Prepared for:

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DRAFT

MINNTAC WATER INVENTORY REDUCTION ENVIRONMENTAL IMPACT STATEMENT

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ABSTRACT
MINNTAC WATER INVENTORY REDUCTION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT
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ABSTRACT: U.S. Steel Minntac (Minntac) proposes to expand its wastewater discharge from its existing tailings basin, located in Mountain Iron, Minnesota. The proposed project would allow Minntac to continue to safely utilize the tailings basin for permitted disposal of fine tailings. The tailings basin is a large surface water and tailings impoundment located to the north of the processing facility. The basin currently has a perimeter of 13.6 miles and occupies a total area of approximately 7,900 acres, with an open water area of about 2,000 acres. The proposed discharge would be at a rate of about 5,000 gallons per minute (2.6 billion gallons annually) and water would be discharged to either the Dark River watershed or the Sandy River watershed, or both watersheds. An engineered siphon system would be constructed to discharge the water near current seepage points that flow to the Dark and Sandy Rivers. Minntac currently discharges to these watersheds from basin seeps, which are regulated under a National Pollutant Discharge Elimination System Permit. This Environmental Impact Statement (EIS) describes current environmental conditions; evaluates the proposed project and alternatives to the proposed project; assesses potential environmental, economic, employment, and sociological impacts associated with the proposed project and alternatives; and identifies mitigation measures to minimize projected impacts. Nine Technical Memoranda and two Technical Summaries were prepared for this EIS and are incorporated by reference. In addition, these Technical Memoranda and Technical Summaries are attached in Volume 2 of this EIS.

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LIST OF ACRONYMS

BAF	Bioaccumulation Factor
BCC	Bioaccumulative Chemical of Concern
BLTM	Branch Lagrangian Transport Model
BOD	Biochemical Oxygen Demand
BSIC	Bioaccumulative Substance of Immediate Concern
˚C	Degrees Celsius
cfs	Cubic feet per second
COC	Constituents of Concern
COD	Chemical Oxygen Demand
DLO	Dark Lake Outlet
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DRO	Diesel-Range Organic
EAW	Environmental Assessment Worksheet
EIS	Environmental Impact Statement
EQB	Environmental Quality Board
˚F	Degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FFS	Focused Feasibility Study
fps	Feet per second
gpm	Gallons per minute
HBV	Health-based Value
HCR	Hydrographically controlled release
IBI	Index of Biotic Integrity
LSD	Lake Superior Datum
MCL	Maximum Contaminant Level
MDH	Minnesota Department of Health
MDNR	Minnesota Department of Natural Resources
MGD	Million Gallons per Day
mg/L	Milligrams per liter
MGY	Million gallons per year
MIBK	Methyl-isobutyl ketone
Minntac	U.S. Steel Minntac
MPCA	Minnesota Pollution Control Agency
NHNRP	Minnesota DNR's Natural Heritage and Nongame Research Program
NM	Not Measured
NPDES	National Pollutant Discharge Elimination System
PMP	Probable Maximum Precipitation
P -E	Precipitation minus evaporation
POTW	Publicly-owned Treatment Works
ppb	Parts per billion
ppt	Parts per trillion
RGU	Responsible Governmental Unit
ROI	Region of Influence
SEP	Standard Error of Prediction
SFRMP	Subsection Forest Resource Management Plan
SI	Saturation Index
SMC	Special Management Complexes
SOC	Schedule of Compliance
SPB	Submerged Packed-bed Reactor

LIST OF ACRONYMS
(Continued)

SPT	Standard Penetration Test
TDS	Total Dissolved Solids
TIN	Total Inorganic Nitrogen
TOC	Total Organic Carbon
TSI	Trophic Status Index
TSS	Total Suspended Solids
SWTM	*Surface Water Quality Technical Memorandum*
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
μg/L	Micrograms per liter
μmhos/cm	Micromhos per centimeter
USGS	United States Geological Survey

EXECUTIVE SUMMARY

INTRODUCTION

This EIS was prepared by the Minnesota Pollution Control Agency (MPCA) based on a proposal by U.S. Steel Minntac (Minntac) located in the city of Mountain Iron, Minnesota. Minntac mines and processes taconite, a mineral rock bearing 15 to 30 percent magnetic iron minerals. Water used in the processing of the ore is discharged to a tailings basin where solids settle. An engineered siphon discharge of water from the tailings basin has been proposed by Minntac. An engineered siphon system would actively move water from within the tailings basin to proposed discharge point(s) in the Sandy River (east) and/or Dark River (west) Watersheds. The maximum proposed discharge would be approximately 5,000 gallons per minute (gpm) (11.1 cubic feet per second (cfs) or 7.2 million gallons per day (MGD)). The proposed discharges would be located near two currently monitored seepage points that flow into the Dark River (Station 020) and the Sandy River (Station 030). This EIS evaluates impacts from this alternative as well as other alternatives, which represent variations in volume and locations of the discharge, (including a possible discharge to the south to the St. Louis River Watershed (Lake Superior Basin), via the West Two River Reservoir) as well as methods to mitigate the potential impacts.

PROJECT BACKGROUND

Minntac operations began in the 1960s and were later expanded during the 1970s. Permits issued allowed for construction of the tailings basin to serve as a disposal area for the tailings generated during the processing of taconite and to store surface water for use at the facilities. Minntac has the capability to generate over 15 million tons of taconite pellets annually. The Minntac processing plant consists of a series of crushers and screens, a concentrator, an agglomerator, and various auxiliary facilities. The concentrator utilizes a series of mills, magnetic separators, classifiers, hydrocyclones, hydroseparators, screens and thickeners, as well as a flotation process. The agglomerator receives the concentrate, which is dewatered using disc filters. The filter cake is then mixed with bentonite and formed into pellets in balling drums. The pellets are dried, heated and fired in a grate kiln and then loaded for rail transport. The plant uses approximately 32,000 gpm of water for slurry and other plant processes. Most of the process water is recycled from the tailings basin. The remainder, or make-up water, comes from the Mountain Iron Pit Reservoir. A small percentage of the water is consumed during mineral processing. The remainder is discharged as with fine tailings as a slurry by a gravity system from the plant to the tailings basin.

The general purpose of the tailings basin is to dispose of fine tailings resulting from the ore processing, allowing fine particles to settle out and to store water for use at the facility. During the routine operation of the tailings basin, fine and coarse tailings are deposited and water is returned to the processing circuit. These tailings reduce the overall available volume of the tailings basin at a rate of approximately 25 acre-feet per day. Seepage discharges through the dike have been estimated at approximately 3,000 gpm. The water in the basin, and in the seepage discharges, has elevated levels of dissolved solids, due in part to mineral buildup resulting from the process water being recycled for 37 years. The mineral buildup results from dissolution of the taconite rock, effluent from air pollution control scrubbers in the plant, and other chemicals and materials introduced during processing to make the taconite pellets. Analysis of the tailings basin water quality over the past 15-20 years indicates that the mineral buildup will continue into the future unless steps are taken to reverse the trend. Minntac and the MPCA are concerned about the increasing concentrations of sulfate, chlorides, hardness, and specific conductance of the waters in the basin. These increasing concentrations are not only affecting the efficiency of the processing circuit, but also are negatively impacting the Dark River and Sandy River Watersheds downstream of the tailings basin seeps. Continued operation of the tailings basin at status quo will result in continued impacts to both the processing plant and to the downstream watersheds.

REGULATORY FRAMEWORK

Discharges from the seeps (for example, stations 020 and 030) are permitted under a National Pollutant Discharge Elimination System (NPDES) Permit No. MN0057207. Under this permit, stations 020 and 030 are designated SD001 and SD002, respectively. The permit was issued by MPCA in 1987 and expired in 1992. Minntac applied for reissuance in a timely manner and is currently operating under the expired permit, as allowed under Minnesota Rule 7001.0160. The permit requires Minntac to monitor the discharges for sulfate and specific conductance. Based on reports submitted by Minntac as required under the permit, elevated levels of these constituents have been noted.

MPCA and Minntac entered into a schedule of compliance (SOC) in December 2001, under which Minntac agreed to evaluate technologies and process modifications to reduce sulfate, specific conductance, hardness, and chloride in the current seepage discharges and assess how efforts to reduce these constituents would be affected by the proposed siphon discharge. Information developed under the SOC is incorporated into this EIS, and will be utilized by MPCA to develop a reissued permit governing discharges from the basin, regardless of whether the proposal that is the subject of this EIS proceeds.

