Poplar River Watershed

Total Maximum Daily Load Report: Turbidity Impairment

For submission to:

U.S. Environmental Protection Agency, Region 5
Chicago, Illinois

Submitted by:

Minnesota Pollution Control Agency
October – 2013

wq-iw10-02e

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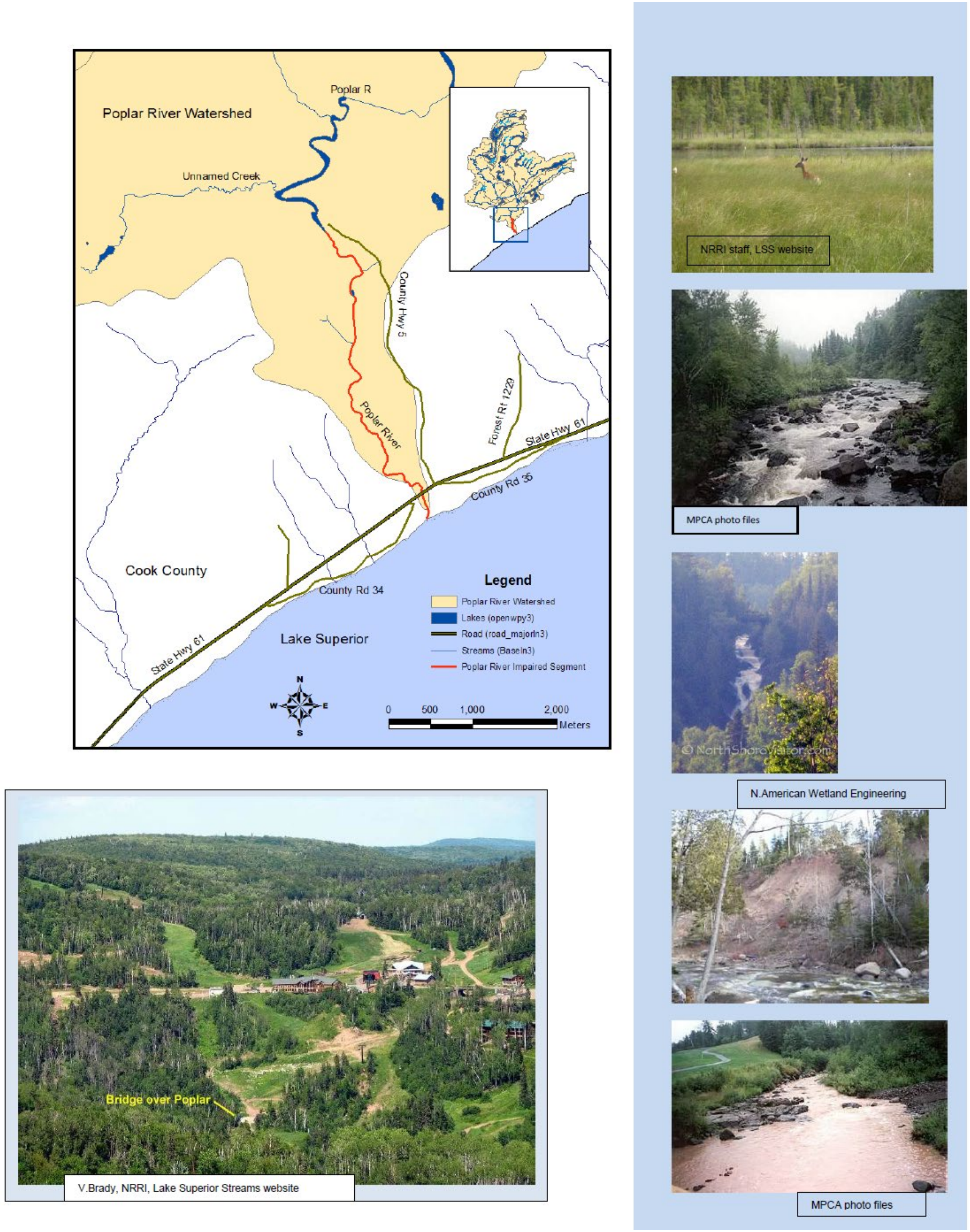


Figure E1 Poplar River watershed and images of watershed located in northeastern Minnesota

Executive Summary

Poplar River is located in northeastern Minnesota and flows through a picturesque landscape of boreal forest and steep hills. The watershed surrounding the lower river is a premier Midwest resort area with ski runs, hiking trails, boating and fishing access sites for recreation. Overall, the river is a high value water resource for the state. Citizen interest in the health of the river is high, whether they are anglers concerned about the native trout fishery or area residents concerned about water quality.

The lower Poplar River is listed as impaired due to exceedances of the 10 NTU turbidity standard. Sampling data demonstrate that exceedances occur frequently at flows greater than 68 Cubic Feet per Second (CFS). Turbidity measurements are highly correlated to sediment measurements, indicating that fine sediment fractions are likely the primary cause of turbidity within the lower Poplar River.

Section 303(d) of the Clean Water Act and Chapter 40 of the Code of Federal Regulations Part 130 require states to develop Total Maximum Daily Loads (TMDLs) for waters not meeting designated uses. The TMDL process quantitatively assesses the impairment factors so that states can establish controls to reduce pollution and restore and protect the quality of their water resources. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of wasteload allocations, load allocations, and a margin of safety. The load allocations address human influenced nonpoint sources and natural background conditions. A margin of safety accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$TMDL = \Sigma\, WLAs + \Sigma\, LAs + MOS \qquad \textbf{Equation 1}$$

Where:

TMDL =	Total Maximum Daily Load (may be seasonal, for critical conditions, or have other constraints)
WLA =	WasteLoad Allocations (point source)
LA =	Load Allocations (non-point source)
MOS =	Margin of Safety (may be implicit and factored into a conservative WLA or LA, or explicit)

To complete a TMDL for the lower Poplar River, a variety of technical approaches and analyses were used to evaluate turbidity and total suspended solids (TSS) sources in the Poplar River watershed. Water quality modeling, a physical channel assessment, field investigations and various statistical techniques were used to define the source, nature, frequency, and magnitude of sediment loading in the river. A Load Duration Curve (LDC) approach was used to determine the TMDL. In addition to providing the loading capacity numbers, LDC plots provide a visual representation of observed load data to 1) Analyze the streamflow conditions under which excursions to the water quality standard occur, 2) Assess critical conditions, 3) Identify potential sources of turbidity, and 4) Quantify the level of TSS reduction necessary to meet the surface water quality criteria for turbidity in the river. Table E1 provides the loading capacity for each flow zone as defined by the LDC approach.

Table E1 Loading Capacity for Each Flow Zone Based on the LDC Approach

	Flow Zone				
	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Flow Interval (CFS)	> 260	260 – 68	68 – 41	41 – 18	< 18
Flow Interval (%)	0 – 10%	10 – 40%	40 – 60%	60 – 90%	90 – 100%
TMDL Capacity (lbs/day)	25,297	7,532	3,281	1,904	736
MOS (lbs/day)	2,530	753	328	190	74
Waste Load Allocation					
Caribou Highlands WW	106	106	106	106	106[2]
Construction stormwater	227	67	28	16	6
Load Allocation (lbs/day)[1]	22,434	6,606	2,819	1,592	550

[1] Allocation is equal to the capacity less the WLA and MOS.
[2] The permit for Caribou Highland's wastewater discharge does not specify discharge based on flow; however, it does specify that discharge may only occur during months when flow in the river provides sufficient dilution.

Sediment Sources and Seasonal Variation

Analysis of the TSS data collected at the two monitoring stations on the lower Poplar River indicates that:

- 68% to 85% of the TSS load measured near highway 61 (station number S000-261) is originating from the lower Poplar River watershed.
- 51% of the turbidity exceedances (observed turbidity > 10 NTU) occur during the highest 10% of flows (i.e. flows greater than 260 CFS).
- 73% of turbidity exceedances occur during the 40% highest flows (i.e. flows greater than 68 CFS).
- 55% of the total sediment load reaches the stream during April and May of each year, indicating that a distinct seasonal trend is present.

The results of the data analyses suggest that the primary sources contributing to elevated levels of turbidity in the lower Poplar River originate from the lower watershed, are associated with high flow events, and are most prevalent during the spring.

In an effort to better understand and quantify sources of sediment in the lower Poplar River that likely contribute to elevated turbidity measurements, computer modeling and a geomorphological assessment were conducted to complement the data analyses conducted. The computer modeling was used to predict sediment loading from upland erosion and the geomorphological assessment looked at “in-channel” and “near channel” sources. Several distinct sources of sediment were identified during the physical channel assessment and computer modeling. These sources include:

Upland Sediment Sources

- Surface erosion from slumps
- Incision along valley slopes (erosion gullies and ravines)
- Localized erosion related to land-use alteration, such as,
  - Ski Runs (including bare trails and access roads)
  - Golf Course areas
  - Developed areas
- Forested areas and first order or ephemeral channels within the forest

- Altered flow pathways (Concentrated upland areas linking sediment flow to channel)

Channel/Near Channel Sediment Sources

- Channel bed incision
- Sudden channel migration (e.g., meander cut-off, channel avulsion, etc.)
- Streambank erosion, such as the river impinging on a slump

- In-stream embedded sediment

Analysis of these sources indicated that the upland sediment sources are most likely to be generated during precipitation events when there is little vegetative cover and/ or when the ground is saturated. Soil particles are detached from the soil matrix and transported to the river via overland flow. Near stream sources likely occur when flow and stage are high and the stream impinges on the barren valley walls aggravating slumping and/ or mass wasting of existing slumps.

A number of altered flow paths were also identified. The identification of these flow paths allows upland modeling to be adjusted to take into account the altered hydrology. Flow paths in the lower Poplar watershed are mainly generated by roads cutting across steep slopes. The road cut intercepts both surface and sub-surface flows. The road cut then reroutes flow downslope via the road ditch instead of the flow continuing to disperse across the hill slope. These flow paths can concentrate flow and deliver sediment in greater amounts and more quickly to the river.

Historical records and air photos were analyzed and interviews conducted with residents to determine if there were a connection between the historical activities of logging, road building, dams, and channel alterations to the current sediment impairment. This historical investigation yielded little evidence of past watershed activities impacting current sediment loads to the river.

The streambanks of the Lower Poplar River are armored with boulders over most of the 2.7 miles of river. Along this stretch of river are numerous bluffs and three ravine outlets. Due to the natural bank armor and remediation efforts (bank stabilization) at two of the slumps nearest the river, a relatively high stage is needed to directly erode these sediment sources. A modeling effort generated from cross-sectional and flow data was completed to determine the river stage that would access these sediment sources. Modeling showed that for a 2-year return period, the streambank contribution to sediment loading would be minimal. This is because the rock that protects the streambed also extends vertically for some distance up the streambank, thus protecting the bank from smaller storm event impacts. As the river stage increases with larger storm events, the sediment load from the banks may increase as the river begins to access some of the less protected higher streambanks and floodplain. However, the contribution would continue to be relatively small as the banks are well protected with vegetation.

Load Duration Curve and Model Outcomes

The LDC approach applied to the Poplar River TSS and flow data sets results in large percent reductions to the existing loads under high and mid-range flow conditions. Table E2 reports the percent reduction required for the flow ranges associated with the watersheds flow zones. They are 89% (High Flows), 68% (Moist-Conditions) and 89% (Mid-Range Flows).

Table E2 Loading Capacity and Required Reductions for Each Flow Zone Based on the Load Duration Curve (with MOS) Approach

	High Flows	Moist	Mid-Range Flows	Dry	Low Flows
Flow Interval (CFS)	> 260	260 – 68	68 – 41	41 – 18	< 18
Flow Interval (%)	0 – 10%	10 – 40%	40 – 60%	60 – 90%	90 – 100%
% Reduction Needed	89%	68%	89%	3%	None

1.0 Introduction

The TMDL report integrates various results of water quality data analysis, watershed modeling, field investigations, physical stream assessments and biological investigations into a summary document. This report discusses: 1) the current status of the turbidity problem in the Poplar River; 2) historical and current sources of turbidity and 3) recommendations concerning appropriate loading of turbidity into the Poplar River to achieve water quality standards. The primary reference materials for this report are:

- **Lower Poplar River Alternative Urban Areawide Review for Cook County, MN and Mitigation Plan, 2005**. Prepared for Lutsen Mountain, Cook County, Minnesota. Prepared by North American Wetland Engineering, P.A. (NAWE) and SE Group. October 18, 2005. This was the first document to be created regarding land use and development capacity in the Lower Poplar River Watershed. The document was created in 2005 and put a cap on the development potential of the area. It is reviewed by the Cook County Planning and Zoning office every five years. A Water Erosion Prediction Project (WEPP) model was produced but was determined to be insufficient to evaluate sediment sources due to its lack of detail in inputs and it did not include the entire watershed. Nevertheless, it is an important part of the body of knowledge on the Poplar River.

- **Poplar River Turbidity Assessment.** USEPA Contract Number 68-C-02-110.Prepared by RTI International, URS Corporation, Environmental Consulting &Technology and Short Elliott Hendrickson, Inc. This report by EPA contractors for the Poplar TMDL process included four distinct tasks: 1) A summary of existing water quality and watershed data. 2) A data summary that included the water chemistry and hydrology information needed to determine sediment loading. 3) Evaluation of an existing watershed model (WEPP) and model runs to identify upland sources of sediment. 4) A physical channel assessment and sediment source identification summary that included implementation recommendations. The report produced estimated loads from defined sources, load duration curve estimates of sediment, and a likely TMDL allocation for completion of the TMDL report. It is the most complete compilation of material used for preparing the TMDL.

- **Poplar River Macroinvertebrate and Habitat Survey.** University of Minnesota Natural Resources Research Institute **(**NRRI) Technical Report Number NRRI/TR-2008/27. Researchers surveyed the biota and stream habitat of the lower mainstem of the Poplar River in August 2007 to obtain baseline information on stream assemblages. Four sites were selected along the Poplar River within the last 3 km before it enters Lake Superior. Poplar River data generated from each sample site were compared to data from 24 other North Shore stream sites sampled over the last 12 years to assess the Poplar River's condition in a regional context. Based on samples from August 2007, the overall determination is that the condition of the Poplar River's macroinvertebrate community is at the poorer end of the spectrum relative to other non-urban North Shore streams.

