B. Hydrologic System

1. System Overview

The South Washington Watershed District hydrologic boundary is illustrated on Figure IV-1 and Map 1. The hydrologic boundary is defined by high topographical points or ridges that delineate drainage basins and the direction that runoff will follow. The hydrologic boundaries or ridges for the watershed are defined typically by elevation 1050 in the north areas, 1000 in the central areas, and 950 in the southern portion. The Mississippi River is the southern boundary of the watershed and has a normal pool elevation of 687. The difference in elevation from the topographic highs to the Mississippi River demonstrates the steep topography that exists in the draws of the watershed in the southern areas.

The Mississippi River is the southern boundary of the South Washington Watershed District. This river is the natural waterway that receives and transports the runoff from the watershed down to the Gulf of Mexico. According to records of the hydrometer station at the Wabasha Bridge in St. Paul, Minnesota, the river at this point has an average discharge rate of 10,530 cubic feet per second (cfs), and a maximum discharge of 171,000 cfs. The Wabasha Bridge station is located approximately 10 miles upstream of the South Washington Watershed District.

In the southern portion of the South Washington Watershed District, there are two major natural drainageways that drain to the Mississippi River. These drainageways run north to south and are located in the southeastern portion of Cottage Grove.

In the north, a central drainageway begins in the north in Oakdale and Lake Elmo and travels approximately 7 miles to Bailey Lake at Dale Road. The outlet for Bailey Lake is a pump station that discharges into a large infiltration basin in Woodbury, known as CD-P85. A permanent outlet to the Mississippi River has been proposed, but has not yet been built. This outlet is identified as a SWWD project and is discussed in greater detail later in the report.

The 34,000-acre SWWD watershed has numerous natural elongated depressions that run through the middle of the northern areas and exist as various ravines in the southern areas. In the north, the depressions typically do not have natural outlets except for very large storms.

Major basin and lake elevations tend to decrease from north to south in the watershed usually following the buried bedrock valley. Powers Lake, which has a history of fluctuating water levels, is located along the path of the bedrock valley and has a water level typically lower than the adjacent Wilmes Lake, but similar to downstream Colby Lake.

South of Gables Lake and DNR Protected Water #84W, the topography changes from a series of depressions to steeply sloped, channels with little evidence of significant flows. The easterly drainageway runs south through the Cottage Grove Ravine Regional Park. A box culvert exists beneath T.H. 61 which drains to the Mississippi River, but some obstructions between the culvert and the Regional Park waterbody in the past have caused flooding of the park entrance road. The recent high water levels in the Regional Park waterbody appear to be caused by higher than normal groundwater elevations in the area.

The westerly drainageway runs northwest to southeast with a series of small drainages feeding into it and outlets into the Mississippi River just west of the 3M industrial complex at the existing wastewater treatment plant. Approximately 9,300 acres of land naturally drains to this drainageway. The topography in this subwatershed is similar to the topography in the rest of the watershed but with moderately steep slopes. The extreme northern portion contains several low depressions that act as landlocked ponding areas. The northwest portion of this subwatershed drains into a landlocked basin located just north of the boundary of the cities of Woodbury and Cottage Grove. The City of Woodbury has installed a lift station to be able to pump from this basin to another landlocked basin on the Woodbury-Cottage Grove border. The northeastern portion flows through an intermittent stream channel which eventually dead ends into a landlocked area just south of 70th Street in Cottage Grove.

The southwestern portion of this subwatershed includes a wide flat river terrace area. The flat terrace areas in the southwest portion of the SWWD drain directly to the Mississippi River through many small drainageways. The terrace areas are very sandy and in their natural state do not appear to produce significant runoff.

2. Existing Drainage System

The SWWD can be divided into four major drainage districts. The North, Central, South East and South West Drainage Districts. The term "Drainage District" is used to describe the hydrologic land features that correspond to land that drains to common areas. The term Drainage District is used here in order not to confuse it with "subwatersheds" which can be used in project financing.

North Drainage District

The North Drainage District is located in the northern portion of the South Washington Watershed District. This drainage district is the smallest of the four drainage districts in the SWWD with an area of 1,600 acres. It is shown as Project Subwatershed 1 on Map 1 at the back of the report. The general drainage system in the North Drainage District is characterized by numerous small drainages and a larger network of partially landlocked wetlands and Armstrong Lake. There are three major wetland basins present, which are DNR Protected Wetlands: #420W, #422W, and #431W. These all drain to Armstrong Lake, which is DNR Protected Water #116W. The southern portion of the drainage district is characterized by a central draw which becomes fairly steep as it nears I-94. There is a steep, 72" culvert under I-94 to carry flows from this drainage area to the south. The intermittent stream from Armstrong Lake to I-94 and beyond to Wilmes Lake is designated a DNR Protected natural waterway.

Central Drainage District

The Central Drainage District receives the flow from under I-94 from the North Drainage District. The Central Drainage District occupies the north-central portion of the South Washington Watershed District and has an area of approximately 17,600 acres. It is shown on Map 1 as Project Subwatersheds 2 and 3.

The Central Drainage District contains 17 DNR protected wetlands along with six lakes, which are also DNR protected waterbodies: Markgrafs, Wilmes, Powers, Colby, Bailey, and Gables lakes. Many of the wetlands and lakes in the drainage district have been connected and incorporated into the main drainage system. The main drainage system runs north to south from I-94 to Bailey Lake, CD-P85, and CD-P86. Gables Lake and East Cottage Grove wetlands, while not currently connected to the main drainage system, are considered part of this drainage district. Several sub-drainage areas flow into the main drainage system. The intermittent stream between I-94 and Wilmes Lake is a DNR protected natural waterway.

There are approximately 500 acres in the Drainage District in the City of Afton. This area, which is mainly farmland, drains into two ponding areas in Woodbury.

Powers Lake is located in a low topographical depression, which requires the use of a pumping facility in order to discharge the outflow to the main drainage system at Wilmes Lake. The pumped outflow rate for Powers Lake will be fairly small, on the order of 5 ~~to 10~~ cfs.

The southeastern portion of the Drainage District consists of a series of land-locked basins that lie along the alignment of the buried bedrock valley. The two major depressions are Gables Lake (DNR #82W) which is in a large depression and is separated by a high point at an elevation of about 900 from a large wetland basin known as the East Cottage Grove Wetland (DNR #84W).

Southeast Drainage District

The Southeast Drainage District is located in the southeastern portion of the SWWD. This area contains approximately 3,200 acres of land. It is shown on Map 1 as Project Subwatershed 4. This area is largely undeveloped and the topography typically has flat plains with steep slopes and a series of elongated depressions. The natural topography forms a dry ravine which runs north to south with some minor landlocked basins within the ravine.

The Cottage Grove Ravine Regional Park (Regional Park) is a major feature of this Drainage District and contains a large waterbody (DNR #87W) within the ravine about midway down the drainage pattern. The water levels in this waterbody have risen in recent years, changing the system from a wetland-like system to more like a lake system. For this report the waterbody will be discussed in the lake section even though it possesses both lake and wetland characteristics. The Regional Park has an outlet under T.H. 10 and 61. Recently, the County has responded to rising water levels in the park's lake that has flooded the entrance roadway by excavating a channel connecting the park's lake to the culvert under T.H. 10 and 61. From T.H. 10 and 61, the ravine travels to the Mississippi River, although there is no evidence that significant flows have traveled through the ravine in recent history.