This EIS was prepared by MPCA as a discretionary EIS under the provisions of Minnesota Rule 4410.2000, subparagraph 3(B). MPCA initiated the project scoping process with notice of the availability of the *Draft Scoping EAW* in the *Minnesota Environmental Quality Board (EQB) Monitor* on May 25, 2001. The *Draft Scoping EAW* provided information about the proposed project and potential resource areas of concern and solicited comments from interested parties. A public scoping meeting was held at the Laurentian Environmental Center on June 27, 2001, during the 45-day comment period. Public comments and MPCA's responses to comments were summarized in the *Final Scoping Decision Document*, which was approved by the MPCA Citizen's Board on December 21, 2001.

Potential major impacts identified during the scoping process and addressed within this EIS document were identified for the following resource areas:

- Surface water hydrology – changes in flow rates, water levels, and the magnitude and frequency of peak-flows.

- Surface water quality – increased concentrations of sulfate, chloride, hardness and total dissolved solids (TDS), as well as changes in general water quality parameters (e.g., pH), and minor constituents (e.g., mercury/methylmercury).

- Wetlands – impacts to wetland vegetation located along streams, rivers, and lakes from hydrologic modifications and to wetland communities resulting from water quality changes.

- Wild rice - impacts associated with hydrologic modifications and water quality impacts, and, additionally, the current location and ecological status (distribution and abundance) of wild rice within the Sandy River, and the reason(s) for decline and absence of wild rice in Twin Lakes.

- Aquatic resources - impacts due to water chemistry, temperature, and hydrologic changes, and the trophic state of downstream waters.

- Wildlife - impacts on the health of animals or their eggs (amphibians) and food chain effects on top-of-the-chain predators due to changes in water quality, and impacts on the foraging success of aquatic hunters due to hydrologic modifications.

- Socioeconomics - impacts on the quality and quantity of resources and the subsequent influence on the economy, especially with respect to the loss or decline of wild rice, trout populations, tourism, recreational areas, property values and current land use.

ENVIRONMENTAL AND SOCIOECONOMIC SETTING

Minntac is located on the Mesabi Range in the city of Mountain Iron, St. Louis County, Minnesota. The entire Minntac complex covers 37,000 acres, including a mine that stretches for 10 miles along the Mesabi Range. The facility includes two mining areas, several processing plants, a heating and utility plant, a water reservoir, and a tailings basin. The tailings basin is a large surface water and tailings impoundment located to the north of the taconite processing facility. The basin currently has a perimeter of 13.6 miles and occupies a total area of approximately 7,900 acres, with an open water area of about 2,000 acres. The tailings basin is situated in the Rainy River Watershed on the north flank of the Laurentian Divide at the headwaters of the Dark River on the west and the Sandy River on the east. Land immediately surrounding the tailings basin is primarily undeveloped is owned by U.S. Steel, with more outlying areas primarily undeveloped and/or used for recreation.

The headwaters of the Dark River begin on the west edge of the tailings basin. The Dark River flows generally northwest through Dark Lake and subsequently into the Sturgeon River approximately 17 miles downstream. The Sturgeon River, in turn, drains into the Little Fork River and ultimately into the Rainy River. The Dark River Watershed contains several lakes and wetland areas along the mainstem of the Dark River. In addition, a stretch of the Dark River, beginning approximately 3.5 miles downstream of Dark Lake and continuing to the confluence with the Sturgeon River, is a Designated Trout Stream. A portion of the seepage from the tailings basin flows west into the Dark River Watershed.

The headwaters of the Sandy River begin on the east edge of the tailings basin. The Sandy River continues for approximately 12 miles through Admiral Lake and through and past the Little Sandy and Sandy Lakes ("Twin Lakes"), to its confluence with the Pike River. The Pike River continues north and ultimately flows into Pike Bay of Lake Vermilion. A portion of the seepage from the tailings basin flows east into the Sandy River Watershed.

Flow within the Dark River and Sandy River Basins varies seasonally with low-flow generally occurring in February and peak-flow generally occurring in April. Monthly average flows within the Dark River varied between 8.6 and 109 cfs at the gauging station at County Road 481. Monthly average flows at the Sturgeon River gauging station downstream of the confluence with the Dark River ranged between 24 and 367 cfs. Flow within the Sandy River basin showed similar trends, with the monthly average flows within the Pike River ranging between 7 and 276 cfs at the gauging station along the Pike River downstream of Sandy River.

Baseline data, reviewed and summarized in the *Surface Water Hydrology and Water Quality Technical Memorandum,* indicate exceedances of a number of State water quality standards during certain flow regimes. Within the Dark River Watershed, sulfate, hardness, specific conductance, and manganese standards have been exceeded. Within the Sandy River Watershed, sulfate, chloride, hardness, and specific conductance standards have been exceeded.

According to St. Louis County wetland maps, the areas bordering the Sandy River are composed primarily of shrub swamps and bogs, and some areas of wooded swamps. There are also two areas where wet meadow occurs on the Sandy River. The areas bordering Sandy Lake and Little Sandy Lake are primarily shrub swamp and bogs. Admiral Lake is bordered primarily by shrub swamp, with a small area of bog on the northern portion of the lake. The Pike River is bordered primarily by shrub swamp, with some wooded swamp also present.

The areas adjacent to the Dark River, from the tailings basin discharge area to Dark Lake, are primarily shrub swamps. There are also two areas where wet meadow occurs on the Dark River. Dark Lake is bordered by some shrub swamps, as well as a small area of wooded swamp. On the Dark River from Dark Lake to the confluence with the Sturgeon River, there is a narrow strip of shrub swamp along the river and then mostly uplands. At and near the confluence of the Dark River and the Sturgeon River, there is a stretch of wooded swamps. The Sturgeon River appears to be primarily bordered by upland vegetation.

Wetland characteristics of the Sandy and Pike River Watersheds make the Sandy and Pike Rivers suitable for production of wild rice. Water currents are mitigated by extensive stream sinuosity and surrounding wetland and bog habitat. These factors buffer the stream against flashiness that could flood and/or uproot immature wild rice plants, or mature plants with weak root systems. Slowed water flow also permits rice seed to settle in specific areas (typically in near-shore areas and other friction points of water flow in the stream course, such as river bends and oxbow areas) and establish root systems. Both the Sandy and Pike Rivers are typical northern Minnesota dark-water streams with extensive humic wetland vegetation borders. Annual humic vegetation and plant straw deposition and build-up acts as an insulator, protecting the mineral substrate from freeze-out in winter. This allows under-ice water and substrate temperatures suitable to maintain rice seed in dormancy, while also preserving it against desiccation through freezing.

The upper portion of the Dark River, upstream of Dark Lake, is a warm-water stream. Downstream of Dark Lake, stream temperatures begin to decrease and continue downstream. Near County Road 65, the river receives cold-water inputs from several tributaries and springs, lowering the water temperature in this segment. In the downstream portion, the gradient increases and the substrate changes to rock, cobble, and sand. In the lower portion, the stream slows and the substrate is composed mainly of sand. The Dark River is unique to this part of Minnesota, with groundwater inputs in the lower portions sustaining a cold-water trout fishery, in comparison to the warm-water streams typical of the area. There is evidence that the groundwater inflows are more substantial further downstream of Dark Lake, with increasing numbers of intolerant fish and macroinvertebrate species that are sensitive to changes in water quality. The reach of the Dark River from County Road 65 to the confluence with the Sturgeon River is listed as a Designated Trout Stream under Minnesota Rule 6264.0050 subpart 4. This reach is considered to be one of the best trout streams in the Grand Rapids Fisheries Management Area, and is a high management priority, with self-sustaining populations of trout. Several other fish species are also typical of the Dark River basin.

The Sandy River is a warm-water stream with an unconsolidated silty substrate, and is more typical of streams in this part of Minnesota. During heavy rains, the transport of organic sediments to the stream from area wetlands occasionally results in problems with dissolved oxygen concentrations. The stream carries a high sediment load and is very discolored. By comparison with the lower Dark River, primarily warm-water fish species are found within the Sandy River.

Over fifty-three species of mammals are known to occur in the northeastern section of Superior National Forest, nearly all of which may be assumed to be found within the project study area. Of these, 13 species are classified by MDNR as "species of concern," 16 as "furbearers," 5 as "small game," and 4 as "big game." Two species, the gray wolf and the lynx, are federally classified as "threatened." Over 200 species of birds are also likely to be found within the study area. Two of the listed bird species within the area, the peregrine falcon and the common tern, are considered by MDNR to be "threatened" and one, the northern bald eagle is listed as of "special concern" by MDNR and "threatened" by the Federal government. A blue heron rookery and a bald eagle nest are located on an island in the tailings basin, approximately one mile from the proposed discharge location. These bird habitats were established after the mine began operation, and to date, normal mine and tailings basin operations and activities have not appeared to affect them. Several species of reptiles are also likely present in the study area. One turtle, the snapping turtle, is of “special concern” to MDNR, while two turtles, the wood turtle and the Blandings turtle are designated “threatened” by MDNR.