- **Poplar River Fisheries – Summary and Trends.** MN DNR Area fisheries report, 2008. This document was prepared in 2008 by the Grand Marais Area Fisheries supervisor for a public meeting. The MNDNR has not done much fish population sampling in the lower stream reach, and no sampling was done prior to 1983. The lack of earlier sampling means that all the information available to the MNDNR is post-development of the majority of resort and townhome complexes. The lower reach was already disturbed or impaired to some degree when the MNDNR started sampling.

- **Poplar River Sediment Source Assessment.** University of Minnesota, March 30 2010. B. Hansen, D. Dutton, J. Nieber, A. Gorham. The main goal of this project was to investigate sediment sources to the Lower Poplar River in more detail than previous studies. The work plan's initial objectives were to conduct more field investigations of near channel sediment sources, identify a reference reach for the Poplar River and select key storms for modeling total sediment loading to the river. Because of the high sediment loads generated from a particular land use, the ski slopes, and the lack of sediment production from the channel, the initial work plan objectives were modified. Data collection relevant to upland erosion processes was enhanced. Hydrology altering flowpaths were identified. Watershed modeling to integrate flow paths, ravines and more well defined watershed sources of sediment was completed. Historical land practices were investigated.

- **Lower Poplar River Watershed Sediment Source Assessment.** University of Minnesota, February 2013. J. Nieber, B. Hansen, C. Arika. This effort refined previous modeling efforts via updated model runs and used field measured parameters as model inputs. Relative to potential sediment production, the model also assessed variability in ski slope vegetation, ski run slope lengths with and without water bar BMPs, artificial snow loads of varying depths, individual hillslope erosion characteristics and erosion from interconnecting hillslope channels.

1.1 Applicable Water Quality Standards

Minnesota's Surface Water Quality Standards provide information on beneficial uses assigned to waterbodies, numeric and narrative standards for pollutants, and non-degradation provisions assigned to high-quality and unique waters. Minnesota Rules, Chapter 7050.0470, identify classifications for waters in major surface water drainage basins, including those applicable to the Poplar River. Per Chapter 7050.0470, classifications applicable to the Poplar River include Classes 1B, 2A, and 3B. The turbidity standard associated with each of these classes is provided in Table 1.1. Of the three, Class 2 is the most restrictive and applicable class and will be used as the water quality target in this report.

Table 1.1 Turbidity Standards Associated with Water Classifications 1B, 2A, and 3B

Water Classification	Minnesota Rules, Chapter	Turbidity Standard (NTU)
Class 1B	7050.0221, subpart 3	Not applicable
Class 2A	7050.0222, subpart 2	10 NTU
Class 3B	7050.0223, subpart 3	No Turbidity Standard

Assessment of Impairment

In 2004 a portion of the Poplar River in the Lake Superior Basin was listed on Minnesota's 303(d) list of impaired waterbodies. The impaired segment (Assessment Unit ID: 04010101-613) includes a 2.73-mile segment of the Poplar River from Superior Hiking Trail bridge to Lake Superior (Figure 1.1). While the most recent 303d list includes both turbidity and mercury as pollutants of concern, this report will only address turbidity only.

Table 1.2 Poplar River Impaired Segment in Minnesota's 2010 303(d) List

Reach	Description	Year Listed	River ID#	Affected Uses	Pollutant/ Stressor
Poplar R.	Superior Hiking Trail bridge to Lake Superior	1998	04010101-613	Aquatic consumption	Hg Water Column
Poplar R.	Superior Hiking Trail bridge to Lake Superior	2004	04010101-613	Aquatic life	Turbidity

1.2 Pollutant of Concern

Turbidity is a unit of measurement quantifying the degree to which light traveling through a water column is scattered by the suspended organic and inorganic particles. In streams, turbidity refers to the cloudiness of the water due to the presence of suspended particles such as silt and clay, dissolved solids, stains, microscopic organisms, and other organic matter. These materials can originate from natural sources as well as from human activities. In the case of suspended sediment, the supply of suspended sediment to a river system is controlled by the characteristics of the soils in the catchment and the erosion and transport mechanisms in the watershed. While some level of turbidity is a function of a stream's natural processes, activities which result in increased erosion, exposure, or transport of sediment to the stream will likely cause increased turbidity. Excessive turbidity, whether through natural processes or human-induced activities, can result in a number of physical, chemical, and biological impacts to a river. In a waterbody like the Poplar River, the most significant and direct impacts can include:

- Alteration of the substrate composition, clogging channel bed interstices and reducing habitat space for small fish and invertebrates
- Marginal changes to the instream channel morphology and general habitat availability
- Reduction in the permeability of the bed material
- A decline in the intergravel concentration of dissolved oxygen
- Reduction in the depth of light penetration into the water column, thereby decreasing rates of photosynthetic activity and thus primary productivity in submerged plants
- Physical damage to leaf surfaces by abrasion and by smothering
- Interference with the behavior, feeding, and growth of fish due to sight and energy constraints in fish and changes in the invertebrate population
- Damage to fish gills by abrasion (hyperplasia) and clogging
- Increase of fish disease
- Increased surface water temperature

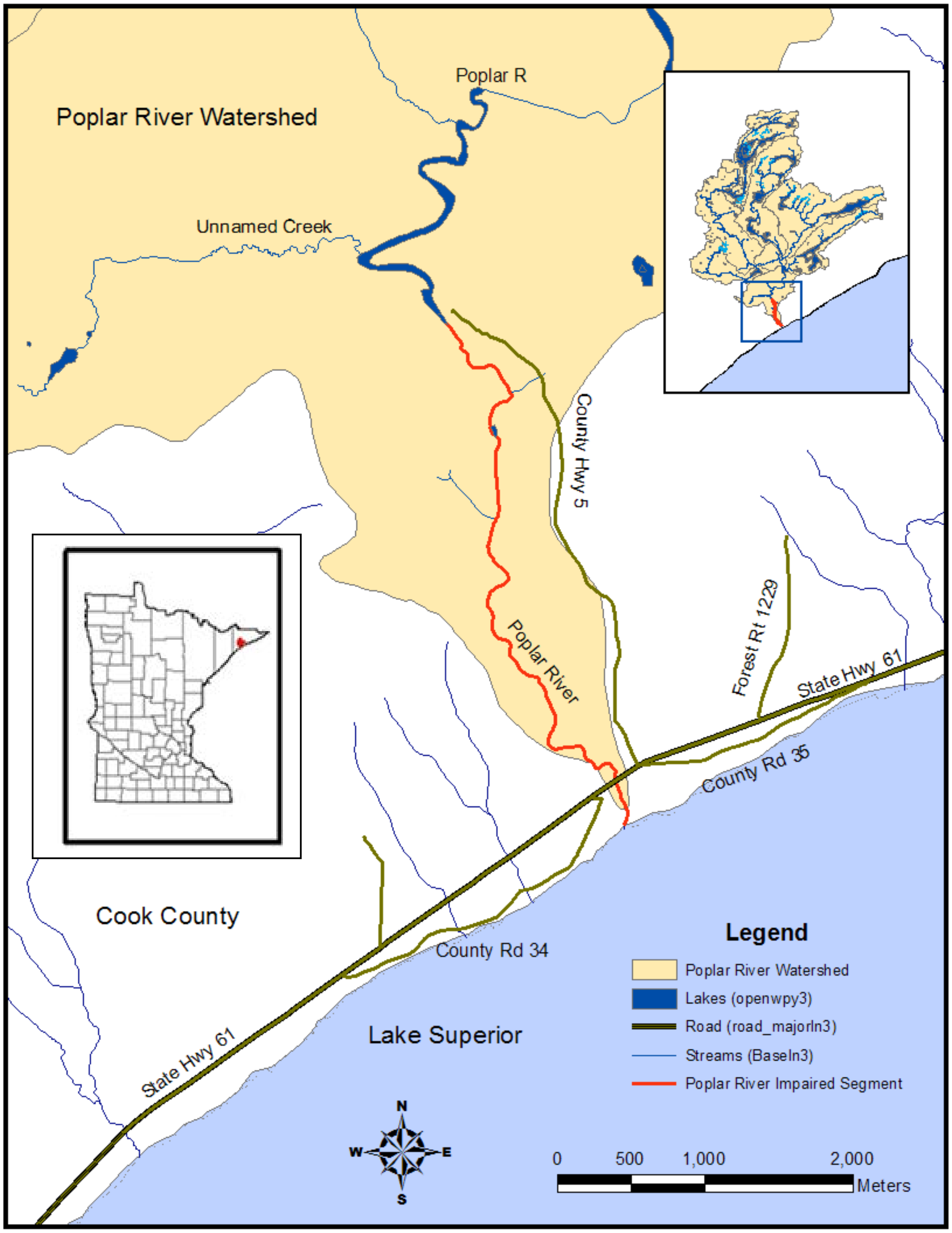


Figure 1.1 Lower Poplar River Watershed Showing 2.73-Mile Impaired Stream Length. GIS Information Obtained from the DNR Data Deli Online at http://deli.dnr.state.mn.us/index.html

1.3 Background Information

1.3.1 General Watershed Description

The Poplar River watershed is located in the Lake Superior Basin (northeast Minnesota) near Lutsen, MN (Figure 1.2). The entire watershed covers an area of approximately 114 square miles with a river distance of approximately 25.5 miles. Poplar River originates within the Boundary Waters Canoe Area and ends at its confluence with Lake Superior. The watershed includes Tait Lake/Tait River, Pike Lake, and Caribou Lake (MPCA, 2002).

The upper watershed of the Poplar River is located on an elevated plateau. A typical elevation in the upper watershed is about 1,300 feet and the average stream gradient is less than 1 percent. The channel is relatively wide (100 feet or more) and characterized by wide meanders. Dense vegetation consisting of willows, reeds, and other hydrophilic grasses buffer the banks which show little signs of erosion. Impressive waterfalls, approximately 150 feet high, mark the transition from the upper watershed to the lower watershed. Downstream of the headwaters area, the river and adjacent watershed narrow considerably as it flows over the escarpment. In this lower watershed area the gradient increases greatly and the channel is defined by bedrock, lacustrine beach, and glacial deposits. These downstream portions of the Poplar River and watershed are characterized as having significant drops in elevation with an average gradient of nearly 4% and containing both forested and non-forested steep slopes. For the purposes of this report, the “Lower Poplar River” will describe the watershed area downstream of the escarpment, a point defined by a bridge crossing of the Superior Hiking Trail.

1.3.2 Climate

Due to its close proximity to Lake Superior, the Poplar River watershed is greatly affected by the moderating effects of Lake Superior. This moderating effect results in cooler summers and warmer winter temperatures. Temperatures range from maximum recorded temperatures of 95ºF to 40ºF below zero. The average temperatures for Lutsen between the years of 1986 and 2006 ranged from 29ºF to 46ºF. Average annual precipitation at Lutsen is 30.33 inches. During the growing season (May-September) precipitation is 17.48inches and normal summer (June, July, August) precipitation is 10.82 inches.

1.3.3 Geology

The geology of the watershed is a product of glaciation. The Great Ice Age formed continental glaciers and subsequent ice streams which eroded underlying rock. Surface rocks and soils in this area are highly weathered and affected by stream erosion of glacial and glacial lake deposits. The Superior Lobe moved west southwestward depositing red clay. The boundary is about three to four miles inland from Lake Superior, crossing the Poplar River at approximately four miles inland from the lake (Grout 1959). The Poplar River is located on the border of the Rainy Lobe and the Superior Lobe (National Oceanic and Atmospheric Administration (NOAA) 2008). NOAA additionally reports that the North Shore Volcanic Group underlays the Lutsen area.

1.3.4 Soils

The Poplar River watershed contains many lakes and wetlands in the upper reaches. The soils in the watershed are primarily red lake clay and Superior Lobe till. Generally soils are highly weathered (over the last 14,000 years), forming as a result of glacial and organic deposits. Soils are poorly drained in depressions and moderately drained on summits and side slopes. Above the 1,000 ft. elevation the soils vary considerably in depth from deep to shallow over bedrock and over gravelly-loamy glacial till moraines. Below 1,000 ft. in elevation, soils are deep to shallow over bedrock and over clayey glacial till moraines.

The Cummins and Grigal soils report of Minnesota (1980) describes soils of the Poplar River watershed as primarily forest soils (mean temperatures cooler than 47^{o}F), with soil textures described as loamy and coarse loamy. The upper reaches are comprised of sandy skeletal and coarse loamy soils. Soils formed in thin till over the bedrock, in gray and brown sandy and gravelly sediments, and in mixed sediments derived from former glaciations.

1.3.5 Land Use

Reported urban land use within the Poplar River watershed totals 3.5%, the highest percentage of urban land use of the MPCA monitored North Shore trout streams. The entire watershed contains 134 miles of streams which form the river and drains into Lake Superior at Lutsen. There are also 87.6 miles of roads throughout the watershed. General land use categories are split between forest (77%), wetland (19%), grassland (1%), open water (1%), bare land (1%) and agriculture (1%).

1.3.6 General Stream Characteristics

The Lower Poplar River has more in common with mountain streams than with typical streams of the Midwest plains. Like many mountain streams, the Lower Poplar River does not fall into a general category of braided or meandering streams. A sharp change in bed elevation is noticeable near the mouth where a succession of falls is present upstream and downstream of Highway 61. Upstream from these falls, the average longitudinal slope is approximately 0.03 (3 percent) and the general shape is flat or slightly convex up. Such longitudinal shapes are common in cases of relatively young rivers developed in glacial valleys.

