

SITE DESCRIPTION

Study Area

General Description

The study area was located in the north central region of Blue Earth County, in South Central Minnesota (Figure 1). Specific water quality, sediment, and benthic macroinvertebrate parameters were monitored at eight sampling sites, along a 51.8 river kilometer (32.2 river mile) stretch of the Blue Earth River running from the south east corner of Section 6 in Lyra Township (T108N, R27W) to the north central portion of Section 14 in Mankato Township (T108N, R26W) (Figure 2). Three sites were located upstream of the Rapidan Reservoir, one was in the reservoir itself, three downstream of the reservoir, and one site was on the Le Sueur River as a control. The eight sampling sites of this study were all located within the Storden-Comfrey-Lomax soil association.

The Blue Earth River Watershed

The Blue Earth River is a sixth order stream which encompasses a total drainage area of about 9,003 square kilometers (3,476 square miles) (Fasching, 1984). Approximately 8,164 square kilometers (3,152 square miles) of the total drainage area exists in Minnesota while 837 square kilometers (323 square miles) are found in Iowa where the river originates (USDA, 1972), (Figure 3). The mean discharge of the Blue Earth at its mouth is nearly 36.8 cubic meters per second (1,300 cubic feet per second) with maximum flood discharge recorded at 1,699 cubic meters per second (60,000 cubic feet per second) (Waters, 1977). The Blue Earth River can account for over one-half of the flood flow in the Minnesota River, of which the Blue Earth is a major tributary. The length of the Blue Earth River, from its junction with the East Branch of the Blue Earth, is 161 kilometers (100 miles). The river drops 87 meters (285 feet) with a mean slope of 0.6 meters per kilometer (3 feet per mile) upstream of the Rapidan Reservoir, and 0.9 meters per kilometer (5 feet per mile) downstream of the Rapidan Reservoir (Waters, 1977).

The watershed is wider than it is long, giving rise to a fan shape rather than the typical teardrop shape. An explanation for this can be attributed to the past capture of the Le Sueur River, at one time a tributary of the Minnesota River, by the Blue Earth River (Fasching, 1984).

Precipitation and Stream Flow

Blue Earth County is described as having a humid, cool, continental climate with warm summers and cold winters. The area receives a mean annual rainfall of 74 cm (29 inches) and a mean annual snowfall of 94 cm (37 in).

The United States Geological Survey (USGS) maintains water-stage recorder-type gauges on the Blue Earth and Le Sueur Rivers. The Blue Earth River gauge is located 0.3 km (0.2 mi) downstream of the dam. The Le Sueur River gauge is located 183 m (600 ft) downstream from the State Highway 66 bridge.

