East Souris River Watershed Hydrology

Watershed Boundary

The East Souris River Watershed (ESRW) is the area east of the Souris River between the Canada-U.S. Boundary and the Town of Souris that contributes runoff to the Souris River. It also includes the headwaters of two U.S. tributaries in Manitoba that originate on the southern slopes of Turtle Mountain and drain into the Souris River. The ESRW is bounded by the Souris River on the west. The ESRW is shown on Figure 1.

Climate

The ESRW has a continental semi-humid climate characterized by significant variations in seasonal and annual temperatures, and precipitation. It is warm and relatively humid in the summer, and very cold and dry in the winter. The mean annual precipitation decreases in a northwesterly direction from 550 mm in the Turtle Mountain Provincial Park to 500 mm at the Souris River[1]. Approximately three-quarters of this precipitation falls as rain, the rest falls as snow. Less than 10% of the average, annual total precipitation results in streamflow. The potential mean annual evapotranspiration loss is about 850 mm[2]. As potential gross evaporation losses are greater than the annual precipitation, the area is generally considered 'water deficient'. The southwest corner is normally the driest corner of the Province.

Water Courses

SSEE has four main watercourses: Waskada, Medora and Chain Lakes creeks and the Blind River that flow into the Souris River. It also has the headwater of the Boundary and Willow creeks that originate on the southern slopes of the Turtle Mountain and flow into North Dakota. Whitewater Lake is considered a closed basin. A map of the various creeks' watershed boundaries is shown on Figure 1 and their respective drainage areas are listed in Table 1.

As shown on Figure 1, all the tributaries in the ESRW drain into the Souris River. Waskada Creek, and the unnamed creek south of it, originate on the western slopes of the Turtle Mountain and flow in a westerly direction into the Souris River near Coulter. It has been reported that Waskada Creek can overflow to Medora Creek at high flows. Medora Creek originates on the northern slopes of the Turtle Mountain and flows northwesterly into the Souris River near Napinka. It has the largest drainage as shown in Table 1. The Blind River enters the Souris River near Melita, whereas, the Chain Lakes Creek enters the Souris River near Hartney. The Blind River and Chain Lakes are entirely on the prairie region. The topography in the prairie region is nearly level resulting in a majority

[1] Agriculture and Agri-Food Canada, Mean Annual Precipitation in the Canadian Prairies for the Standard 30 Year Period 1971- 2000.

[2] Agriculture and Agri-Food Canada, Mean Annual Gross Evaporation in the Canadian Prairies for the Standard 30 Year Period 1971- 2000.

of the soils being imperfectly drained. Willow and Boundary creeks run off the southern slopes of the Turtle Mountain into the Souris River near Upham, ND.

Table 1: ESRW drainage areas.

Water Course	Drainage Area in km^2
Waskada Creek	**177.5**
Medora Creek	**436.3**
Unnamed Creek	**122.7**
Blind River	**221.7**
Chain Lakes Creek	**353.9**
Willow Creek	**188.2**
Boundary Creek	**201.0**
Whitewater Lake	**732.6**

Hydrometric Data

Streamflow and lake level data has been collected at 11 hydrometric gauging stations within the ESRW for varying time periods since the mid 1960s. The locations of the 11 hydrometric gauging stations are shown on Figure 2. Table 2 indicates, that for each of the stations, the type of data collected, the period of record and the gross drainage of the gauge.

Historic streamflow data is available on Waskada, Medora and Turtlehead creeks. Their respective gross drainage areas are shown on Figure 2. The gauging stations operated annually during the period March through October from the mid 1960s to the mid 1990s. In 1994, the operating period of the Waskada and Medora creek gauges were reduced to the spring freshet period, March through May. The Waskada Creek station was discontinued in 2002. The operation of the Turtlehead Creek station was discontinued in 1996. The Medora Creek is the only gauging station still operating. The three gauges have a minimum of approximately thirty years of data.

Realtime water level data is available for Medora Creek near Napinka (05NG020) and Whitewater near Boissevain (05NG023) from Environment Canada's website.

http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp

Streamflow Characteristics

The daily discharge data for the gauging stations on Waskada, Medora and Turtlehead creeks were statistically analyzed to determine runoff characteristics of the ESRW. The results of the analysis are presented as follows:

a) Waskada Creek

The combined streamflow data for Waskada Creek near Cranmer (05NF014) and north of Cranmer (05NF011) is representative of streams running off the Turtle Mountain Escarpment. The gross drainage area of station 05NF014 is 108.9 km^2. The station has an effective to gross drainage area ratio of 0.81. The gross drainage area boundary is defined as the area at a specific location, enclosed by its drainage divide, which might be expected to entirely contribute runoff to that specific location under extremely wet conditions. The effective drainage area is that portion of a drainage area which might be expected to entirely contribute runoff to the main stream during a median (1:2 year event) runoff year. This area excludes marsh and slough area and other natural storage areas, which would prevent runoff from reaching the main stream in a year of average runoff. The effective to gross drainage area ratio is an indication of how well an area is drained. A perfectly drained area has a ratio of one.

The mean monthly discharge data for Waskada Creek is shown in Table 3. Based on available data, Waskada Creek has an average runoff during the 1965 to 2002 period of 1,900 dam^3 or 18 mm over the entire watershed. The annual runoff depths for Waskada Creek from 1966 to 1994 are shown on Figure 3. They range from a minimum of 0 mm in 1977 to a maximum of 80 mm to 1976. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff.

The bargraph on Figure 4 illustrates the distribution of annual runoff for Waskada Creek, an escarpmental stream. It can be seen that the majority of runoff, 85%, occurs as a result of snowmelt and early spring rains when the watershed is still saturated. The maximum daily discharge of each year, as well as the date it occurred, was reviewed. It revealed that in 20 of the 29 years, the annual peak flow occurred during the spring runoff, and in 9 out of the 29 years the peak flow occurred during the summer growing period.

The statistical analysis of the Waskada Creek data indicates, as shown in Table 4, the frequency of the expected annual and rainfall peak discharges and annual runoff volumes with their corresponding unit depths.

Waskada Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 5. The spring runoff hydrographs show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur.

Table 4: Waskada Creek near Cranmer (05NF014) Frequency of Flood Flows and Runoff Volumes

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Rainfall Peaks in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	1.132	25.5	14.2	7300	67.0
2%	0.884	19.9	9.9	6400	58.8
10%	0.413	9.3	3.4	3900	35.8
20%	0.262	5.9	1.8	2800	25.7
50%	0.102	2.3	0.5	1200	11.0
70%		-	-	660	6.1
80%		-	-	440	4.0
90%		-	-	240	2.2

b) Medora Creek

The majority of the Medora Creek near Napinka (05NG020) drainage area is located on the prairie region. It is, therefore, a good index of the runoff from the prairie region. The drainage area at the gauging station is 313.6 km^2. The Medora Creek gauging station has an effective to gross drainage area ratio of 0.14 indicating the area is poorly drained.

The recorded mean monthly flows for Medora Creek are shown in Table 5. Based on available data, Medora Creek near Napinka has an average runoff during the 1966 to 2003 period of 4600 dam^3 or 14.7 mm over the entire watershed. The annual runoff depths for Medora Creek from 1966 to 1994 are shown on Figure 3. They range from a minimum of 0 mm in 1977 to a maximum of 77 mm in 1976. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff. The bargraph on Figure 4 illustrates the distribution of annual runoff for prairie streams. It can be seen that the majority of runoff, 90%, occurs in the March to May period.

The maximum daily discharge of each year, as well as the date it occurred, was reviewed. It revealed that in 26 of the 29 years, the annual peak flow occurred during the spring runoff, and in 3 out of the 29 years the peak flow occurred during the summer growing period.

The statistical analysis of the Medora Creek data indicates, as shown in Table 6, the frequency of the expected annual peak discharges and annual runoff volumes with their corresponding unit depths.

Medora Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 6 The spring runoff hydrographs show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur. The peak discharge on

Medora Creek near Napinka (05NG020) normally occurs one to two days later in the year than on Waskada Creek near Cranmer (05NF014). This do to its larger drainage area.