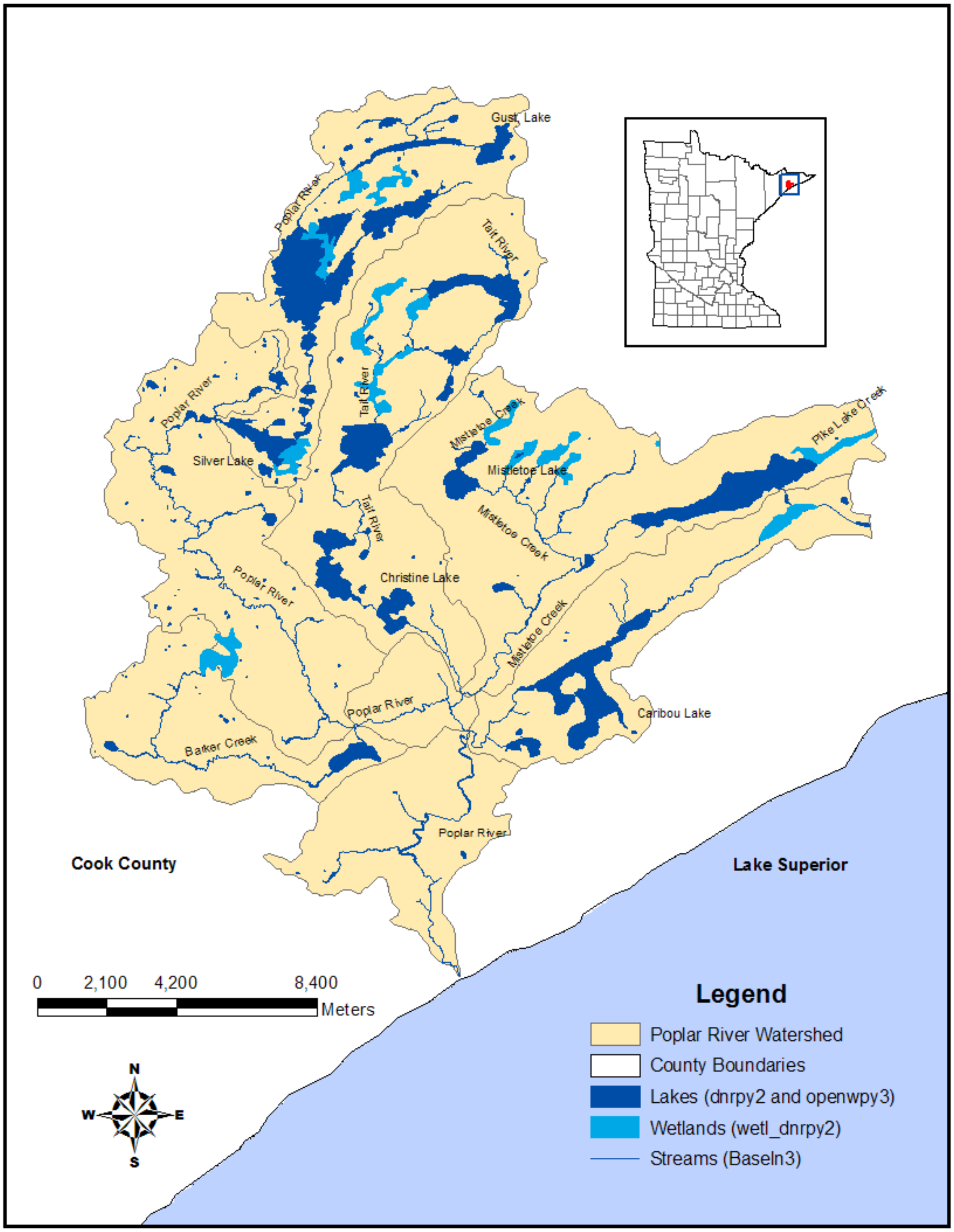


Figure 1.2 Poplar River Watershed

The Lower Poplar River flows through a valley that is approximately 120 to 250 feet deep and 500 to 1000 feet wide. The average side slopes of the valley vary between 10 and 25 degrees (18% to 50%). The channel lacks a well defined floodplain and, for the most part, is confined by the topography of the valley. In some places, one side of the channel is flanked directly by the valley slopes. In other places, however, the valley is sufficiently wide and flat and it could be considered a narrow floodplain. The channel displays some lateral mobility and as a result several entrenched meanders have developed. Channel reaches resemble mountain drainage basins and include bedrock, cascade, step-pool, plane-bed, and pool-riffle features as described by the process-based classification of Montgomery & Buffington (1997).

1.3.7 Stream Biology

In 2008, a MN DNR fisheries report summarized trends observed in the Poplar River fish populations. The report indicated that the highest populations of wild brook trout occur in the upper reaches of the river. Below the waterfall, the river supports a spring run of rainbow trout (steel head); fall runs of pink Chinook and Coho salmon, and; a fall run of coaster (lake-run) brook trout. The report describes the lower Poplar River (the last 2.7 miles) as an area that is not stocked by the DNR, but in years prior may have been privately stocked. The DNR has minimal sampling within this lower reach. No sampling occurred prior to 1983, and no sampling occurred above the falls prior to 1990. All data are considered collected in "post-development" where the "lower reach was already disturbed, or impaired". The brook trout population "is small by comparison to population levels farther upstream, and by comparison to other streams in this area". Below the falls, summer sampling of juvenile steel head and brook trout is sparse. Lack of spawning habitat within the lower 2.6 miles may limit brook trout and steel head reproduction. Factors such as marginal water temperature, low winter flows, limited area with suitable substrate (coarse gravels) and siltation can greatly affect suitability of habitat. The DNR report suggests the stream bed substrate may have changed significantly from assessments of 1961, and 1989 to 1995:

> *"In 1994 and 1995, MNDNR Fisheries crews reported clay and silt sediment knee-deep in places in the pools just above the mouth. Prior to that time the pool areas were relatively clean. In a 1961 survey, that area (Sector I, mouth to the first falls) had a bottom consisting of 67% rubble, 10% boulder, 10% gravel, 10% sand, and 3% silt. Rainbow trout and brown trout were present, and based on visual observation, were described as abundant. In a 1989 DNR Fisheries stream survey, bottom types in the same stretch were reported to have been boulder, rubble, and gravel, with no silt or muck reported."*

In 2008, U of MN NRRI biologists completed a macroinvertebrate investigation of the impaired reach of the Poplar River. The report, "Poplar River Macroinvertebrate and Habitat Survey" (NRRI Technical Report Number NRRI/TR-2008/27) concluded the center of the stream channel was moderately shaded, water temperatures were typical of North Shore streams in August, flow was high and the stream bottom type was dominated by large material, mostly boulder and cobble size rocks. The higher velocity has kept deposits of sand, silt, and clay in the stream bottom quite low. Biologists concluded there should be adequate amounts of interstitial space (crevices among the rocks) to provide habitat for stream invertebrates.

Poplar River habitat types were dominated by riffles and runs, with very few bank, pool, or depositional-type habitats. Qualitative habitat evaluation index (QHEI) scores were relatively high, but would have been higher had more fish cover habitat been available. The amount of organic matter in sediments was relatively low, and only one site contained much large woody debris. Because the banks of the stream are wooded, the low amount of large woody debris indicate that most of the wood entering the stream is probably smaller in size and/or gets washed downstream during storms.

While a total of 107 unique macroinvertebrate taxa were collected from the lower mainstem of the Poplar River, researchers felt the taxa “richness” at Poplar sites was lower than expected for the river’s size. Mayflies, stoneflies, and caddis flies were relatively diverse at Poplar sites. However, the relative abundance of this group was lower than expected. Conversely, Poplar River sites have high proportions of stress tolerant invertebrates. A number of indicators point to the lower mainstem of the Poplar being a physically harsh environment. These indicators included a high current velocity even during low flow, large average substrate (boulders and cobbles), invertebrate assemblages that are primarily hardier species filling more niches, and an overall low “tolerance value” at the sampled sites. These combination of factors led researchers to describe the lower Poplar River as at “the poorer end of the condition spectrum relative to other non-urban North Shore streams.”

1.4 Description of Study and Methods

A variety of technical approaches and analyses were used to evaluate turbidity and total Suspended Solids (TSS) sources in the Poplar River watershed. The approaches described in this section include defining the source, nature, frequency, and magnitude of sediment loading in the river. Sources of existing water quality, streamflow, soil survey, modeling, and meteorological data used to assess turbidity in the Poplar River are provided in Table 1.3. Technical and statistical approaches applied by the project team, and the intended purpose of each approach are provided in Table 1.4.

Table 1.3 Existing Data Used to Support the Assessment of Turbidity and TSS Sources in the Poplar River Watershed

Data Category	Source
Water quality data	##MPCA - Environmental Data Access database
Streamflow data	USGS - Poplar River at Lutsen, MN gage station (04012500)
Streamflow data	MPCA - Poplar River near Lutsen, MN station (01101001)
Soil Survey Information	Soil Survey of North Shore of Lake Superior Coastal Zone Management Area 1977 USDA SCS & MN Ag and NRCS STATSGO
Water quality data	MPCA - Poplar River flow, stage, turbidity data
Model Results	Lower Poplar River AUAR report – Cook County Poplar River Turbidity Assessment –RTI/URS report for EPA/MPCA
Meteorological data	Climatology Working Group, University of Minnesota
Land use/cover data, Soil data	Minnesota Department of Natural Resources (DNR) Data Deli

Table 1.4 Technical Approach or Analysis Used for Source Assessment

Analysis or Technical Approach	Project Purpose
Correlation coefficients, linear regressions, and simple statistics	Relationship between turbidity and other water quality parameters
	Assess variability between turbidity methods
	Relationship between TSS and flow
	Estimate streamflow in the Poplar River during 1976-2001
	Snowmelt and snow pack influence on sediment loading
Cumulative frequency histograms	Poplar River temporal and spatial trends and assesses the use of Pigeon River gage data in estimating Poplar River streamflow (1976-2001).
Drainage Area Ratio method	Estimate flow at upstream monitoring station

U.S. Army Corps of Engineers FLUX model	Seasonal and annual loading estimates at the upstream and downstream locations
	Evaluate average monthly load at upstream and downstream stations
	Evaluate sediment load originating in Lower Poplar Watershed area.
	Critical conditions
Flow and load duration curves	Provide a visual representation of streamflow conditions under which turbidity exceedances occur
	Assess turbidity conditions under different flow conditions, including the rise and fall of the hydrograph, duration and magnitude of water quality criteria exceedances, seasonality, and critical conditions
	Assess snowmelt, event runoff, and base flow contributions to flow and turbidity levels
	Identify potential sources of turbidity by the conditions under which they occur
	Calculate TSS loading capacities
RTI WEPP 2006.5 modeling	Assess upland sources of sediment
	Assess sediment loading under four scenarios: pre-development conditions, current conditions, current conditions with nonpoint source runoff controls, and build-out conditions.
	Comparison of total and average simulated and observed sediment loads (annual and monthly)
	Assess critical conditions
	Estimate land use contributions of sediment
	Long-term sediment load analysis
Stream cross section measurements, width/ depth measurements, photographs, soil and substrate characteristics, and vegetation observations	Identify and quantify the primary sources and processes responsible for suspended sediment in the system
	Understand the evolution and current condition of the stream channel
	Document locations of landslides and ravines and other erosion processes contributing sediment to the Poplar River
	Document sediment grain size distribution
	Document visible signs of erosion

	Classify the river under Montgomery and Buffington (1997)
U of MN NRRI biological assessment	Evaluate macroinvertebrate habitat and populations, calculate indices and scores for assemblages
U of MN BBE field investigations, modeling applications and more detailed source investigations	Refine source evaluations and load estimates from previous studies
	Identify priority sources and locations for BMP implementation
U of MN WEPP 2010 hillslope and watershed options	Refine modeling inputs, use field measured parameters, assess ski slope vegetation, length, snowmaking, assess ephemeral channels
MN DNR fisheries report summary	Summarize fishery trends, data from all recent assessments, and reference to historical information

2.0 Water Quality Data and Evaluation

Turbidity and TSS are the primary water quality constituents of concern in this project. Data for these parameters are available at three locations in the Poplar River watershed. They are identified as 1) MPCA station S000-753, 2) U of MN NRRI "Lake Superior Stream Project" sonde station (located upstream of the State Highway 61 overpass), and 3) MPCA station S001-261.

The primary source of turbidity and TSS data are samples collected by the MPCA at stations S000-753 and S001-261 through the Minnesota Milestone River Monitoring Program and North Shore Load Project. The Minnesota Milestone River Monitoring Program is MPCA's ambient water quality program. This program is a long term monitoring program with the goal of understanding the overall trend of water health in Minnesota. Water quality data collected in the Poplar River as part of the ambient program were collected periodically between 1973 and 1999 at station S000-261. The purpose of the North Shore Load Project was to assess current water quality conditions using state of the art monitoring techniques, provide baseline information for detection of water quality trends over time, and assist in the development of stream protection and remediation management options for public, private, and commercial interests.

Historic and recent streamflow data in the lower Poplar River are available through the USGS National Water Information System (NWIS) and DNR/ MPCA Cooperative Stream Gaging websites. Daily data are available between 1912 – 1968 and 2002 – 2006. Because streamflow is an important component in assessing sediment loading and turbidity impairment and developing the load duration curve, flows were estimated for the 1969 – 2002 period missing from the flow record. Three USGS stations, each located in close proximity to the Poplar River station, were analyzed as potential reference stations for the Poplar River. Based on the use of correlation coefficients and linear regressions, the Pigeon River at Middle Falls, Minnesota, was found to be the best source for estimating flow during periods when flow data are not available at the Poplar River near Lutsen, MN station.

Water quality and flow data are presented and discussed in greater detail in the RTI /URS/SEH report titled "Poplar River Turbidity Assessment." Historically, turbidity has been measured in the Poplar River using different types of meters but the measurements have been reported simply as NTU. Recent evaluations by the USGS of the various meters in use identified the need for separate reporting units for the different meter types and configurations (Pavelich 2002, Ankcorn 2003, Miller 2004, and Anderson 2005). The turbidity data for the Poplar River is present mostly in NTU and NTRU reporting units. A recent comparison of paired NTU and NTRU values, conducted by MPCA staff, indicated that there was no significant difference between the two in a comparison of North Shore streams data, such that the units are assumed to be equivalent. See MPCA report titled "Evaluation of Paired Turbidity Measurements".

2.1 Water Quality Data Analysis

Data assessment identified several key conclusions about the temporal and spatial extent of turbidity measurements and TSS concentrations. On a seasonal basis, TSS loads were found to be highest at the upstream station during the months of April and May and highest at the downstream location during April, May, and June. Turbidity values were found to increase significantly between the upstream and downstream stations during the spring and summer months. The lower Poplar River watershed was found to contribute 66-89% of the load observed at the downstream station between April and October. Using FLUX software, annual TSS loading from the lower Poplar River was estimated to vary from 994 tons to 2,194 tons between 2001 and 2006 and from 68% to 85% of the total load estimated at the downstream sampling station. Turbidity exceedances were observed primarily under moderate and high-flow conditions with most exceedances occurring under flows greater than or equal to 60 cfs. A 60 cfs is equivalent to a flow recurrence interval of ~ 45% at the downstream station.