Several important recreation resources are located within the Sandy River and Dark River Watersheds. Two of particular interest include the North Dark River Trail and the Little Fork River State Canoe and Boating Route. The North Dark River Trail is a 1.3-mile hiking trail located 11 miles northwest of the town of Virginia that follows the east bank of the Dark River through a jack pine forest plantation and loops back on an old logging road. The Little Fork River State Canoe and Boating Route is a 135-mile long State-designated canoe route along the Little Fork River. It is generally used by experienced whitewater canoeists only and includes short stretches of Class-II rapids separated by long stretches of quiet river. There is also abundant wildlife along the route.

The area near the Minntac facility encompasses portions of St. Louis County, including the cities of Mountain Iron and the townships of Wuori, Sandy, Greenwood, Lake Vermilion, Pike, Embarrass, Kugler, Breitung, Great Scott, Sturgeon, Balkan, Linden, Morcom, and Willow Valley. The total population for St. Louis County is 200,568 with over half of that located in the immediate Duluth area 60 miles south of the project area. The area is very sparsely populated, with a density of approximately 30 persons per square mile. Development within the area is characterized by clusters of largely single family dwellings located along rivers and streams, around lakes, and along some thoroughfares. There are many vacation homes and recreational cabins located in the area, particularly along the Dark River and along the Pike River toward Pike Bay and Lake Vermilion.

Minntac has a direct impact on the economy of Northeastern Minnesota, employing 1200 people. Minntac also contributes significantly to the region's economy indirectly through the utilization of goods and services provided by local suppliers, and through the payment of state and local taxes. The overall economic impact of the Minntac operation on the area's economy is estimated in the millions of dollars per year.

People in the area work primarily in the wood products, mining, tourism, and service industries. Two sectors, agriculture and tourism, are of particular interest for purposes of assessing the impacts from the proposed project and alternatives. The vast majority of St. Louis County residents also work in the county, with some workers commuting to neighboring Itasca, Koochiching, Carlton, and Douglas County, Wisconsin.

WATER BALANCE

The water contained in the tailings basin comes from two primary sources: direct precipitation (5,920 million gallons per year (MGY)) and mineral processing/fine tailings slurry discharge (17,470 MGY). The portion of water present in the tailings basin that is a direct result of precipitation was calculated using a long-term average of 26 inches of precipitation per year. Precipitation was applied to the total tailings basin watershed of 8,385 acres, which includes the plant area.

Based on an annual water balance model developed to reflect operating conditions, it was estimated that 17,470 MGY of water are discharged as fine tailings slurry to the tailings basin. This slurry water is accumulated from a variety of secondary sources including return water, makeup water, crude ore feed, fluxstone moisture, and indurator combustion. Most of the water introduced into the process system is discharged to the tailings basin (96 percent).

By regulation, the difference between precipitation minus evaporation (P-E) may be discharged subject to water quality limitations. As indicated above, the tailings basin accumulates approximately 5,920 MGY from precipitation and evaporation accounts for about 1,843 MGY of loss. Subtracting evaporation from precipitation (P-E) results in 4,077 MGY (excess precipitation). This 4,077 MGY equates to 7,757 gpm; therefore the proposed discharge of 5,000 gpm is realistic as far as the (P-E) water ratio is concerned. This ratio indicates that the tailings basin water volume should be increasing. However, the water balance associated with managing the tailings basin return water required for mineral processing is more complex. A recent water balance evaluation reveals that, over the short term in fact, the tailings basin is losing water under the current operational conditions. In evaluating the risk of dam overtopping, it was concluded that the water levels can be managed adequately by controlling make-up water pumping activities.

Minntac's basin operating plan includes using Cell M-1 for fine tailings disposal. Filling this cell will result in a change in area of the water pool and result in changes in the water balance. The current clear water pool area of 2,612 acres (August 2002) includes 529 acres in Cell M. When water in Cell M is displaced with tailings, total storage area for clear water decreases. Manipulation of the water balance indicates that adding the Cell M water volume to Cells 1 and 2 would result in a surface elevation increase of 5.4 feet in the clear water pool.

PROJECT ALTERNATIVES

The Environmental Quality Board (EQB) rules require that an EIS evaluation address at least one alternative from each of several alternative types, or provide a concise explanation of why an alternative from a particular alternative type is not evaluated. At least one alternative from each alternative type is evaluated within this EIS. The proposed project and alternatives are summarized as follows:

- **Alternative A: Proposed Project (Proposed Action) -** Siphon discharge of 5,000 gpm of tailings basin water to the Dark River Watershed, Sandy River Watershed, or a combination of the Dark River and Sandy River Watersheds.

- **Alternative B: Alternative Sites -** Siphon discharge of 5,000 gpm of tailings basin water to optional sites including Laurentian Creek, St. Louis River Watershed, or multiple watersheds.

- **Alternative C: No Build (No Action) -** No discharge, with remaining life at status quo.

- **Alternative D: Alternative Technologies -** Non-discharging alternatives including tailings basin perimeter dike raising, water level reduction through operational use, water level reduction through process water adjustment, or tailings basin west expansion.

- **Alternative E: Design Alternatives -** Siphon discharge of 5,000 gpm through alternate siphon placement modification or management of Dark Lake effluent discharge.

- **Alternative F: Modified Scale or Magnitude Alternatives -** Siphon discharge of reduced volume.

- **Alternative G: Alternatives Incorporating Reasonable Mitigation Measures -** Discharge of 5,000 gpm of Submerged Packed-Bed (SPB)-treated water: to Sandy River, Dark River, a combination of the Sandy and Dark Rivers, Laurentian Creek, St. Louis River Watershed, or multiple watersheds.

- **Alternative H: Mitigation Suggested through Comments:** MPCA has considered the comments received during the scoping process and has included appropriate alternatives incorporating suggested mitigation measures in the above alternative scenarios.

Throughout the EIS process, a number of combined alternatives have been identified. These include the following:

- Portioning untreated tailings water discharge (equally or in unequal proportions) between the Sandy River, the Dark River, Laurentian Creek, and the West Two River, effectively also proportionally dividing the mass of key constituents, namely chloride, TDS, conductivity hardness, conductivity, and the aforementioned metals.

  Additionally, with detailed evaluation, another variation on the discharge to the Sandy and Dark Rivers and/or the St. Louis River Watershed could be developed whereby the discharge and split between the watersheds are varied. This management strategy is termed "hydrographically controlled release" or HCR. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River Watershed during periods of temperature extremes to protect the trout habit. Similarly, flow could be directed from the Sandy River, or routed down Laurentian Creek during periods critical for wild rice production.

- Use of the SPB system alone to treat all effluent prior to discharge into Sandy River, Dark River, West Two River, or a combination thereof.

- Use of the SPB in conjunction with a managed schedule of direct, untreated discharge of tailings basin water.

- Siphon placement and differential untreated tailings water discharge, either seasonally to a watershed, split between watersheds, or both.

- Use of the SPB system with discharge to the south (West Two River) and potentially diverting existing pit dewatering flow from the south to use for Minntac plant makeup, effectively reducing total sulfate mass loadings.

ENVIRONMENTAL, ECONOMIC, EMPLOYMENT, AND SOCIOLOGICAL IMPACTS

Potential impacts associated with the implementation of the proposed project or project alternatives are discussed with respect to each of the resource areas presented above. Baseline conditions for each of the resources areas were first identified and described. Then the potential impacts to the baseline conditions were evaluated. The potential impacts identified for each resource area are summarized briefly below.

Surface Water Hydrology Impacts

Alternative A: Proposed Project (Proposed Action)

A hydrologic impact analysis was performed to evaluate potential effects of the proposed project and project alternatives to the baseline hydrologic conditions of the Dark River and Sandy River Watersheds. The effects of the proposed discharge on the hydrologic systems were assessed in terms of the following:

- Relative percent increase to historic flows
- Potential increased water depths, flooding and overland flow
- Potential increased channel scouring, erosion and sedimentation
- Potential impacts to in-stream structures (bridges, pipes, culverts)
- Potential for changes in groundwater flow to streams

Monthly average flow - The average flow at the points of discharge from the tailings basin, with an additional 11.1 cfs, would increase 1,360 and 988 percent at the point of discharge on the Sandy and Dark rivers, respectively. With an additional 5.6 cfs, representing an equal split of discharge between the Sandy and Dark River Watersheds, average flows would increase 637 and 450 percent at the points of discharge, respectively. Thus, an increase in discharge of up to 11.1 cfs from either of these points would greatly increase average river flows. Throughout the watersheds, the low-flow periods would be affected by the additional flow to a greater degree than the high-flow periods.