Table 6: Medora Creek near Napinka (05NG020) Frequency of Flood Flows and Runoff Volumes

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	1.137	51.7	21500	68.6
2%	0.946	43.0	17400	55.5
5%	0.680	30.9	12200	38.9
10%	0.477	21.7	8600	27.4
20%	0.288	13.1	5320	17.0
50%	0.084	3.8	1790	5.7
70%	-	-	740	2.4
80%	-	-	400	1.3
90%	-	-	160	0.5

c) Turtlehead Creek

Turtlehead Creek above Deloraine Reservoir (05NG016) has a drainage area of 74.9 km^2 and is indicative of runoff from upland streams. The Turtlehead Creek gauging station has an effective to gross drainage area ratio of 1.0 indicating the area is well drained.

The mean monthly discharge data for Turtlehead Creek above Deloraine Reservoir is shown in Table 7. Based on available data from 1964 to 1996, Turtlehead Creek above Deloraine Reservoir has an average runoff of 2,350 dam^3 or 31 mm over the entire watershed. The annual runoff depths for Turtlehead Creek from 1966 to 1994 are shown on Figure 3. They range from a minimum of 0 mm in 1977 to a maximum of 121 mm in 1975. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff. The bargraph on Figure 4 illustrates the distribution of annual runoff for upland streams. It can be seen that the majority of runoff, 88%, occurs in the March to May period.

The maximum daily discharge of each year, as well as, the date it occurred was reviewed. It revealed that in 26 of the 33 years the annual peak flow occurred during the spring runoff, and in 7 out of the 33 years the peak flow occurred during the summer growing period.

The statistical analysis of Turtlehead Creek data indicates, as shown in Table 8, the frequency of the expected annual and rainfall peak discharges and annual runoff volumes with their corresponding unit depths.

Turtlehead Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 7. The spring runoff hydrographs

show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur. The spring runoff on Turtlehead Creek has a tendency to occur later and be of a longer duration than the corresponding events on Waskada and Medora creeks.

Table 8: Turtlehead Creek above Deloraine Reservoir (05NG016) Frequency of Flood Flows and Runoff Volumes

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Rainfall Peaks in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	0.712	12.5	16.1	8900	118.8
2%	0.555	9.7	11.1	7900	105.5
10%	0.271	4.8	3.6	4900	65.4
20%	0.178	3.1	1.8	3700	49.4
50%	0.078	1.4	0.5	1600	21.4
70%	-	-	-	720	9.6
80%	-	-	-	420	5.6
90%	-	-	-	180	2.4

d) Summary

In summary, analysis of the available streamflow data in the ESRW indicates the following:

- Streamflow varies considerably over the months and years.
- Annual streamflow usually peaks in April and May, during the spring runoff period.
- On average, 85 to 90% of the annual runoff volume occurs in the period from the beginning of March to the end of May.
- Escarpment and prairie streams can experience years of no flow.
- All streams can experience periods of extended zero flow during the summer period. As a result, all streams in the ESRW are hydrologically classified as intermittent streams.
- The annual runoff from the three watercourses differs based mainly on their size and topography.
    - Streams in the upland areas of the Turtle Mountain produce the greatest unit runoff depths.
    - Unit runoff depths from escarpmental (Waskada) and prairie (Medora) streams are similar in moderate to wet runoff years.
    - The unit runoff depth from escarpmental streams is much greater than prairie streams in below normal and drought years. This is because the effective to gross drainage area ratio an indicator of depressional storage is greater for escarpmental streams. That is, there is a greater percentage of the watershed of escarpmental streams contributing flow during below normal runoff years.

- The spring flood peak characteristics of escarpmental (Waskada) and prairie (Medora) streams are similar. It is their drainage area size that determines the magnitude and timing of annual peaks.
- On the major watercourses, spring flooding is more significant than flooding from summer precipitation events. It is the smaller drainage areas (less than about 30 km^2) that are sensitive to rainfall events. Localized flooding can occur in the smaller poorly drained areas from excessive rainfall.
- The southwest corner of the Province is generally considered a chronic drought area due to is low runoff rates.

Whitewater Lake Watershed[3]

Whitewater Lake Watershed has a drainage area of 732.6 km^2. Its main feature is Whitewater Lake, which varies in size from 130 km^2 (50 mi^2) in very, wet years to nil during times of extreme drought. The watershed is considered a closed basin, which means it, has no outlet except under extremely wet, high water conditions. The natural outlet is into Medora Creek to the west, with spillage occurring at about elevation 498.65 metres (1636 ft)[4]. The northern half of the Watershed is located in the prairie region in which the surface deposits consist of lacustrine silts and clays. The Turtle Mountain, reaching a height of about 230 m (750 feet) above the Lake, is the most prominent feature of the southern portion. Runoff from the Turtle Mountain is rapid and flows in well-defined channels. Channels in the vicinity of Whitewater Lake are poorly defined or non-existent due to the numerous small scattered potholes and sloughs in the area. High water table, salinized soils and poor surface drainage characterize the area surrounding the lake.

Whitewater Lake receives most of the surface inflow from the intermittent streams originating in the Turtle Mountain. Because of the elevation of the outlet, Lake levels rise if rainfall and inflow are greater then evaporation and drop when evaporation is greater. Mean monthly recorded water levels for Whitewater Lake are shown in Table 9. Mean monthly reconstructed and recorded levels for the Lake for the period 1921 to 2003 are shown on Figure 8. As indicated by the plot, the Lake was virtually dry from the fall of 1934 until the spring of 1941. This period corresponds to a time of 1930's drought. Levels were below average during most of the 1960's and the early 1980s to mid 1990s. The highest recorded level of 497.55 m (1632.4 feet) was from May 5 to 11, 1976, after a series of wet years. High water levels cause extensive flooding.

The Lake is very shallow, having an average depth of 0.76 m (two and a half feet) at elevation 495.9 m (1627 ft) and is therefore, greatly influenced by wind. A wind setup of 0.3 m to 0.6 m (one or two feet) can result in flooding as far as three kilometers (two miles) inland. It can take several weeks for this water to drain because of the flatness of the area surrounding the lake.

[3] Report on Measures for Controlling High Levels on Whitewater Lake. (Manitoba, Whitewater Lake Interdisciplinary Committee, July 1977).
[4] PFRA Plan #70510

The following listed studies have indicated that projects proposed for the control and development of Whitewater Lake were not economically viable.

- Report on Hydrologic and Hydraulic Investigations, Whitewater Lake Area (Manitoba 1971).
- Resource Management Alternatives in the Whitewater Lake Area(Ransom, 1972)
- Report on Measures for Controlling High Levels on Whitewater Lake. (Manitoba, Whitewater Lake Interdisciplinary Committee, July 1977).

Water Allocation

The total spring volume of water available for allocation on intermittent streams is based on either the eight out of ten-year (80%) or the seven out of ten-year (70%) risk level.

Under the 80% risk level, one half of the water volume available on a given intermittent stream in eight out of ten years can be allocated. The eight out of ten-year volume is estimated as the 80^{th} percentile value from a duration curve of spring (March to May) volumes. While one-half of the eight out of ten volume is allocated for use, the other half is allocated for maintenance of stream "health" or to maintain the ecological integrity of the stream system, referred to as Instream Flow Needs (IFN). For the 80% risk level, shortages can be expected in two out of 10 years on average.

Under the 70% risk level, the allocated volume is equal to the 70% spring volume minus one half of the 80% spring volume allocated to IFNs. For the 70% risk level, shortages can be expected in three out of 10 years on average.

The allocable spring volumes along with licensed water use in the ESRW are shown in Table 10. In total approximately 287 dam^3 could be allocated at the 80% risk level and 1194 dam^3 at the 70% risk level. Presently, licensed allocation in the ESRW is seven dam^3.

Table 10: Allocable Spring Volumes.

STREAM	Allocable Volume in dam^3		Licensed Volume in dam^3
	Risk Level		
	80%	70%	
WASKADA CREEK	26	101	7
BLIND RIVER	53	224	0
MEDORA CREEK	105	441	0
CHAIN LAKES CREEK	85	358	0
UNNAMED TRIBUTARY SOUTH	18	70	0
TOTAL	287	1194	7

Metigoshe Lake[5]

Metigoshe Lake, an international lake, is a highly developed resort area on both sides of the Canada-United States boundary. The lake covers an area of approximately 615 ha (1520 acres) of which 24.4 ha (60 acres) are in Canada. The maximum depth of Metigoshe Lake is 7.3 m. The Lake is controlled, with free overflow occurring at the fsl of 651.65 m (2138.0 ft) into Oak Creek, a tributary of Willow Creek. Dromore Lake upstream is connected to Metigoshe Lake. The drainage area of Metigoshe Lake is 165.6 km^2, which is almost entirely in Canada. Water levels have been recorded on Metigoshe Lake near Metigoshe, ND (05NF804) since 1953. A plot of the lake's mean monthly water levels are shown on Figure 9.