2.2 Turbidity-Total Suspended Solids Relationship

Turbidity is measured in turbidity units, not as a concentration, so another parameter that is measured as a concentration must be used to represent turbidity for the calculation of loadings in the watershed. To accomplish this, correlation coefficients were determined for several parameters at the Poplar River downstream station. TSS was found to have a high correlation with turbidity (0.97) based on a data set of 85 values collected during 2002–2006. Given this finding, laboratory data collected during the period 2001–2006 were used to develop a correlation between turbidity and TSS at the Poplar River downstream location. Figure 2.1 provides a linear regression on 101 paired, log-transformed TSS and turbidity measurements. The regression resulted in the following TSS-turbidity relationship:

$$\textbf{Log TSS (mg/L)} = (0.9953 * \textbf{Log Turbidity (NTRU)}) + 0.0705$$

$$R^2 = 0.8973$$

Using this correlation, 10 NTU was determined to be equivalent to 11.64 mg/L TSS.

Turbidity as a standard analytic method was originally designed to be limited to a measurement range of 0 to 40 NTU with higher turbidities being measured using dilution (MPCA, 2006b). Measurement of turbidity in samples with very high NTU values can increase error. A second approach to limiting variability in developing the turbidity-TSS relationship was to develop the correlation using paired samples under conditions where the turbidity value is less than or equal to 40 NTU. Figure 2.2 provides a linear regression on TSS and turbidity data collected downstream using NTRU methods only, and under conditions where the turbidity value is less than or equal to 40 NTU. Based on this correlation, 10 NTU is equivalent to 12.39 mg/L TSS. Given the correlations of 11.64 mg/L TSS using all data and 12.39 mg/L TSS using turbidity data less than 40 NTU, **for the purposes of this report, a value of 12 mg/L TSS will be used as the equivalent TSS concentration for the 10 NTU water quality standard.**

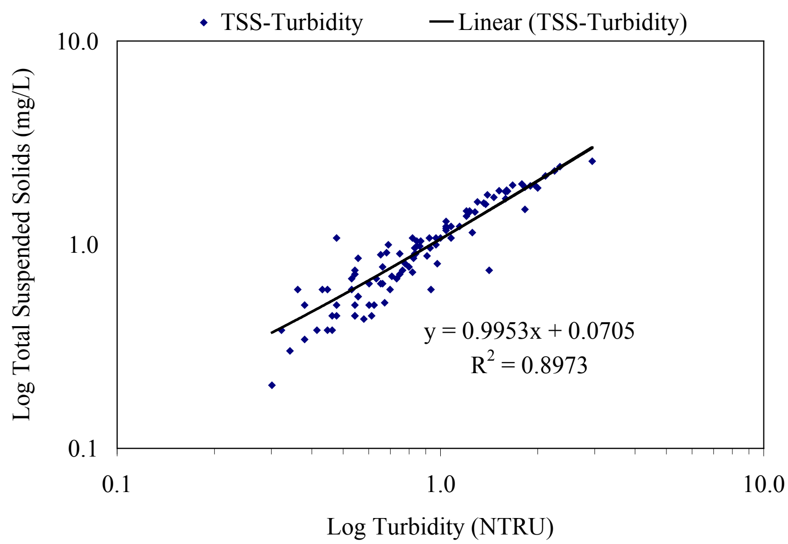


Figure 2.1 Turbidity-TSS Correlation Using All Available Data at the Downstream Site (S000-261) 2001-2006 Log-Transformed Data -

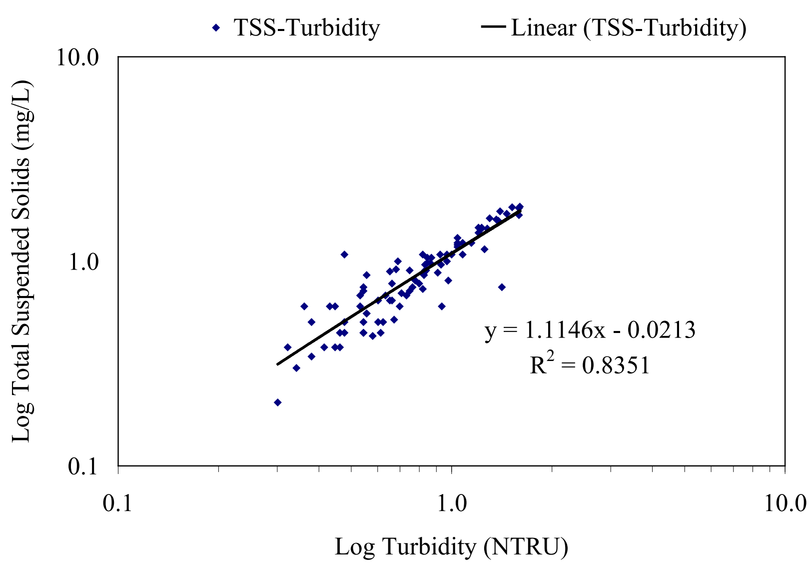


Figure 2.2 Turbidity-TSS Correlation Using only Values Less Than or Equal to 40 NTU at the Downstream Site (S000-261) Using Log-Transformed Data Collected During 2001–2006

3.0 Sediment Load Analysis and Outcomes

FLUX model runs and flow and load duration curve analysis were completed to calculate sediment loads to the river. The following sections summarize the outputs. Greater detail and all supporting materials for these calculations can be found in the RTI/URS document "Poplar River Turbidity Assessment."

3.1 FLUX model analysis

Flow and sampling data were entered into FLUX for both stations. Based on the error statistics and graphical representations of flow, load, and concentration, two different regression methods were used to estimate loads in the Poplar River. Methods and results for each station are arrayed or graphed in the tables and charts below.

The entire record of data was used at each site to estimate sediment loading. The data were lumped together because the accuracy and precision of the techniques used by FLUX are improved with greater amounts of data. In addition, the data collected prior to 2001 contains lower concentration and flow values. Data collected after 2001 includes greater frequency of high flow and storm related events. The variety of flow and concentration levels collected during these periods improved the load estimates. It was determined that stratifying data by individual year was not necessary because no significant change to the watershed or climate has occurred that would affect sediment loading to the river; however, since most data were collected between April and October of each year the relationship developed via FLUX was only applied to these months. An average winter concentration was used to calculate loads for November through March. The same method was applied to the upstream and downstream data sets.

Table 3.1 Flow weighted TSS concentrations for all stratification periods for upstream station (S001-753).

Period	Flow =< 400 cfs	Flow > 400 cfs
November - March	2.4 mg/L	2.4 mg/L
April - October	3.3 mg/ L	11.1 mg/L

Table 3.2 Estimated annual loads at the upstream station (S001-753).

Year	Load (Tons)
2001	1055
2002	169
2003	282
2004	474
2005	465
Average	**489**

Figure 3.1 Estimated average monthly load at the upstream station (S001-753).

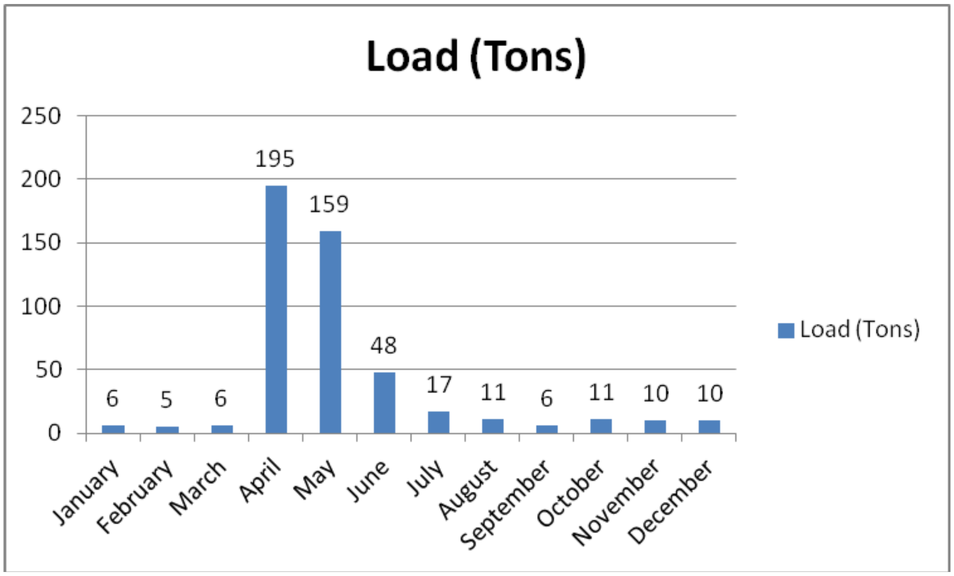


Figure 3.2 Estimated annual loads and average at the downstream station (S000-261).

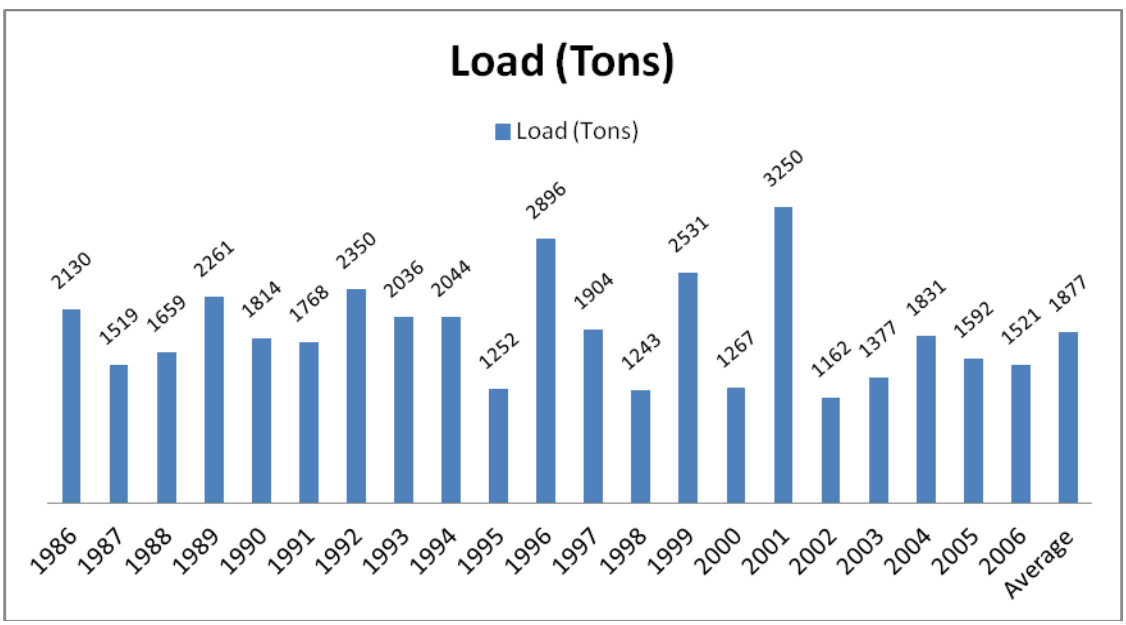
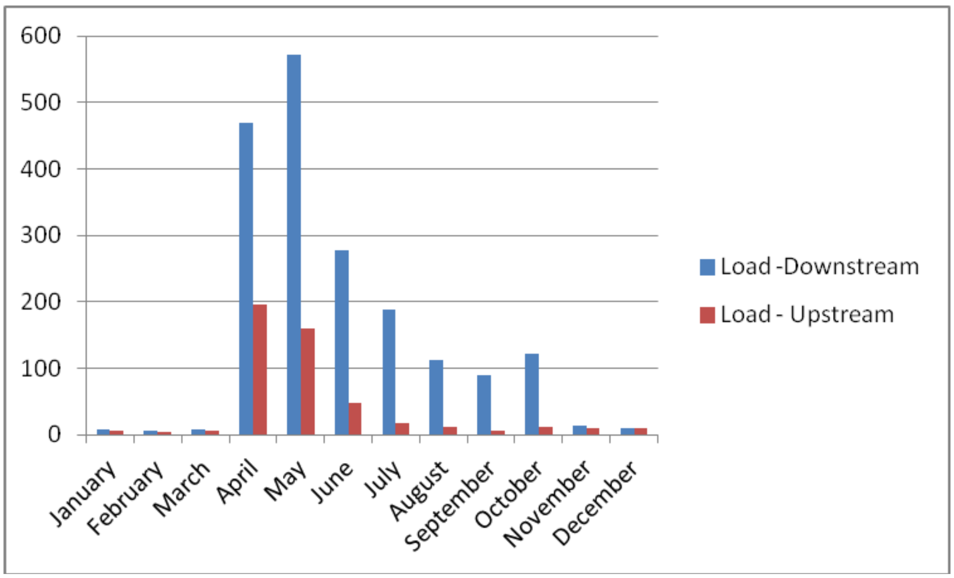


Table 3.3 reports the annual loads estimated for both stations. It demonstrates that load from the lower Poplar River watershed ranges from 994 tons to 2194 tons and varied from 68 to 85% of the total load estimated at the downstream sampling station (S001-261). Figure 3.3 compares monthly loads at both stations. This comparison provides information on the seasonality of loads delivered to the River from the lower Poplar River. It demonstrates that most of the load is delivered between April and October, with the highest load occurring during April and May of each year.

Table 3.3 Comparison of annual loads at both sampling stations.

Year	Downstream (Station S000-261)	Upstream (Station S001-753)	Load (tons/year) from lower Poplar River Watershed	Percent of load at S000-261 attributable to lower Poplar River Watershed
2001	3250	1055	2194	68%
2002	1162	169	994	85%
2003	1377	282	1095	80%
2004	1831	474	1358	74%
2005	1592	465	1127	71%

Figure 3.3 Estimated average monthly loads for upstream and downstream stations 1973-2006



3.2 Flow and Load Duration Curve Analysis

When streamflow gage information is available, a Load Duration Curve (LDC) is useful in identifying and differentiating between storm-driven and steady-input sources (Stiles, 2001, 2002; Cleland, 2002, 2003). The LDC method is based on comparison of the frequency of a given flow event with its associated water quality load. Values that plot below the curve represent samples below the concentration threshold; whereas, values that plot above represent samples that exceed the concentration threshold. For this project, a LDC was used to: 1) Provide a visual representation of streamflow conditions under which turbidity exceedances have occurred, 2) Assess critical conditions, 3) Identify potential sources of turbidity, and 4) Quantify the level of TSS reduction necessary to meet the surface water quality criteria for turbidity in the river. Given the nature of the LDC method, loading estimates are fairly gross and need to be evaluated as such.