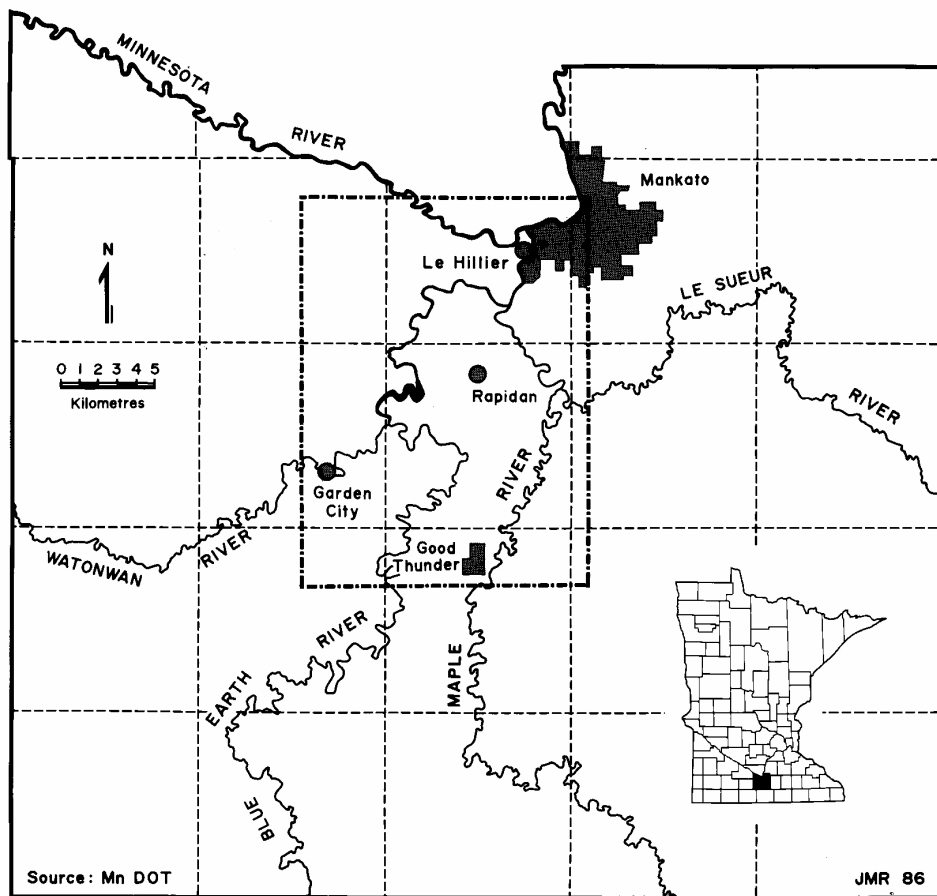


Figure 1. Location of study area in Blue Earth County, Minnesota

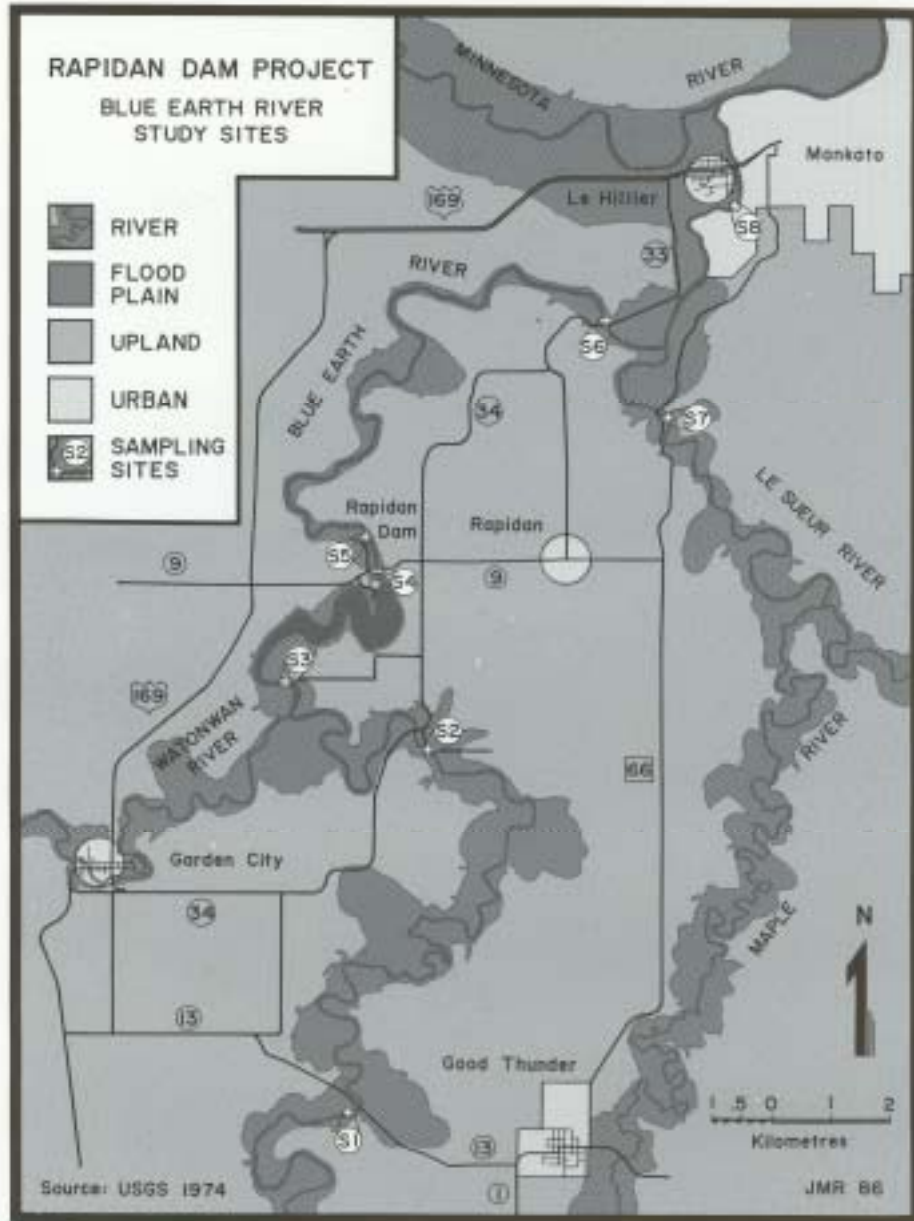


Figure 2. Location of sampling sites in the study area

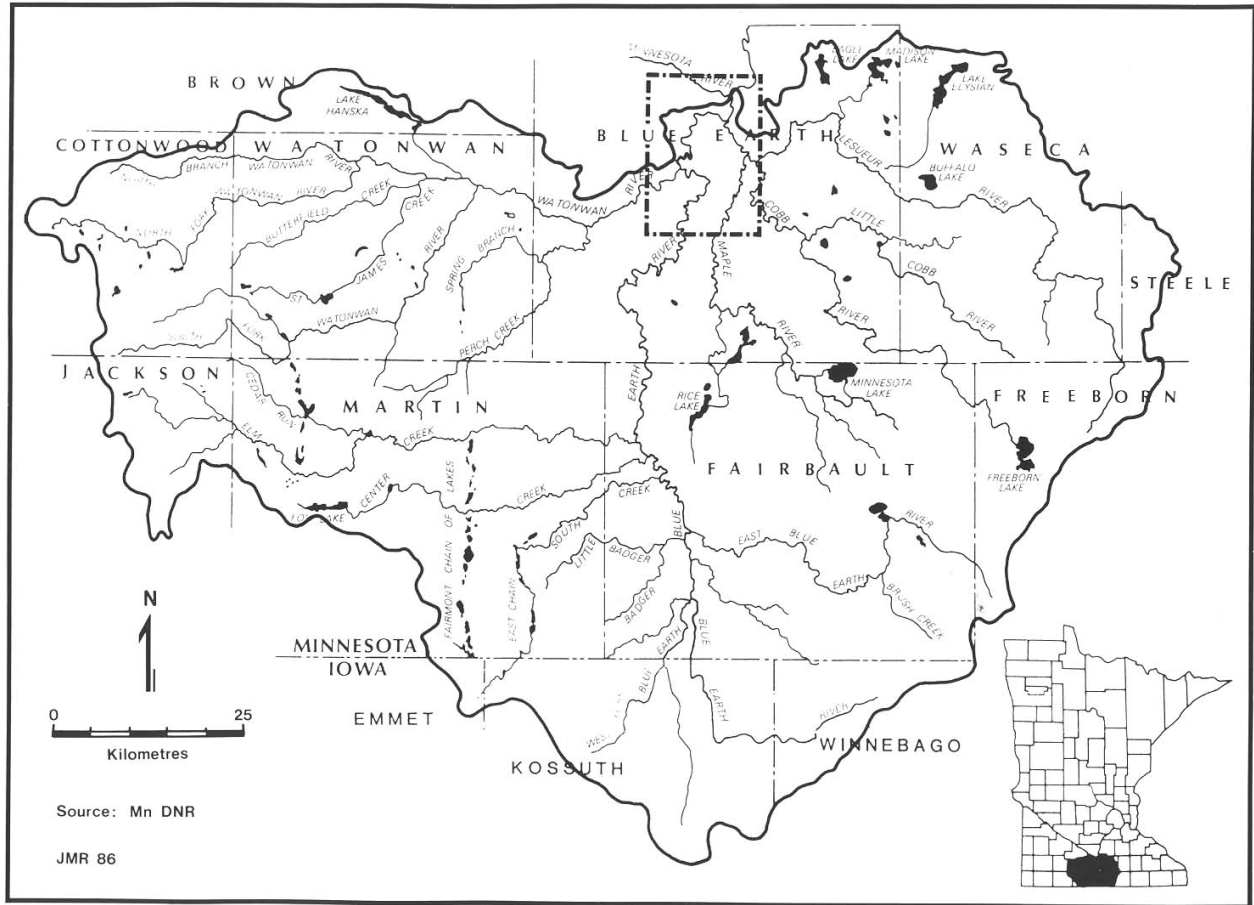


Figure 3. Blue Earth River watershed

The Rapidan Dam and Reservoir

The Rapidan Reservoir is in Rapidan Township (Sec 7 and 8, T107N, R27W and R28W) and is located 2.8 km (1.7 mi) west of Rapidan, MN on BE County Road 9. The Reservoir, with a surface area of 168 hectares (415 acres), has a volume of 1.03×10^7 cubic meters (3.62×10^8 cubic feet), a maximum depth of 9 meters (29.5 feet) and does not exhibit thermal stratification during the summer. The reservoir is contained by a 126-meter (414 foot) wide, 25.1 meter (82.5 foot) high dam (Figure 4). The reservoir is only a maximum of 13 feet deep in the channel at the bridge over the reservoir close to the dam and gets shallower quickly as one moves up reservoir or out of the channel. The dam contains a total of six tainter gates, each 2.7 meters (9 feet) in height, and can be manually or electrically operated. The tainter gate nearest to the east bank of the river, can also be automatically operated by a mechanism which monitors pond elevation. Two Allis-Chalmers, 1750 mm (69 in), Kaplan-type turbines draw