V. **Watershed Characteristics and Resources**

A. Physical Environment

This section describes the physical environment in the SWWD, including climate and precipitation, topography, geology, soils, and groundwater.

1. Climate and Precipitation

The climate in the South Washington Watershed is similar to that over all the Seven County Metropolitan Area. Winters include extended periods of below freezing temperatures with an average temperature of 17^{o}F. Summer is fairly short with warm temperatures and high humidity and an average temperature of 70^{o}F. The annual normal temperature is 44EF. In most years there are at least 120 days with a daily minimum temperature above freezing.

As described in the Soil Conservation Service (SCS) Hydrology Guide for Minnesota, total annual precipitation in the watershed is approximately 28 inches, including 46 inches of snowfall. Table IV-1 presents 24-hour rainfall amounts for various recurrence intervals. The recurrence interval is a measure of the probability of occurrence of the storm event. For example, a 5-year storm has a
1-in- 5, or 20%, chance of occurring or being exceeded in any given year, while a 100-year storm has only a 1-in-100, or 1%, chance. Also shown in Table IV-1 are the 24-hour 100-year and the 10-day 100-year precipitation events. HDR Engeneering estimated these in their June 2002 Engineers Report: “Central Draw Project and Flood Storage Area Maps”. HDR utilized rainfall data from Huff and Angel to estimate the mean 100-year 24-hour rainfall event for the South Washington Watershed District. It was determined

that this amount was 6.3 –inches. HDR then utilized the techniques presented by Huff and Angel to determine the upper 95% confidence interval for that event which corresponds to 1.5 inches or a 7.8-inch event. The 100-year 24-hour storm evaluated for the purposes of flood storage area mapping and system design is 6.3 inches in 24-hours. The 7.8-inch event was used to determine the adequacy of the proposed design to provide capacity to manage a larger emergency overflow for a 100-year 24-hour event. HDR also utilized rainfall data from Huff and Angel to estimate the mean 100-year 10-day rainfall event for the South Washington Watershed District. It was determined that this amount was 9.3 inches. HDR then utilized the techniques presented by Huff and Angel to determine the upper 95% confidence interval for that event which corresponds to 1.3 inches or 10.6-inches. The 100-year 10-day storm evaluated for the purposes of flood storage are mapping and system design is 9.3 inches in 10-days. The 10.6-inch event was used to determine the adequacy of the proposed design to provide capacity to manage a larger emergency overflow for a 100-year 10-day event (HDR, 2002).

Table IV-1. Storm Events

Recurrence Interval, Years	24-hour Rainfall Amount, Inches	10 Day Rainfall Amount, Inches
2	2.8	
5	3.6	
10	4.2	
25	4.8	
50	5.3	
100	6.03	
100	7.8*	
100		9.3
100		10.6*

*95% Confidence interval used for emergency outflow modeling

The 1997 Plan listed a 100 yr 10 day 7.2” runoff event as a likely scenario that should be used in modeling storm events in SWWD. Since 1997 the District has had EOR (Emmons & Oliver Resources, 2001) conduct some preliminary modeling using the 100 yr 10 day 7.2” runoff event. Results of these studies are presented in Section IV, B 3a. of this plan. However, as a part of some recent floodplain modeling done by the District this traditionally used 100 yr 10 day 7.2” runoff event was researched in further detail to determine if it was an appropriate measure for conditions found within the SWWD. The information revealed by HDR’s research (HDR, 2002) led to the replacement of this 100 yr 10 day 7.2” runoff event standard with the more accurate 100 yr rainfall standards listed in the table above. The District will continue to take into consideration the 100 yr 10 day 7.2” runoff event in evaluation of future projects however; it’s reliability as an affective measure is now highly questionable.

2. Topography

The northern half of the South Washington Watershed District has a general drainage direction that runs north to south through the middle of the watershed. This drainage system has a series of elongated, sometimes isolated, depressional areas which contain the lowest elevations in this part of the watershed. Elevations above sea level range from 1070 in Oakdale to 880 at the Woodbury/Cottage Grove boundary. The major drainageway in the northern part conveys the stormwater from the cities of Oakdale and

Lake Elmo, through Wilmes Lake and Colby Lake, to Bailey Lake in Woodbury. The terrain of this portion of the watershed is characterized by long continuous slopes, large spacing between ridges and knolls, and flat and wide valleys and draws.