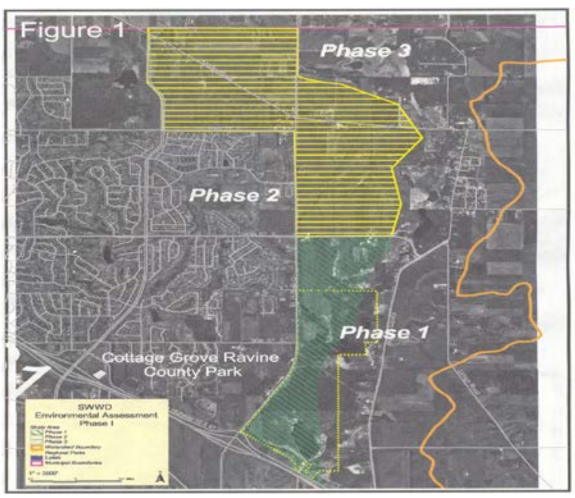
The Southeast Drainage District contains one protected DNR wetland: #87W. The ravine from 80th Street through the Regional Park and to the Mississippi River has been designated a protected natural waterway under the DNR's Protected Waters Program although much of the ravine does not show evidence of flowing water. The lack of flowing water is presumably due to the excessively well drained sandy soils in the tributary drainage area and in the ravine bottom itself.

a. Environmental Assessment Of The Southeast Drainage District

The District has conducted a environmental assessment of the Southeast Drainage District as a part of an overflow route feasibility study. This route has been labeled the County Road 19 corridor. The corridor was studied in two phases. Figure 1 Illustrates the study area, phase two encompasses both phases 2 &3 in the map. The District hired

EOR to access whether an Overflow route through the Park and the ravine would cause significant environmental impacts. Below is summary of the primary findings of the analysis and a summary discussion for the areas of most concern. Tables 1 and 2 summarize the environmental issues that have been identified as the most important potential concerns, potential mitigation options, and the regulatory or coordination entity that would potentially be involved. Refer to (Emmons & Oliver Resources, 2000) for details on Management Segment locations.

Figure 1



Phase I Table 2

Category	Specific Issue	Mgm't Segment #	Potential Mitigation Options	Regulatory/ Coordinating Entity
Soils / Surface Water Flows	Erosion Potential	1, 3, 4, 6E, 8E, 9E, 6W, 7W	Stable low flow channel, channel stabilization, gradient controls	MPCA, Cottage Grove
Natural Communities	Mesic Oak Forest	6E	Low flow channel through the area to minimize inundation	DNR
	Tree loss	3-5, 7E, 7W, 8W	Low flow channel to minimize inundation, replace with flood tolerant tree species	Cottage Grove, DNR
Wetlands / Rare Features	Degraded Fen	3	Direct flow away from higher quality plant communities	Cottage Grove, DNR
Recreation	Flooding of Entrance Road	2	Raise entrance road (existing problem for park) and install outlet to minimize lake fluctuations	Washington County, Met Council
	Flooding of trails	2, 3, 4, 5, 6W, 7W	Trail relocation, additional trail loops, boardwalks/foot bridges, paved trails	Washington County, Met Council
	Vegetation change (loss of tree canopy)	3-5, 7W, 8W	Low flow channel to minimize inundation, replace with flood tolerant tree species	DNR, Washington County, Met Council

Phase II Table 1

Category	Specific Issue	Potential Mitigation Options	Regulatory/ Coordinating Entity
Soils / Surface Water Analysis	Erosion Potential	Protect overflows into ponding areas and channel stabilization where channels are feasible.	MPCA, Cottage Grove
Natural Communities	Community 1C	Restoration of degraded oak savanna as part of CD-P86 north Management Plan	DNR, Cottage Grove
	Vegetation disturbance in Phase I	Reclamation to presettlement vegetation – oak savanna, oak woodland, and prairie	DNR, Cottage Grove
Hydrogeology	Infiltration to aquifer	Monitor infiltration to ensure low risk to groundwater	MPCA

The District also studied the erosive effects of routing storm water piped from regional detention/infiltration areas through the county park ravine in Cottage Grove. A velocity analysis completed by EOR provided sufficient information regarding the stabilization measures needed for the west ravine, therefore, shear stresses were analyzed for the main channel only. The results of the shear stress analysis for the Cottage Grove Ravine are summarized in Table 5. The table shows the erosion potential rating for each section, with approximately 60% of the total length of the ravine exceeding the shear stress threshold at a flow rate of 90 cfs (Emmons and Olivier Resources, 2002).

Table 5: Shear Stress Analysis (request a electronic copy from EOR)

						Existing Conditions							
						90 cfs		120 cfs		150 cfs		180 cfs	
Section Number	Station Number From	Station Number To	Length (ft.)	Existing Vegetation Cover	Shear Threshold (lb/sf)	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential
0+00	-2+50	1+00	350	Unmaintained	1.5 - 2.5	0.17	Low	0.16	Low	0.14	Low	0.14	Low
1+00	1+00	2+00	100	field grass	↓	0.43	Low	0.51	Low	0.55	Low	0.62	Low
2+00	2+00	3+00	100	Wooded forest,	1.0 - 2.0	0.36	Low	0.42	Low	0.49	Low	0.54	Low
3+00	3+00	4+00	100	good ground cover	↓	0.46	Low	0.50	Low	0.54	Low	0.58	Low
4+00	4+00	5+00	100			1.25	Medium	1.47	Medium	1.67	High	1.85	High
5+00	5+00	6+00	100	Pond									
6+00	6+00	7+00	100	Wooded forest,	1.0 - 2.0	0.88	Low	0.99	Low	1.08	Medium	1.15	Medium
7+00	7+00	7+50	50	good ground cover		2.40	Excessive	2.51	Excessive	2.70	Excessive	2.92	Excessive