reservoir water through 2.7 meter (9 feet) long penstocks located at a depth of 7 meters (23 feet) with outlets located at a depth of 1.7 meters (5.5 feet) below the centerline of the turbines (centerline=811msl). At a normal pool elevation of 266 m above mean sea level (874 msl), a head of 15.2-18.9 meters (50-62 feet) is produced. Each turbine drives a generator rated at 2500 kilowatts for a maximum potential output of 5 megawatts. Water is released during the months of July through September primarily for power generation during peak power demands (approximately 1200-1900 hour, Monday through Sunday). The maximum flow release capacity during a peak power generation is 34 cubic meters per second (cms) (1,200 cubic feet per second (cfs)). Nongeneration flow consists solely of an automated flow release outlet (minimum flow outlet) 91 cm (36 in) in diameter, with an inlet located at a depth of 1.2 meters (4 ft) at normal pool elevation and an outlet located on the east wall of the powerhouse. The minimum flow outlet is in operation if the flow entering the reservoir is less than 2.8 cms (100cfs) and is required by the licensing contract from fisheries (Jordan, 1986). Peaking operation dropped the reservoir (pool) about one foot as a result of a five to six hour event starting at normal pool elevation of 874 msl and 300 cfs flowing over the dam or turbines prior to the event. Since the reservoir is basin shaped, it drops up to two feet per event if the event start up occurs when the pool is already down. By 1987 the reservoir had already silted in significantly therefore limiting peaking capacity (Jordan, 2004). Run-of-the-river power generation occurs when the flow entering the reservoir is greater than 2.8 cms and the reservoir is not being filled.

Sampling Sites

Water Chemistry and Sediment Sites

Refer to Figure 2 for the locations of all sites within the study area. Sites 1-4 are upstream of the dam and sites 5-8 are downstream of the dam.

Site 1 (S1)

This site was located in Lyra Township (NE1/4, SE1/4, Sec 6, T106N, R27W) and was the site situated the farthest upstream from the reservoir. The site was located 3 km (2 mi) west of the town of Good Thunder on Blue Earth (BE) County Road 13. Sampling was conducted 46 m (56 yds) upstream of the bridge. Deciduous woods bordered the site upstream right and left, and downstream right and left.

Site 2 (S2)

The site was located in Rapidan Township (SW1/4, SE1/4, Sec 17, T107N, R27W) 91 m (100 yds.) East of BE County Road 34 on BE County Road 126. The site was located 46 m (50 yds) southeast of BE 126, and was bordered by deciduous woods in all four directions.