7Q10 minimum flow - The potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 7Q10 minimum flow were evaluated throughout the watersheds from the upstream to downstream stations. The data indicate more than a thousand percent increase in 7Q10 minimum flow at the upstream stations and on the order of a hundred percent increase in 7Q10 minimum flow at the downstream stations in both watersheds. However, it is more realistic that some component of the additional flow volume would be attenuated into the storage capacity (e.g., lakes and wetland areas) of the watersheds. In addition, it should be noted that the absolute increases in 7Q10 minimum flows would be well below the average stream flows in the channels.

Peak storm flow - the potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 2-, 5-, 10-, 25-, 50- and 100-year storm event flows were also evaluated. The evaluation indicated that increases to peak flows associated with a 2-year storm event would range from approximately 3 to 6 percent at certain downstream locations for 5.6 cfs and 11.1 cfs additional flow, respectively. At further downstream stations, peak flows would range from less than 1 percent to slightly greater than 1 percent for 5.6 cfs and 11.1 cfs additional flow, respectively.

Water Levels, Flooding and Overland Flow - the potential for increased flooding and overland flow at the gauging stations downstream of the discharge points is minimal based on relatively small changes in water levels resulting from the increased flows. However, the locations of these ratings are relatively far downstream of the proposed discharge point. Therefore, it is likely that smaller channels further upstream and within the headwater areas may be prone to higher degrees of flooding and overland flow. The additional proposed discharge is insignificant when compared to the predicted 100-year flow volumes; therefore the 100-year flood plain should define any areas of maximum potential flooding.

Channel Scouring, Erosion and Sedimentation - potential effects of scouring, erosion and sedimentation would be the most significant at the most upstream locations of the watersheds, where the discharge would be introduced (near the tailings basin seeps). The proposed discharge poses a many fold increase in base flow when compared with the current seepage rates. The percentage increases during larger storm event flows (five- to 100-year event flows) would be sequentially less. The discharge of an additional 5.6 cfs to 11.1 cfs of flow to the current seep locations could potentially cause adjustments in the plan and profiles of the channels as the channels must down-cut and widen to accommodate the increased flow volumes. Stream velocities, channel boundary stresses and stream power would all increase, translating into a combination of increased bank erosion, increased sediment scouring and stream morphology changes downstream of the tailings basin. Increased flows would potentially destabilize the channels and could result in increased sediment flux and total suspended solids (TSS) concentrations, and the potential to violate turbidity water quality standards for some distance downstream as the stream adjusts to the increased flow volume, until such time that the channel readjusts. The percentage increases resulting from a discharge from the basin during larger storm event flows (5- to 100- year event flows) would be sequentially less.

In-Stream Structures - Current in-stream structures (bridges, pipes, culverts, etc.), are designed for a 100-year storm event flow. The potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 100-year storm event flow was evaluated. The evaluation indicated that the relative percent impacts to the estimated 100-year storm events are less than two percent combined with 11.1 cfs of additional flow, and less than or equal to one percent combined with 5.6 cfs of flow. Therefore, impacts to in-stream structures are not expected as a result of the additional discharge.

Alternative B: Alternative Sites

Laurentian Creek - discharge to Laurentian Creek would create similar impacts to those described for the Sandy River Watershed with the primary difference that there would be no additional impacts to the headwaters of Sandy River (near Station 030), Admiral Lake, Little Sandy Lake or Sandy Lake. However, there would be hydrologic impacts to Laurentian Creek as a result of this alternative. It may be presumed that the relative hydrologic impacts to Laurentian Creek would be similar to those discussed for the upstream portion of the Sandy River.

St. Louis River Watershed - discharge to the St. Louis River Watershed would most likely occur via Minntac's permitted discharge point (Permit No. MN0052493, Outfall SD001) located south of the tailings basin and adjacent to the West Pit Area in the city of Mountain Iron. Water discharge at Outfall SD001 flows approximately 2 miles south via and unnamed drainage ditch, through a small wetland and into the West Two River Reservoir. The outfall is permitted for an average discharge of 5.0 MGD (7.7 cfs) and maximum discharge of 33.2 MGD (51.4 cfs). Therefore, it may be concluded that this outfall location could accommodate the additional proposed discharge of 11.1 cfs with respect to the maximum permitted amount. However, the average proposed flow at this location (11.1 cfs) would be greater than the current average flow (8.2 cfs). Therefore, relative hydrologic impacts as a result of this increased flow may be expected downstream of Outfall SD001 to the West Two River Reservoir. Water releases from the reservoir are controlled through a spillway and therefore, no significant hydrologic impacts are expected downstream.

Alternative C: No Build (No Action)

Under the No Build Alternative, the proposed discharge would not be permitted and the current tailings deposition and basin water recycle operations would continue. Potential hydrologic impacts associated with this alternative are anticipated to be minimal.

Alternative D: Alternative Technologies

An alternate technology under consideration is to raise the perimeter dikes on the tailings basin. With regard to hydrologic impacts, this alternative would result in conditions generally similar to the No Build Alternative. There will, however, be a small increase in seepage rates as a result of the increased water levels in the basin.

Alternative E: Design Alternatives

The proposed design alternative related to siphon placement in the tailings basin would not result in any changes to the hydrologic impact analysis, because it does not change the flow rate downstream of the discharge points as compared to the proposed project (Alternative A). However, management of the flow from Dark Lake into the Dark River in order to regulate stream temperature would generally be designed to discharge higher flows during the high spring flow periods in order to allow smaller discharges during the summer and winter low-flow periods. This action would result in slightly greater hydrologic impacts during the high-flow periods.

Alternative F: Modified Scale or Magnitude Alternatives

Reduction in the magnitude of discharge to either watershed would accordingly reduce the associated impacts. However, the volume of discharge required to meet some of the objectives of the project would likely have impacts on the order of those discussed in the impact analysis for the proposed project (Alternative A).

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

This alternative is concerned with operation of the Submerged Packed-Bed (SPB) system, which is currently under review by Minntac. The objective of the SPB system operation is related to improvement of water quality prior to discharge and, as such, would have no different impact to the hydrology of the watersheds than has been discussed for Alternative A. However, in addition, Minntac has evaluated alternatives of discharging 11,000 gpm (24.5cfs) treated plant water to the tailings facility without a direct discharge, or discharging 2,400 gpm (5.3 cfs) of treated plant effluent to the tailings facility with an HCR-managed discharge averaging 11.1 cfs to the Sandy River. The general evaluation of this action is that any discharge above 11.1 cfs would have proportionally greater impacts than those discussed for the proposed Alternative A.

Surface Water Quality Impacts

Alternative A: Proposed Project (Proposed Action)

As discussed previously, the current tailings basin seepage results in elevated concentrations of some key constituents in both watersheds. Under some flow conditions, certain water quality standards are already exceeded at or near the seeps. Due to the elevated baseline concentrations in the Dark River and Sandy River, any substantial additional discharge from the Minntac tailings basin would likely result in additional impact to surface water quality in these watersheds. Impacts of the proposed new discharge to the Dark and Sandy Rivers would diminish with time if pollutant concentrations in the tailings basin and tailings basin seepage are effectively reduced. The maximum downstream impacts generally would be most acute initially.

The number of exceedances of water quality standards for sulfate, TDS, and hardness are anticipated to increase along the Dark River within the section of Designated Trout Stream with the proposed 5.5 cfs or 11.1 cfs discharge. Manganese, which is currently exceeding standards, would continue to do so under either of the proposed discharge scenarios. Similarly, the data indicate that along the section of the Sandy River containing wild rice beds, there would also be increases in the numbers of exceedances of chloride, TDS, specific conductance and hardness water quality standards Based on these data, the Dark River and Sandy River do not have sufficient capacity to assimilate some key constituents without exceeding standards.

Additionally, the percentage of water quality exceedances increases with increasing flow discharge rates from the tailings basin. The relative magnitude of the impact associated with the split discharge scenario, therefore, is less than the magnitude associated with discharging the full flow volume to either of the rivers exclusively.

