & Associates	6/14/89
<b>GATEWAY STORM SEWER IMPROVEMENTS UTILITY IMPROVEMENT PROJECT</b>	48-02-171 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	
<b>GATEWAY UTILITY REHABILITATION PHASE 1 - SANITARY SEWER RELOCATION 2002</b>	48-01-157 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	7/11/02
<b>GLENGROVE INDUSTRIAL PARK 2001 IMPROVEMENTS</b>	48-00-123 Reg. No. 40503	Bonestroo Rosene Anderlik & Associates	3/20/01



Title	Project #	Designer/Engineer	Stamp Date
GROVE PLAZA PHASE III STREET AND STORM UTILITY IMPROVEMENTS 2002	48-01-146 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	2/27/02
GROVE PLAZA UTILITY IMPROVEMENTS 2001	48-01-146 Reg. No. 40503	Bonestroo Rosene Anderlik & Associates	10/18/01
HADLEY AVENUE SOUTH GRANGE BOULEVARD TO 90TH STREET SOUTH	4800137 S.A.P. 180-107-003 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	3/21/02
HAMLET AVENUE SOUTH UTILITY AND STREET IMPROVEMENTS PROJECT 1996	48393 Section #20 96008 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	8/21/96
HARDWOOD AVENUE CORRIDOR IMPROVEMENTS UTILITY, STREET AND STREET IMPROVEMENTS STORM SEWER	M.S.A.P. 180-112-07 48-01-148 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	
HIDDEN VALLEY 10TH ADDITION UTILITY, STREET, & STREET LIGHTING IMPROVEMENTS 2001	48-01-143 Reg. No. 40503	Bonestroo Rosene Anderlik & Associates	6/12/01
HIDDEN VALLEY 11TH ADDITION UTILITY, STREET & STREET LIGHTING IMPROVEMENTS 2003		Bonestroo Rosene Anderlik & Associates	
HIDDEN VALLEY 4TH ADDITION UTILITY AND STREET IMPROVEMENT PROJECTS 1993	48291 Section #8 93002 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	6/16/93



Title	Project #	Designer/Engineer	Stamp Date
<b>HIDDEN VALLEY 5TH &amp; 6TH ADDITIONS UTILITY AND STREET IMPROVEMENTS PROJECT 1994</b>	48338 Section #8 94003 Reg. No. 22785	Bonestroo Rosene Anderlik & Associates	5/25/94
<b>HIDDEN VALLEY 7TH ADDITION UTILITY, STREET, &amp; STREET LIGHTING IMPROVEMENTS 1998</b>	48-98-407 Section #8 98104 Reg. No. 25799	Bonestroo Rosene Anderlik & Associates	9/9/98
<b>HIDDEN VALLEY 9TH ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2000</b>	48-00-127 Section 8 C.P.00104 Reg. No. 25799	Bonestroo Rosene Anderlik & Associates	7/19/00
<b>HIDDEN VALLEY ADDITION SEWER &amp; WATER EXTENSIONS 1986</b>	48162 Section #8 86003 Reg. No. 6911	Bonestroo Rosene Anderlik & Associates	6/4/86
<b>HIGHLAND HILLS ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2002</b>	4802167 Lic. No. 25799	Bonestroo Rosene Anderlik & Associates	4/27/02



Title	Project #	Designer/Engineer	Stamp Date
<b>HINTON HEIGHTS FIRST ADDITION STREET, UTILITY IMPROVEMENTS 1979</b>	Section #8 79001 Reg. No. 4602	Bonestroo Rosene Anderlik & Associates	10/17/79
<b>INDUSTRIAL PARK UTILITY RELOCATION 2000</b>	48-98-372		
<b>MEADOW ACRES UTILITY AND STREET IMPROVEMENTS PROJECT 1993</b>	48299 Section #20 93011 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	4/7/93
<b>MEADOW ACRES UTILITY AND STREET IMPROVEMENTS PROJECT 1993</b>	48299 Section #20 93010 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	4/7/93
<b>MINNESOTA TIMBER RIDGE 6TH ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2004</b>	City Proj. #04109 Proj. # 48-03- 185 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	
<b>MISSISSIPPI DUNES ADDITION, PHASE 1 UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2003</b>	City Proj. #02110 Proj. #48-02- 172 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	7/17/03
<b>NON STORM-SEWER DESIGN STORM SEWER SCHEDULE-THOMPSON GROVE RECONSTRUCT</b>	4800137 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	2/1/02