A flow duration curve analysis was performed to identify the flow regimes during which excursions of the water quality criteria occur. This step determines the relative ranking of a given flow based on the percentage of time that the flow is historically exceeded. Figure 3.4 is a flow duration curve developed for the Poplar River station at Lutsen, MN. Thirty years (1976-2006) of measured and estimated flow were used to generate the flow duration curve. Flow data between 1976 and 2002 were estimated using flow data at the Pigeon River near Grand Portage, Minnesota, USGS gage and flows measured by MPCA were used for the period between 2002 and 2006. A detailed explanation of the approach used to estimate flows in the Poplar River is provided in the RTI/URS report.

Using TSS as a surrogate for turbidity, the streams' loading capacity under each flow condition was determined by multiplying the TSS-equivalent (12 mg/l) of the turbidity water quality standard by flow.

Once the relative rankings were calculated for flow, monitoring data were matched to flow by date to compare observed water quality to the flow regime during which it was collected. This analysis can help define the flow conditions under which excursions occur and identify the sources of the impairment. Concentrations that plot above the target TSS concentration of 12 mg/l and in the interval between 90% and 100% of days in which flow is exceeded indicate the possible influence of a steady-input source contribution. Concentrations that plot in the interval between 10% and 60% suggest the presence of storm-driven and steady-input source contributions. A combination of both storm-driven and steady-input sources occurs in the transition zone between 60% and 90%. Concentrations that plot above 95% or below 10% represent values occurring during either extreme low- or high-flow conditions. As observed in Figure 3.5, the majority of TSS measurements over 12 mg/L occurred at higher flows that have a frequency of occurrence of about 45%. This frequency of flow event is equivalent to a streamflow of 60 CFS.

Table 3.4 provides a summary of 2001-2006 turbidity data, including the number of exceedances to the turbidity standard under each flow range. As previously discussed, the relative proportion of turbidity from upland, riparian, and in- or near-stream sources can also be assessed using the LDC. During the 2002-2006 period, over half of the measurements found to exceed the 10 NTU threshold were present in the highest flow zone suggesting the importance of addressing near-stream sources when identifying measures to reduce turbidity.

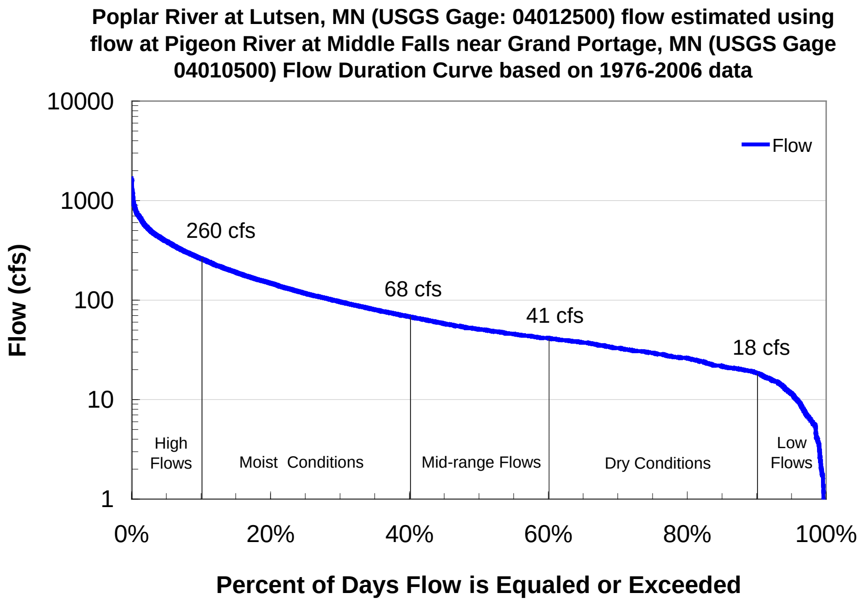


Figure 3.4 **Flow Duration Curve for the Poplar River at Lutsen, MN. A Thirty-Year Flow Period (1976-2006) in the Poplar River was used to generate the Flow Curve. Flows Between 1976 and 2001 were Estimated in the Poplar River Using Pigeon River at Middle Falls Near Grand Portage, MN Flows and an Established Flow Correlation Between the Two Gage Stations**

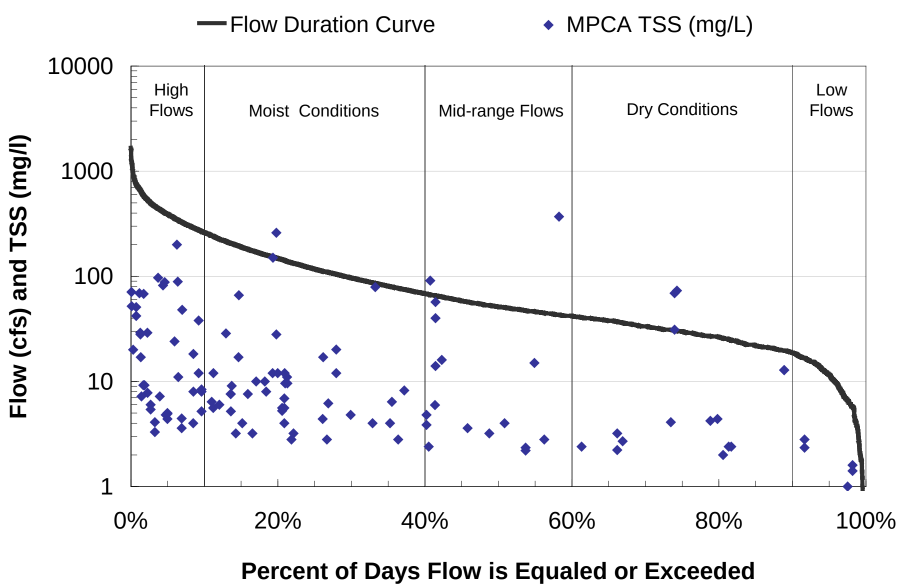


Figure 3.5 Flow Duration Curve for the Poplar River at Lutsen, MN and TSS Data Collected at the Lower Poplar MPCA Station (S000-261) During 2001-2006

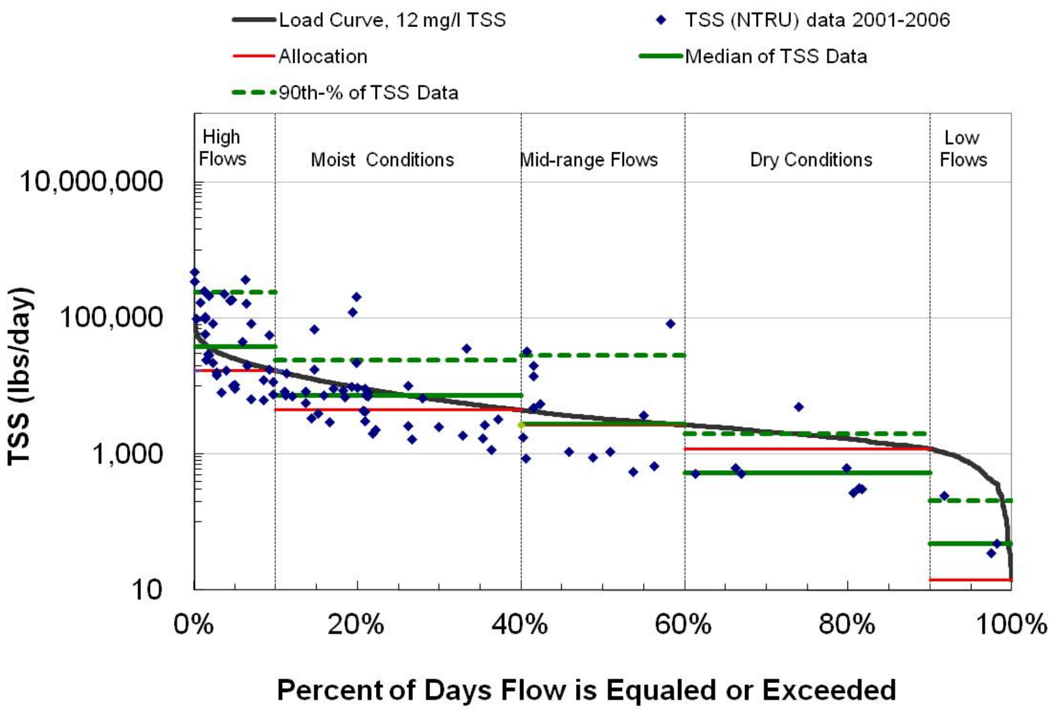


Figure 3.6 Load Capacity Curve for the Poplar River at Lutsen, MN using TSS as a Surrogate for Turbidity in the Poplar River. Median values are also represented for the flow ranges.

Table 3.4 Summary of Turbidity Samples and the Number of Samples Above 10 NTU Within Each Flow Range of the LDC. This Table Includes Measured Turbidity Values Collected During 2001-2006

Flow Range (% of days flows are equaled or exceeded)	Flow Range (CFS)	Number of Turbidity Samples	Number of Turbidity Samples > 10 NTU	Percent of Samples > 10 NTU
0–10%	Above 260	36	18	50%
10–40%	260–68	40	9	23%
40–60%	68 – 41	14	7	50%
60–90%	41 – 18	8	1	13%
90-100%	Below 18	3	0	0%

4.0 TMDL Calculation, Allocations and Final Analysis

A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS). The load allocations address human influenced nonpoint sources and natural background conditions. A margin of safety accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \Sigma\,\text{WLAs} + \Sigma\,\text{LAs} + \text{MOS} \qquad \textbf{Equation 2}$$

4.1 Reductions Required to Meet Water Quality Standards

As previously discussed, Total Suspended Solids data was paired with flow data in relation to a load capacity curve. Median and 90^{th} percentile values were calculated using the data available within each flow zone. Percent reductions required in each flow zone are based on a comparison between the "Allocation" to the "Current Load" (the 90th percentile of the TSS data within each flow zone as shown in Figure 3.6).

4.2 TMDL equation, Waste Load Allocation, Load Allocation and Margin of Safety

Based on the LDC methodology described in the previous section of this report, Table 4.1 shows the Total Maximum Daily Load of TSS for each flow zone. The total daily loading capacity was calculated using the mid-point flow rate for each of the flow zones as shown in Figure 3.6. This analysis results in total daily load capacities for the high, moist, mid, dry and low flow zones of 25,297, 7,532, 3,281, 1,904, and 736 pounds, respectively.

Table 4.1 Loading Capacity for Each Flow Zone Based on the Load Duration Curve Approach

	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Flow Interval (CFS)	> 260	260 – 68	68 – 41	41 – 18	< 18
Flow Interval (%)	0 – 10%	10 – 40%	40 – 60%	60 – 90%	90 – 100%
TMDL Capacity (lbs/day)	25,297	7,532	3,281	1,904	736
MOS (lbs/day)	2,530	753	328	190	74
Waste Load Caribou Highlands WW	106	106	106	106	106
Construction stormwater	227	67	28	16	6
Load Allocation (lbs/day)	22,434	6,606	2,819	1,592	550

4.2.1 Waste Load Allocation

A WLA was calculated for the Caribou Highlands wastewater facility and construction stormwater permit activities in the target are of the TMDL.

To calculate a wasteload allocation for Caribou Highlands wastewater facility, the monthly average limit of 48 kg/day TSS translates to 106 lbs/day TSS. The facility generally discharges TSS well below this limit and the permitted load represents a very small fraction (<1%) of the total load calculated for the lower watershed. Therefore, the recommended wasteload allocation for the treatment lagoon is based on the permitted TSS load limit and does not result in an additional reduction for the facility. The WLA for the facility is 106 lb/day in each flow category. Since the facility discharges below this limit, this WLA can also allow for future growth expansion should it be needed at the facility.

The construction stormwater allocations were set at 1% of the loading capacity after the Caribou Highlands WLA and the MOS were subtracted. One percent matches well with the anticipated likely buildout that may occur in the Lower watershed over time, as documented in the AUAR buildout scenarios described in Sections 5 and 6. A review of recent construction stormwater permits showed a <1% impact from construction based on per acre area. The WLA for construction stormwater is shown in Table 4.1.

4.2.2 Load Allocation

The load allocation was computed as the load remaining after the WLAs and MOS was subtracted from the total loading capacity. The load allocation for the Poplar River is shown in Table 4.1.

4.2.3 Margin of Safety

A Margin of Safety (MOS) for each of the five flow zones was calculated by using an explicit 10% of the TMDL capacity total. The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. For example, in Figure 3.6 the median load in the high flows range is 25,297 pounds. The MOS at 10% is 2,530 pounds. In the Poplar River, this method of assigning MOS results in ranges of allocations for the MOS of 74 to 2,530 pounds across the five flow conditions (Table 4.1).

4.3 Seasonal Variation

Seasonal and annual loading estimates at the upstream and downstream locations were estimated using both FLUX and WEPP models. Using FLUX, TSS loads were found to be highest at the upstream station during the months of April and May and highest at the downstream location during April, May, and June. Monthly loading comparison showed that loading contributions from the lower Poplar River watershed varied seasonally. The lower Poplar River watershed contributed 66-89% of the load observed at the downstream station between April and October. Turbidity values were found to increase significantly between the upstream and downstream stations during the spring and summer months. Results from WEPP modeling confirmed the seasonal trends found using FLUX.

The water quality data collected between 2001 and 2006 also suggests seasonal variations in factors affecting turbidity levels. Table 4.2 reports the number of exceedances by month for 2001 through 2006 and demonstrates that 18 of 35 (51%) exceedances occurred during the month of April.

Table 4.2 Monthly Summary Statistics for Turbidity at Downstream Sampling Location (S000-261) for Years 2001-2006

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Downstream 2001 – 2006	Count			1	39	9	15	12	15	5	6		
	Average			2.8	28.1	25.6	9.4	78.5	16.9	19.2	4.3		
	Maximum			2.8	220	92.0	39.0	890	100	67.0	8.6		
	Minimum			2.8	3.5	2.4	2.3	2.8	2.0	2.6	2.2		
	Standard Deviation				47.6	32.2	10.6	256	26.2	27.0	2.3		
	Number > 10 NTU			0	18	4	4	1	5	3	0		

WEPP 2006.5 and FLUX model runs were used to evaluate relative source loading. More detail on source estimates from upland areas, channel and near channel sources is provided in Section 5.

On a seasonal basis, TSS loads were found to be highest at the upstream station during the months of April and May and highest at the downstream location during April, May, and June.