The southern half of the South Washington Watershed has two distinctive types of topography. In the west, the topography varies from nearly flat to fairly steep slopes and the landscape is fairly well dissected by a series of draws that ultimately discharge to the Mississippi River. The southwest corner of the watershed contains a very flat terrace area. Land surface elevations range from 1000 in the north to a low of 687, which is the normal pool elevation of the Mississippi River. In the east, the ground surface has elongated depressions that could be classified as intermittent streams, except very near the Mississippi River where the drop in elevation is rapid and the topography is somewhat bluff-like. There is one dominant ravine in the east with landlocked depressions in it. Topography in this area varies from elevation 980 in the north to the normal pool elevation of the Mississippi River of 687 in the south. Ravine areas in this southern half of the watershed are generally wooded with areas above the ravines flat and open for farming. Figure IV-1 shows the topographic and legal boundaries of the watershed.

3. Geology

Bedrock Geology

The bedrock geology of the SWWD reflects a complex mixture of depositional and erosional environments. During the early Paleozoic age, shallow seas covered the area. Carbonate was deposited in the deeper marine environments, silt-sized particles in the transitional areas, and sand in the near-shore and beach areas of the ancient sea. Over time, these sediments were compressed and solidified into sedimentary rocks.

Erosion of these sedimentary rocks occurred when the sea retreated, and deposition occurred when the sea advanced. Depending on the depositional environment, the bedrock formations exhibit the characteristics of aquifers or aquitard. Refer to the Washington County Geologic Atlas Plate 2 for more information and schematics of the bedrock sedimentary stratigraphic column.In the SWWD, the Mount Simon sandstone

formation comprises the Mount Simon aquifer, which is a regionally significant water source. It is composed of fine-to-coarse-grained sandstone and ranges in thickness from 160 to 225 feet. The aquifer is generally not used in the SWWD, due to the depth of the formation and the availability of other sources. The Mount Simon sandstone grades into the Eau Claire formation, which consists of approximately 100 feet of shale interbedded with
siltstone and fine-grained sandstone. The Eau Claire is considered an aquitard (does not pass water freely).

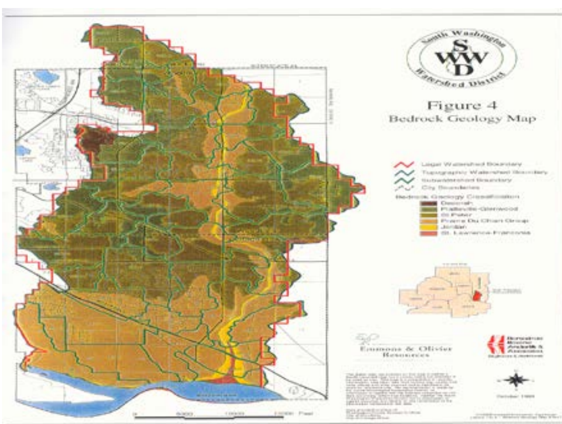
The Eau Claire grades into the Ironton-Galesville formation, which consists of siltstone interbedded with fine to coarse-grained sandstone. The Ironton-Galesville is considered an aquifer, although it is not used widely in the SWWD. Overlying the Ironton-Galesville are the Franconia and St. Lawrence formations. The Franconia is composed of very fine-grained sandstone, while the St. Lawrence is a sequence of thinly bedded dolomitic shale and siltstone. These formations are both considered aquitards, although they exhibit permeabilities that are suitable for domestic water supply development.