Deloraine Reservoir

Deloriane Reservoir was constructed on Turtlehead Creek in 1962 to provide a water supply for the Town of Deloraine and water for stock during drought periods. The dam is operated to maintain a full supply level (fsl) of 540.1 m (1772 ft). The Reservoir at the fsl has a maximum depth of 12 m, covers an area of 31 ha and contains 1730 dam^3 of water. The firm annual yield is estimated at 271 dam^3 or about one sixth of its storage capacity.

The riparian outlet normally remains closed. Riparian releases are made upon request if sufficient water is available for primary uses. Spring releases may be made from the riparian outlet to improve the water quality in the reservoir for water supply or fisheries purposes.

The drainage area of the reservoir is 76.7 km^2. Water levels have been recorded on Deloriane Reservoir near Deloraine (05NG814) since 1963. A plot of the lake's mean monthly water levels are shown on Figure 10. As shown on Figure 10, the reservoir does not annually fill. During extended drought period such as the 1980s water levels dropped 2.5 metres below fsl.

[5] Regulation of Sharpe, Dromore and Metigoshe Lakes, prepared by the Sharpe, Dromore and Metigoshe Lakes Regulation Committee, May 1975.

Table 2: ESRW Hydrometric data.

Station Number	Station Name	Years of Operation	Period of Operation	Type of Data	Gross Drainage area in km^2
05NG810	Coatstone Reservoir near Deloraine	1989 to present	April to October	Water level	4.7
05NG814	Deloriane Reservoir near Deloraine	1963 to present	Annual	Water level	76.7
05NF804	Metigoshe Lake near Metigoshe, ND	1953 to 1972 1973 to present	Annual April to October	Water level Water level	165.6
05NG020	Medora Creek near Napinka	1966 to 1993 1994 to present	March to October March to May	Discharge Discharge	1046.2
05NF014	Waskada Creek near Cranmer	1974 to 1993 1994 to 1996 2000 to 2002	March to October March to May March to May	Discharge Discharge Discharge	108.5
05NG023	Whitewater lake near Boissevain	1970 to present	March to October	Water level	732.6
05NF011	Waskada Creek north of Cranmer	1965 to 1973	March to October	Discharge	97.7
05NG011	Turtlehead Creek near Deloriane	1959 to 1963	March to October	Discharge	92.4
05NG016	Turtlehead Creek above Deloraine Reservoir	1964 to 1996	March to October	Discharge	75.0
05NG017	Turtlehead Creek below Deloraine Reservoir	1964 to 1996	March to October	Discharge	76.7
05NF807	Sharpe Lake near Deloraine	1972 to present	March to October	Water level	21.8

TABLE 3: WASKADA CREEK NEAR CRANMER (05NF011and 05NF014)

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam^3
1965	-	-	0.00	0.14	0.17	0.05	0.00	0.12	0.12	0.00	-	-	1,590
1966	-	-	0.25	0.02	0.12	0.04	0.29	0.00	0.00	0.00	-	-	1,940
1967	-	-	0.15	0.08	0.02	0.00	0.00	0.00	0.00	0.00	-	-	660
1968	-	-	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.00	-	-	130
1969	-	-	0.00	1.35	0.01	0.00	0.01	0.00	0.00	0.00	-	-	3,560
1970	-	-	0.25	0.53	0.07	0.00	0.00	0.00	0.00	0.00	-	-	2,240
1971	-	-	0.00	0.05	0.00	0.36	0.19	0.00	0.00	0.00	-	-	1,600
1972	-	-	0.34	0.14	0.00	0.44	0.00	0.00	0.00	0.00	-	-	2,410
1973	-	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	40
1974	-	-	0.00	1.68	0.25	0.05	0.17	0.00	0.00	0.00	-	-	5,610
1975	-	-	0.00	1.78	0.28	0.05	0.00	0.00	0.00	0.07	-	-	5,680
1976	-	-	1.44	1.85	0.02	0.00	0.00	0.00	0.00	0.00	-	-	8,730
1977	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
1978	-	-	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	-	-	180
1979	-	-	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,090
1980	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.02	-	-	1,220
1981	-	0.24	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	730
1982	-	-	0.01	0.58	0.00	0.01	0.00	0.00	0.00	0.01	-	-	1,610
1983	-	-	0.26	0.33	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,580
1984	-	-	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	-	-	120
1985	-	-	1.77	0.13	0.00	0.10	0.01	0.00	0.00	0.00	-	-	5,380
1986	-	-	0.20	0.09	0.03	0.00	0.02	0.00	0.00	0.00	-	-	900
1987	-	-	0.46	0.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,310
1988	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	30
1989	-	-	0.40	0.48	0.00	0.00	0.04	0.00	0.00	0.00	-	-	2,450
1990	-	-	0.00	0.03	0.00	0.01	0.08	0.00	0.00	0.00	-	-	340
1991	-	-	0.01	0.00	0.00	0.00	0.43	0.00	0.00	0.00	-	-	1,190
1992	-	-	0.89	0.02	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,430
1993	-	-	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	90
1994	-	-	0.08	0.00	0.00	-	-	-	-	-	-	-	220
1995	-	-	1.08	0.24	0.01	-	-	-	-	-	-	-	3,540
1996	-	-	0.01	1.12	0.01	-	-	-	-	-	-	-	2,960
2000	-	-	0.01	0.00	0.02	-	-	-	-	-	-	-	60
2001	-	-	0.03	1.45	0.01	-	-	-	-	-	-	-	3,860
2002	-	-	0.00	0.00	0.00	-	-	-	-	-	-	-	0
Minimum	-	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
Maximum	-	0.24	1.77	1.85	0.28	0.44	0.43	0.12	0.45	0.07	-	-	8,730
Mean	-	0.24	0.22	0.37	0.03	0.04	0.04	0.01	0.02	0.00	-	-	1,900

TABLE 5: MEDORA CREEK NEAR NAPINKA (05NF020)

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam^3
1966	-	-	0.38	0.13	0.08	0.07	0.02	0.00	0.00	0.00	-	-	1,780
1967	-	-	0.00	0.22	0.10	0.00	0.00	0.00	0.00	0.00	-	-	840
1968	-	-	0.02	0.01	0.00	0.00	0.00	0.14	0.24	0.03	-	-	1,140
1969	-	-	0.00	3.00	0.41	0.12	0.17	0.02	0.00	0.00	-	-	9,700
1970	-	-	0.00	1.36	0.52	0.01	0.00	0.00	0.00	0.00	-	-	4,960
1971	-	-	0.00	0.18	0.01	0.37	0.39	0.00	0.00	0.00	-	-	2,480
1972	-	-	0.97	0.21	0.04	0.14	0.08	0.02	0.02	0.00	-	-	3,960
1973	-	-	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-	-	100
1974	-	-	0.00	2.95	0.71	0.10	0.01	0.00	0.00	0.00	-	-	9,800
1975	-	-	0.00	3.62	1.10	0.14	0.03	0.12	0.10	0.21	-	-	13,910
1976	-	-	0.00	8.81	0.33	0.18	0.01	0.00	0.00	0.00	-	-	24,190
1977	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
1978	-	-	0.00	0.38	0.01	0.00	0.00	0.00	0.00	0.00	-	-	1,010
1979	-	-	0.00	1.05	0.14	0.01	0.00	0.00	0.00	0.00	-	-	3,120
1980	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	30
1981	-	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	330
1982	-	-	0.00	1.85	0.00	0.01	0.00	0.00	0.00	0.00	-	-	4,820
1983	-	-	0.29	1.16	0.00	0.00	0.00	0.00	0.00	0.00	-	-	3,810
1984	-	-	0.07	0.00	0.07	0.01	0.00	0.00	0.00	0.00	-	-	420
1985	-	-	2.76	0.39	0.00	0.20	0.09	0.00	0.00	0.00	-	-	9,180
1986	-	-	0.45	0.13	0.12	0.00	0.00	0.00	0.00	0.00	-	-	1,860
1987	-	-	1.48	0.23	0.00	0.00	0.00	0.16	0.00	0.00	-	-	5,000
1988	-	-	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	100
1989	-	-	0.14	0.97	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,880
1990	-	-	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.00	-	-	270
1991	-	-	0.01	0.00	0.00	0.01	0.53	0.00	0.00	0.00	-	-	1,470
1992	-	-	2.15	0.07	0.01	0.00	0.00	0.00	0.00	0.00	-	-	5,970
1993	-	-	0.09	0.01	0.00	0.00	0.04	0.00	0.00	0.00	-	-	380
1994	-	-	0.40	0.05	0.00	-	-	-	-	-	-	-	1,200
1995	-	-	3.17	1.01	0.08	-	-	-	-	-	-	-	11,320
1996	-	-	0.00	3.31	0.25	-	-	-	-	-	-	-	9,250
1997	-	-	0.02	2.31	0.04	-	-	-	-	-	-	-	6,180
1998	-	-	1.24	1.35	0.03	-	-	-	-	-	-	-	6,920
1999	-	-	3.09	1.01	1.09	-	-	-	-	-	-	-	13,810
2000	-	-	0.01	0.00	0.00	-	-	-	-	-	-	-	30
2001	-	-	0.00	3.68	0.09	-	-	-	-	-	-	-	9,800
2002	-	-	0.00	0.00	0.00	-	-	-	-	-	-	-	0
2003	-	-	0.77	0.49	0.05	-	-	-	-	-	-	-	3,460
Minimum	-	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
Maximum	-	0.08	3.17	8.81	1.10	0.37	0.53	0.16	0.24	0.21	-	-	24,190
Mean	-	0.08	0.46	1.05	0.14	0.05	0.05	0.02	0.01	0.01	-	-	4,620