7+50	7+50	8+00	50			0.30	Low	0.46	Low	0.61	Low	0.80	Low
8+00	8+00	9+00	100		↓	1.57	High	1.83	High	1.90	High	2.55	Excessive
9+00	9+00	10+00	100	Wooded forest,	1.0 - 1.5	0.95	Low	0.72	Low	0.82	Low	0.90	Low
10+00	10+00	10+60	60	good ground cover,		1.83	Excessive	2.04	Excessive	2.09	Excessive	1.33	High
10+60	10+60	11+00	40	mowed grass on		0.63	Low	0.70	Low	0.75	Low	0.70	Low
11+00	11+00	12+00	100	trail		0.28	Low	0.35	Low	0.43	Low	0.48	Low
12+00	12+00	13+00	100			0.88	Low	1.05	Medium	1.20	Medium	1.35	High
13+00	13+00	14+00	100			1.65	Excessive	1.79	Excessive	1.90	Excessive	1.98	Excessive
14+00	14+00	15+00	100			1.43	High	1.58	Excessive	1.72	Excessive	1.85	Excessive
15+00	15+00	16+00	100			1.19	Medium	1.30	High	1.39	High	1.47	High
16+00	16+00	17+00	100			0.72	Low	0.84	Low	0.95	Low	1.06	Medium
17+00	17+00	18+00	100			0.53	Low	0.61	Low	0.68	Low	0.76	Low
18+00	18+00	19+00	100			0.96	Low	1.09	Medium	1.20	Medium	1.29	High
19+00	19+00	20+00	100		↓	0.85	Low	1.00	Low	1.14	Medium	1.27	High
20+00	20+00	21+00	100	Wooded forest,	0.8 - 2.0	0.48	Low	0.58	Low	0.67	Low	0.76	Low
21+00	21+00	22+00	100	good ground cover,		1.45	High	1.68	High	1.89	High	2.08	Excessive
22+00	22+00	23+00	100	trail on channel's		0.79	Low	0.91	Medium	1.02	Medium	1.12	Medium
23+00	23+00	24+00	100	right or left bank		1.39	Medium	1.65	High	1.87	High	2.07	Excessive
24+00	24+00	25+00	100			0.95	Medium	1.06	Medium	1.16	Medium	1.25	Medium
25+00	25+00	26+00	100			1.09	Medium	1.30	Medium	1.49	High	1.66	High
26+00	26+00	27+00	100			0.73	Low	0.85	Medium	0.95	Medium	1.04	Medium
27+00	27+00	28+00	100		↓	3.14	Excessive	3.41	Excessive	3.67	Excessive	3.91	Excessive
28+00	28+00	29+00	100	Wooded forest,	1.0 - 1.5	0.08	Low	0.10	Low	0.12	Low	0.14	Low
29+00	29+00	29+50	50	good ground cover,		0.37	Low	0.14	Low	0.16	Low	0.17	Low
29+50	29+50	30+00	50	grass on trail		0.36	Low	0.33	Low	0.34	Low	0.42	Low
30+00	30+00	31+00	100			0.03	Low	0.05	Low	0.06	Low	0.08	Low
31+00	31+00	32+00	100			0.65	Low	0.74	Low	0.72	Low	0.66	Low
32+00	32+00	36+00	400		↓	0.53	Low	0.61	Low	0.68	Low	0.75	Low
36+00	36+00	37+00	100	Wooded with deadfall	0.3 - 1.0	0.25	Low	0.29	Low	0.33	Medium	0.36	Medium
37+00	37+00	38+00	100		↓	0.70	High	0.87	High	1.01	Excessive	1.16	Excessive
38+00	38+00	39+00	100			1.12	Excessive	1.26	Excessive	1.39	Excessive	1.51	Excessive
39+00	39+00	40+00	100	Pine and spruce	0.25 - 0.7	0.54	High	0.54	High	0.57	High	0.60	High
40+00	40+00	41+00	100	plantation, no ground		0.88	Excessive	1.00	Excessive	1.07	Excessive	1.13	Excessive
41+00	41+00	42+00	100	cover		0.57	High	0.64	High	0.71	Excessive	0.75	Excessive
42+00	42+00	43+00	100			0.63	High	0.72	Excessive	0.78	Excessive	0.85	Excessive
43+00	43+00	44+00	100			0.64	High	0.75	Excessive	0.85	Excessive	0.94	Excessive
44+00	44+00	45+00	100			1.75	Excessive	2.02	Excessive	2.25	Excessive	2.45	Excessive
45+00	45+00	46+00	100			1.09	Excessive	1.14	Excessive	1.17	Excessive	1.21	Excessive
46+00	46+00	48+00	200		↓	0.32	Medium	0.37	Medium	0.42	Medium	0.46	Medium
48+00	48+00	49+00	100	Clean oak forest,	0.4 - 1.0	0.30	Low	0.32	Low	0.34	Low	0.36	Low
49+00	49+00	50+00	100	medium density		1.18	Excessive	1.30	Excessive	1.52	Excessive	1.62	Excessive
50+00	50+00	52+00	200	underbrush		0.58	Medium	0.71	High	0.81	High	0.94	High
52+00	52+00	54+00	200		↓	0.51	Medium	0.58	Medium	0.65	Medium	0.71	High
54+00	54+00	58+00	400	Unmaintained	0.3 - 1.0	2.58	Excessive	2.93	Excessive	3.23	Excessive	3.48	Excessive
--	--	--	--	channel with medium		--	--	--	--	--	--	--	--
--	--	--	--	density forbs/shrubs		--	--	--	--	--	--	--	--
58+00	58+00	68+00	1000	Pond									
68+00	68+00	69+00	100	Wooded with deadfall,	0.4 - 1.0	0.85	High	0.71	High	0.42	Medium	0.25	Low
69+00	69+00	70+00	100	low-medium density		1.18	Excessive	1.47	Excessive	1.57	Excessive	1.88	Excessive
70+00	70+00	71+00	100	underbrush		2.06	Excessive	2.28	Excessive	2.65	Excessive	2.80	Excessive
71+00	71+00	72+00	100			0.81	High	0.96	High	1.12	Excessive	1.24	Excessive
72+00	72+00	73+00	100			1.28	Excessive	1.43	Excessive	1.57	Excessive	1.69	Excessive
73+00	73+00	75+00	200			1.20	Excessive	1.24	Excessive	1.45	Excessive	1.55	Excessive
75+00	75+00	80+00	500		↓	1.71	Excessive	1.94	Excessive	2.08	Excessive	2.24	Excessive
--	--	--	--		--	--	--	--	--	--	--	--	--
--	--	--	--		--	--	--	--	--	--	--	--	--
80+00	80+00	81+00	100		0.4 - 1.0	1.12	Excessive	1.06	Excessive	1.12	Excessive	1.10	Excessive
81+00	81+00	85+00	400	Bare channel,	0.2 - 0.7	2.69	Excessive	3.08	Excessive	3.40	Excessive	3.72	Excessive
--	--	--	--	Unmaintained	--	--	--	--	--	--	--	--	--
--	--	--	--		--	--	--	--	--	--	--	--	--
85+00	85+00	91+00	600	Mowed pasture	0.4 - 1.0	1.41	Excessive	1.09	Excessive	1.67	Excessive	1.49	Excessive
91+00	91+00	95+00	400		↓	1.58	Excessive	2.06	Excessive	1.92	Excessive	2.58	Excessive