Title	Project #	Designer/Engineer	Stamp Date
<b>OAKWOOD HEIGHTS 3RD ADDITION WATER AND SEWER EXTENSIONS 1985</b>	48154 Section #8 85001 Reg. No. 6971	Bonestroo Rosene Anderlik & Associates	8/21/85
<b>PINE ARBOR 1ST ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2003</b>	City Proj. #01110 Proj. #48-01-151 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	5/16/03
<b>PINE GLEN 2ND ADD. UTILITY AND STREET IMPROVEMENTS PROJECT 1994</b>	48325 Section #20 94008 Reg. No. 22785	Bonestroo Rosene Anderlik & Associates	5/25/94
<b>PINE GLEN 3RD ADD. UTILITY AND STREET IMPROVEMENTS PROJECT 1995</b>	Section #20 95008	Bonestroo Rosene Anderlik & Associates	
<b>PINE GLEN 7TH ADDITION UTILITY IMPROVEMENTS AND HAMLET AVENUE SOUTH &amp; 98TH STREET SOUTH STREET IMPROVEMENTS 1999</b>	Section #20 99104	Bonestroo Rosene Anderlik & Associates	
<b>PINE GLEN ADDITION UTILITY AND STREET IMPROVEMENTS PROJECT 1993</b>	48295 Section #20 93013 Reg. No. 13481	Bonestroo Rosene Anderlik & Associates	3/17/93
<b>PINE SUMMIT 1ST ADDITION UTILITY, STREET, &amp; STREET LIGHTING IMPROVEMENTS 2000</b>	48-00-116 Section 6 C.P.00100 Reg. No. 21122	Bonestroo Rosene Anderlik & Associates	5/24/00



Title	Project #	Designer/Engineer	Stamp Date
<b>PINE SUMMIT 2ND ADDITION UTILITY, STREET, &amp; STREET LIGHTING IMPROVEMENTS 2001</b>	48-01-145 Section 6 C.P. 01105 Reg. No. 25799	Bonestroo Rosene Anderlik & Associates	11/8/01
<b>PINE SUMMIT 4TH ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2002</b>	48-02-163 Lic. No. 25799	Bonestroo Rosene Anderlik & Associates	5/1/02
<b>PINE SUMMIT 6TH ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2003</b>	City Proj. #03118 Proj. # 48-03- 183 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	9/18/03
<b>PINE SUMMIT 7TH ADDITION UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2003</b>	City Proj. #03119 Proj. # 4803186 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	9/13/03
<b>PINECLIFF 2ND ADDITION</b>	20319-02 Reg. No. 22709	James R. Hill, Inc.	4/4/05
<b>PINEHILL ACRES FIRST ADDITION SEWER &amp; WATER EXTENSIONS 1977</b>	Section #20 77002 4848 Reg. No. 6971	Bonestroo Rosene Anderlik & Associates	7/6/77
<b>PINEHILL ACRES SECOND ADDITION SEWER &amp; WATER EXTENSIONS 1978</b>	4862 Section #20 78003	Bonestroo Rosene Anderlik & Associates	11/14/78



Title	Project #	Designer/Engineer	Stamp Date
<b>PINEHILL ACRES STORM SEWER EXTENSION 1982</b>	48111 Section #20 82002	Bonestroo Rosene Anderlik & Associates	7/7/82
<b>STORM SEWER AUG. 1960 THOMPSON GROVE ESTATES 1ST ADDITION</b>	Section #17 Reg. No. 6349	Minder Engineering Co., Inc.	8/1/60
<b>STORM SEWER THOMPSON GROVE ESTATES 3RD ADDITION</b>	Section #16 Reg. No. 6349	Minder Engineering Co., Inc.	4/13/62
<b>SUMMERHILL CROSSING UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2004</b>	City Proj. #01111 Proj. #4801154 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	6/7/04
<b>SUMMIT AT HIGHLAND HILLS UTILITY, STREET &amp; STREET LIGHTING IMPROVEMENTS 2002</b>	48-02-165 Lic. No. 25799	Bonestroo Rosene Anderlik & Associates	8/14/02
<b>THOMPSON ESTATES 7TH &amp; 8TH ADDITION STORM SEWER</b>	Section #17 64001 Reg. No. 6971	Bonestroo Rosene Anderlik & Associates	6/1/64
<b>THOMPSON GROVE ESTATES 2ND ADDITION</b>	Section #16 Reg. No. 6349	Minder Engineering Co., Inc.	10/4/61
<b>THOMPSON GROVE ESTATES 4TH ADDITION</b>	Section #16 62007 Reg. No. 6349	Minder Engineering Co., Inc.	7/10/62
<b>THOMPSON GROVE, DISTRICT-D PAVEMENT MANAGEMENT PROJECT 2002</b>	4800137 Lic. No. 40503	Bonestroo Rosene Anderlik & Associates	3/22/02
<b>TIMBER RIDGE ADDITION UTILITY, STREET, &amp; STREET LIGHTING IMPROVEMENTS 2001</b>	48-01-141 Reg. No. 40503	Bonestroo Rosene Anderlik & Associates	7/31/01