Table 7: TURTLEHEAD CREEK ABOVE DELORAINE RESERVOIR (05NF016)

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam^3
1964	-	-	0.00	0.57	0.65	0.03	0.01	0.00	0.00	0.00	-	-	3,310
1965	-	-	0.00	0.69	0.25	0.30	0.23	0.04	0.07	0.07	-	-	4,340
1966	-	-	0.30	0.50	0.26	0.05	0.03	0.00	0.00	0.00	-	-	3,010
1967	-	-	0.02	0.15	0.13	0.02	0.00	0.00	0.00	0.00	-	-	820
1968	-	-	0.02	0.03	0.02	0.01	0.01	0.20	0.02	0.01	-	-	880
1969	-	-	0.00	2.29	0.17	0.03	0.10	0.00	0.00	0.00	-	-	6,770
1970	-	-	0.00	0.57	0.52	0.02	0.00	0.00	0.00	0.00	-	-	2,900
1971	-	-	0.00	0.67	0.04	0.67	0.05	0.00	0.02	0.06	-	-	3,930
1972	-	-	0.78	1.54	0.23	0.19	0.00	0.01	0.00	0.00	-	-	7,240
1973	-	-	0.07	0.01	0.01	0.06	0.02	0.02	0.00	0.01	-	-	520
1974	-	-	0.00	1.50	0.79	0.15	0.02	0.00	0.00	0.00	-	-	6,480
1975	-	-	0.00	1.79	0.61	0.15	0.01	0.00	0.09	0.16	-	-	7,350
1976	-	-	0.12	2.38	0.17	0.03	0.00	0.00	0.00	0.00	-	-	7,030
1977	-	-	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-	-	60
1978	-	-	0.02	0.07	0.02	0.01	0.01	0.00	0.00	0.00	-	-	310
1979	-	-	0.00	0.35	0.17	0.03	0.00	0.00	0.00	0.00	-	-	1,420
1980	-	-	0.01	0.04	0.00	0.00	0.00	0.00	0.01	0.01	-	-	180
1981	-	-	0.18	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-	-	550
1982	-	-	0.04	0.50	0.07	0.04	0.00	0.00	0.00	0.00	-	-	1,700
1983	-	-	0.04	0.62	0.13	0.02	0.00	0.00	0.00	0.00	-	-	2,150
1984	-	-	0.07	0.01	0.12	0.01	0.00	0.00	0.00	0.00	-	-	540
1985	-	-	0.25	0.50	0.11	0.15	0.08	0.00	0.00	0.00	-	-	2,880
1986	-	-	0.23	0.44	0.46	0.01	0.00	0.00	0.00	0.00	-	-	3,030
1987	-	-	0.15	0.29	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,170
1988	-	-	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	-	-	90
1989	-	-	0.01	0.14	0.00	0.00	0.00	0.00	0.00	0.00	-	-	410
1990	-	-	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	-	-	170
1991	-	-	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	-	-	70
1992	-	-	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	-	-	420
1993	-	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-	70
1994	-	-	0.12	0.06	0.02	0.01	0.00	0.00	0.00	0.00	-	-	570
1995	-	-	0.32	0.78	0.49	0.05	0.01	0.00	0.00	0.00	-	-	4,380
1996	-	-	0.02	0.76	0.27	0.03	0.00	0.00	0.00	0.00	-	-	2,830
Minimum	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	60
Maximum	-	-	0.78	2.38	0.79	0.67	0.23	0.20	0.09	0.16	-	-	7,350
Mean	-	-	0.09	0.53	0.17	0.06	0.02	0.01	0.01	0.01	-	-	2,350

TABLE 9: WHITEWATER LAKE NEAR BOISSEVAIN (05NG023)

	Recorded Mean Monthly Water Level in Metres												Average Level
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	metres
1970	-	-	-	-	-	-	-	-	496.004	495.974	495.980	-	495.986
1971	-	-	-	-	496.163	-	496.172	496.071	496.007	496.025	-	-	496.088
1972	-	-	-	-	496.373	496.419	496.379	496.342	496.266	496.211	496.202	-	496.313
1973	-	-	-	-	496.245	496.248	496.269	496.263	496.230	496.211	496.193	-	496.237
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	497.168	497.071	496.986	496.973	497.001	497.013	-	497.035
1976	-	-	-	-	497.519	497.458	497.367	497.245	497.132	497.034	-	-	497.292
1977	-	-	-	-	496.964	496.894	496.845	496.745	496.714	496.690	496.656	-	496.787
1978	-	-	-	-	496.763	496.726	496.678	496.483	496.437	496.382	496.336	-	496.544
1979	-	-	-	-	496.839	496.794	496.672	496.531	496.501	496.452	496.403	-	496.599
1980	-	-	-	-	496.397	496.236	496.169	496.211	496.242	496.239	496.269	-	496.252
1981	-	-	-	496.257	496.214	496.132	496.056	495.995	495.986	495.931	-	-	496.082
1982	-	-	-	496.230	496.208	496.175	496.105	496.022	495.916	495.958	495.983	-	496.075
1983	-	-	-	-	496.175	496.099	496.007	495.873	495.800	495.760	495.745	-	495.923
1984	-	-	-	495.803	495.855	495.775	495.605	495.452	495.346	495.394	-	-	495.604
1985	-	-	-	495.852	495.775	495.708	495.699	495.614	495.593	495.583	495.565	-	495.674
1986	-	-	-	-	495.928	495.846	495.782	495.675	495.580	495.577	495.565	-	495.708
1987	-	-	-	495.791	495.711	495.611	495.516	495.501	495.443	495.349	495.364	-	495.536
1988	-	-	-	495.327	495.321	-	-	-	-	-	-	-	495.324
1989	-	-	-	495.492	495.379	495.373	-	-	-	-	-	-	495.415
1992	-	-	-	495.452	495.428	-	-	-	-	-	-	-	495.440
1995	-	-	-	-	495.967	495.952	495.900	495.769	495.696	495.663	-	-	495.825
1996	-	-	-	496.147	496.202	496.220	496.178	496.181	496.096	496.062	-	-	496.155
1997	-	-	-	496.032	496.440	496.352	496.294	496.178	496.077	496.032	-	-	496.200
1998	-	-	-	496.403	496.355	496.330	496.358	496.339	496.245	496.230	496.230	-	496.311
1999	-	-	-	496.458	496.611	496.797	496.733	496.626	496.565	496.519	-	-	496.615
2000	-	-	-	-	496.181	496.129	496.117	496.032	495.980	495.928	495.913	-	496.040
2001	-	-	-	496.333	496.333	496.263	496.178	496.083	495.940	495.858	495.839	-	496.104
2002	-	-	-	495.907	495.870	495.827	495.757	495.836	495.812	495.763	496.330	-	495.888
2003	-	-	-	495.699	495.785	495.730	495.620	495.577	568.617	495.556	495.705	-	504.786
Minimum	-	-	-	495.327	495.321	495.373	495.516	495.452	495.346	495.349	495.364	-	495.324
Maximum	-	-	-	496.458	497.519	497.458	497.367	497.245	568.617	497.034	497.013	-	504.786
Mean	-	-	-	495.946	496.185	496.250	496.221	496.145	498.892	496.053	496.072	-	495.324