Low - Below lower limit of threshold
Medium - Between lower limit and midpoint range of threshold
High - Between midpoint range and upper limit of threshold
Excessive - Above upper limit of threshold

Note: Decreasing shear stresses with increasing flow for a few sections is likely due to unique channel geometry, transitions, and backwater effects

Table 5 : Shear Stress analysis continued with stabilization recommendations

					Stabilization Measures for 90 cfs									Additional Possible Sta	
						90 cfs		120 cfs		150 cfs		180 cfs			
Section Number	Station Number From	Station Number To	Length (ft.)	Stabilization Measures	Estimated Shear Threshold (lb/sf)	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Maximum Shear Stress (lb/sq.ft.)	Erosion Potential	Additional Stabilization Measures for 120 cfs	Ac M
0+00	-2+50	1+00	350	N/A	1.5 - 2.5	0.17	Low	0.16	Low	0.15	Low	0.13	Low	N/A	
1+00	1+00	2+00	100	N/A	↓	0.44	Low	0.51	Low	0.58	Low	0.64	Low	N/A	
2+00	2+00	3+00	100	N/A	1.0 - 2.0	0.36	Low	0.43	Low	0.48	Low	0.52	Low	N/A	
3+00	3+00	4+00	100	N/A	↓	0.45	Low	0.50	Low	0.53	Low	0.56	Low	N/A	
4+00	4+00	5+00	100	Check Dam/Veg. Mgmt.	1.2	0.30	Low	0.34	Low	0.37	Low	0.40	Low	N/A	
6+00	6+00	7+00	100	N/A	1.0 - 2.0	0.91	Low	1.02	Medium	1.12	Medium	1.21	Medium	Veg. Mgmt.	
7+00	7+00	7+50	50	Check Dam/Veg. Mgmt.	1.2	0.03	Low	0.09	Low	0.19	Low	0.28	Low	N/A	
7+50	7+50	8+00	50	N/A	1.0 - 2.0	0.37	Low	0.56	Low	0.73	Low	0.91	Low	N/A	
8+00	8+00	9+00	100	Check Dam/Veg. Mgmt.	1.2	0.61	Low	1.25	Excessive	1.48	Excessive	1.58	Excessive	New Lined Channel	
9+00	9+00	10+00	100	N/A	1.0 - 1.5	0.72	Low	0.65	Low	0.48	Low	0.36	Low	N/A	
10+00	10+00	10+60	60	Check Dam/Veg. Mgmt.	1.2	0.47	Low	1.19	Low	1.27	Excessive	1.34	Excessive	N/A	
10+60	10+60	11+00	40	N/A	1.0 - 1.5	0.44	Low	0.67	Low	0.71	Low	0.76	Low	N/A	
11+00	11+00	12+00	100	N/A		0.90	Low	0.35	Low	0.42	Low	0.49	Low	N/A	
12+00	12+00	13+00	100	N/A		0.85	Low	1.01	Medium	1.16	Medium	1.29	High	Veg. Mgmt.	
13+00	13+00	14+00	100	Check Dam		0.03	Low	0.05	Low	0.06	Low	0.07	Low	N/A	
14+00	14+00	15+00	100	Check Dam	↓	0.48	Low	0.55	Low	0.60	Low	0.65	Low	N/A	
15+00	15+00	16+00	100	Veg. Mgmt.	1.2	1.15	Low	1.25	Excessive	1.35	Excessive	1.43	Excessive	Check Dam	
16+00	16+00	17+00	100	N/A	1.0 - 1.5	0.74	Low	0.87	Low	0.99	Low	1.10	Medium	N/A	
17+00	17+00	18+00	100	N/A		0.52	Low	0.60	Low	0.66	Low	0.74	Low	N/A	
18+00	18+00	19+00	100	N/A		0.96	Low	1.09	Medium	1.20	Medium	1.29	High	Veg. Mgmt.	
19+00	19+00	20+00	100	N/A	↓	0.85	Low	1.00	Low	1.14	Medium	1.26	High	N/A	
20+00	20+00	21+00	100	N/A	0.8 - 2.0	0.65	Low	0.78	Low	0.90	Medium	1.01	Medium	N/A	
21+00	21+00	22+00	100	Check Dam		0.52	Low	0.59	Low	0.66	Low	0.71	Low	N/A	
22+00	22+00	23+00	100	N/A		0.78	Low	0.92	Medium	1.04	Medium	1.16	Medium	Veg. Mgmt.	
23+00	23+00	24+00	100	Check Dam	↓	0.32	Low	0.39	Low	0.47	Low	0.55	Low	N/A	
24+00	24+00	25+00	100	Veg. Mgmt.	1.2	0.85	Low	0.95	Low	1.04	Low	1.10	Low	N/A	
25+00	25+00	26+00	100	Veg. Mgmt.	1.2	0.92	Low	1.09	Low	1.37	Excessive	1.40	Excessive	N/A	
26+00	26+00	27+00	100	Veg. Mgmt.	1.2	0.82	Low	0.96	Low	1.06	Low	1.18	Low	N/A	
27+00	27+00	28+00	100	Check Dam	0.8 - 2.0	0.75	Low	0.79	Low	0.63	Low	0.76	Low	N/A	
28+00	28+00	29+00	100	N/A	1.0 - 1.5	0.12	Low	0.15	Low	0.17	Low	0.19	Low	N/A	
29+00	29+00	29+50	50	N/A		0.12	Low	0.46	Low	0.18	Low	0.18	Low	N/A	
29+50	29+50	30+00	50	N/A		0.79	Low	0.40	Low	0.41	Low	0.45	Low	N/A	
30+00	30+00	31+00	100	N/A		0.01	Low	0.05	Low	0.07	Low	0.08	Low	N/A	
31+00	31+00	32+00	100	N/A		0.70	Low	0.74	Low	0.82	Low	0.75	Low	N/A	
32+00	32+00	36+00	400	N/A	↓	0.46	Low	0.53	Low	0.60	Low	0.66	Low	N/A	
36+00	36+00	37+00	100	Deadfall/Veg. Mgmt.	1.2	0.30	Low	0.35	Low	0.39	Low	0.43	Low	N/A	
37+00	37+00	38+00	100	Deadfall/Veg. Mgmt.		0.16	Low	0.20	Low	0.24	Low	0.28	Low	N/A	
38+00	38+00	39+00	100	Deadfall/Veg. Mgmt.	↓	0.29	Low	0.36	Low	0.42	Low	0.48	Low	N/A	
39+00	39+00	40+00	100	New Lined Channel	3.0 in channel	0.74	Low	0.91	*Low / Exc.	0.81	*Low / Exc.	0.78	*Low / Exc.	Larger Channel	
40+00	40+00	41+00	100	New Lined Channel	0.25 - 0.7 outside	1.44	Low	1.48	*Low / Exc.	1.84	*Low / Exc.	1.91	*Low / Exc.	Larger Channel	
41+00	41+00	42+00	100	New Lined Channel	of channel	1.04	Low	1.28	*Low / Exc.	1.24	*Low / Exc.	1.19	*Low / Exc.	Larger Channel	
42+00	42+00	43+00	100	New Lined Channel		1.15	Low	1.09	*Low / Exc.	1.22	*Low / Exc.	1.18	*Low / Exc.	Larger Channel	
43+00	43+00	44+00	100	New Lined Channel		1.22	Low	1.63	*Low / Exc.	1.30	*Low / Exc.	1.30	*Low / Exc.	Larger Channel	
44+00	44+00	45+00	100	New Lined Channel		1.39	Low	1.09	*Low / Exc.	1.09	*Low / Exc.	1.27	*Low / Exc.	Larger Channel	
45+00	45+00	46+00	100	New Lined Channel		1.13	Low	1.17	*Low / Exc.	1.13	*Low / Exc.	1.04	*Low / Exc.	Larger Channel	
46+00	46+00	48+00	200	New Lined Channel	↓	0.72	Low	0.83	*Low / Exc.	1.03	*Low / Exc.	1.27	*Low / Exc.	Larger Channel	
48+00	48+00	49+00	100	New Lined Channel	3.0 in channel	1.33	Low	1.82	*Low / Exc.	1.40	*Low / Exc.	0.90	*Low / Exc.	Larger Channel	
49+00	49+00	50+00	100	New Lined Channel	0.4 - 1.0 outside	1.87	Low	1.99	*Low / Exc.	2.51	*Low / Exc.	3.65	*Exc. / Exc.	Larger Channel	
50+00	50+00	52+00	200	New Lined Channel	of channel	0.28	Low	0.13	*Low / Low	0.18	*Low / Low	0.01	*Low / Low	N/A	
52+00	52+00	54+00	200	New Lined Channel	↓	0.49	Low	0.34	*Low / Low	0.28	*Low / Low	0.12	*Low / Low	N/A	
54+00	54+00	55+50	150	Check Dam/Line Existing Channel	3.0 in channel	0.54	Low	0.58	*Low / Med.	0.61	*Low / Med.	0.63	*Low / Med.	Additional Channel Lining	Ad
55+50	55+50	57+00	150	Check Dam/Line Existing Channel	0.3 - 1.0 outside	0.60	Low	0.65	*Low / Med.	0.69	*Low / High	0.72	*Low / High	Additional Channel Lining	Ad
57+00	57+00	58+00	100	Check Dam/Line Existing Channel	of channel	0.59	Low	0.58	*Low / Med.	0.54	*Low / Med.	0.48	*Low / Med.	Additional Channel Lining	Ad
68+00	68+00	69+00	100	Deadfall/Veg. Mgmt.	1.2	1.03	Low	1.13	Low	1.17	Low	1.19	Low	N/A	
69+00	69+00	70+00	100	Deadfall/Veg. Mgmt.		1.04	Low	1.22	Excessive	1.31	Excessive	1.45	Excessive	N/A	
70+00	70+00	71+00	100	Check Dam/Veg.Mgmt.		0.45	Low	0.53	Low	0.60	Low	0.63	Low	N/A	
71+00	71+00	72+00	100	Deadfall/Veg. Mgmt.		0.77	Low	0.88	Low	0.98	Low	1.07	Low	N/A	
72+00	72+00	73+00	100	Check Dam/Veg.Mgmt.		0.50	Low	0.54	Low	0.57	Low	0.59	Low	N/A	
73+00	73+00	75+00	200	Deadfall/Veg. Mgmt.		0.96	Low	1.03	Low	1.10	Low	1.14	Low	N/A	
75+00	75+00	76+75	175	Check Dam/Veg.Mgmt.		0.56	Low	0.65	Low	0.74	Low	0.81	Low	N/A	
76+25	76+75	78+50	175	Check Dam/Veg.Mgmt.		0.78	Low	0.88	Low	0.98	Low	1.06	Low	N/A	
78+50	78+50	80+00	150	Check Dam/Veg.Mgmt.		0.72	Low	0.80	Low	0.89	Low	0.94	Low	N/A	
80+00	80+00	81+00	100	Deadfall/Veg. Mgmt.	↓	1.09	Low	1.13	Low	1.14	Low	1.15	Low	N/A	
81+00	81+00	82+50	150	Check Dam/Line Existing Channel	3.0 in channel	0.62	Low	0.59	*Low / High	0.54	*Low / High	0.42	*Low / Med.	N/A	Ad
82+50	82+50	84+00	150	Check Dam/Line Existing Channel	0.2 - 0.7 outside	0.56	Low	0.51	*Low / High	0.42	*Low / Med.	0.28	*Low / Med.	N/A	Ad
84+00	84+00	85+00	100	Check Dam/Line Existing Channel	of channel	0.13	Low	0.11	*Low / Low	0.11	*Low / Low	0.10	*Low / Low	N/A	
85+00	85+00	91+00	600	Class B Turf	2.1	1.16	Low	1.26	Low	1.33	Low	1.38	Low	N/A	
91+00	91+00	95+00	400	Class B Turf	↓	1.41	Low	1.61	Low	1.80	Low	1.98	Low	N/A	

1.2 based on lower limit for long native grasses
2.1 based on Class B turf
3.0 based on unvegetated non-degradable RECP

* First erosion potential classification is for shear stress with respect to in-channel threshold, second classification is with respect to outside of channel. Channel designed for 90 cfs so all shear stresses for 90 cfs compared to threshold in channel.