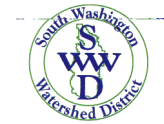


Title	Project #	Designer/Engineer	Stamp Date
WATER AND SEWER EXTENSIONS PINEHILL ACRES 4TH ADDITION 1987	48174 Section #20 87009	Bonestroo Rosene Anderlik & Associates	4/13/87
WATER AND SEWER EXTENSIONS WHIRLPOOL CORPORATION 1975	Agreement No. 58176 S.P. 8205-61 (T.H. 61-3) Section #20 75002 4833	Bonestroo Rosene Anderlik & Associates	11/4/75
WATER, SEWER AND STREET BASE IMPROVEMENTS HIDDEN VALLEY SECOND ADDITION 1988	48194 Section #8 88002 Reg. No. 6971	Bonestroo Rosene Anderlik & Associates	4/15/88



**APPENDIX B  
DETAILED MODEL OUTPUT MAPS AND TABLE  
FOR THE WEST DRAW WATERSHED**

South Washington  
Watershed District



West Draw  
Watershed Model:  
Existing Conditions

Modeling Results for  
Entire West Draw Area

6.3-inch, 24 hour, 100-year Storm  
Type II Distribution

**PFR** = Peak Flow Rate  
**PSV** = 100-Year Peak  
Storage Volume

**Legend**

- Junction
- Pipe or Culvert
- Channel
- Overflow Route
- West Draw Subwatersheds
- 100-yr Peak Flood Area

\* Channel Cross-Sections, Channel  
Lengths, Culvert Inverts, Road  
Elevations, and Stage-Storage  
Volumes based on SWWD Contour  
Information (2000).

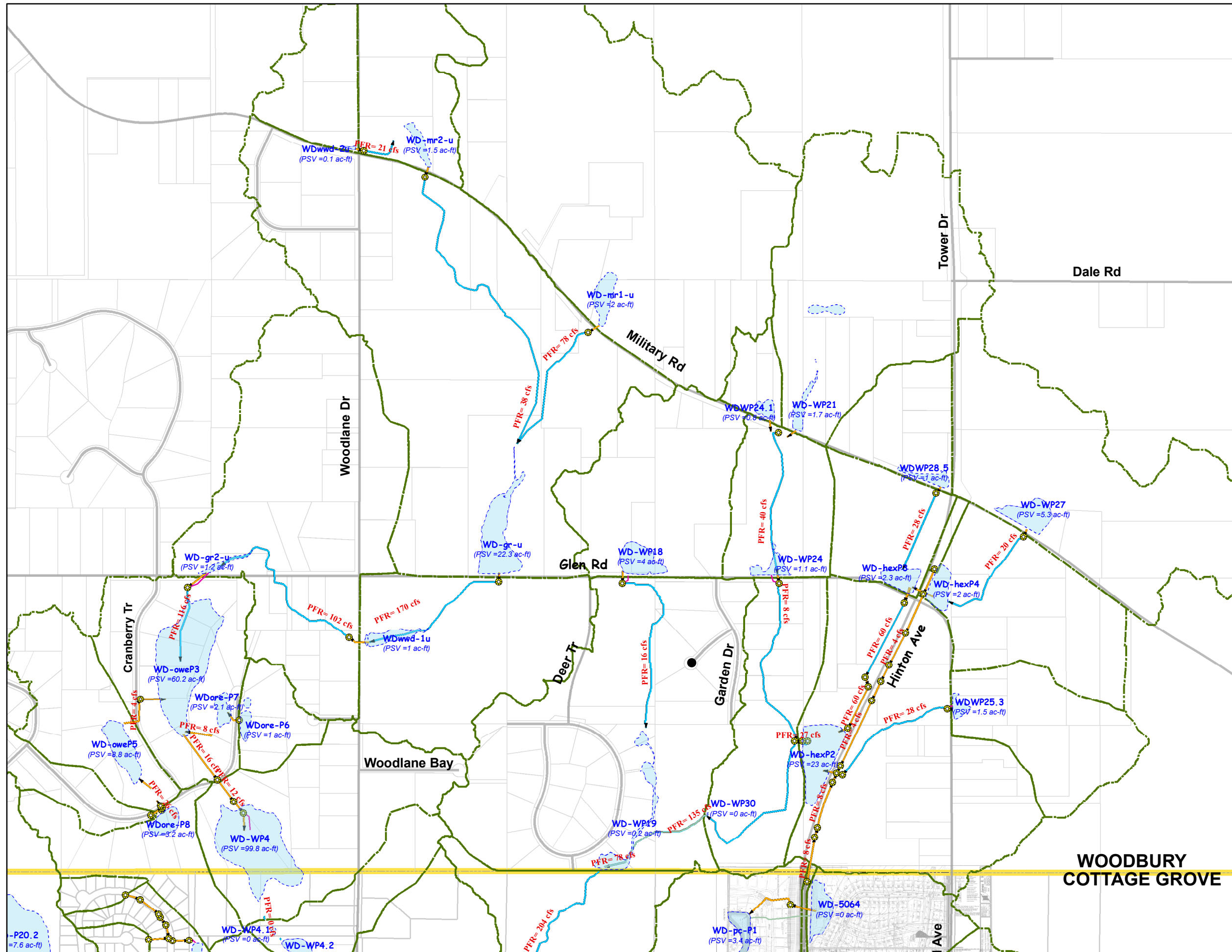
\* Culvert Sizes Based on Woodbury  
Sewer Map