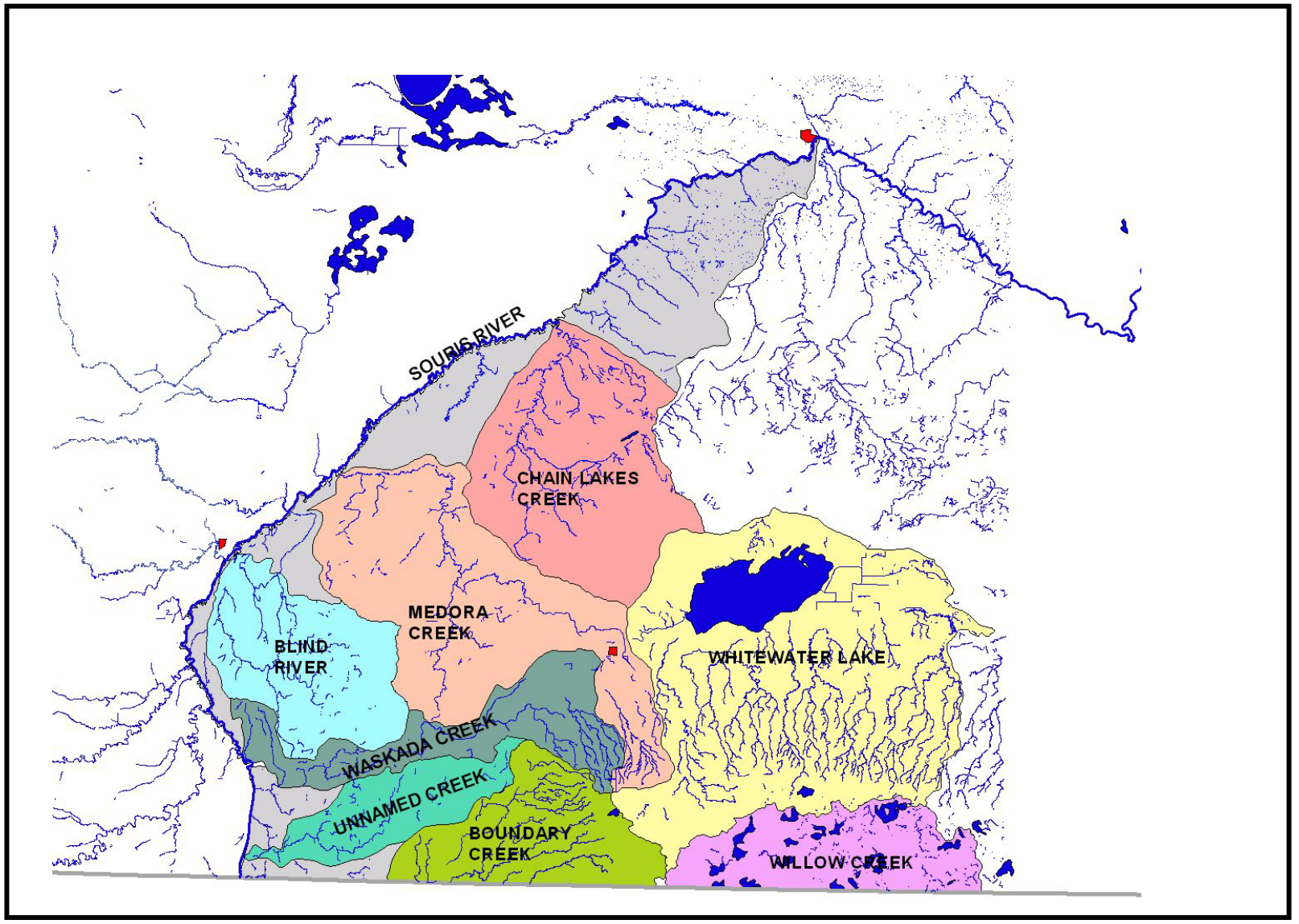

Figure 1: East Souris River Watershed drainage areas.

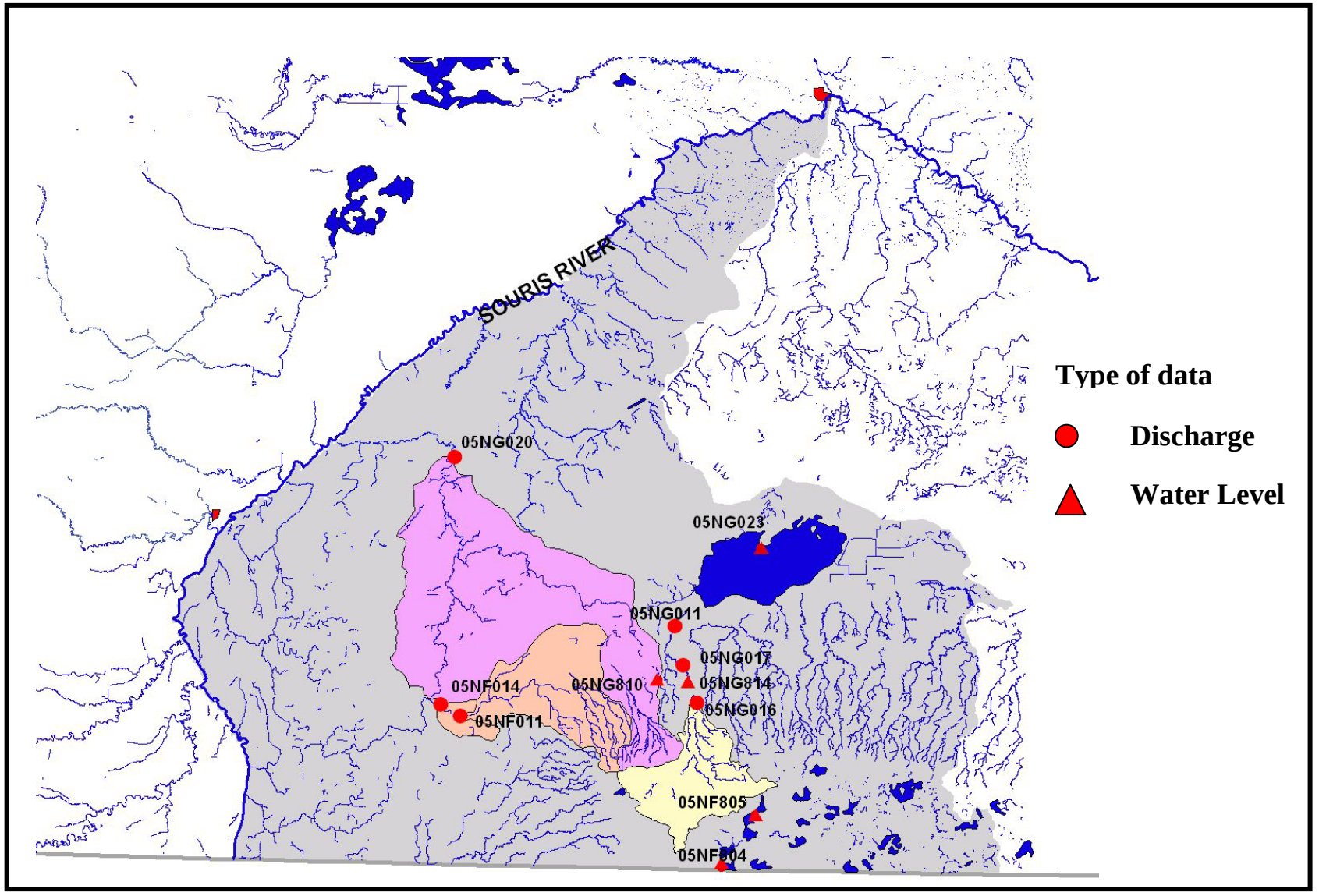

Figure 2: Location of hydrometric gauging stations and the drainage areas of Waskada, Medora and Turtlehead Creek streamflow gauging stations.