The Jordan formation overlies the St. Lawrence. It is composed of fine-to-coarse-grained sandstone, approximately 100 feet thick. The Jordan forms the lower portion of the regionally significant Prairie du Chien-Jordan aquifer. The Prairie du Chien group is a series of thinly bedded dolostone and sandstone approximately 200 feet thick. The Prairie du Chien formation represents a past erosional surface; consequently, the fracturing caused by exposure provides secondary permeability and makes the formation a very productive aquifer. Taken together, the Prairie du Chien - Jordan aquifer provides water for the cities of Oakdale, Cottage Grove, and Woodbury, along with numerous high capacity irrigation, commercial, industrial, and public supply wells in the watershed.

Overlying the Prairie du Chien group is the St. Peter Sandstone. This formation is present in the central portion of the watershed. It has been eroded away in other parts of the watershed. Where it exists, the St. Peter is roughly 150 feet thick and consists of fine- to medium-grained well-sorted sandstone. The basal portion of the formation is considered an aquitard, while the upper two-thirds is considered an aquifer. The Platteville-Glenwood formation and remnants of the Decorah shale overlie the St. Peter, primarily in the northwestern portion of the watershed. Both of these units are considered aquitards.

The bedrock surface in the watershed was altered by glacial processes during the Pleistocene epoch, approximately 1.5 million years ago. The most prominent feature is a north-south trending bedrock valley cutting through the center of the watershed. The valley was formed by a glacial tributary to the Mississippi River. The valley was excised into the Jordan sandstone, creating a hydraulic connection between overlying glacial sediments and deeper aquifers.

Figure V- 1 shows the bedrock geology of SWWD (Emmons & Oliver Resources, 1998).



In the IMS study the South Washington Bedrock Valley was described as having significant affects on groundwater flows in the region. Figures V-2, and V-3 depict a plaine and crossection view of this prominent geologic feature.

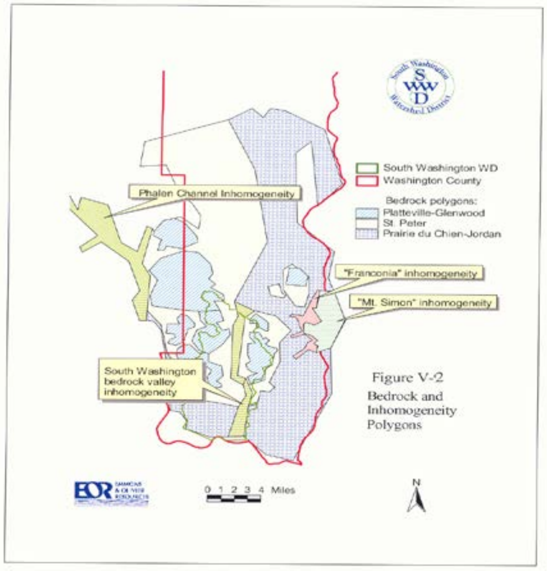
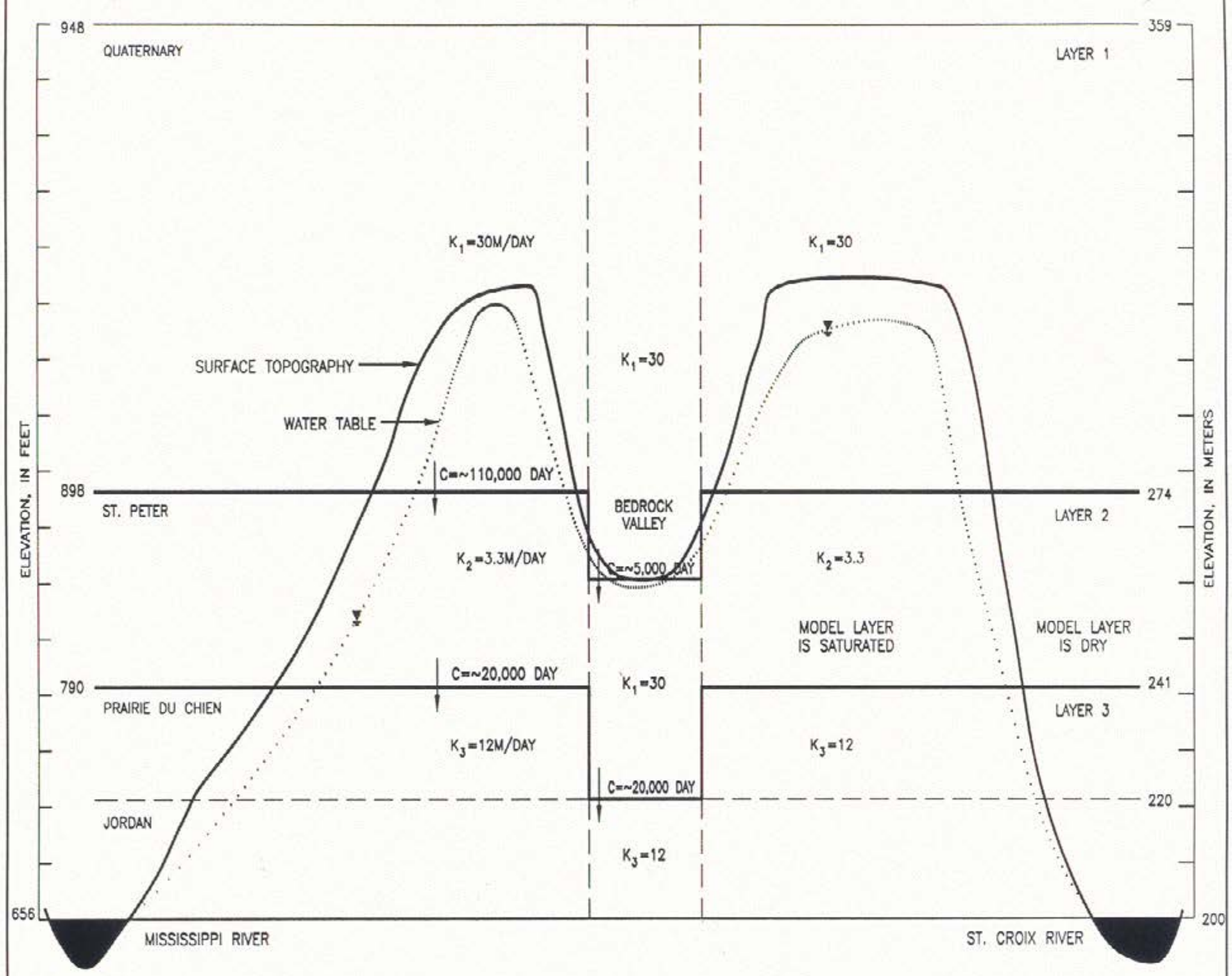