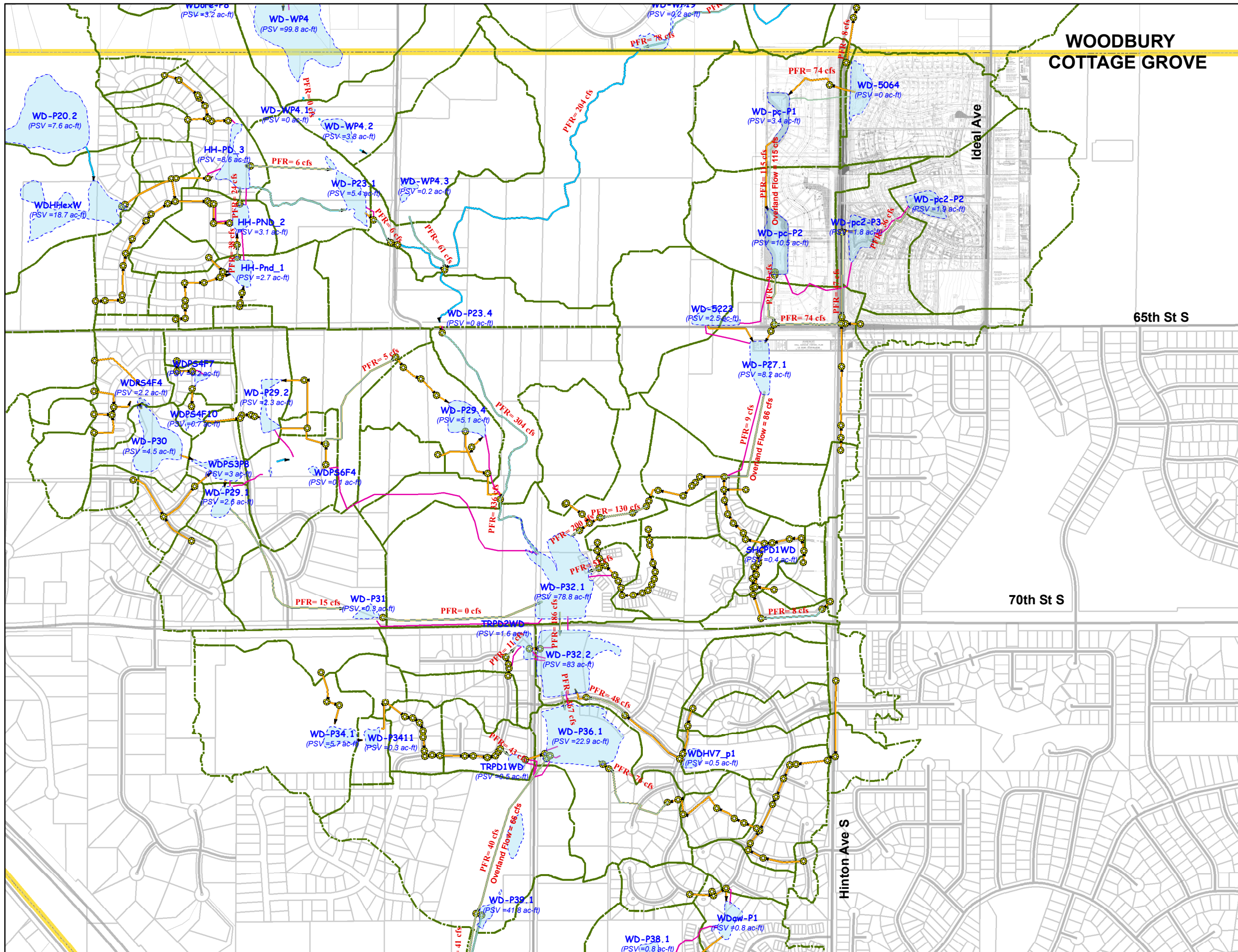


0 190 380 760 Feet



Source: Wdraw\_HDR\_60805\_long.xp  
June 8, 2005





South Washington  
Watershed District



West Draw  
Watershed Model:  
Existing Conditions

Modeling Results for  
Entire West Draw Area

6.3-inch, 24 hour, 100-year Storm  
Type II Distribution

**PFR** = Peak Flow Rate  
**PSV** = 100-Year Peak  
Storage Volume

**Legend**

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- Channel
- Overflow Route
- West Draw Subwatersheds
- 100-yr Peak Flood Area