Site 3 (S3)

This site was located on the D.P. Friederichs farm in Rapidan Township (NW1/4, NW1/4, Sec 18, T107N, R27W). A dramatic change occurred at this site between the July 9th and July 23rd baseline samplings of 1984. During this time span, repairing of the floodgates and reinforcement of the Rapidan Dam was completed. Subsequently, the gates were closed to allow the water level of the recently enlarged reservoir to rise and flooding of S3 occurred. Flow at S3 was reduced to the point where it was no longer visibly detectable and silt deposition occurred quickly. The site was bordered in all four directions by deciduous woods. Cattle grazed upstream left and downstream right portions.

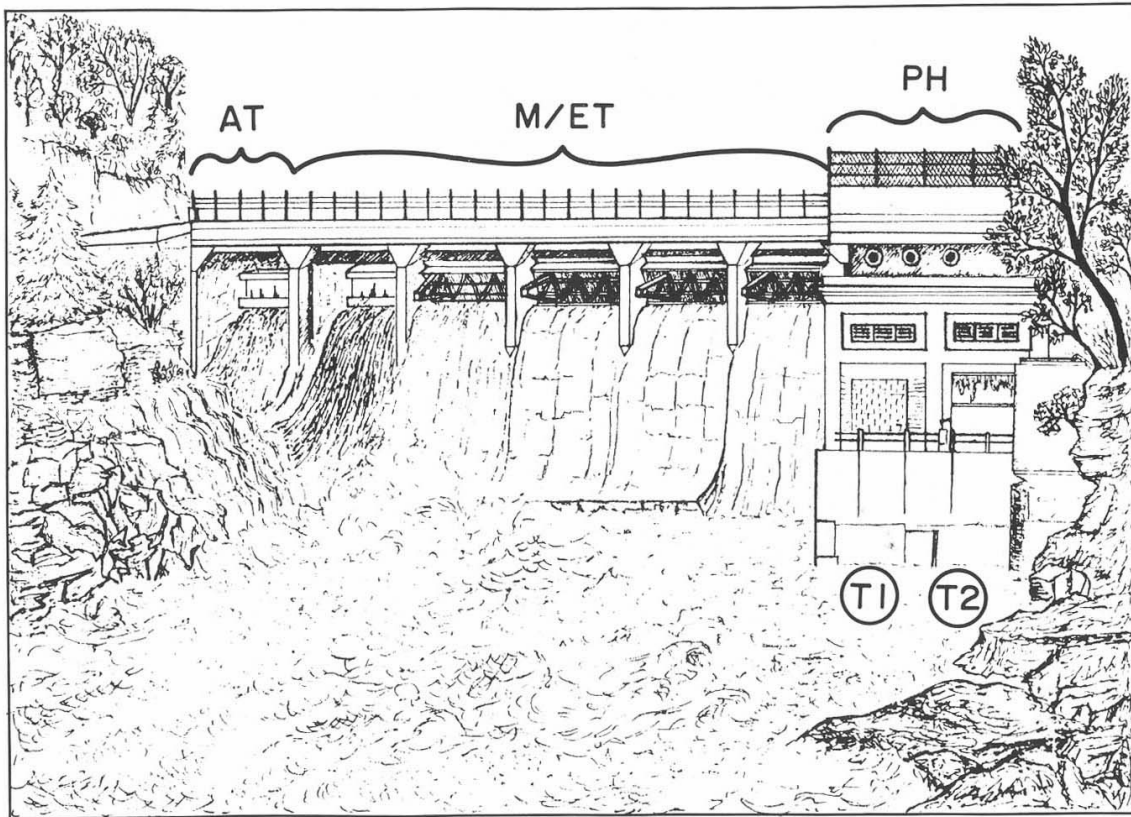


Figure 4. The Rapidan Dam looking south, in an upstream direction (Strom, 1985).
PH: Powerhouse **M/ET: Manually/Electrically controlled tainter gates**
AT: Automated tainter gate **T1: Turbine #1 outlet** **T2: Turbine #2 outlet**

Site 4 (S4)

The site was located in Rapidan Township (SW1/4, NW1/4, Sec 8, T107N, R27W) 0.4 km (0.25 mi) south of BE County Road 9. This site was the lower portion of the Rapidan Reservoir and sampling was conducted at the public boat landing. Deciduous, wooded, sandstone bluffs bordered the site upstream left and downstream right, while deciduous woods bordered upstream right and downstream left.