Figure V-2
Bedrock and Inhomogeneity Polygons



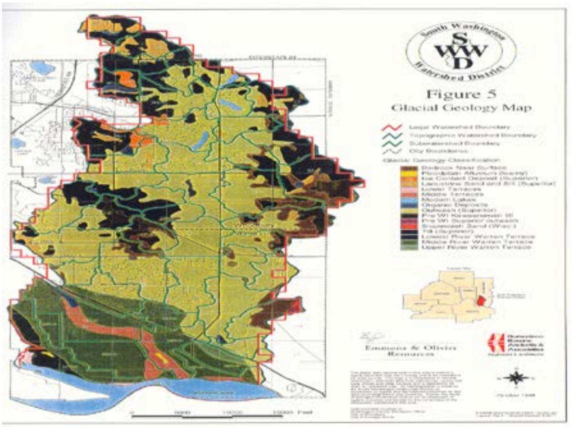
EMMONS & OLIVIER RESOURCES 3825 LAKE ELMO AVENUE NORTH LAKE ELMO, MINNESOTA 55042 (651) 770-8448	SOUTH WASHINGTON WATERSHED DISTRICT GENERALIZED CROSS-SECTION AND MODEL CONFIGURATION		FIGURE V-3
	EOR PROJECT #: SWWD	FILENAME: X-SECTION.DWG	DATE: 04/26/98

Surficial Geology

The topography of the SWWD is dominated by sediments dating from the late Wisconsinan glaciation, roughly 10,000 to 35,000 years ago. Meltwater from the Superior lobe of the Labradorean ice sheet created wide outwash plains throughout much of the watershed, creating regionally valuable sand and gravel deposits. As the glacier retreated, ice blocks were left behind in topographic lows on the bedrock surface. Melting of these ice blocks created many of the land-locked depressions and small lakes in Woodbury and Cottage Grove, including Bailey and Gables Lakes.