\* Channel Cross-Sections, Channel Lengths, Culvert Inverts, Road Elevations, and Stage-Storage Volumes based on SWWD Contour Information (2000).

\* Culvert Sizes Based on Woodbury Sewer Map



0 190 380 760 Feet



# South Washington Watershed District



## West Draw Watershed Model: Existing Conditions

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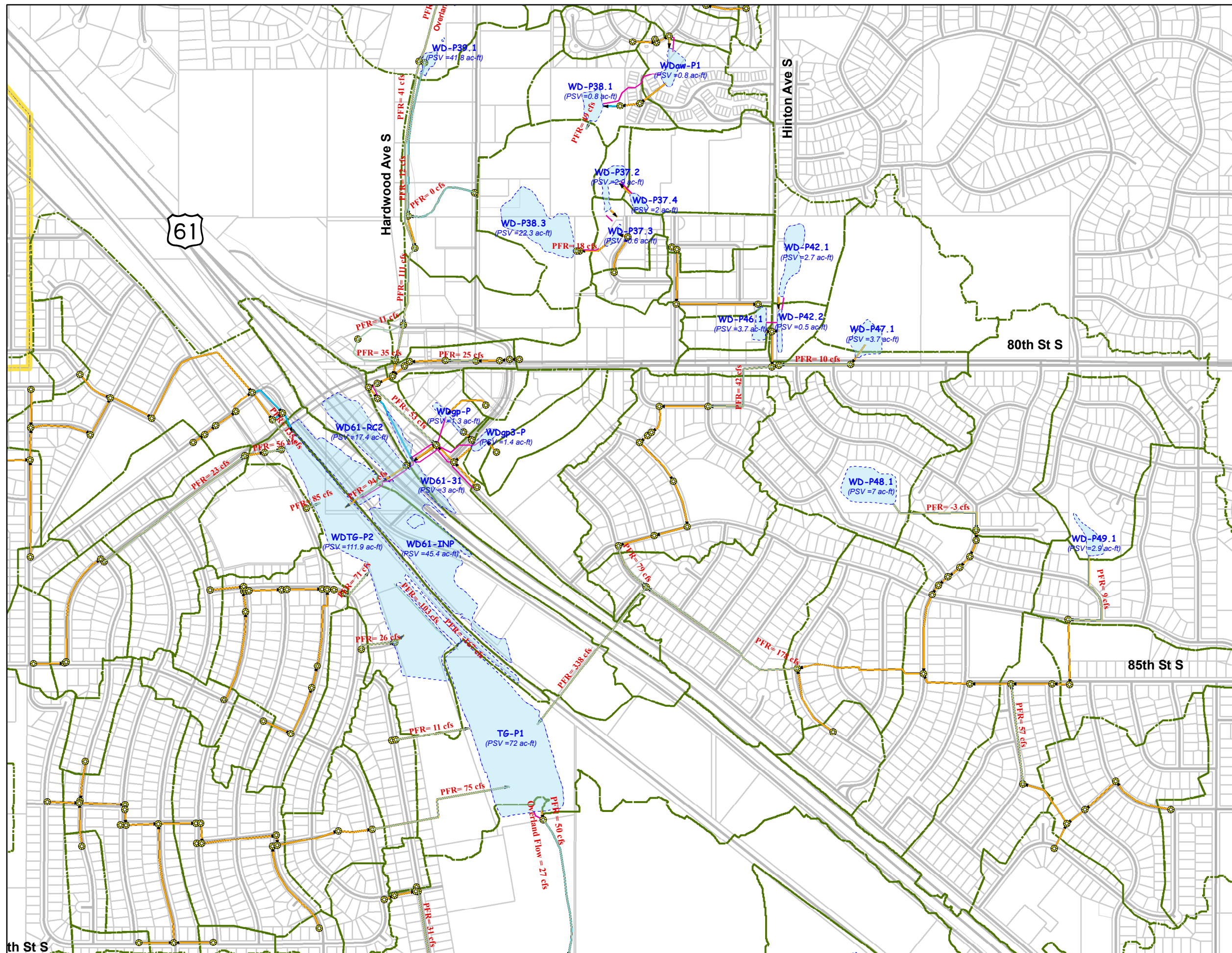
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0 190 380 760 Feet