The mercury concentration in the tailings basin is lower than the baseline concentrations in the Dark and Sandy Rivers, so the proposed new discharge would lower the average mercury concentrations in these receiving waters. However, recent research has shown that sulfate addition may promote the methylation of mercury. Under anaerobic conditions, sulfate provides one of several components needed for the growth of a certain type of bacteria responsible for methylation of mercury in the environment. Therefore, increased sulfate concentrations associated with the proposed project could result in an increase in methylmercury and fish tissue mercury concentrations in the impacted downstream waters.

Alternative B: Alternative Sites

Laurentian Creek Discharge - The purpose of discharging water to Laurentian Creek would be to bypass Sandy and Little Sandy Lakes and associated wild rice beds. Downstream of the confluence of Laurentian Creek and the Sandy River, along the Pike River and into Pike Bay of Lake Vermilion, the impacts would be similar to those of the proposed project (Alternative A).

St. Louis River Watershed Discharge - As discussed above, the NPDES-permitted Outfall SD001 is permitted for a maximum 33.2 MGD (51.4 cfs) of mine pit water discharge. The average permitted discharge is 5.0 MGD (7.7 cfs). The discharge scenario with the maximum potential water quality impacts to the St. Louis River Watershed would be a discharge of 100 percent tailings basin water. Under this scenario, numerical water quality standards would likely be exceeded at the discharge point for specific conductance, chloride and hardness. The more restrictive Class 2 standards for mercury apply to waters of the Lake Superior Basin (e.g., St. Louis River Watershed). Specifically, a standard of 0.0013 μg/L applies (verses 0.0069 μg/L in the Sandy and Dark River Watersheds). Based on the concentrations of mercury in the tailings basin, exceedance of the mercury standard in the discharge itself could occasionally occur. Impacts downstream of the discharge, however, would likely be mitigated to some degree by additional dilution from tributaries and groundwater baseflow. Additionally, other scenarios with less discharge (e.g., splitting the discharge between the St. Louis River Watershed and other discharge locations) would minimize the impacts. Implementation of this alternative scenario would also result in lesser impacts to the Dark River and Sandy River as compared to the proposed project (Alternative A).

Multiple Watershed Discharge and HCR -An alternative to a single point discharge would be a discharge partitioned to multiple watersheds, including the scenario where a portion of the discharge is routed to both the Sandy and Dark Rivers. A more detailed variation of this scenario could be developed whereby the ratio of total discharge and/or the location of the discharges is varied with time. This alternative would be a variation of the HCR, discussed previously. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River Watershed during periods of temperature extremes to protect the trout habit. Similarly, flow could be directed from the Sandy River, or routed down Laurentian Creek during periods critical for wild rice production. These types of discharge scenarios could result in less adverse impacts when compared to the proposed project.

Alternative C: No Build (No Action)

The No Build Alternative would result in additional impacts to the surface water system over the long-term. Data indicate that, with continued use of the tailings basin, the water quality would continue to degrade. This could result in increased concentrations of solutes in the seepage from the tailings basin and the subsequent increase in concentrations in the Sandy River and Dark River.

Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising - Since this alternative would not address the water quality in the tailings basin and, thereby, the basin seepage, the seepage would continue to adversely impact water quality in the Sandy River and the Dark River. In addition, increased water levels in the tailings basin would increase seepage rates due to higher hydraulic heads.

Water Level Reduction - A reduction of the water level in the tailings basin through operational changes could reduce seepage rates and improve water quality in the Sandy River and the Dark River, if the improvements are not off-set by increasing constituent concentrations in the tailings basin. However, it is probable that the reduced water level would be accompanied by a further degradation of the water quality in the tailings basin.

Alternative E: Design Alternatives

Siphon Placement - Siphon placement could be altered to help mitigate direct impacts due to changes in temperature or dissolved oxygen levels immediately downstream of the tailings basin. This alternative would not otherwise change the potential water quality impacts from what is expected under Alternative A.

Dark Lake Effluent - Hydraulic control of the Dark Lake outflow (e.g., reducing flow from Dark Lake during warm periods) could mitigate the temperature impact on the trout habitat of the Designated Trout Stream section of the Dark River.

Alternative F: Modified Scale or Magnitude Alternatives

Reduction in the magnitude of the discharge to either watershed would accordingly reduce the associated impacts. However, the volume of discharge required to meet some of the objectives of the project would likely have impacts on the order of those discussed in the impact analysis for the proposed project. Therefore, any reduction in discharge rates will reduce the impact, but it is not likely that an adequate discharge can occur to the Sandy River or Dark River that would not result in additional exceedances of water quality standards. This alternative would be more effective if the discharge was piped to a relatively unimpacted watershed. For example, the flow volume to the south discharge (St. Louis River Watershed) could be modulated to reduce impacts.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Minntac is evaluating an SPB system to reduce sulfate concentrations in the proposed discharge. Therefore the use of an SPB system could decrease the concentrations of sulfate in the discharge. However, the SPB system will not significantly alter the impact associated with a number of other constituents like chloride and hardness. In addition, elevated concentrations of constituents associated with the SPB system, such as, elevated total organic carbon would also have to be mitigated by including additional treatment. SPB discharge to the tailings basin associated with an HCR discharge can help mitigate chemical impacts associated with implementation discharge using the SPB system.

Wetland Impacts Associated With Hydrologic Changes

One of the major factors affecting zonation, composition, germination, and survival of freshwater wetland species along lakes and rivers is water depth, flooding duration, and frequency of inundation. These three aspects of river or lake hydrology will also affect other components of the wetland ecosystem such as organic matter decomposition, nutrient concentrations, and sedimentation. Changes in water levels can kill existing vegetation and allow species present as seeds in the seed bank that are more tolerant of high water levels to become established. Alteration of water levels may also cause a shift in dominant species. Thus, changes in hydrology affect species composition and can alter competition dynamics.

Alternative A: Proposed Project (Proposed Action)

Impacts Due to Changes in Surface Water Hydrology - wetland areas are present near the tailings basin seeps. If these areas are affected by flooding from discharge and slight increases in water levels or length of inundation occur, invasive emergents such as cattails should adapt. If large increases occur and the areas are covered by permanent standing water, the vegetation may succeed to rooted submergent and floating plant communities. With an additional discharge of 11.1 cfs, the average flow at the point of discharge and immediately downstream (upstream of Dark Lake or Little Sandy and Sandy Lakes) would increase substantially. If water levels increase in these areas or the soil surface becomes continually flooded, changes in vegetation will occur. However, the effects of flooding on vegetation would depend on flooding depth, frequency, duration, water velocity, and other factors.

Changes in water levels may occur in Admiral Lake, Little Sandy Lake, Sandy Lake and Dark Lake. An increase in flooded areas could negatively affect shrub swamps and bogs located on lake margins. The extent of damage, including mortality, would depend on water clarity, elongation rates, and energy reserves of the plants.

The changes in surface flow and water levels due to discharge from the tailings basin downstream of the lakes (i.e., downstream of Dark Lake and along the Pike River) would not be significant enough to harm vegetation or cause changes in reproduction success or competition. Water levels along these sections of the Dark River and Pike River would increase not more than a few inches. These increases in water levels should not have a negative impact on vegetation.

The large percent increases in flow during the 7Q10 low-flow periods due to additional discharge would likely result in significant impacts to the rivers during these times. This difference in water flow could have a major impact on vegetation, based on impacts discussed previously.

Impacts Due to Increased Channel Scour, Erosion, and Sedimentation - The potential increases in channel scouring, erosion and sedimentation in channels would most likely occur during higher flow periods (e.g., during 2-year storm event flows). However, the percent increases in flows due to the additional discharge during these storm events would be smaller at locations farther downstream of the discharge points. At these downstream locations, the impacts would be minimal and the degree of channel scouring, erosion and increased sedimentation would fall within the normal hydrologic conditions. However, at the more upstream locations where the discharge would be introduced (i.e., near the tailing basin seeps), the effects would be greater. The proposed discharge would cause a substantial increase in flow, which could potentially cause adjustments in the channels due to down-cutting and widening to accommodate the excess flow. Stream velocities, channel boundary stresses and stream power could all increase, translating into a combination of increased bank erosion, increased sediment scouring, and stream morphology changes downstream of the tailings basin. Increased flows could destabilize the channels and result in increased sediment flux and TSS concentrations for some distances downstream as the stream adjusts to the increased flow volume. Thus, it may be qualitatively stated that the greatest impacts with regard to channel scouring, erosion and increased sedimentation would occur at the upstream discharge points.