Superior lobe outwash sands and gravels mantle the bedrock surface in the watershed. The thickness of these glacially derived sediments ranges from less than ten feet in portions of Cottage Grove, to greater than 300 feet in the central buried bedrock valley cutting through Woodbury and Cottage Grove. The marked lack of outwash in southern Cottage Grove is due to variation in water level in the Mississippi River over time. Two separate terraces are apparent along the river in southern Cottage Grove. These terraces correspond to various periods of river downcutting in response to water level changes. The lack of glacial sediments in these terrace areas is cause for concern because of the proximity of the Jordan sandstone to the surface, and the potential for contamination of the aquifer.

The SWWD consists mostly of outwash formations of sand and gravel that allow for significant infiltration. These formations are illustrated on Figure 5 (Emmons & Oliver Resources, 1998).



a. Cottage Grove Ravine Tunnel Valley

The ravine is a tunnel valley, formed by glacial melt waters at the time when ice was in ,contact with the land surface at this location. This particular tunnel valley may have been formed

during the Illinoisan ice age and was partially filled in by Wisconsin-aged outwash deposits. As such, it is one of the oldest landscapes within the city limits, one that probably afforded ancient Native Americans an inviting habitat. A few isolated finds of Archaic and Woodland period artifacts have been made and several Euro-American sites and structures exist along the margins of the tunnel valley (Robert Vogel,1991).

Hydrogeology

There are four major aquifers available for use in the watershed. The water table aquifer is generally unconfined and recharged through direct infiltration from precipitation and leakage from surface water bodies. The surface aquifer discharges to the St. Croix and Mississippi Rivers, with a potentiometric high occurring in the northern portion of Washington County. The gradient of the water table system is relatively flat in the central portion of the watershed, but steepens near the Mississippi River in Cottage Grove. The water table aquifer has not been a major source for groundwater development, although the capability of the unit to produce water is high, particularly in the major and minor buried bedrock valleys. Water quality is generally very good, with the exception of locally contaminated areas. Currently, Cottage Grove is exploring the water supply potential of buried valleys in the city.

The Prairie du Chien - Jordan aquifer is the source for all high capacity wells in the watershed. It is confined by the St. Peter throughout the north central portion of the watershed; elsewhere, it is generally unconfined and overlain by glacial drift. Where the St. Peter exists, the Prairie du Chien - Jordan is recharged through leakage from the basal St. Peter. Where it is overlain by glacial sediments, the aquifer is generally unconfined and recharged by outwash deposits. The aquifer discharges to the Mississippi and St. Croix Rivers; a potentiometric high exists in the northern half of Washington County. The gradient is flat in the central portion of the watershed, but steepens near the Mississippi River. The potentiometric surface of the Prairie du Chien - Jordan aquifer is roughly 10-50 feet below that of the water table aquifer. Water quality in the aquifer is generally good, although tritium analysis of supply wells in Cottage Grove and Woodbury show a portion of the water contributing to the wells is less than 50 years old, indicating a vulnerability to contamination.

The Franconia-Ironton-Galesville aquifer is confined by the St. Lawrence formation in Washington County, which is the local source of recharge to the aquifer. The flow system in the aquifer closely resembles that of the Prairie du Chien - Jordan aquifer, but the water level is approximately 25'-50' lower than that of the Prairie du Chien Jordan aquifer. The Franconia-Ironton-Galesville aquifer is not used in the SWWD, primarily because of the availability of the Prairie du Chien - Jordan aquifer.