Southwest Drainage District

The Southwest Drainage District is located in the southwestern portion of the SWWD and has an area of 11,400 acres. It is shown as Project Subwatersheds 5, 6, and 7 on Map

1. The main drainage system runs northwest to southeast, starting in the southwestern corner of Woodbury and would eventually discharge to the Mississippi River in the south in Section 34. Several storm drainage facilities connect into this main system along T.H. 10 and 61. The Southwest Drainage District topography has natural ponding areas in the very upper reaches with ravines in the central portions and flatter river terraces in the southern areas.

This Drainage District begins in Woodbury just east of La Lake which is outside the SWWD. The northwestern portion of the Drainage District is landlocked and has a tributary area of 852 acres. The elevation of the topographic high point separating the last depression at the Woodbury-Cottage Grove border and the intermittent stream is approximately 880.

The central portion of this drainage district has a western branch and an eastern branch. The western branch includes what is known locally as the West Draw and passes under T.H. 10 and 61 near 80th Street. The eastern branch crosses T.H. 10 and 61, east of Jamaica Avenue. The two branches join just south of T.H. 10 and 61 at DNR protected wetland #86W.

The southern portion of the Southwest Drainage District is typically flat with sandy soils and in some places shallow bedrock. The amount of direct runoff that can potentially drain into this ravine makes it an important waterway. This waterway must pass through three ponding/wetland areas before reaching the Mississippi River. The channel and the wetland in the ravine are protected by the DNR. A small portion of the Southwest Drainage District drains directly into the Mississippi River through small local drainageways.

3. Existing Flood Level Information

Federal Flood Insurance Studies (FISs) are available at the DNR's Division of Waters and the City of Cottage Grove. The only FISs addressing areas in the SWWD are those areas directly adjacent to the Mississippi River. For further information on the extent of the floodplain along the river, the FIS for Cottage Grove is available from the City of Cottage Grove.

All the cities with waterbodies in the watershed have some form of local stormwater plans that give some information on flood levels of the waterbodies in the watershed. The information in the plans continues to change and be updated as changes occur in the communities. This data is generally more accurate than the level of detail used in a watershed management plan and therefore was used by reference in developing the WMP. The detailed local information on flood levels can be obtained through the public works departments of each city.

a. Surface Water Modeling

EOR used the HydroCAD model that has been built up by the city of Woodbury to model four storm event scenarios. The model included data on most of the Northern half of the SWWD and a few areas of Cottage Grove that lie adjacent to and south of CD-P85 and CD-P86. The scenarios modeled are as follows:

- Current MUSA build-out (existing) for the 24-hour, 6.0" rainfall event
- Ultimate development for 24-hour, 6.0" rainfall event
- Current MUSA build-out (existing) for the 10 - day, 7.2" snowmelt runoff event
- Ultimate development for the 10 - day, 7.2" snowmelt runoff event

Modeling assumptions built into the four scenarios controlled for: infiltration rates, initial basin elevations, lift station pumping levels and factors inherent to using HydroCAD. Details on these assumptions can be found in the Emmons & Oliver Resources (IMS) Phase II Report starting on Page IV – 4.

Tables IV-5 and IV-6 summarize the rainfall (6.0") and snowmelt (7.2") preliminary modeling results for the various timing scenarios and levels of management at key locations in the system to provide an overview of how the system behaves under different scenarios.

Table IV-5. Summary of Results at Key Location - 6.0" Rainfall Event

Waterbody	Init. Water Level [ft]	Woodbury's Plan HWL [ft] *	Lowest Elev. [ft] (house/structure)	Runoff Volume Downstream [Ac.-Ft.]					HWL [ft]				
				(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Powers Lake	888.0	893.9	898.6	138	244	244	244	244	892.0	893.7	893.7	893.7	893.7
Markgrafs Lake	925.0	928.7	932.2	106	136	136	136	136	927.3	928	928	928	928
Wilmes Lake	901.1	906.5	911 - 912	1066	1239	1220	1220	1220	909.4	909.9	909.8	909.8	909.8
CD-P56 (Preswick Golf Course)	870.0	887.0	900.5	1700	1892	1880	1880	1880	885.7	886.0	886.1	886.1	886.1
Bailey Lake (North & South)	868.5	877.0	883.0	1590	1766	2269	2542	2567	875.2	875.4	877.2	878.7	878.6
CD-P85	885.0	N/A		345	421	766	980	1013	915.1	915.1	915.1	915.1	915.1
CD-P86 (North Lobe)	875.6	N/A	908.6-County Rd.19	0	0	0	0	0	892.9	893.6	897.5	899.0	899.2

* For a 100-Year, 24-Hour, 6" Rainfall Event

(1) Current conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (3 cfs)
(2) 2005 conditions same as (1)
(3) 2010 conditions same as (1)
(4) 2015 conditions same as (1)
(5) 2020 conditions same as (1)

Table IV-6. Summary of Results at Key Locations - 7.2" Snowmelt Runoff Event

Waterbody	Init. Water Level [ft]	Woodbury's HWL [ft] *	Lowest Elev. [ft] (house/structure)	Runoff Volume Downstream [Ac.-Ft.]						HWL [ft]					
				(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
Powers Lake	888.0	893.9	898.6	281	281	376	376	376	376	893.4	893.4	897.2	897.2	897.2	897.2
Markgrafs Lake	925.0	928.7	932.2	248	248	248	248	248	248	929.0	929.0	929.0	929.0	929.0	929.0
Wilmes Lake	901.1	906.5	911 - 912	2410	2410	2490	2490	2490	2490	913.8	913.8	913.9	913.9	913.9	913.9
CD-P56 (Preswick Golf Course)	870.0	887.0	900.5	4130	4130	4335	4551	4551	4551	891.2	891.2	892.2	893.3	893.3	893.3
Bailey Lake (North & South)	868.5	877.0	883.0	4105	4105	4260	4476	5139	5987	881.2	881.2	881.5	882.2	880.9 **	881.4 ***
CD-P85	885.0	N/A		2470	2470	2533	2697	3476	4272	915.3	915.3	915.3	915.3	915.5	915.6
CD-P86 (North Lobe)	875.6	N/A	908.6-County Rd.19	868	297	917	998	1885	2377	901.0	906.4	901.2	901.2	904.2	905.8

* For a 100-Year, 24-Hour, 6" Rainfall Event

** Upgrade of Bailey Lake L.S. assumed in the modeling (4 pumps, peak pumping rate = 120 cfs) to compensate HWL at Bailey Lake due to no improvements

*** Upgrade of Bailey Lake L.S. assumed in the modeling (5 pumps, peak pumping rate = 135 cfs) to compensate HWL at Bailey Lake due to no improvements

(1) Current conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (2 cfs)

(2) Current conditions as defined in (1) plus adding 5' x 350' overflow earth berm at the south end of CD-P86

(3) 2005 conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (2 cfs)

(4) 2010 conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (2 cfs)

(5) 2015 conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (2 cfs)

(6) 2020 conditions. No infiltration and no retrofitting detention assumed except for CD-P85, CD-P86, CD-P50, Pioneer Dr. wetland and Bailey Lake (2 cfs)