Alternative B: Alternative Sites

Laurentian Creek - This alternative would result in the discharge bypassing Sandy and Little Sandy Lakes and flow into the downstream stretch of the Sandy River. Discharge to Laurentian Creek would create similar impacts to those described for the Sandy River Watershed. However, it may be noted that the size of the watershed for Laurentian Creek at the assumed discharge location is similar to the watershed size for the headwaters of Sandy River prior to the tailings basin construction. Therefore, assuming a general correlation between watershed area and stream flow, it may be presumed that the relative hydrologic impacts to Laurentian Creek would be similar to those discussed for upstream Sandy River.

St. Louis River Watershed - Minntac's permitted discharge point (NPDES Permit # MN0052493 - Outfall SD001) would be used for discharge to the St. Louis River Watershed. The changes to discharge with this alternative would change baseline conditions. Baseline conditions are considered to be 100 percent mine pit dewatering discharge, while the alternative to this is 100 percent tailings basin discharge with no mine pit water discharge or some blend of water. This outfall location could accommodate the additional proposed discharge of 11.1 cfs during the typical range of flow conditions. However, the average proposed flow at this location would be greater than the current average flow. Relative hydrologic impacts as a result of this increased flow may occur, such as increased channel scouring and erosion, water level increases and overland flow, and increased sediment flux and TSS concentrations from Outfall SD001 to the West Two River Reservoir.

Multiple Watersheds - Dividing discharge among multiple watersheds can relieve some of the impacts that may occur if only one watershed receives the entire discharge. Again, seasonal variations in river flow should be observed and mimicked if minimal impacts are desired.

Alternative C: No Build (No Action)

With no change in the tailing basin management, no new hydrologic impacts would occur. However, over time, chronic impacts to wetland communities may be seen due to gradually increasing water pollutant concentrations in the seepage discharges. ., .

Alternative D: Alternative Technologies

Tailing Basin Perimeter Dike Raising - there may be some potential for additional seepage as a result of the increased water level in the basin. As discussed previously, with increased seepage, the area of cattail and other emergent wetland species may increase or, if permanent flooding occurs, succession to rooted submergents and floating species may occur.

Water Level Reduction through Operational Use - This alternative would likely have no significant impacts to downstream wetlands, although resulting seepage rates may marginally decrease as water levels are reduced.

Water Level Reduction through Process Water Adjustment - This alternative would likely have no significant impacts to downstream wetlands, although resulting seepage rates may marginally decrease as water levels are reduced.

Alternative E: Design Alternatives

Siphon Placement - the proposed design alternative related to siphon placement in the tailings basin would not result in any changes to hydrology because it does not change the flow rate downstream of the discharge points. However, it would affect the temperature and dissolved oxygen content of the discharge water. Impacts of changes in temperature and dissolved oxygen concentrations are discussed below in regard to water quality changes.

Dark Lake Effluent - this alternative is designed to mitigate temperature differences between tailings basin water and receiving water. Impacts of changes in temperature and dissolved oxygen concentrations are discussed below in regard to water quality changes.

Alternative F: Modified Scale or Magnitude Alternatives

The closer the discharge of basin water mimics the natural hydrologic fluctuations (high and low water periods) of receiving water bodies, the lower the impact would be to wetland communities. Even if the natural high and low water periods are preserved, if the flow and water level are significantly increased, negative impacts would still occur. If the majority of the discharge occurs when flow is at its highest and when vegetation is dormant, impacts on wetland vegetation would be less. The lower the additional discharge from the tailings basin (from normal, historical discharge), the less the impacts will be to wetlands.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

This alternative would have similar impacts to the hydrology of the watersheds as discussed Alternative A.

Wetland Impacts Associated with Surface Water Quality Changes

Alternative A: Proposed Project (Proposed Action)

The concentrations of sulfate, chloride, TDS, hardness, fluoride and manganese would increase as a result of the additional discharge, but these changes would decrease with distance from the discharge point. Thus, vegetation closer to the discharge points would be more severely affected by mineral toxicity than would vegetation farther downstream. The concentrations of sulfate in the Dark River and Sandy River receiving basin discharge are much higher than average concentrations without discharge. For sulfate-sensitive species, the higher concentrations due to tailings basin discharge could cause problems such as reduced growth and reproductive success and death. On the other hand, if the species are not sensitive to sulfate, the higher concentrations may not produce negative effects. The increase in sulfate concentrations may cause negative effects to sensitive vegetation along the Dark River, the Sandy River and associated lakes. The increases in concentrations of chloride, TDS, and fluoride would not be significant enough to impact wetlands. Depending on the sensitivity of the species involved, manganese, pH (alkalinity) and hardness levels associated with a discharge could have negative impacts on downstream vegetation.

Alternative B: Alternative Sites

Laurentian Creek - Discharge of tailing basin water into Laurentian Creek would cause similar impacts to wetland vegetation as discharge to either the Sandy River or Dark River.

St. Louis River Watershed - Under this alternative, impacts to vegetation would be similar to those discussed under Alternative A, with the severity of the impact dependent upon the degree to which the tailings basin water quality differs from the mine pit water quality.

Alternative C: No Build (No Action)

This alternative would result in additional impacts to the surface water system. Data have shown that with continued use of the tailings basin, the water quality would continue to degrade as the result of evapo-concentration. This would result in increasing concentrations of solutes in the seepage in the tailings basin. Over time, chronic impacts to wetland communities could occur due to the gradual deteriorating of seep water quality that would occur if no siphon discharge was permitted.

Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising - raising the tailings basin perimeter dike would continue to adversely impact water quality in the Sandy River and the Dark River due to evapo-concentration raising concentrations of regulated constituents and increased seepage rates due to higher hydraulic heads. Because many marsh species, such as cattails and reeds, are tolerant of metals and other pollutants, an increase in constituents should not cause problems. Species that are more sensitive to pollutants may decrease in numbers and diversity and invasive emergents may increase and form monocultures of undesirable species.

Water Level Reduction - a reduction in the water level of the tailings basin could reduce seepage rates and improve water quality in the Sandy and Dark Rivers, provided that constituents don't increase in concentration due to evapo-concentration. However, it is probable that the reduced water level would be accompanied by a further degradation in water quality of the basin and, thus, no net improvement would be seen in receiving water bodies. Thus the impacts to wetland vegetation would be similar to those discussed for the tailings basin perimeter dike raising.

Alternative E: Design Alternatives

These design alternatives focus primarily on mitigating impacts of temperature differences in the Sandy River and Dark River. A small change in temperature should have no negative impacts on vegetation.

Alternative F: Modified Scale or Magnitude Alternatives

Although reducing the volume of the discharge would reduce impacts to water quality, it may still be assumed that constituents of concern, such as sulfate and calcium, may still cause problems to wetlands downstream.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Implementation of the SPB system could result in a number of water quality modifications. Data from the piloted SPB system indicates that sulfate concentrations may be consistently reduced by as much as 50%, while reductions in TDS, specific conductivity and hardness would be none to slight. The data also indicates that the concentrations of some other constituents in the effluent such as alkalinity, manganese, and oxygen demand may increase. Although this data, in part, reflects the fact that the pilot SPB system was specifically operated to evaluate sulfate reduction and was not optimized for control of other parameters, it is expected that additional treatment of the SPB effluent to mitigate elevated concentrations of other constituents would be required prior to a discharge outside the basin. The overall benefits of using an SPB system for sulfate reduction, therefore, would need to be weighed against any negative impacts that increased concentrations of other effluent parameters might have on downstream wetland vegetation.

<u>Wild Rice Impacts</u>

Alternative A: Proposed Project (Proposed Action)

Impacts Due to Relative Percent Flow Increases - a comparison of monthly annual baseline flows in the Sandy River to flows adjusted for 5.6 and 11.1 cfs tailings basin discharge scenarios was conducted. This evaluation revealed that the addition of 5.6 cfs tailings basin discharge to baseline stream flows would cause an increase in monthly flow within the stated flow criteria maximum for wild rice. The 11.1 cfs discharge would result in flows outside the acceptable range for wild rice, and therefore, impacts would occur. Additionally, chronic impacts to the rice beds may occur if flow is stabilized with tailings basin discharge and the incidence of disturbance within the river channel is reduced. Under these conditions, wild rice, which prefers periodic disturbance regimes, could be impacted. Wild rice beds located further upstream within the Sandy River would not be as buffered from relative flow impacts as beds located further north in the Pike River, since in headwater areas of the river proposed flows have the potential to well exceed the baseline wild rice flow criteria.