Source: Wdraw\_HDR\_60805\_long.xp  
June 8, 2005



South Washington  
Watershed District



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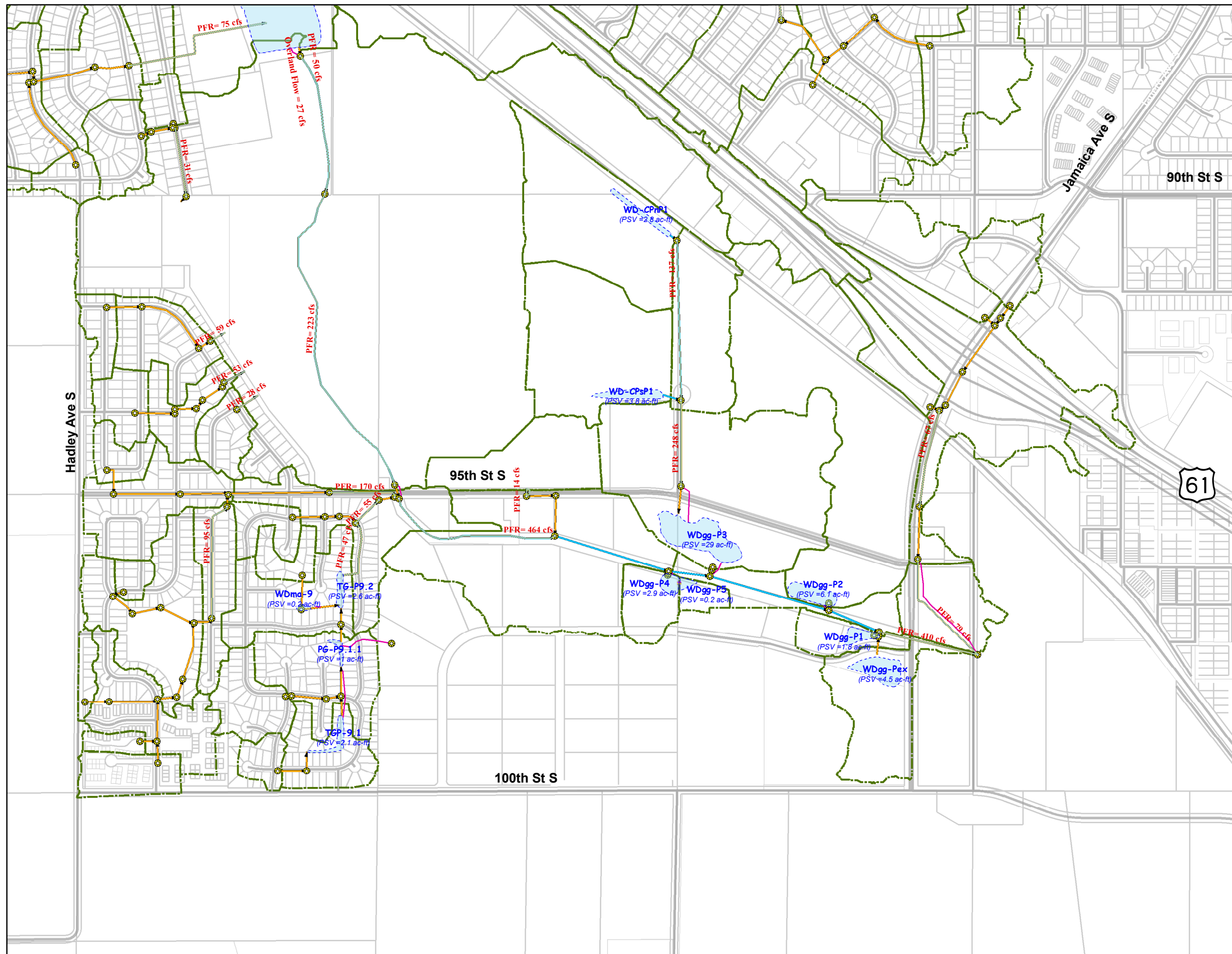
\* Culvert Sizes Based on Woodbury  
Sewer Map