Monthly loading comparison showed that loading contributions from the lower Poplar River watershed varied seasonally. The lower Poplar River watershed contributed 66-89% of the load observed at the downstream station between April and October. April and May had greater sediment load than the other months. Turbidity values were found to increase significantly between the upstream and downstream stations during the spring and summer months. On an annual basis, loads at the upper station averaged 489 tons/year, and loads at the downstream station averaged 1,877 tons/year. Of the annual loads analyzed, 2001 had the highest total TSS load at both the upstream and downstream locations. Using FLUX, annual sediment loading from the lower Poplar River was estimated to vary from 994 tons to 2,194 tons and from 68% to 85% of the total load estimated at the downstream sampling station.

4.4 Critical Conditions

Turbidity data available between 2001 and 2006 at the downstream station were collected during spring, summer, and fall months under a wide range of flows and environmental conditions. Monthly turbidity averages during this period were found to be highest during April, May, and June. WEPP modeling predictions were consistent with the data and reported highest average monthly loads to occur in April and May.

The load duration curve developed for the downstream location showed that exceedances to the turbidity standard occur under moderate to high flow conditions (Figure 4.1). In general, few exceedances were observed under dry and low flow conditions below 40 cfs. Under conditions where flows were at or above 60 CFS (flow frequency of ~ 45% recurrence), the number of exceedances increased. Most turbidity violations occurred under high flows greater than 250 cfs (flow frequency of ~ 10% reoccurrence).

In developing TMDLs, MPCA guidance describes the use of a weight of evidence approach to understand the relationship between the load duration curve intervals and turbidity sources. This approach uses these assumptions in identifying likely sediment sources contributing to the excess turbidity in the stream:

1. Mid-range flows usually represent the rise of a hydrograph as it progresses out of the dry condition range and enters into wetter conditions. The zone of land use that is most likely to contribute during this period would be the riparian corridor of the river. This is because limited upland soil saturation and quite possibly soil erosion has yet to take place during the early period of storm events or in smaller events that can only deliver localized eroded soils (purple dashed oval in Figure 4.1).

2. Moist condition flows generally indicates the area where material loading typically originates from both upland soils which under these wetter conditions are now saturated and begin contributing to the more efficient transport of eroded materials and continue to move riparian corridor eroded materials (solid black oval in Figure 4.1).

3. High flows usually represent the material loading which indicates bank or river bluff contributions. Sufficient energy exists at these flow regimes to cause mass wasting and the breakdown of consolidated materials such as glacial lake clay deposits (red

dotted oval in Figure 4.1).

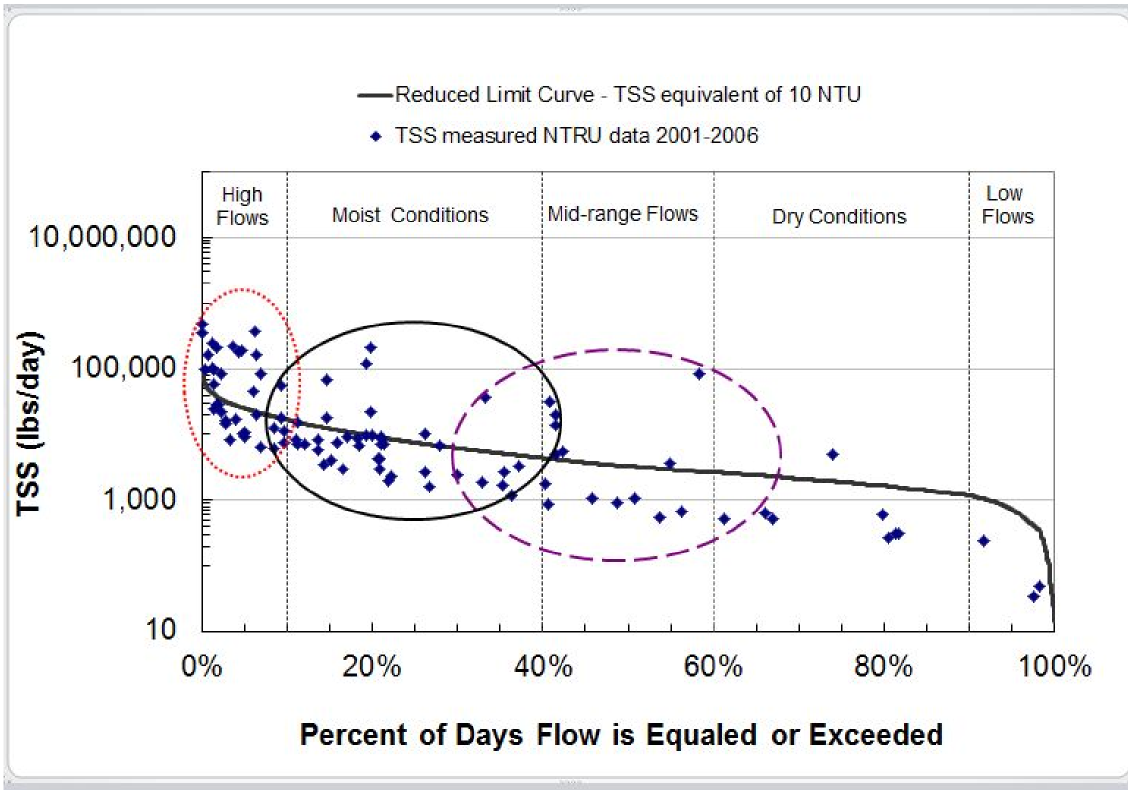


Figure 4.1 Load Duration Curve for the Poplar River at Lutsen, MN Identifying Flow Ranges for TSS Source Identification

Given these factors, critical conditions for turbidity impairment appear to be present during significant runoff events present under moist and high flow conditions that often occur during March, April, and May. During these high flow events, near-stream and in-stream sources are expected to contribute a significant portion of the total TSS load. Under mid-range to moist conditions, the relative proportion of near stream sources to upland sources may be expected to decrease.

4.5 Necessary Load Reductions

Table 4.3 provides percent reductions required under each flow zone based on the LDC approach. These percentages are based on a comparison of the 90th-percentile TSS load within each flow zone to the loading capacity at the mid-point of the respective flow zone. The percent reductions provide an estimate of the reductions needed to remove the Poplar River from the MN impaired waters list for turbidity based on MPCA procedure to list waters that show greater than 10% exceedance of the 10 NTU aquatic life standard. These reductions should be considered only rough estimates needed to reduce sources and should not be confused with the allocation targets identified to meet the 10 NTU standard on all days.

Table 4.3 Required Reductions for Each Flow Zone Based on the Load Duration Curve Approach

	Flow Zone				
	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Flow Interval (CFS)	> 260	260 – 68	68 – 41	41 – 18	< 18
Flow Interval (%)	0 – 10%	10 – 40%	40 – 60%	60 – 90%	90 – 100%
Capacity (lbs/day)	25,297	7,532	3,281	1,904	736
Current Load (lbs/day)[1]	240,623	23,853	28,607	1,956	207
Percent Reduction Needed[2]	89%	68%	89%	3%	none

1 Current Load is equal to the 90th percentile value for each flow zone.
2 Percent Reduction needed is based on a comparison of the 90th percentile daily load to the capacity at the mid-point of the flow zone.

5.0 Sediment Sources

In an effort to better understand and quantify sources of sediment in the lower Poplar River that likely contribute to elevated turbidity measurements, computer modeling and a geomorphological assessment were conducted to complement the data analyses conducted. The computer modeling was used to predict sediment loading from upland erosion and the geomorphological assessment looked at “in-channel” and “near channel” sources. Several distinct sources of sediment were identified.

5.1 Source Assessment and General Findings

A source assessment is used to identify and characterize the known and suspected sources of turbidity in the Poplar River watershed. Non-point sediment sources in the lower Poplar River watershed include both upland and channel/near channel sources. Upland sediment erosion is the result of many factors including: intensity and magnitude of precipitation, antecedent conditions, cover, soil texture, slope, and land uses. Erosion from upland sources was predicted by a modeling effort (the WEPP model) to occur during large rainfall events, or when smaller rainfall events occurred during wetter conditions and impacted areas with less cover and greater slope which were more prone to erosion. Some WEPP model inputs were field verified. Channel and near channel erosion includes erosion originating from the erosive power of the stream. The critical conditions for these sources are during high flow/stage. Channel sediment loads were estimated via field investigation and some modeling efforts. The upland and near channel sources identified as contributing to turbidity in the lower Poplar River are listed below:

Upland Sediment Sources

- Surface erosion from slumps
- Incision along valley slopes (erosion gullies and ravines)
- Localized erosion related to land-use alteration, such as,
  - Ski Runs (including bare trails and roads, also assessed as distinct sources)
  - Golf Course areas
  - Developed area
  - Combined flow pathways
- Natural forested area with ephemeral or first order channels between hillslopes

Channel/Near Channel Sediment Sources

- Channel bed incision
- Sudden channel migration (e.g., meander cut-off, channel avulsion, etc.)
- Streambank erosion, such as the river impinging on a slump

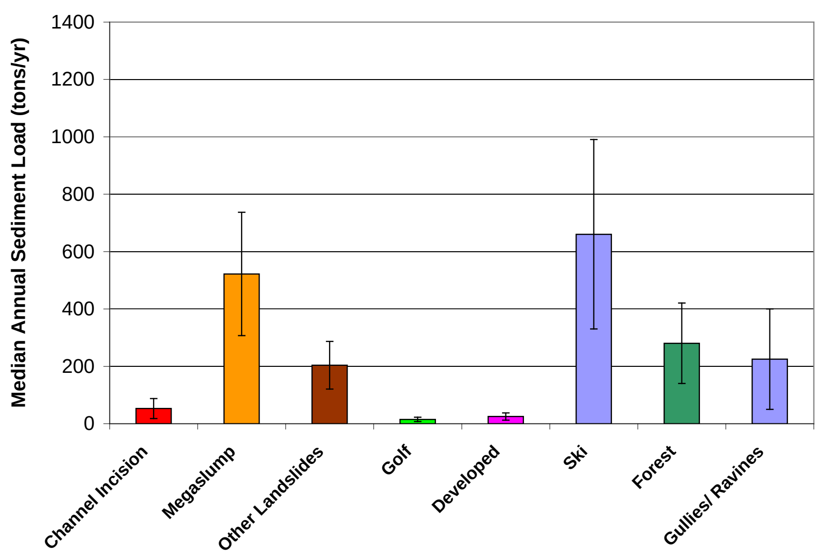


Figure 5.1 Median Annual Sediment Load (Tons/Year), by Land Use, Estimated using WEPP 2006.5 and RTI Physical Channel Assessment Field Investigation. Bars Represent Estimated Maximum and Minimum

Of the sediment sources identified and quantified, six may be controlled to some extent. Slumps, runoff from the golf course, developed areas, ski runs, roads and trails can be controlled. Gullies and ravines formed from concentrated runoff can be mitigated to varying degrees. These sources contribute an average of 83% of the sediment load to the lower Poplar River. Slumps and gullies/ ravines are naturally occurring processes; however, land use changes may have contributed to the enlargement of the largest slump (megaslump) and several ravines. Natural sediment sources contribute between 17% and 64% of the total sediment load, depending on whether slumps and gullies/ravines are deemed natural. Forty-six percent (46%) of the sediment load originates from altered land use cover types. More detail is provided in Section 5.3 which summarizes averages predicted by models, field investigations and aerial photography review.

5.2 Summary of Sediment Loads from Point Sources

Four permitted facilities are located in the Poplar River watershed. Of these, only one, assigned to Caribou Highlands Lodge, is a NPDES permit subject to TSS limits. The permit also requires monthly monitoring for turbidity and flow. The Caribou Highlands Lodge (MN0053252) wastewater treatment facility maintains a treatment lagoon that periodically discharges to the Poplar River. The treatment facility has maintained compliance with its discharge permit since 1999.

In 2003, the permit was modified to increase the monthly average limit of allowable TSS from 24 kg/day to 48 kg/day and to increase the maximum weekly average from 35 kg/day to 70 kg/day. Other TSS and flow limits remained consistent with pre–2003 requirements.

Annual and monthly TSS loads from the Caribou Highlands discharge were calculated for the 2001- 2007 period. The range of annual loads was found to be between 0.4 tons/year to 1.9 tons/year. The monthly average limit of 48 kg/day TSS translates to 106 lbs/day TSS, and a maximum weekly average limit of 70 kg/day TSS translates to 154 lbs/day TSS. While the facility generally discharges TSS well below this limit, the permitted load represents a very small fraction (<1%) of the total load calculated for the lower watershed. For the purposes of this report, the recommended wasteload allocation for the treatment lagoon is based on the permitted TSS load limit and does not result in an additional reduction for the facility.

As development continues in the watershed, construction stormwater is also an expected source of potential sediment. An allocation of one percent has been provided for that occurrence. However, construction stormwater activities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program. The following section provides further information on the importance of stormwater management associated with development scenarios.

5.3 Estimating Sediment from Model Predictions and Field Investigations

Upland soil erosion from the principal land types in the watershed was evaluated using the WEPP model. Upland erosion, for the purposes of this study, includes erosion on land surfaces influenced by precipitation and runoff. It does not include stream bank erosion, such as at the slumps from high stream stage; however, upland erosion does include sheet, rill and interrill erosion from slump areas. Upland erosion sources provide sediment laden runoff during rainfall events that result in surface runoff. Larger runoff events typically result in larger sediment load to the Poplar River.

5.3.1 Watershed Erosion Prediction Program (WEPP) Modeling Results

Several studies have been conducted to quantify sediment sources to Poplar River. RTI provided the first estimates and reported them in the "Poplar River Turbidity Assessment" report in the chapter titled "Additional Characterization and Estimation of Turbidity Impairment Using WEPP 2006.5". A 2009 field study by the University of Minnesota (U of MN) provided a better characterization of the runoff processes occurring in the watershed by collecting additional field data and field observations, and running a more detailed application of WEPP 2010.

The purpose of developing a WEPP computer model for the lower Poplar River was to provide a scientifically defensible assessment of upland sediment sources and help define the best locations for enhanced best management practices to reduce sediment. To assess upland sources of sediment several computer model scenarios were evaluated by RTI. The scenarios allowed the unit area loading of each land use to be calculated and four alternate land use scenarios to be evaluated. The scenarios included:

- Existing conditions, which as the name implies, represents the lower watershed as it exists currently.

- Pre-Development conditions scenario represents the watershed in pre-development conditions (e.g. it is 100% covered with mature forest).