The last major aquifer in the watershed is the Mount Simon sandstone. This aquifer is recharged through leakage from the Eau Claire confining unit within the county and subcrops to the north and northwest of the county. Information on groundwater movement within the aquifer is based on very limited data, but it appears that the St. Croix River is the primary discharge boundary for the aquifer. Because of the lack of data, a gradient is not obvious. The water level in the aquifer ranges from 0 - 150 feet below that of the Franconia-Ironton-Galesville aquifer. Currently, the Mount Simon aquifer is not an important water source for the watershed, although it could be in the future if contamination or excessive head loss become a problem with the Prairie du

Chien - Jordan aquifer. The availability of the Mount Simon aquifer is not a given and the DNR would be issuing appropriation permits assuming it meets the DNR=s criteria. Water quality in the Mount Simon is good, but iron, manganese and excessive hardness can occur.

Groundwater Sensitivity

The Minnesota Geological Survey (MGS) and DNR rated the sensitivity of the water table aquifer and Prairie du Chien - Jordan aquifer in the watershed based on the relative travel time for water-soluble, geologically inert contaminants released at the surface to reach the water surface of each aquifer. The travel time was evaluated according to: 1) depth to water, and 2) vertical conductivity of geologic materials.

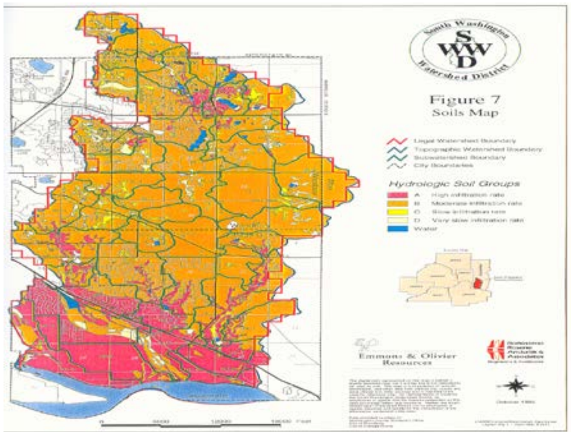
For the water table aquifer, the entire watershed was rated as high or very high. This indicates that the residence time of groundwater in this system is on the order of weeks to years. This means that water infiltrating in the watershed will reach the water table system in a very short period of time, leaving little opportunity for attenuation of contaminants through degradation.

For the Prairie du Chien - Jordan aquifer, groundwater sensitivity ranged from high in the Cottage Grove area, to moderate and moderately high in the eastern portion of the watershed, to very low in the western portion near Woodbury. See the Washington County Geologic Atlas Plate 6 for more detailed information.

4. Soils

Covering the glacial deposits are soils. Soils are small particles deposited by water and wind and enriched by decaying plant material. The SCS Soil Survey is the reference document for soils information. The soils map from the SCS shows broad areas that have a distinctive pattern of soils. Each map unit consists of several soil types. The unit is named according to the predominant soil type; therefore, the soils making up one unit can occur in other units, but in a different pattern.

The SWWD is comprised of a variety of soils that have predominately moderate to high infiltration rates. Figure 7 illustrates the soil infiltration rates within the watershed (Emmons & Oliver Resources, 1998).



The most common soils, such as those in the Antigo-Chetek-Mahtomedi map unit and the Sparta-Dickman-Hubbard map unit, are formed dominantly in outwash under deciduous hardwood forest or prairie. The Antigo-Chetek-Mahtomedi soils are well drained to excessively drained, medium textured to coarse textured soils, typical on low convex side slopes or knolls, crests and side slopes. The Sparta-Dickman-Hubbard soils are somewhat excessively drained and are coarser textured soils than the Antigo type. These soils occupy broad flats and knolls. The surface layer is dark brown-black loamy sand, while the subsoil is dark brown sandy loam in the upper part and dark brown sand underneath. Typical seasonal high water tables for these soils are below a depth of 6 feet. Other soils in the SWWD are also well drained and sandy loamy types.

Crops and pastures produced in the farming soils of the watershed include corn, soybeans, oats, legume hay, bromegrass, alfalfa, and Kentucky bluegrass. Common native trees include a variety of pines (such as the red pine, eastern white pine, and jack pine), American elm, maples, and oaks (red, white and bur). Soil erosion is a common problem on disturbed sites. However, the erosion problem can be much worse when there are steep slopes present.