0 190 380 760 Feet



Source: Wdraw\_HDR\_60805\_long.xp  
June 8, 2005





**POND OUTLET SUMMARY TABLE**

<b>Upstream Pond</b>	<b>Pond NWL (ft)</b>	<b>Overflow Elevation (ft)</b>	<b>Upstream Invert (ft)</b>	<b>Downstream Invert (ft)</b>	<b>Pipe Size (in)</b>	<b>Approx. Length (ft)</b>	<b>Outlet Type</b>	<b>Maximum Stage (ft)</b>
HH-PD_3	900.00	907.40	900.00	900.07	10	54	Circular Pipe	906.4
HH-Pnd_1	911.00	914.20	911.00	906.60	24	110	Circular Pipe	914.3
HH-PND_2	900.00	907.40	900.30	900.00	24	146	Circular Pipe	906.5
PG-P9.1.1	797.50	805.00	799.90	797.44	30	157	Circular Pipe	806.6
SHCPD1WD	915.00	918.00	915.00	914.67	30	31	Circular Pipe	916.8
TG-P1	782.00	788.00	782.32	782.00	30	87	Circular Pipe	788.2
TGP-9.1	800.50	807.00	800.50	798.00	18	180	Circular Pipe	807.9
TG-P9.2	794.98	801.50	794.98	790.94	30	606	Circular Pipe	803.1
TRPD1WD	828.00	830.00	828.00	827.72	24	30	Circular Pipe	829.6
TRPD2WD	816.00	816.50	816.00	815.72	24	16	Circular Pipe	819.1
WD-5064	941.40	938.00	933.50	920.00	36	236	Circular Pipe	935.1
WD-5223	906.00	898.10	898.10	897.03	30	462	Circular Pipe	903.9
WDaw-P1	860.00	868.00	863.89	859.19	15	293	Circular Pipe	865.6
WDgg-P1	767.30	776.00	772.00	771.37	8	41	Circular Pipe	773.3
WDgg-P2	768.30	778.00	773.00	772.90	10	22	Circular Pipe	778.1
WDgg-P4	768.20	775.00	773.00	772.58	8	14	Circular Pipe	774.6
WDgg-P5	773.00	777.00	773.00	768.20	12	40	Circular Pipe	774.7
WDgg-Pex	772.00	780.50	775.00	773.37	18	160	Circular Pipe	774.8
WDgp3-P	796.50	804.00	796.50	791.00	24	205	Circular Pipe	800.5
WDgp-P	800.10	805.00	800.10	801.80	18	8	Circular Pipe	805.1
WD-gr2-u	866.00	872.00	866.00	862.00	42	256	Circular Pipe	871.9



Upstream Pond	Pond NWL (ft)	Overflow Elevation (ft)	Upstream Invert (ft)	Downstream Invert (ft)	Pipe Size (in)	Approx. Length (ft)	Outlet Type	Maximum Stage (ft)
WD-gr-u	919.90	922.00	919.90	919.80	36	82	Circular Pipe	925.7
WD-hexP2	920.00	927.40	916.00	916.00	24	47	Circular Pipe	927.2
WD-hexP3	951.00	957.90	951.00	950.50	2 x 30	146	Circular Pipe	954.9
WD-hexP4	952.00	957.90	952.00	951.00	42	208	Circular Pipe	955.4
WDHHexW	923.30	932.50	923.30	923.30	8	25	Circular Pipe	933.3
WDHV7_p1	848.01	854.00	848.01	847.79	15	40	Circular Pipe	852.8
WD-mr1-u	954.00	966.00	954.00	948.00	36	116	Circular Pipe	956.9
WD-mr2-u	982.00	988.00	982.00	981.00	36	97	Circular Pipe	984.9
WDore-P6	856.76	862.00	856.76	855.56	18	31	Circular Pipe	859.6
WDore-P7	855.15	862.00	855.15	848.00	24	244	Circular Pipe	856.0
WDore-P8	857.19	868.00	857.19	856.85	18	17	Circular Pipe	862.6
WD-oweNP	852.00	860.00	856.51	855.97	12	143	Circular Pipe	862.0
WD-oweP3	848.00	854.00	848.00	841.80	24	513	Circular Pipe	856.0
WD-oweP5	852.00	860.00	852.00	849.90	12	338	Circular Pipe	857.3
WD-P20.2	934.00	936.50	936.50	932.50	-	320	Channel	937.0
WD-P23.1	872.00	878.00	875.01	874.57	30	101	Circular Pipe	876.0
WD-P23.4	845.58	854.00	845.58	844.21	84	64	Circular Pipe	848.3
WD-P27.1	897.00	901.20	897.00	893.46	18	975	Circular Pipe	902.5
WD-P29.1	925.40	926.70	925.40	897.00	18	1547	Circular Pipe	929.3
WDP29.1o	0.00	0.00	922.00	904.00	24	119	Channel	918.0
WD-P29.2	910.20	915.20	910.20	907.69	15	504	Circular Pipe	913.9
WD-P29.4	823.50	830.70	823.51	821.59	24	481	Circular Pipe	827.7
WD-P30	932.00	935.50	932.00	927.00	12	131	Circular Pipe	935.4
WD-P31	895.00	897.00	894.50	813.00	24	1446	Circular Pipe	897.0