- Build-Out conditions scenario represents the watershed with additional development as described in the Areawide Urban Assessment Review (AUAR) for the Lower Poplar River.

- Stormwater control scenario represents existing conditions with the addition of erosion control measures.

The predicted sediment load from the four scenarios of alternate land uses are reported in Figure 5.2. They indicate that additional development, as described by landowners as likely future development, may contribute to increased sediment load if no nonpoint source controls are implemented. At maximum, those future projects impact 140 acres of land in a mix of residential and commercial improvements. Details can be found in the AUAR document. The scenario "Stormwater Control" indicates that with improved vegetative cover and runoff controls, erosion can be reduced well below existing conditions. It does not indicate that these are regulated stormwater sources. The "Predevelopment" scenario was completed to provide a prediction of the sediment load if no resort or ski area existed within the watershed. This scenario demonstrates that even with no land use alteration a significant amount of sediment would be delivered to the Poplar River.

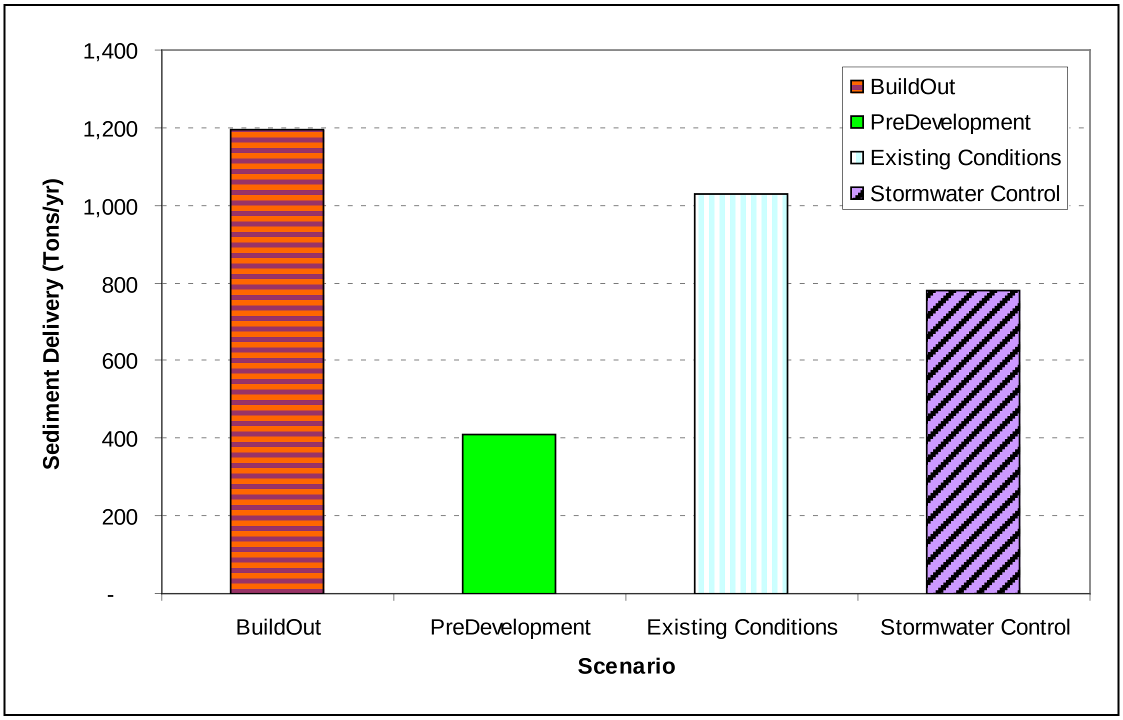


Figure 5.2 Scenario Comparison- Average Sediment Delivery (Tons/Year) WEPP 2006.5

To further enhance and refine the RTI work, the U of MN performed a modeling analysis with the improved WEPP 2010, using both the hillslope and watershed options. Some elements were unique to the WEPP 2010 model run, among them: 1) the use of field measured saturated hydraulic conductivity as a model input: 2) inclusion of a restricting layer to impede drainage: and, 3) assessment of winter conditions. More specifically, a 4 inches per hour rate was the lowest field measured conductivity identified and was used for the model run. The restricting layer was assigned a low permeability different from the WEPP default choice and is more representative of area geology. A freeze/ thaw cycle with varying vegetated cover and artificial snow pack, representative of the ski resort operation, was also evaluated.

WEPP 2010 identified 195 discrete hillslope units and interconnecting upland channels of first order or higher order streams within the Lower Poplar River watershed area. Overland runoff from hillslopes and upland channel erosion was calculated. With good vegetative cover on a ski slope, and high value biomass residue of decaying vegetation, sediment was shown to be reduced by 2/3 under a typical shorter grass ski slope cover. Figure 5.3 displays a cumulative average annual sediment yield and clearly indicates the value of robust vegetated cover during the growing season, and a subsequent high value leaf litter providing surface cover on soil.

Ski slope length adjustments were also evaluated. A common best management practice at ski resorts is the use of water bars to break up long slopes. Water bars act as small terraces to slow and re-direct rain or snowmelt, thereby reducing surface erosional features from forming. WEPP 2010 model results indicated a reduction of 4.7 tons/year to .3 tons/year on a simulated ski slope. See Table 5.2 for details.

The application of artificial snow was also evaluated. In general, more snow translated to increased sediment. However, the vegetated cover condition, the biomass residue condition and slope length mitigated total sediment produced. See Table 5.2 which summarizes the modeling exercise.

Other sediment sources reviewed by the University team included roads, slumps, ravines and interconnected flow pathways. Each was assigned a sediment total. Roads were evaluated with the Rosgen Road Impact Index procedures, which evaluate more characteristics than typical GIS derived calculations for road surface areas. The Rosgen method includes proximity to stream, number of stream crossings of the road, road slope, road surfacing material and ditch lining. Slumps and ravines were reviewed in the field and these measurements were used in the WEPP modeled outputs. Flow pathways which link sediment sources of roads, ravines/gullies, upland channels, and ski slopes were identified and three specific areas were identified as critical source areas for future Best Management Practices (BMP) work.

The following tables and charts show results of the University WEPP 2010 model runs.

Table 5.1. Soil erosion values from 5 year simulation for the Lower Poplar River Watershed

Watershed Erosion Prediction Project Method (WEPP 2010) – 5-year results				
Land use	Area Under Cover Type (acres)	Proportion of area under cover	Soil Loss (ton/ac/yr)	Soil Loss Rate (ton/yr)
Developed	30.0	0.030	0.0	0.0
Forest	743.4	0.739	0.006	6
Golf	85.8	0.085	0.07	6
Ski	146.5	0.146	3.92[&&]	575[&&]
Upland channels	--	--	--	312
Total	1005.7	1.000	1.08[&]	1,092

[&]Average rate

[&&]This value is for the case of short grass prairie cover with an LAI equal to 0.5. For tall grass prairie and LAI = 4.0 the equation rate is 0.9 tons/ac/yr or 143 tons/year

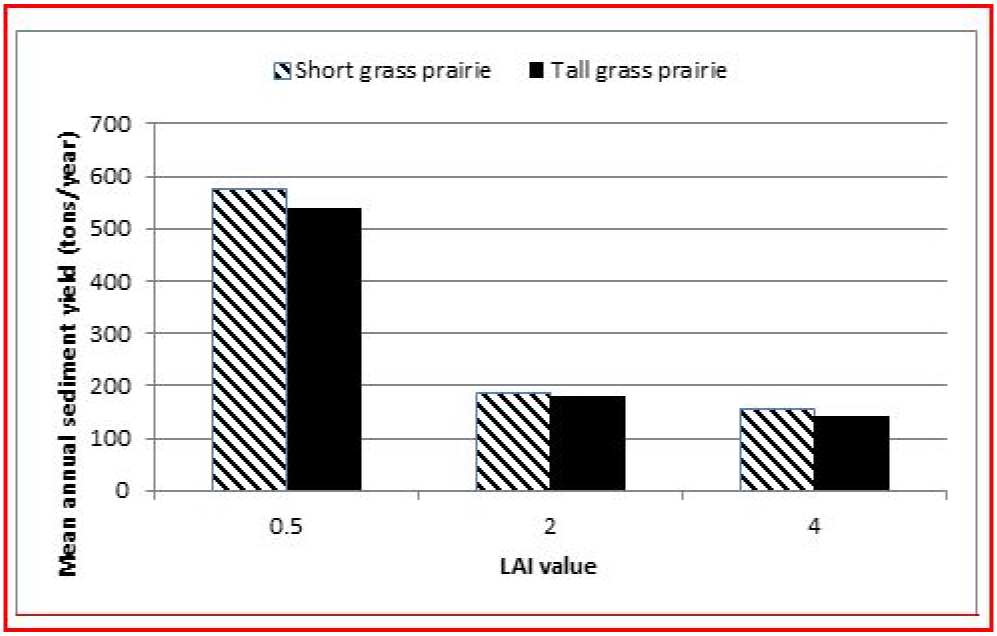


Figure 5.3. Cumulative mean annual sediment yield from ski slopes under various cover conditions

Note: Biomass growth potential of grass is reflected by the leaf area index (LAI). Two vegetation classifications are considered, short grass prairie and tall grass prairie. LAI values include 0.5, poorest quality conditions: 2.0 and 4.0 indicate best growth and cover conditions. A larger LAI value results in a smaller mean annual sediment yield.

Table 5.2. Mean annual sediment (tons/acre/year) delivered to the toe of the hillslope for various conditions of added artificial snow (given as depth of snow water equivalent), vegetative cover, and slope length. The vegetative cover is expressed by type, either short grass prairie (SG) or tall grass prairie (TG) and by leaf area index (LAI). LAI of .5 indicates poorest quality vs. 4.0 high quality with dense coverage on plant and dense leaf drop on soil. The slope length used for nearly all of the calculations was 680 feet. See last item, shortened slope.

Vegetative cover Type, LAI	Snow water equivalent of artificial snow (inches)			
	0 inches	10.8 inches	20.9 inches	31.5 inches
SG, 0.5	3.0 t/a/y	5.0 t/a/y	12.6 t/a/y	53.8 t/a/y
SG, 2.0	0.32	0.97	1.3	3.5
SG, 4.0	0.22	1.3	0.96	2.3
TG, 0.5	2.7	4.6	11.2	47.3
TG, 2.0	0.27	0.93	1.0	2.8
TG, 4.0	0.23	0.86	0.77	1.93
SG, 0.5 with half slope length (340 feet)	0.96	0.5	0.3	0.08

Streambank, streambed, gully and ravine erosion processes were evaluated using a physical channel assessment. These sources often contribute a significant portion of the overall sediment budget. The consequence of increased streambank erosion is both water quality degradation as well as increased stream channel instability and accelerated sediment yields. These sources tend to be most active with higher flow levels.

The physical stream channel assessment looked at “near stream” sources of sediment, such as bank erosion, slump erosion, channel migration, channel bed incision, and incision along valley slopes. A variety of techniques were used to assess the characteristics of the stream and estimate erosion from “near channel” sources. See the two reports produced by EPA contractor RTI/URS and the U of MN researchers for details. Estimates of sediment from each “near channel” source were defined on an annual average basis; however, sediment from these sources is likely the result of high flow and/or precipitation events that provide a large sediment load infrequently. The channel sources that were investigated are summarized briefly in the following paragraphs.

Channel bed incision and stream lateral migration were not a significant source of fine sediment. However, when these processes occur in the vicinity of the valley slopes, they can be a factor in the formation and expansion of landslides which in turn can mobilize large amount of fine, suspended sediment from the walls of the valley.

- **Channel Bed Incision**

Channel incision is an ongoing geological process which characterizes all high-gradient North Shore streams flowing into Lake Superior. These streams continue to cut down in the glacial till material, slowly adjusting the shape and slope of the longitudinal profile. This process, however, takes place at a relatively slow rate and, on an annual basis, will not result in the mobilization of significant amounts of suspended sediment from the streambed. While the channel bed itself is not a significant source of suspended sediment, channel incision may play a role in the occurrence of landslides observed in the vicinity of the channel. Channel bed incision may occur simultaneously with the gradual streambank migration discussed below.

- **Sudden Channel Migration (e.g. Meander Cutoff)**

Aerial photographs taken in 1934, 1991, and 2003 suggest that rapid lateral migration has taken place at certain locations. The meander cut-offs and channel diversions have likely entrained a significant amount of sediment including a suspended load fraction. However, these kinds of sudden channel migrations are one-time events associated with abnormally high flow rates. Most of the suspended load that would have been generated this way was dispersed throughout the stream and flushed out of the system. Empirical evidence and laboratory study indicate that pulses of fine sediment in streams are dispersed rather fast (Cui et al., 2003).

- **Streambank Erosion**

Stream bank erosion implies gradual channel migration, as opposed to major sudden changes, such as channel avulsions or meander cut-offs, which are one time processes associated with extreme flow events. Generally speaking, stream bank erosion in alluvial streams could greatly increase the amount of suspended load due to the local degradation and collapse of the banks. However, in the case of the Lower Poplar River the banks are armored with large size boulders and there is little evidence of active, on-going bank erosion.

- **Landslides near the Active Channel ("Megaslump" and other slumps)**

In places where the active channel is near the valley wall, landslides are likely to form and become larger as the channel shifts laterally. Such places could be considered the equivalent of gradual streambank erosion except that it is the slope of the valley that is being eroded and not the streambank. One very large slump area has been christened the "Megaslump" due to an extensive height and length of the landslide.

The unvegetated soil surface of the land slide appears to be highly erodible. Given its size and proximity to the channel, the Megaslump area is a likely major source of fine sediment. The translation of the eroded surface mentioned above suggests that the sediment delivery mechanism was a progressive slope failure, the collapsed material being washed into the stream. Stream observations in the vicinity of the Megaslump reveal that the embeddedness is above the average and the larger cobble size particles are buried into finer sand-sized sediment in a proportion of 25 to 40 percent suggesting a higher influx of sediment.

Two other landslides, both smaller in size than the Megaslump, were documented in the east side of the valley. These landslides are located 1) a short distance downstream of the Megaslump on the east side and 2) in the upstream ski hill area (approximately 2 miles upstream from the mouth) also on the east bank along a major meander bend. Based on aerial photographs the stream migrated approximately 80 feet towards the southeast between 1934 and 2003. In the vicinity of each of these landslides and a short distance downstream, the proportion of finer sediment trapped in the streambed (i.e., embeddedness) is higher than the typical average suggesting on-going erosion at all of these places.