Site 5 (S5)

This site was the first site immediately downstream of the dam and was located in Rapidan Township (SE1/4, SE1/4, Sec 6, T107N, R27W) 0.4 km (0.25 mi) north of BE County Road 9. Access to the site was accomplished by using the private access road immediately east of The Dam Store, a small café and bait shop, located just west of the dam. Wooded sandstone bluffs bordered downstream right and upstream left. Deciduous woods bordered downstream left and upstream right.

Site 6 (S6)

The site was located in South Bend Township (NW1/4, SE1/4, Sec 27, T107N, R27N) just under 5 km (3 mi) south of U.S. Highway 169 on BE County Road 33. The sampling location was 46 m (50 yds) upstream of the bridge. Deciduous woods bordered the site upstream right and downstream left. Row crop and pasture land bordered upstream left and downstream right.

Site 7 (S7)

This site was on the Le Sueur River, a major tributary of the Blue Earth. It was located in Mankato Township (SW1/4, NW1/4, Sec 35, T108N, R27W) 5 km (3 mi) south of U.S. Highway 169 on Minnesota State Highway 66. Sampling was conducted 46 m (50 yds) upstream of the bridge. A dense stand of willow bordered the site upstream left and downstream right, while private residential land bordered upstream right and downstream left.

Site 8 (S8)

The site was located in Mankato Township (NW1/4, NE1/4, Sec 23, T108N, R27W) and was the site situated the farthest downstream of the reservoir. It was reached by driving to the southeast corner of the town LeHillier, MN, by way of Eleanor Street. The actual sampling site was 46 m (50 yds) beyond the levee in a northeast direction. Deciduous wooded sandstone bluffs bordered the site upstream left and downstream right, while deciduous woods bordered upstream right and downstream left.

See Appendix A for photographs of each site.

Sediment Bedload Sites

Two cliff locations were selected, one on the Blue Earth River and one on the Watonwan River. At each location sites were selected upstream and downstream of the sandstone cliffs.

Blue Earth River:

Site 1 was just downstream (west) of the tall sandstone cliff located downstream of the Hwy 34 bridge over the Blue Earth River in Section 17. Samples sites a and b were on dry riverbed. The river had approximately four to five foot banks on either side here. Site 2 was slightly upstream of the beginning of the sandstone cliff halfway between the cliff and bridge. Sample sites a and b were on dry river bed. Approximately 5-6 foot tall banks were on both sides of the river at this location.

Watonwan River:

Site 3 was near the N.W. corner of Blue Earth County Fairgrounds in Garden City, Minnesota downstream of a very tall stepped sandstone cliff N.E. of the river across from the fairgrounds. Sample site a was on dry river bottom. Facing downstream, west, the left bank was 7 foot tall and the right bank was 3 foot tall. Site 4 was located far upstream of the cliff used as a reference at Site 3. It was downstream, S.S.E., of the Highway 169 bridge over the Watonwan in Garden City. All sampling sites were submerged. The banks on both sides were about 5 foot tall and there was a very large sandbar island located upstream of the bridge.

Macroinvertebrate Sites

The macroinvertebrate study utilized a modified sampling strategy of water quality Sites 1-8. Site 5 was divided into 5 sub-areas stretching 0.2 km (0.125 mi) to 0.8 km (0.5 mi) downstream of the dam. Site 5e is used in this report; see Danks 1991 for other site data on Site 5. Sites 2, 5e, 5d, 5c, 5a, 6 and 7 were chosen for detailed analysis because they represented an upstream reference site (S2), sites that would reflect discharge impacts (S5e, S6) and a control site (S7). Sampling was attempted at two stations within each site. Station 1 was located near-shore in water of slower velocity, whereas Station 2 was located offshore in deeper and faster water. At some sites both habitat types were not present, therefore only one station was sampled. See Danks (1991) for more detailed site and station descriptions.