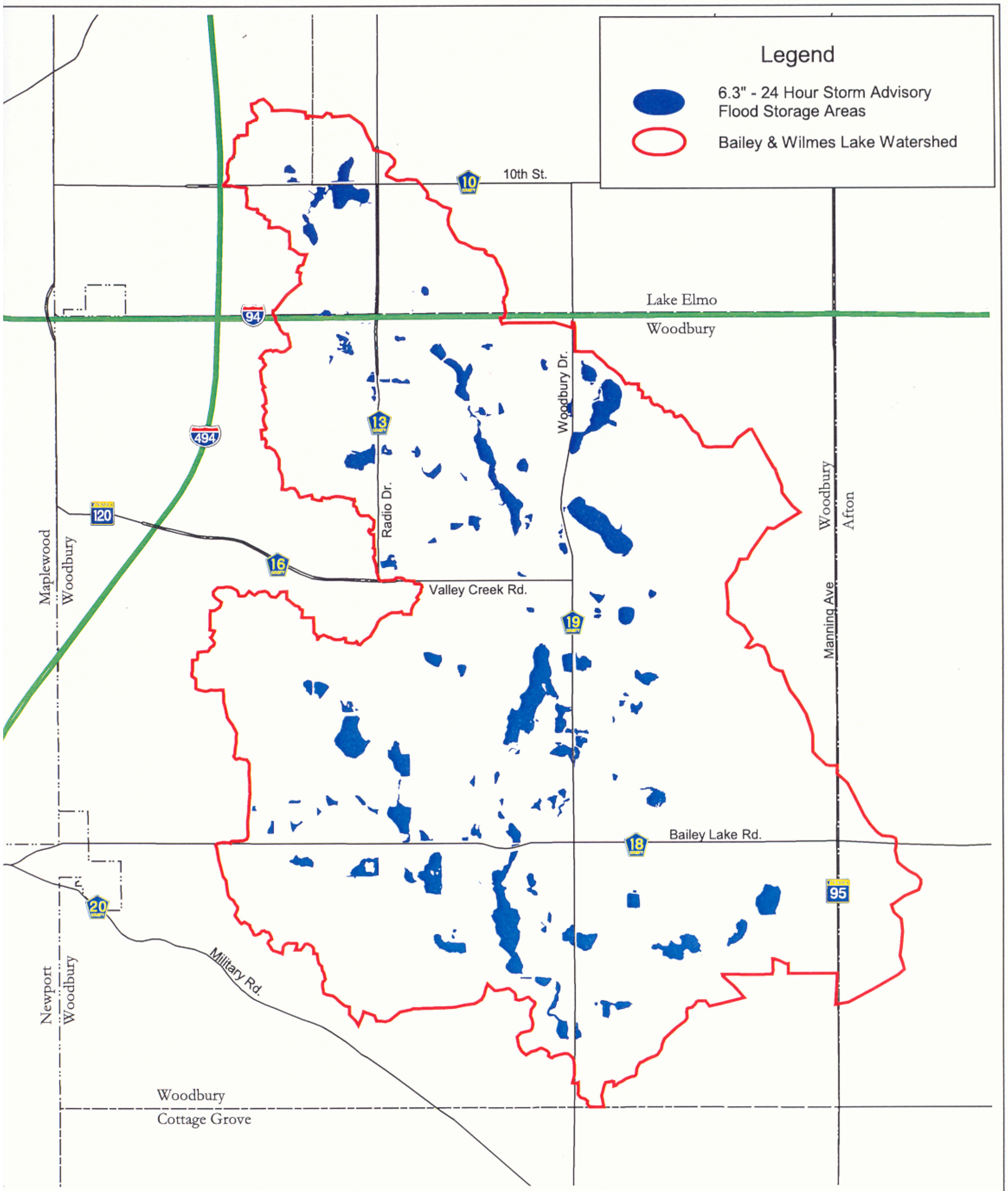
As demonstrated in Table IV -5, for the 6.0" rainfall event the stormwater system with only five managed infiltration areas, including North CD-P86, is capable of handling the 100-year rainfall event from now at least through 2020 with no outflow from of North CD-P86.

The 7.2" snowmelt 100-year event is spread over a longer period of time (l0-days), but accounts for a much higher volume of runoff than the 100-year rainfall event (approximately 2 1/2 times). In a naturally landlocked watershed such as the SWWD, the large volume events become critical to the system. Table IV -6 shows that with minimal management (only the five infiltration basins), the system could produce outflow out of North CD-P86, likely into South CD-P86 and/or Gables Lake. The outflow could range from 900 acre-feet to less than 300 acre-feet with the addition of one improvement, a berm at CD-P86. Through the year 2020, the volume increases to about 2,400 acre-feet if no additional management is done (Emmons & Oliver Resources, 2001).

b. Flood Storage Areas for Bailey and Wilmes Lake Watershed: Data Results from HDR's "Central Draw Project And Flood Storage Area Maps"

The proposed Central Draw Overflow Project is intended to provide principal and emergency outlet capacity for this land locked watershed under existing conditions up through completion of Woodbury's Phase I AUAR development area.

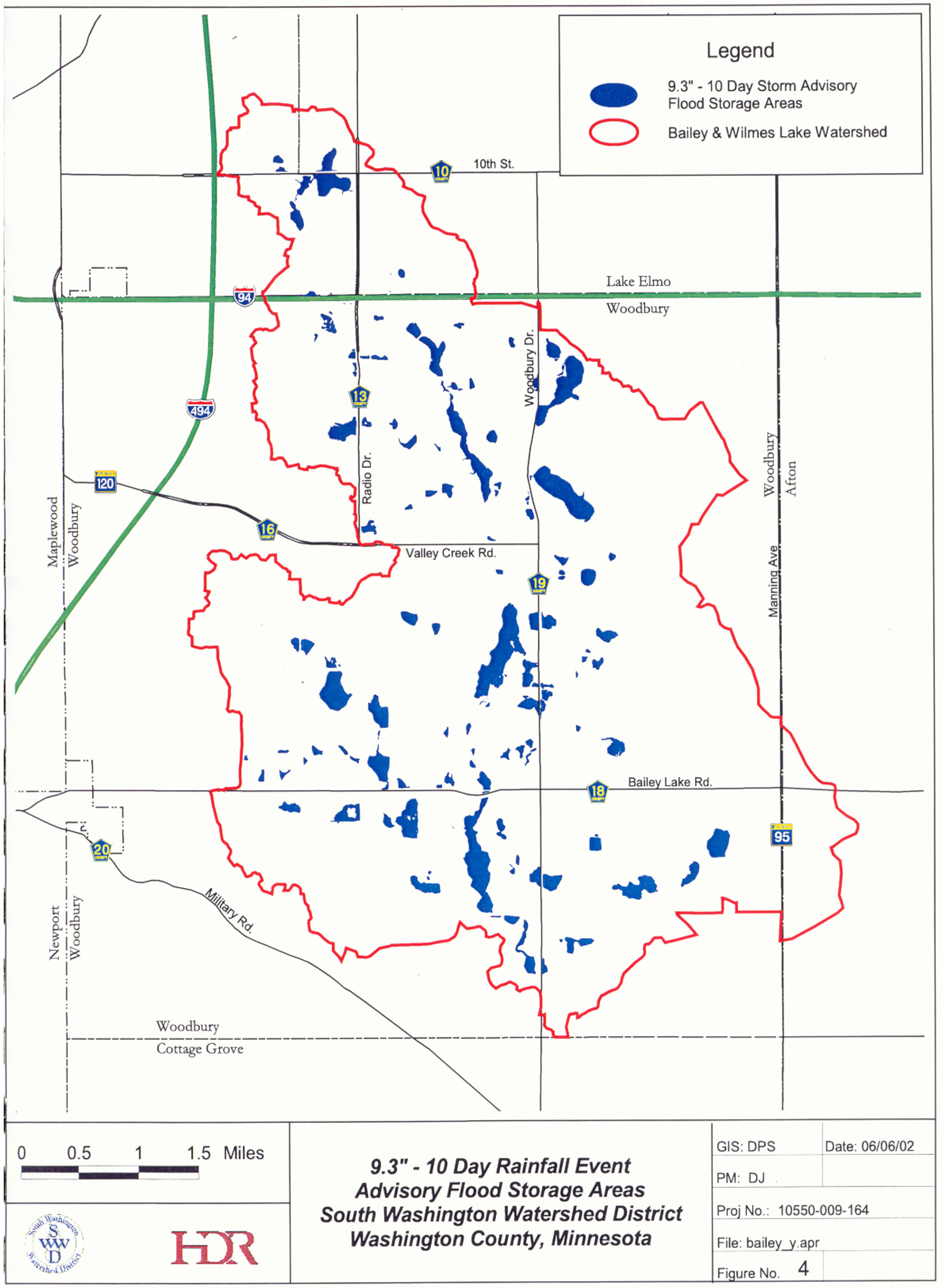
Figure 3 and Figure 4 present the existing condition advisory floodplain maps flood storage areas for this watershed for the 100-year 24-hour and 100-year 10-day precipitation events respectively. It is important to recognize that much of the flooding is local in nature and related to issues with the Municipal drainage systems. The maps presented illustrate the floodplains storage area water levels with a functioning Bailey Lake outlet as proposed in this project. They also document the locations of storage assumed in the project design.