Other landslides, even smaller in size, are located in an upstream forested area where there has been little to no change in the land use.

- **Incision along Valley Slopes – Gullies and Ravines**

Gullies and ravines are common erosion features in places of concentrated runoff along steep slopes. Such features are a common natural occurrence and part of the drainage basin denudation process. However, the gullies that are naturally occurring evolve relatively slowly into ephemeral tributaries to the main stream. By contrast, the erosion gullies that formed as the result of concentrated storm water discharge from developed areas are fast evolving and can mobilize large amounts of sediment.

There are several places of concentrated runoff within the Lower Poplar River valley that emerged as a result of the recreational-based development (ski trails, ATV trails, access roads, ski lifts, resorts, facility buildings, etc.). In some places visible efforts have been made in recent years to limit, eliminate, or mitigate the gully erosion and to convey the runoff flow to the stream in a controlled, non-erosive way. Most notably, the runoff from the eastern tributary valley near Eagle Mountain where many of the ski trails and local roads are located is routed across a series of swales. These swales were landscaped across the slope to break the slope surface into smaller segments and control the erosive power of the runoff. Small size drains have been installed along the swales and efforts to vegetate and stabilize the sloped surfaces between swales have been made.

A place of concentrated runoff that resulted in a large erosion ravine was identified in the very upstream part of the river. A 320-foot long ravine spans through a forested area from the north end of the main road (Ski Hill Road) to the edge of the stream. This ravine is approximately 10 to 20 feet deep. The average longitudinal slope is approximately 21 degrees (40%). To a certain extent, the bottom of the ravine appears to be have been reinforced with debris and boulder rock material. The side slopes, however, are un-vegetated and very steep (over 45 degrees) with potential for future soil erosion. Given its size and proximity to the river, this erosion ravine is likely to contribute a significant amount of fine sediment to the stream. The stream bottom at the bottom of this ravine shows a higher than average proportion of finer sediment (i.e., higher embeddedness, approximately 25 to 30 percent). Another erosion ravine, smaller in size (approximately 180 feet long and 10 feet deep) is located in the main ski area on the east side of the valley. It extends from a ski lift post to the most upstream bridge before the rapids.

Erosion Estimates from the Channel, Ravines and Landslides

Rough estimates of the amount of sediment eroded from these sources were made using a variety of methods: measurements made in the field and from available aerial photography, WEPP modeling and the Sekeley empirical model estimate for landslides. The estimation methods are described in the chapter titled "Physical Channel Assessment" of the larger text "Poplar River Turbidity Report" by RTI/URS (2008) and the U of MN report "Lower Poplar River Watershed Sediment Source Assessment". Both reports indicate the channel itself represents only a minor source of suspended sediment, less than 50 tons/year to virtually no contribution. Rough estimates of suspended sediments from the major erosion ravines are similar (225-243 tons/year). Landslide contributions are more variable between the two reports. Based on photo analysis and field evaluations, the RTI report determined 726 tons/yr of sediment originated with landslides. Using the Sekeley model method, U of MN researchers estimated 188 tons/yr.

6.0 Reasonable Assurance

Reasonable assurances must be provided to demonstrate the ability to reach and maintain water quality standards. These assurances may be regulatory or non-regulatory in their nature. Regulatory approaches are generally permitted approaches. MPCA, MN DNR and Cook County exercise permitting authorities which will mitigate and/or improve water quality in Poplar River via limits on stormwater and wastewater associated with new development. MPCA and Cook County stormwater authorities require review and compliance of erosion and sediment controls for all future development projects. In addition, Cook County manages the area under the limits set in the "Lower Poplar River Alternative Urban Areawide Review" document and Mitigation Plan. NPDES permits also set limits for any future wastewater expansions. The county water management plan and annual plan of work for the county soil and water district provide direction and management for non-regulatory performance goals to improve water quality. These include continued public education and awareness, assistance with Best Management Practices installations, and a focused effort to stay engaged in impaired watersheds.

Various technical and funding sources are used to execute the annual work goals of the county Water Management Program and the Soil and Water Conservation District (SWCD) projects. These include but are not limited to a mix of programs such as local government cost share funds, state and local revolving loan funds, conservation reserve program funds, federal 319 program funds, state clean water partnership and clean water legacy funds, federal coastal program funds and federal Great Lakes erosion control funds. To ensure a stable source of state water project funding, Minnesotans approved an amendment to secure three-eighths of one percent sales tax as dedicated funding earmarked for the protection, enhancement and restoration of lakes, rivers, streams, groundwater and drinking water sources. (Clean Water, Land and Legacy Act Amendment approved November 4, 2008)

Additionally, BMPs have been installed which have already demonstrated benefits. Local resource managers are showcasing and promoting these activities. A local board of landowners has formed, the Poplar River Management Board, and has begun installation of BMPs and are partnering with the county SWCD to complete a series of BMPs calculated to significantly reduce sediment inputs to the river. Local landowners have also gone on record via the draft implementation plan to continue long-term operation and maintenance of BMPs. This collaboration to date has created a sustained working partnership among the various partners working within the Lower Poplar River for water quality improvement.

7.0 Monitoring Plan Summary

Monitoring will include water quality and flow sampling of the river, and routine inspection of the permanent stormwater best management practices.

A flow monitoring station is managed by the MN Department of Natural Resources and is identified on the map as Station 01101001. Water samples are collected annually at this site for the MPCA Major Watershed Load Monitoring project and at 10 year intervals for the MPCA Intensive Watershed Monitoring Program. Under the protocol of the Watershed Load program, approximately 25-30 samples are collected each year across a range of flow and precipitation events.

MPCA biological monitoring of the river is scheduled for 2013 as part of the Intensive Monitoring program. Data collected and evaluated will include fish and macroinvertebrates. Stream channel embeddedness identified in the University of Minnesota NRRI biological report will be evaluated for improvements. A more thorough habitat evaluation is a future project the area landowners want to engage in upon completion of proposed Best Management Practices listed in the implementation plan for the TMDL. MN DNR Fisheries monitoring and assessments occur per scheduled updates of fisheries plans.

Current and future stormwater structures and best management practices will be inspected and evaluated during each field season. A standardized checklist will be used to generate a work order of maintenance and/or corrective follow-up actions.

8.0 Implementation

Based on the source assessment and observations regarding the critical conditions related to turbidity levels in the lower Poplar River several implementation activities should be considered. Many activities designed to minimize and control erosion are currently taking place within the watershed. Recommending detailed implementation activities is beyond the scope of this TMDL document. Detailed BMPs are described in a separate implementation plan. The following list is a general summary of suggested improvements:

- Ski runs appear to contribute significant amounts of sediment. Activities related to increasing vegetative cover and controlling erosion should be continued.

- The policy of evaluating resort related trails and roads should be continued and actions designed to reduce erosion from these sources should be taken.

- The ravines, gullies and intercepting flow pathways identified in this report should be further investigated. Erosion associated with these locations should be mitigated by slowing and/or removing the flowing water and restoring the areas so further erosion does not occur.

- The megaslump should be stabilized to limit further erosion. Impacts from the wastewater discharge pipe should be evaluated and other options for its location considered. Other slumps or bluff erosion should be investigated for improved management.

- Runoff from impervious areas, dirt roads, parking lots, and bare areas should be controlled and treated if found to have high turbidity levels, or contributes to the formation of ravines or gullies.

- Low Impact Design (LID) recommendations from the development mitigation plan (AUAR) should continue to be incorporated into future growth/new developments. Construction stormwater activities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired water, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

- A draft implementation plan has been developed listing specific BMPs and their locations to improve erosion control and sediment management. Many BMPs have been constructed and recent water quality monitoring shows improvement. The draft implementation plan will receive public review and is expected to be finalized after the TMDL report is completed.

- To date, approximately $1.6 million dollars has been expended on BMP design and implementation. These were projects to stabilize major slumps, ravines and large concentrated areas of stormwater flowpaths. Additional BMPs could cost another $1 million to fully implement.

9.0 Public Participation

Public participation has remained a key component of the TMDL process and is described below. Locally and regionally, the resort community and the river are high profile areas of interest. Some early problems occurred in the process. They included the rapid "turnaround" of the original TMDL contractor deliverables. The TMDL work was under EPA contract and contract limits required rapid review and limited sharing beyond a very small team. This resulted in confusion or dissatisfaction with the process for local project staff and the public tracking the project. MPCA contracted a second effort to further refine and understand the impairment sources and maintain a better dialog with local project staff and the public. MPCA staff convened several meetings for input and review of the sediment source evaluations and regular attendance at bi-monthly meetings of the local stakeholder group.

The TMDL report was public noticed on July 8, 2013 for a 30 day comment period. Two comment letters were received. One letter reflected the perspective of numerous non-profit organizations. Three meetings were attended by MPCA staff to inform groups of the public notice time period, how to comment on the TMDL, and where to find the report and comment instructions on the MPCA website. Local groups represented at these meetings included the Cook County Water Management Advisory Committee, the Cook County Coalition of Lake Associations, and the Poplar River Management Board.

9.1 Overview of Locally Managed Public Involvement

This section outlines the process that was undertaken to engage, educate and inform citizens, businesses and local government regarding the Poplar River TMDL project. The major items coordinated by the Cook County Soil and Water Conservation District include:

- Web page development for dissemination of project information on the website http://www.lakesuperiorstreams.org.

- Email list serve development and maintenance, a watershed address list of nearly 200 contacts that informs citizens when reports are posted, and provide meeting notifications at http://www.co.cook.mn.us/subscribe.html.

- Public comment tracking (formal and informal) (181 total comments), various newspaper articles and power point presentations archived;

- Events/meetings advertisement via mailings, local newspapers ads, email notifications via email list serve and the Poplar River website;

- Participation in Poplar River Management Board meetings, the local landowners organization for Lower Poplar River activities;

- Media Outreach via press releases and radio interviews;

- Local government outreach via routine updates to county commissioners (bi-monthly-quarterly), staff (weekly) and SWCD supervisors (monthly); and,

- Educational outreach through personal visits, phone calls, letters and emails (to landowners, PRMB, Lake Superior kayakers, etc.). Educational topics ranged from questions about the applicability of MPCA's turbidity standard to the Poplar River, the biological monitoring report, chemistry sampling on the river, watersheds in general and many others.

The Lake Superior Streams web page serves as a regional source for information on water quality and land use issues affecting water bodies along Minnesota's Lake Superior shoreline. MN Sea Grant Extension was contracted to assist in the development of the Poplar River TMDL web page, provide education and outreach and plan meetings in support of the TMDL project. This contract ended in 2008. A page was created specifically for the Poplar River TMDL which includes official documents for the project, public meeting notices, minutes from public meetings, links to the Cook County SWCD site, general educational information on TMDL's and other related topics. The web page describes what a TMDL is and why the Poplar River was listed as impaired. The Poplar River TMDL web page is located at the following address and a screen shot is presented below: http://www.lakesuperiorstreams.org/northshore/poplar/TMDL/index.html.

Figure 9.1 - Poplar River TMDL Web Page Screenshot

Comments about the TMDL project have been received in various forms including emails, letters, letters to the editor and interviews. SWCD staff stressed that these comments while very useful should be resubmitted when the draft TMDL is published. University of Minnesota -Sea Grant Extension staff summarized the comments. The top five topics included erosion, the turbidity standard, the watershed boundary delineation, hydrology issues and the formation of a special management district in the area of the impairment. Other major contentious issues centered on general wastewater management in the watershed with reference to ongoing development, the Caribou Highlands resort wastewater discharge pipe location and impact to river, and a policy concern regarding the use of public funds to pay for river restoration.

Public meetings were held throughout the project. The first public meeting was held at the Cathedral of the Pines campground facility in Lutsen, Minnesota and provided an overview of the data assessment summary and introduced the RTI staff, the original EPA contractor selected to complete the TMDL. Various meetings continued in 2007 and 2008. Presentations included information on biological monitoring, fisheries, the final EPA contractor's report, watershed hydrology and likely next steps in the completion of the TMDL.

From 2009 through the current year, the Poplar River Management Board (PRMB), Cook SWCD, MPCA, local township officials and county residents with watershed interests have held numerous meetings together. While differing perspectives exist relative to questions of natural background sediment loading in rivers found along Lake Superior, or current application of the turbidity standard in natural streams, a core group continues to attend bimonthly meetings, and communicate regularly via email and phone. The local press covers each meeting.

More recently, the county SWCD and area landowners were awarded a Great Lakes Commission (GLC) grant for Poplar River sediment reduction projects. While award of the funds was not directly tied to the TMDL, findings from the TMDL work helped define the grant application and scope of work. The public outreach that is required by the GLC grant complements the outreach for the TMDL.

9.2 Anticipated Longer-term Public Participation

This project has built capacity within the Cook County SWCD to work with MPCA on this and future TMDL and monitoring projects. It has introduced and reinforced the need for defensible watershed science and identification and use of water quality monitoring to identify impacts from landuse changes in the watershed. The Cook County community now better understands the sensitive nature of North Shore geology, especially that of the Poplar River valley. The project has created a structure to address impairment in the watershed. Questions regarding the appropriateness of a 10 NTU standard in the context of targeting load reductions of sediment were explored. Various stakeholders provided feedback on the standard which is now in a state revision review process. This has affected the consensus of "next steps" in the TMDL process, whether to move forward quickly or delay a bit. Next step options in the TMDL process have been laid out and the stakeholders are involved. The process and cost of implementing a TMDL will hopefully influence the county to make land use decisions that are protective of water resources. More watershed landowners understand the complexity of watershed science and the role and need for a TMDL study on the Poplar River.

A continued involvement with the PRMB and various engaged citizens has resulted from this contract. The PRMB has grown to involve a broader community of landowners in the watershed than the original Board members. The PRMB meets more frequently on a defined schedule than they did at their inception. A more strengthened partnership evolved among watershed landowners and local government representatives by SWCD supervisors and staff as well as township and county commissioners attending PRMB meetings and public meetings.

Public education and being involved with the process benefited new watershed organizations within the county like the Flute Reed Partnership. The Flute Reed River is also a stream impaired by sediment. The partnership has developed a water quality monitoring program and undertaken tree planting and other educational and outreach activities in their watershed. Cook County SWCD will stay involved with the project if funding is present. They will be instrumental in completion of the Flute Reed TMDL, drafting of the implementation plan, overseeing BMP and river restoration work and interfacing with the stakeholders of the project.

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