Impacts Due to Water Level Changes, Flooding, and Overland Flow - average 7Q10 low-flow values were calculated throughout the watershed. Adding additional flow in the amount of either 5.6 or 11.1 cfs might result in upstream locations near the headwaters of the Sandy River exhibiting a very substantial winter flow increase. However, data for the Pike River show potentially small stage height increases. These relatively small, projected changes in water levels are within the wild rice water level criteria range, and would have minimal impact on wild rice in the Pike River.

Impacts Due to Channel Scouring, Erosion, and Sedimentation - erosion and channel scouring would likely occur during periods of high channel flow. Erosion and channel scouring would transport particulate sediment particles downstream. If sediment deposition occurs over existing rice beds, viable rice seed could be covered and germination might be retarded as a result of poor oxygenation or inappropriate germination temperature. Successive year crop failures would likely result in permanent rice plant community failure, since no viable seed would remain to re-establish plants. Greater erosion due to channel scouring from the additional discharge would likely occur in the upper reaches of the Sandy River. Transported sediment from such scouring could be transported downstream, cover rice seed, and impact its ability to germinate. While periodic impact from natural flood conditions would likely occur and is anticipated, transported sediment likely would have less impact on the wild rice beds farther downstream in the Pike River.

Impacts Due to Changes in Water Quality - the most significant change to the Sandy River system under the proposed project would be increased sulfate concentrations. Baseline sulfate levels seen at all stations exceeded the Class 4 standard of 10 mg/L 97 percent of the time. The sulfate level necessary for wild rice has been debated for many years. Toxicity levels of sulfate are likewise not well defined. Wild rice has been reported in water with sulfate levels of 2 to 1,300 mg/L. Therefore, the potential impacts to wild rice due to increased sulfate levels are uncertain.

There are no established standards for chloride, hardness, fluoride, and manganese in relation to wild rice. Acidification of wetlands due to acid drainage can impact pH and elevate and mobilize concentrations of certain metals in solution from varied sources, and increase bioavailability of these metals to aquatic plants and fauna. However, no acid condition exists at Minntac or is expected from a discharge. The criteria range of pH suitable for wild rice is 6.0 to 8.5. It is expected that significant pH changes above the upper criteria level would not consistently occur. Thus, impacts to wild rice, either through direct physiological alteration or through lowered-pH metal mobilization and toxicity, would not be expected. Impacts due to increases in alkalinity, TDS, dissolved oxygen and temperature may occur.

Alternative B: Alternative Sites

Laurentian Creek - impacts due to discharge to Laurentian Creek would be similar to those discussed under Alternative A. However, possible impacts to wild rice downstream of the confluence of Sandy River and Laurentian Creek would be the same or greater than with discharge through Sandy and Little Sandy Lakes. Possible greater long-term impacts may occur as water with high levels of sulfate would be directed completely via channel flow to rice beds in the Sandy River, without the option of flow reduction and possible sulfate retention within Sandy and Little Sandy Lakes.

St. Louis River Watershed - wild rice beds within West Two River and West Two River are reportedly minimal to absent. Therefore, impacts to wild rice beds within the West Two River Reservoir and West Two River are not anticipated.

Multiple Watersheds - one obvious option in regard to multiple watersheds is to divide the discharge between the Sandy River and the Dark River. The potential discharge of either 11.1 cfs or 5.6 cfs ("split flow") to the Sandy River also may include variable flow, with attention given to the timing of the discharge to accommodate seasonal growth processes of wild rice. This "biologically-controlled release" (or hydraulically-controlled release) of tailings discharge would accommodate spring germination of rice growth by limiting or severely reducing flow discharge between the months of April-June. By limiting flow discharge over already increased runoff flows, rice plants would less likely be dislodged and lost. Similarly, discharge might be curtailed in low-flow months (January-March). This would cause rice seed less exposure to more concentrated sulfate residual, present as a result of low natural stream flow during this time of the year. Discharge would be optimally released during summer and fall months (July-November), when wild rice is in its mature form, and less likely to be impacted by temporary high flow and sulfate residuals.

Alternative C: No Build (No Action)

Under this alternative, sulfate concentrations in the Sandy River would likely increase since concentrations in the tailings basin would slowly rise over time. Therefore, potential impacts to wild rice beds would be similar to Alternative A, but would extend further into the future, since no mechanism for reduction of sulfate in the basin would be implemented.

Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising - Under this alternative sulfate concentrations in the Sandy River would likely increase. Therefore, potential impacts to wild rice beds would be similar to Alternative A.

Water Level Reduction - This alternative may result in a slight decrease in downstream sulfate concentration due to reduced seepage flow from the basin. However, the magnitude of such a reduction would likely not be large enough to significantly benefit downstream wild rice.

Water Level Reduction through Process Water Adjustment - This alternative may result in a slight decrease in downstream sulfate concentration due to reduced seepage flow from the basin. However, the magnitude of such a reduction would likely not be large enough to significantly benefit downstream wild rice.

West Tailings Basin Expansion - this alternative would not impact wild rice in the Sandy River.

Alternative E: Design Alternative

Siphon Placement - water from within the basin may be of varied temperature, depending on the time of year siphoned, and the depth from which the water is collected. If discharge water with a temperature different from the receiving water is released, thermal impacts to wild rice in the Sandy River may occur.

Alternative F: Modified Scale or Magnitude Alternatives

Reduction of discharge flow rates may reduce the immediate impact to wild rice, but would likely still create a prolonged, chronic impact condition.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

The SPB system would likely reduce sulfate concentrations and therefore, reduce potential impacts to wild rice. The SPB system would not however, by itself, reduce sulfate to meet wild rice growth and production criteria within the Sandy River. Additionally, it has been found that, in the absence of associated mitigation measures, such as direct discharge, the SPB system would not concurrently reduce both sulfate along with TDS, chloride, and conductivity. Further, some metals concentrations such as barium, and manganese) could increase and negatively affect downstream wild rice.

Aquatic Resources Impacts

Alternative A: Proposed Project (Proposed Action)

Potential impacts resulting from the proposed project would likely be most prevalent in the reach of the Dark River from the point of discharge to Dark Lake. Likewise, the potential impacts would be most prevalent in the reach of the Sandy River from the point of discharge to Little Sandy Lake. However, data on the aquatic biota and aquatic habitat in these reaches are limited. However, the potential impacts on these river reaches are expected to be minor. Increased flows resulting from the proposed project would be beneficial to the fish and macroinvertebrate communities that may be present in these reaches during normally low-flow periods, but may result in shifts of habitat usage by fish during other periods of the year. Substrate characteristics would likely change in response to the increased flows, especially during the initial period of increase. Increased velocities and reduced residence time may increase scouring and nutrient replenishment that can result in a shift of the community structure of the stream. Adverse impacts to the fish and macroinvertebrate communities that may be present in these reaches resulting from changes in temperature or DO produced by the proposed project are not expected. Aquatic toxicity issues associated with an increase in dissolved solids is possible and would need to be evaluated prior to implementation.

Downstream of Dark Lake, the proposed project would likely have adverse impacts on the trout. The changes in water temperature produced by these flows would make the habitat less suitable for trout and may also have an adverse impact on the coldwater-associated macroinvertebrates and the coldwater fish species.

The hydrological impacts to Little Sandy Lake and Sandy Lake are not expected to be detrimental. The increased flows would provide more aquatic habitat during low-flow periods and would reduce conditions producing winterkill in Little Sandy Lake and Sandy Lake. Adverse water quality impacts to Little Sandy Lake and Sandy Lake are expected to be minimal. No adverse impacts to the aquatic biota resulting from the proposed project are expected downstream of Little Sandy Lake and Sandy Lake to Lake Vermilion.

Alternative B: Alternative Sites

Laurentian Creek - the potential impacts to aquatic biota in Laurentian Creek would likely be similar to those in Sandy Creek. There may be more oxygenated water in Laurentian Creek, which may lessen the impacts.

St. Louis River Watershed - any potential impacts to aquatic biota in the West Two River Watershed upstream of the West Two River Reservoir would likely be similar to those for the headwaters of the Dark and Sandy Rivers. However, impacts downstream of the West Two River Reservoir would be substantially reduced by the buffering afforded by the reservoir.