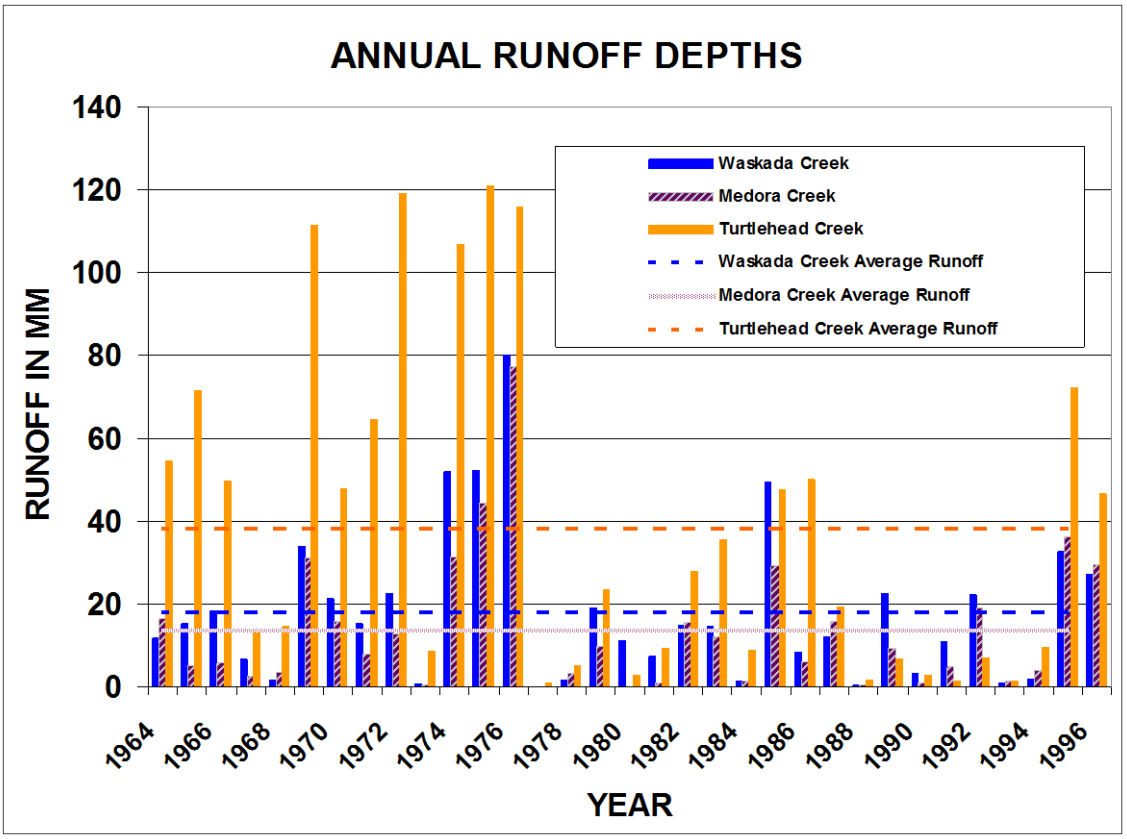

Figure 3:Annual runoff depths for Waskada, Medora and Turtlehead creeks.

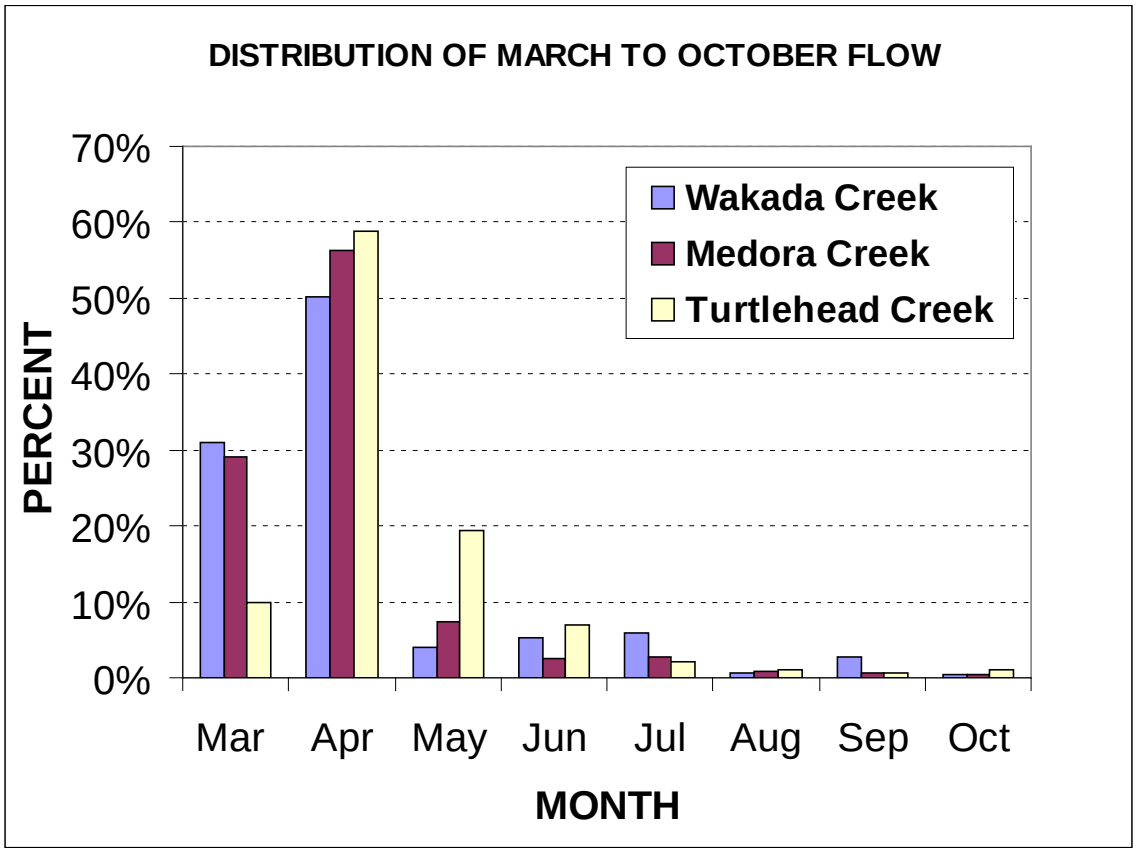

Figure 4: March to October flow disctribution for Waskada, Medora and Turtlehead creeks.

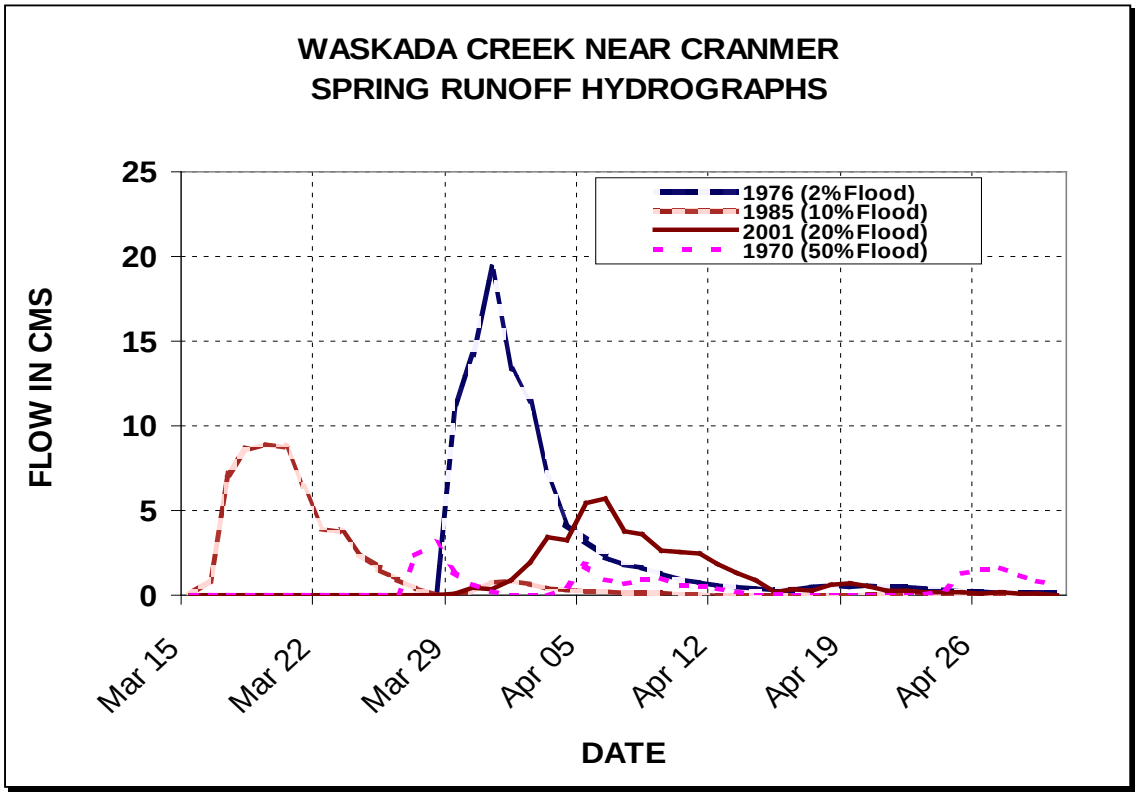

Figure 5: Waskada Creek near Cranmer (05NF014) spring runoff hydrographs.