Upstream Pond	Pond NWL (ft)	Overflow Elevation (ft)	Upstream Invert (ft)	Downstream Invert (ft)	Pipe Size (in)	Approx. Length (ft)	Outlet Type	Maximum Stage (ft)
WD-P32.1	800.00	805.00	802.50	802.00	72	211	Circular Pipe	818.7
WD-P32.2	796.00	805.00	805.21	805.12	48	172	Circular Pipe	818.4
WD-P34.1	891.00	896.00	891.00	890.50	12	48	Circular Pipe	894.8
WD-P3411	890.50	894.70	890.50	887.00	18	268	Circular Pipe	891.6
WD-P36.1	805.00	815.00	802.26	802.26	12	8	Circular Pipe	818.3
WD-P37.2	854.00	862.00	854.00	850.70	12	86	Circular Pipe	860.6
WD-P37.3	844.00	854.00	844.00	840.00	21	312	Circular Pipe	848.3
WD-P37.4	860.00	870.00	860.00	858.25	15	132	Circular Pipe	870.2
WD-P38.1	852.50	855.60	855.60	850.00	-	86	Channel	855.8
WD-P38.3	828.00	846.00	850.10	850.00	12	40	Circular Pipe	834.7
WD-P39.1	804.60	820.97	808.05	808.05	18	7	Circular Pipe	812.6
WD-P42.1	0.00	0.00	858.70	854.90	18	109	Circular Pipe	862.6
WD-P42.2	0.00	0.00	854.90	853.78	18	69	Circular Pipe	862.8
WD-P46.1	854.90	860.00	854.90	853.78	18	68	Circular Pipe	864.1
WD-P47.1	0.00	0.00	865.80	858.69	12	219	Circular Pipe	869.4
WD-P48.1	850.00	856.00	850.74	848.50	12	944	Circular Pipe	853.6
WD-P49.1	847.10	870.00	847.10	806.07	12	916	Circular Pipe	866.0
WD-pc2-P2	953.40	947.00	946.00	929.00	24	626	Circular Pipe	949.4
WD-pc2-P3	934.20	928.00	926.59	925.50	30	119	Circular Pipe	930.7
WD-pc-P1	912.00	915.00	912.00	910.00	15	677	Circular Pipe	915.8
WD-pc-P2	910.00	913.40	908.00	911.00	12	29	Circular Pipe	915.2
WDPS3P8	927.00	0.00	927.00	925.40	12	62	Circular Pipe	929.2
WDPS4F10	919.54	925.00	919.54	918.75	18	322	Circular Pipe	923.7
WDPS4F4	932.20	935.50	932.20	932.00	24	54	Arch Pipe	935.4



Upstream Pond	Pond NWL (ft)	Overflow Elevation (ft)	Upstream Invert (ft)	Downstream Invert (ft)	Pipe Size (in)	Approx. Length (ft)	Outlet Type	Maximum Stage (ft)
WDPS4F7	924.50	930.00	924.26	924.26	30	38	Arch Pipe	926.3
WDPS6F4	904.00	914.00	909.00	908.68	18	43	Circular Pipe	904.8
WDTG-P2	777.50	788.10	778.04	777.90	72	30	Box Culvert	788.2
WD-WP18	938.00	944.00	938.00	937.00	24	107	Circular Pipe	940.9
WD-WP19	900.00	908.00	900.00	856.00	-	3486	Channel	902.2
WD-WP21	996.00	1002.00	996.00	988.00	24	98	Circular Pipe	998.2
WD-WP24	962.00	968.00	962.00	960.00	30	80	Circular Pipe	965.6
WDWP24.1	992.00	996.00	992.00	988.00	12	105	Circular Pipe	993.3
WDWP25.3	962.00	0.00	962.00	960.00	18	47	Circular Pipe	968.1
WD-WP27	980.90	986.00	980.90	980.00	24	72	Circular Pipe	985.1
WDWP28.5	982.00	986.00	982.00	978.00	24	69	Circular Pipe	984.6
WD-WP30	914.00	920.00	914.00	900.00	-	397	Channel	915.2
WD-WP4	840.00	855.00	864.00	863.50	-	29	Channel	857.1
WD-WP4.1	853.50	864.00	864.00	863.50	-	19	Channel	853.5
WD-WP4.2	852.50	864.00	872.00	871.50	-	75	Channel	859.8
WD-WP4.3	862.00	870.00	862.00	856.00	-	601	Channel	862.5
WDwwd-1u	912.00	926.00	912.00	904.00	36	194	Circular Pipe	913.5
WDwwd-2u	1002.00	1004.00	1002.00	1000.00	36	78	Circular Pipe	1004.3