0 0.5 1 1.5 Miles

6.3" - 24 Hour Rainfall Event
Advisory Flood Storage Areas
South Washington Watershed District
Washington County, Minnesota

GIS: DPS	Date: 06/06/02
PM: DJ	
Proj No.: 10550-009-164	
File: bailey_y.apr	
Figure No. 3	



The Project and flood storage areas identified in this report are utilized to establish the rate, volume and timing of overflows that can be accommodated from the upstream watershed for the storm events analyzed under existing conditions. Therefore, this plan becomes a point of reference to compare the impact of future development on the design of overflow systems. In regards to Woodbury's Phase I AUAR area, the design of the project assumes Woodbury will commit to the rate, volume and timing of flows as predicted by HDR in our modeling. The city has been provided copies of our model files. Specific areas where rate, volume and timing are assumed include:

- PL1-1 Powers Lake
- CL1E10-1 Wetland area south of Golden Eagle Circle in the Eagle Valley Golf Course/Home Development (Outlot K)
- CL1E5-1 Wetland area on Margaret M. Bailey property SE of the intersection of Dorset Lane and Raleigh Road.
- CL1N4-1 Klaus Becker property SE of the intersection of St. John's Drive and Valley Creek Road.
- CL1N6-1 Pond south of Grand Valley Lane within the Eagle Valley Golf Course/Home Development (Outlot B)
- CL1E9-1 Wetland area east of Eagle Valley Drive and west of White Eagle Drive within the Eagle Valley Golf Course/Home Development (Outlot C)

These inflow points are illustrated in Figure 5.

Insert Figure 5 here

The purpose of the flood storage area maps is not to limit development but to document and account for existing water storage locations within the watershed in order to design the project. Future changes that affect the rate, volume or timing of runoff from these basins will affect the operation and reliability of the project. It is important to document existing conditions in order to understand how future development will impact the built and natural environment and make necessary modifications to proposed watershed management plans for these areas.

4. Stormwater Management in the Watershed

a. History

Stormwater management became a significant issue in the 1970's when the watershed encountered steady suburban-type urbanization. Until the early 1980's, the principal institutions responsible for local stormwater management planning and implementation were the cities. Early stormwater management planning in the watershed included the 1979 Woodbury Storm Drainage Plan and the 1984 Cottage Grove Comprehensive Storm Drainage Plan. Both plans included the entire city, which covered most of the area in the SWWD.

The drainage systems presented in the plans accounted for full development of the cities. The general approach used in the Woodbury and Cottage Grove plans is to provide outlets for landlocked basins once urbanization occurs to control water levels in the basins. The connection of numerous landlocked areas within the northern portion of the watershed necessitated planning for a central drainage system. The 1979 Woodbury plan shows the central drainage system as carrying runoff water from the northern portion of the watershed to its southern border. It would then need to be transported downstream to the Mississippi River. The central drainage system shown consists of a gravity system connecting the lakes that lie in the center of the watershed.

The 1984 Cottage Grove plan shows the upstream central drainage flow from Woodbury being carried through the eastern portion of the city to the Mississippi River. The planned stormwater system consisted of gravity connections between landlocked basins and a natural drainage channel to the Mississippi River. The other areas in Cottage Grove in the western and central portions of the city were shown to be conveyed to the Mississippi River through pipes, man-made channels, and natural channels and includes outlets for landlocked areas in the city.

The cities of Oakdale and Lake Elmo prepared or had prepared for them basic stormwater plans that documented existing hydrologic conditions and flows. The City of Afton did not prepare stormwater plans for the portion in the SWWD. The portion of Lake Elmo in the SWWD (which includes areas that are now in Oakdale) was covered by a 1986 Lake

Elmo-Cottage Grove Ravine WMO Local Water Management Plan prepared for the City by the Washington County Soil and Water Conservation District. The 1986 Lake Elmo plan does not propose any significant modifications to the existing drainage system except to repair and maintain the drainage way and further study of the 100-year flood plane at the time of any major development in the area.

Pursuant to Minnesota's 1982 Surface Water Management Act, a joint powers Watershed Management Organization (WMO) called the Cottage Grove Ravine WMO was formed in 1984 to manage the water resources of the area that is now the SWWD. The joint powers agreement included the same five cities that are currently included in the SWWD. The boundaries of the two organizations are virtually the same except that the WMO included the eastern half of Grey Cloud Island which is not included in the current SWWD boundaries.

The Cottage Grove Ravine WMO prepared a draft Watershed Management Plan (WMP) in 1988. The WMO draft WMP includes a drainage system generally consistent with the city plans. The central drainage system shown is a series of landlocked basins interconnected and an outlet system to the Mississippi River. The Cottage Grove Ravine WMO draft WMP shows additional ponding north of I-94 not shown in the 1986 Lake Elmo Plan.

The Cottage Grove Ravine WMO draft WMP stresses cooperative efforts by the member cities. The WMO outlined a process where implementation and enforcement of controls would be carried out by the cities once they adopted their Local Municipal Management Plans. The WMO draft WMP was never adopted since the WMO could not obtain a four-fifths majority to adopt the WMP as was required in the joint powers agreement.

With the WMO unable to adopt and implement its WMP, the WMO was dissolved which led to the formation of a Watershed District (WD) in 1993 known as the Cottage Grove Ravine WD. The Cottage Grove Ravine WD decided in 1995 to change its name to the

South Washington Watershed District (SWWD) to prevent confusion with the City of Cottage Grove. The SWWD is the entity that has prepared this WMP.

The SWWD is faced with the past issues of addressing intercommunity water resource issues such as preventing flooding due to urbanization as the drainage system continues to be expanded to include new areas. In addition, the SWWD is also responsible to address new concerns over water quality, lakes, wetlands, and loss of natural areas. The SWWD shares the approach used by the WMO to keep as much of the implementation and enforcement as possible at the local level in order to reduce administrative costs. Like the WMO, the SWWD will still maintain oversight to ensure compliance with the standards presented in the WMP.

The majority of the drainage issues and improvements that were needed in the watershed up until now have been implemented by the individual cities. The nature of the improvements up until now have been fairly easy to implement at a local level, even though some improvements have included some portion of intercommunity drainage. The major drainage or flood control issues facing the SWWD at this time are intercommunity drainge improvements that are not easily dealt with at a city level.

The largest drainage improvement facing the watershed currently is the potential for flooding in the central draw in Woodbury until an outlet of some type is provided. The potential for flooding in the central draw is due to the rapid urbanization of the watershed. The urbanization has led to the connection of many landlocked areas as shown in the Cities= previous stormwater plans. However, the outlet that was assumed in the stormwater plans does not yet exist.

In 1993, the City of Woodbury began looking at what intermediate steps and options would be possible at Bailey Lake, which was the end of the central draw drainage system at that time. The summer of 1993 was an unusually wet period and Bailey Lake water levels increased significantly, covered Dale Road, and flooded and killed many older trees around the basin.

In 1994, the City of Woodbury took several measures to formalize Bailey Lake as part of the City=s stormwater drainage system and to provide additional capacity to the system to help prevent flooding. The improvements at Bailey lake included:

∃ Acquire the land encompassing the Bailey Lake basin through fee title and easements.
∃ Raise Dale Road to prevent it from being flooded based on the 1979 Stormwater Plan HWL established for Bailey Lake.
∃ Relocate one home at the south end of Bailey Lake that was inadvertently built too low.
∃ Raise several driveways for homes at the south end of Bailey Lake.
∃ Install an outlet structure with removable stop logs at Dale Road to allow control of the Bailey Lake NWL.