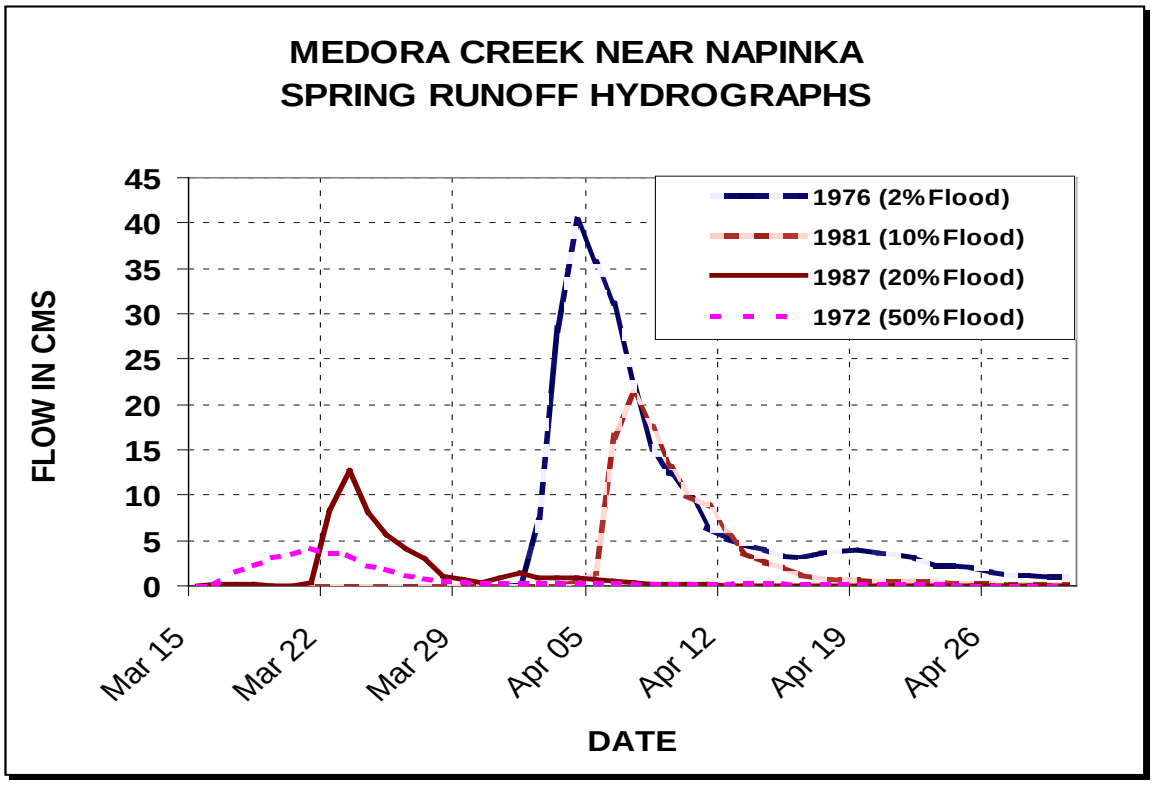

Figure 6: Medora Creek near Napinka (05NG020) spring runoff hydrographs.

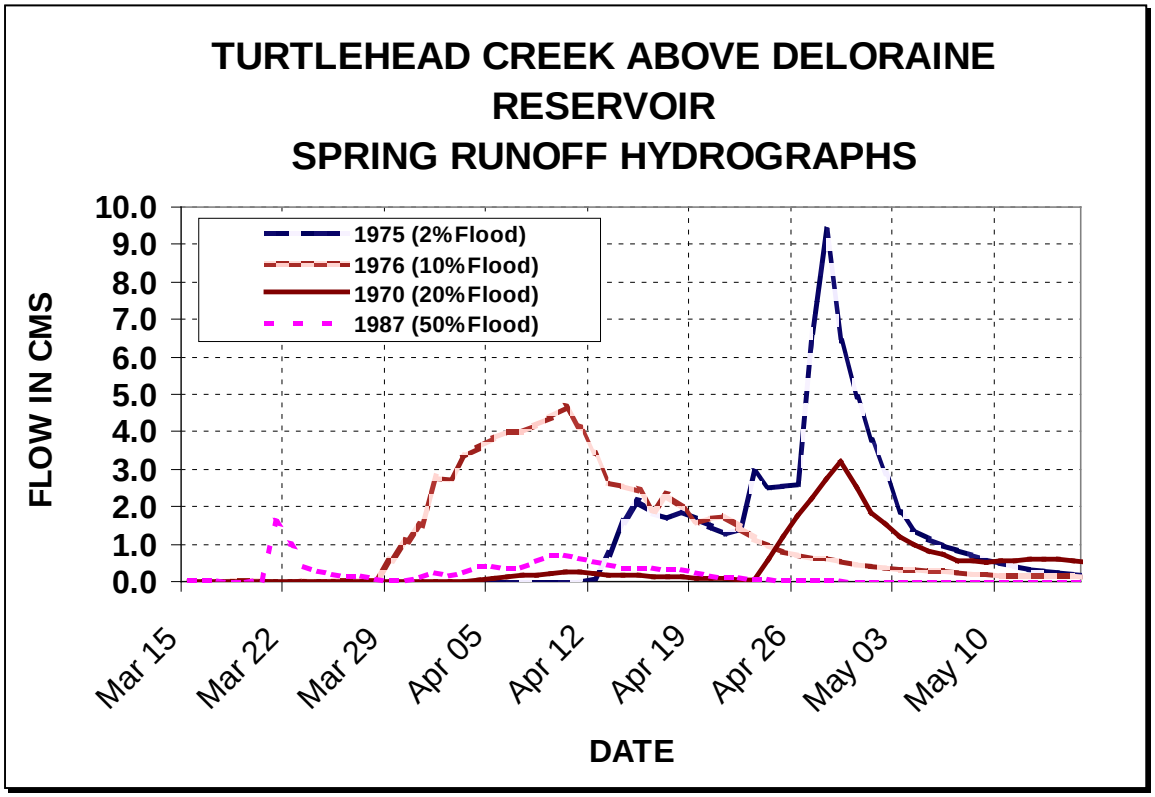

Figure 7: Turtlehead Creek above Deloraine Reservoir (05NG016) spring runoff hydrographs.

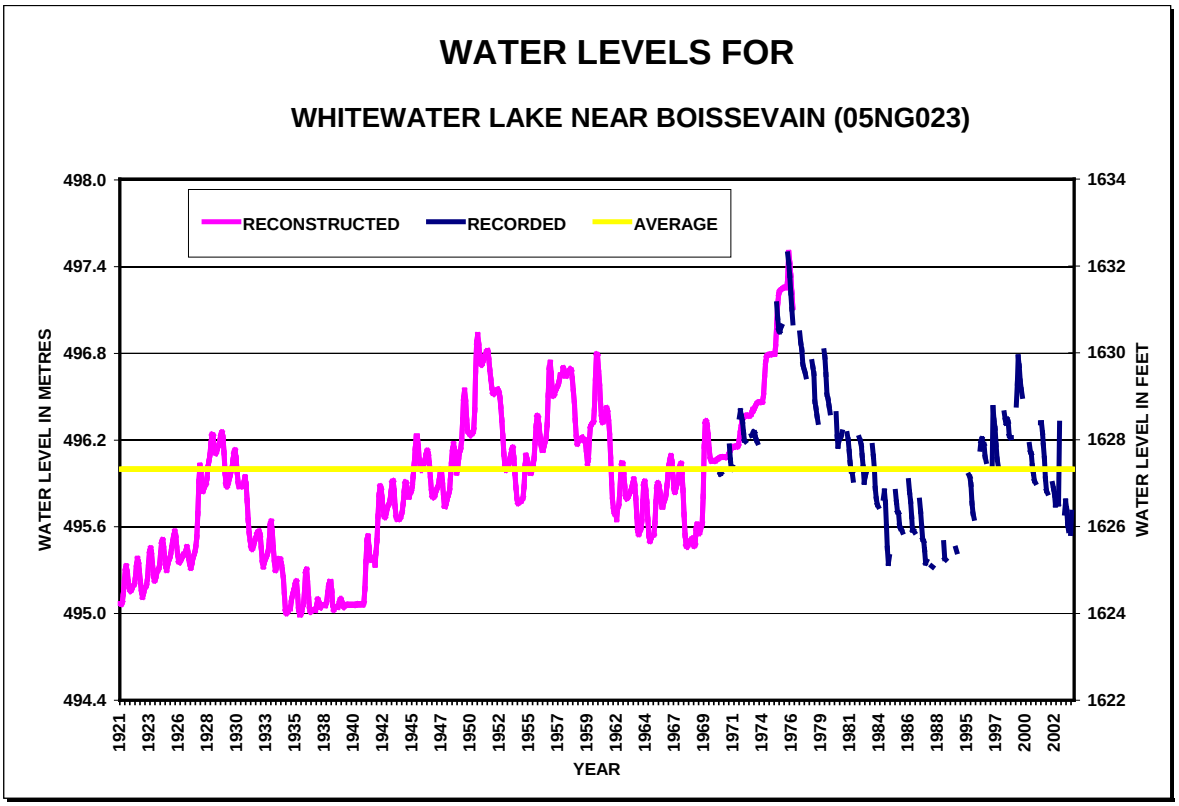

Figure 8: Whitewater Lake recorded and reconstructed mean monthly water levels.

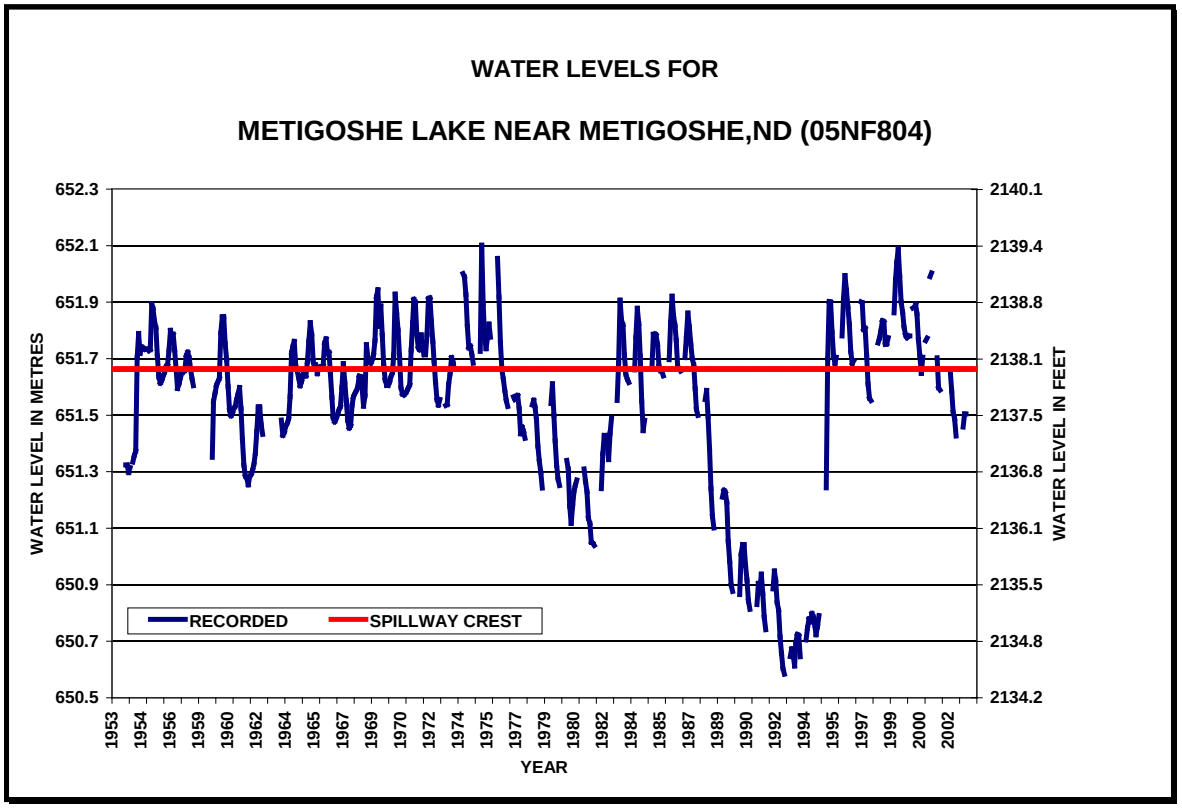

Figure 9: Metigoshe Lake recorded mean monthly water levels.

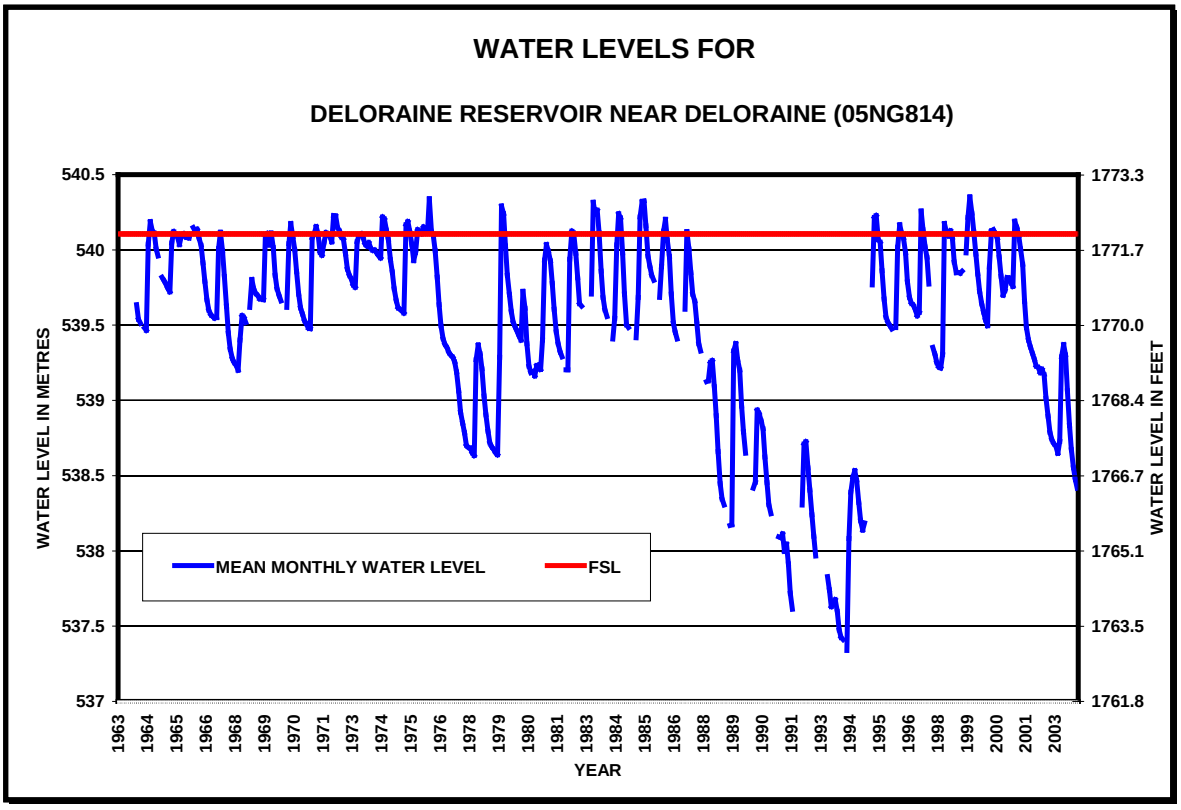

Figure 10: Deloraine Reservoir recorded mean monthly water levels.