The City of Woodbury also incorporated several improvements to provide additional capacity to the system and lower, but not eliminate, the flooding risk until an outlet was provided. The extra capacity was generally in the form of additional storage and infiltration areas and included:

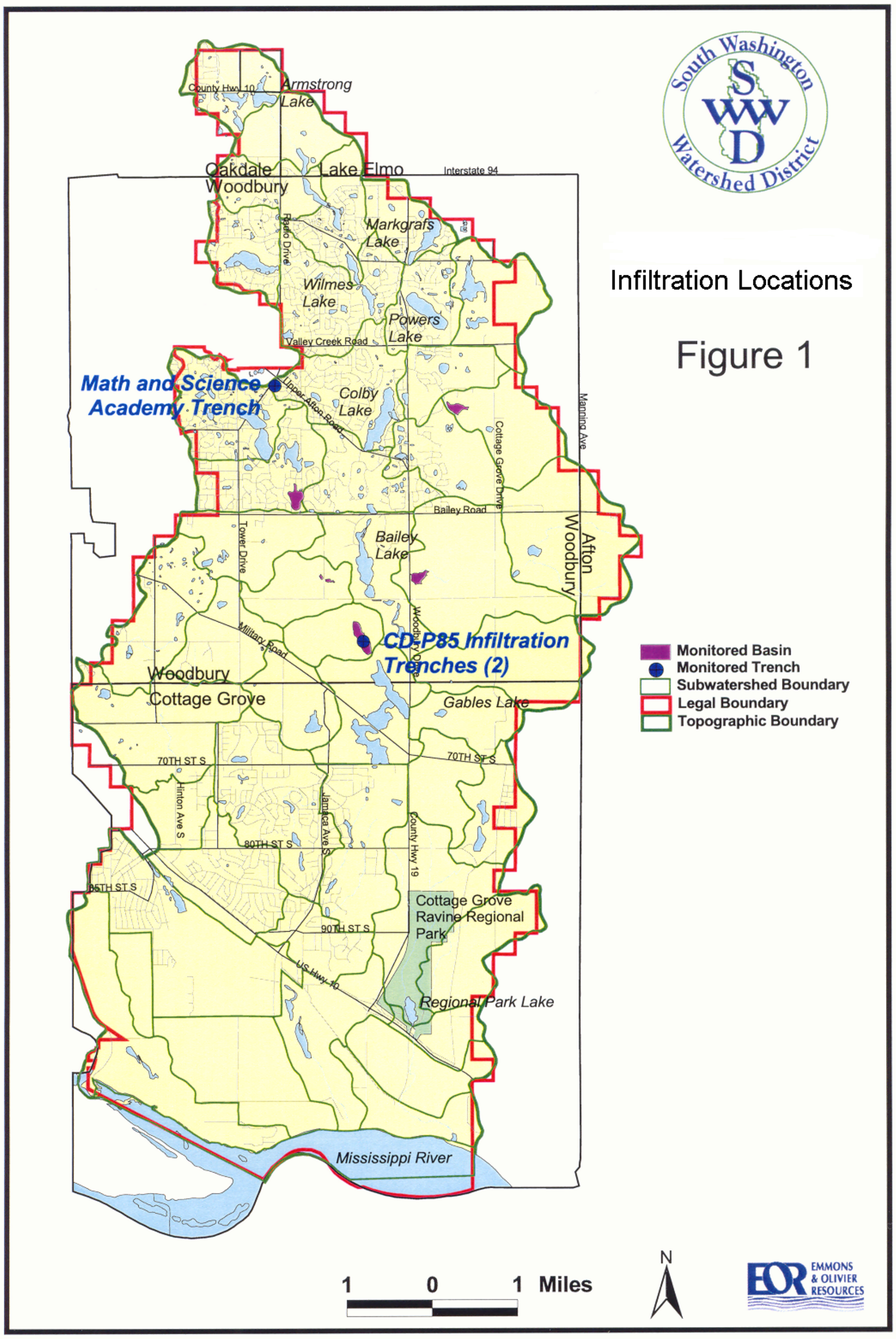
∃ Open a channel from Bailey Lake at Dale Road to a depression (South Bailey Stormwater Basin) that appears to be good for infiltration along County Road 19.
∃ Purchase land for a ponding and infiltration basin at the cent of Section 34 known as CD-P85.
∃ Build a lift station with an ultimate capacity of 180 cfs and install half of the pump and force main capacity at South Bailey Stormwater Basin to pump water approximately 30 feet higher to CD-P85.

b. Complying With New Water Quality Regulations

The State of Minnesota is currently developing an NPDES Phase II Storm Water program for Municipal Separate Storm Sewer Systems. The permit will be adopted by the State in March of 2003. This permit will regulate the cities of Woodbury and Cottage Grove. As it is currently drafted, the permit would not allow new discharges of stormwater to the Mississippi River without extensive justification (HDR, 2002). In addition to NPDES Phase II requirements a section of the Mississippi River that receives storm water from the SWWD has been designated as the Mississippi National River Recreation Area. Any new discharge of storm water to this segment of river is restricted if prudent and feasible alternatives can be identified. Finally, this section of the Mississippi River has a Total Maximum Daily Load (TMDL) Allocation. If a TMDL is approved by the USEPA Storm Water Pollution Prevention Program's in the SWWD must be modified as appropriate, to meet the applicable requirements and schedules of the TMDL implementation plan (HDR, 2002).

5. Infiltration Potential

Emmons and Olivier Resources (EOR) Inc. studied infiltration rates at five different infiltration basins in the SWWD as part of their Infiltration Management Study (IMS) Phase II Report (Emmons and Olivier Resources, 2001). Each basin's infiltration rate is considered to be representative of other infiltration basins within its sub watershed. These representative sites allow the SWWD to predict the potential for infiltration throughout their watershed. Figure 1 identifies the site locations and their corresponding sub watershed boundaries.



6. Infiltration Envelopes

The following infiltration envelopes presented in Tables (1,2,3,4,5,7,9,11,12) represent the highest and lowest infiltration rates observed for each basin over the course of the study. The SWWD should use these envelopes to estimate infiltration rates throughout the watershed (Emmons and Olivier Resources, 2001).

Each basin's infiltration rate envelope is described by two different functions. The infiltration rate in inches per hour demonstrates the capacity of the basin as a function of depth of water in the basin. The volumetric infiltration rate in cubic feet per second demonstrates the capacity of the basin as a function of basin size and geometry.

Table 1. Infiltration Rate Envelopes for CD-P50

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.03 - 0.32	0.03 – 1.00
Low end of range	0.02 – 0.14	0.03 – 0.60

Table 2. Infiltration Rate Envelopes for CD-P69 - Spring

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.35 – 0.37	1.42 – 1.78
Low end of range	0.07 – 0.12	0.29 – 1.31

Table 3. Infiltration Rate Envelopes for CD-P69 - Summer

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.19 – 0.27	0.85 – 1.19
Low end of range	0.11 – 0.12	0.57 – 0.91

Table 4. Infiltration Rate Envelopes for CD-P76

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.23 – 0.60	0.22 – 4.30
Low end of range	0.12 – 0.48	0.22 – 4.57

Table 5. Infiltration Rate Envelopes for CD-P82

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.04 – 0.34	0.13 – 3.22
Low end of range	0.04 – 0.30	0.13 – 3.63

Table 7. Infiltration Rate Envelopes for CD-P85 w/o Improvements

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
Range	0.14 – 1.15	0.16 – 19.7

Modifications to the natural site conditions were made at CD-P85 two determine if the installation of pipes and or trenches would improve infiltration rates.

Table 9. Infiltration Rate Envelopes for CD-P85 w/ Infiltration Tubes

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.36 – 1.37	1.6 – 10.8
Low end of range	0.22 – 0.72	1.32 – 22.8

Table 11. Infiltration Rate Envelopes for CD-P85 w/ Infiltration Tubes and Trenches

Infiltration Rate Envelope	Infiltration Rate [inches/hour]	Volumetric Infiltration Rate [cfs]
High end of range	0.72 – 2.76	0.3 – 55.5
Low end of range	0.41 – 1.21	0.3 – 21.7

Infiltration data from trenches at CD-P85 and the Math and Science Academy were combined to determine the following infiltration rate envelopes for the infiltration trenches.

Table 12. Infiltration Rate Envelopes for the Infiltration Trenches: 1999 and 2001

Infiltration Rate Envelope	Infiltration Rate [inches/hour]
High end of range	0.19 – 1.71
Low end of range	0.19 – 1.17