Alternative C: No Build (No Action)

Under the no-build alternative, discharge would not be allowed and operations would continue as they are now. Although some impacts are expected for water quality due to continued concentration of solutes and increased seep concentration, this would have little impact on DO. The aquatic biota in the headwaters of the Dark and Sandy Rivers may experience some impacts under the No Build Alternative. However, biological information for the headwaters of the two rivers is not available, so specific impacts cannot be determined. The concentrations of the water quality parameters of concern are concentrated at the seep sites. If concentrations continue to increase in the basin, seep concentrations would also increase, potentially having a negative impact on the aquatic biota. However, any water quality impacts on the Sandy River from the seeps would be mitigated to some extent by the buffering capacity of Little Sandy and Sandy Lakes. On the Dark River, several small tributaries enter downstream of the seep, increasing baseline flows, and increasing dilution. Dilution would also occur within Dark Lake, reducing concentrations downstream.

Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising - under this alternative, the tailings basin water would continue to evapo-concentrate and elevate concentrations of the water quality constituents. In addition, increased water levels in the tailings basin could increase seepage rates due to higher hydraulic heads. Therefore, this alternative may have an adverse impact on the biological community present in the headwaters of the Dark and Sandy Rivers. Specific impacts, however, cannot be determined because the fish and macroinvertebrate fauna for the headwaters are not known.

Tailings Basin Water Level Reduction - reducing the water level in the basin through removal of water for other purposes would have no impact on the fish and macroinvertebrate populations within the Dark River and Sandy River. In addition, there are no expected impacts on the aquatic trophic structure due to operational changes that reduce the water level in the tailings basin.

Alternative E: Design Alternatives

Siphon Placement - siphon placement could have an impact on the DO concentrations downstream of the selected discharge point and could therefore have an adverse impact on the fish and macroinvertebrate communities within the Dark River and Sandy River. If the intake of a new discharge siphon were placed low, such that it drew water from the bottom of the basin, there could be major reductions in DO immediately downstream of the tailings basin. This would be a seasonal impact that would be most significant during 7Q10 low-flow periods that occur during warm spring and summer months, when the basin discharge would comprise most, or all, of the stream flow in this reach.

Dark Lake Effluent - water discharged from the tailings basin into the Dark River would reaerate back to equilibrium before reaching Dark Lake. Consequently, there are no impacts on the DO concentrations in Dark Lake. However, controlling the discharge out of Dark Lake would have impacts on the downstream DO concentrations if low DO water were withdrawn from the lake, or the downstream flow became proportionally comprised of more groundwater than present conditions. However, reaeration appears to occur rapidly in the Dark River, making it unlikely that low DO concentrations would continue far downstream. Due to the rapid reaeration, DO impacts are expected to be insignificant. There would be no adverse impacts to the aquatic biota associated with control of the Dark Lake outflow.

Alternative F: Modified Scale or Magnitude Alternatives

Dissolved Oxygen and Aquatic Life - the magnitude of discharge to the river has little effect on the reaeration of water moving through the stream channel. Consequently, the impacts would be the same as Alternative A. It is also unlikely that changes in scale would have a significant impact on the aquatic communities within the Sandy and Dark Rivers. Baseline conditions for the water quality constituents of concern are already elevated in the tailings basin, therefore any discharge would result in increases in concentrations. The predicted concentrations for the different water quality parameters under 5.6 cfs discharge are not as reduced as might be expected, when compared to the predicted concentrations under 11.1 cfs discharge. It is apparent, therefore, that changes in the scale of the discharge would not result in a similar change in scale for water quality. According to the Dark River thermal model, temperature impacts are predicted to occur even with a 5.6 cfs discharge, although the impacts would be somewhat reduced with the reduced discharge.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

If effluent from the SPB were released directly into the Dark River or the Sandy River, there could be negative impacts on downstream aquatic resources related to dissolved oxygen consumption and elevated nutrient levels. Elevated levels of oxygen demanding substances and

Nutrients such as phosphorus and ammonia were measured in outflow from the piloted SPB system. Although this data, in part, reflects the fact that the pilot SPB system was specifically operated to evaluate sulfate reduction and was not optimized for control of other parameters, it is expected that additional treatment of the SPB effluent to mitigate elevated concentrations of oxygen demanding substances and nutrients would be required prior to a discharge outside the basin. Also, if SPB effluent was discharged only to the tailings basin rather then directly to the Dark or Sandy Rivers, the negative impacts on aquatic resources associated with higher concentrations of oxygen demanding substances and nutrients would be greatly reduced or eliminated.

The hydrologically related impacts of directly discharging SPB treated effluent into the Dark and Sandy Rivers would be the same as those of the proposed project. Temperature and DO changes of the discharge into the Dark River or the Sandy River would be mitigated to some by tertiary treatment, but impacts on the Dark River Designated Trout Stream section would still occur.

Potential Wildlife Impacts

The proposed changes in stream flows may affect wildlife in two possible ways: (1) through hydrologically induced changes in habitat (principally); and (2) through changes in water chemistry. Changes in habitat would result primarily from increases in overbank flooding. These events would have to be of sufficient magnitude and duration to alter the long-term water levels in off-stream wetlands and hence the vegetation of these areas. Any changes in vegetation resulting from a discharge, (which may in turn impact wildlife habitats) would be gradual, requiring years or even decades, to become noticeable. Potential chemical changes relating to levels of molybdenum, sulfur and methylmercury may have implications for downstream wildlife populations.

Potential Socioeconomic Impacts

Alternative A: Proposed Project (Proposed Action)

Impacts Related to Hydrologic Changes, Flooding, and Overland Flow - the proposed project would affect water levels and low-flows in both the Dark River and Sandy River and may contribute to limited flooding and overland flows within the headwater areas. These hydrologic changes may also result in some sporadic channel scouring, erosion, and sedimentation in both the Dark River and Sandy/Pike Rivers. These potential impacts may affect property values and land uses immediately adjacent to the rivers. It is expected that there may be localized impacts that affect land uses (e.g., North Dark River Trail), most likely those related to maintenance of lakeshore and utilization of the lakeshore or streamside for recreational purposes. It is possible that such changes to surface water flows may affect roadways. These hydrologic changes are not expected to impact roadway bridges, property values, or land uses along the Pike Bay shoreline on Lake Vermilion due to the fact that attenuation of such surface water flows results in negligible changes. It is concluded that these impacts would be relatively minor, except in perhaps some localized cases, and it is not expected that land uses would change outright as a result of flow changes.

Impacts Related to Changes in Water Quality - As discussed above, temperature effects in the Dark River may affect the viability of trout habitat throughout the Designated Trout Stream section downstream of Dark Lake. That area is already considered to contain marginal trout habitat, and elevated temperatures and suppressed groundwater inflows would result in deterioration of the habitat. This impact would likely not be allowed by the MDNR since the designation is defined by State statute. The economic impacts as a result of the loss of a Designated Trout Stream would include direct, indirect, and induced economic activity related to coldwater angling and tourism. Coldwater angling also provides significant social benefits, including social affiliation, personal achievement, nature appreciation, relaxation, escape, and fishing for recreation. The local economic and social impacts of loss of the Dark River Designated Trout Stream would be relatively minor compared with the overall regional tourism and angling economy. However, there would likely be indirect impacts including reduced property values and reductions in related recreational activity along the Dark River that may occur as a result of loss of the trout fishery. There is no known trout fishery on the Sandy/Pike River.

If increased concentrations of sulfate lead to methylation of mercury and increasing accumulations of mercury in fish tissue, there could be continued impacts to the economic activities related to recreational angling and the commercial fishery. Both the MDH and the MPCA have established consumption advisories and related thresholds for recommended maximum human consumption of fish. It is possible that such advisories could become more severe if methylation of mercury increased in the Sandy/Pike and Dark Rivers and Pike Bay due to the proposed project. This could in turn have direct, indirect, and/or induced impacts on employment, income, and property values within the area of influence.

Alternative B: Alternate Discharge Sites

Laurentian Creek - implementation of this alternative would reduce potential economic and social impacts to the Dark River. However, increased methylation of mercury due to increased sulfate levels may occur which could impact recreational and commercial fishery activities within the Sandy/Pike Rivers, as well as Pike Bay and Lake Vermilion more generally.

St. Louis River Watershed - while there is residential and agricultural development along the West Two Rivers south of the reservoir, it is expected that increased flows may result in only minor impacts to land uses and property values along that river reach, particularly in the vicinity of Cherry.

Multiple Watersheds - discharge to multiple watersheds would likely reduce the impacts to the trout fishery and property values along the Dark River. However, this split discharge alternative would still result in deterioration of trout habitat in the Designated Trout Stream on the Dark River and these impacts would be similar to those described under Alternative A. Additionally, potential increases in the methylation of mercury due to increased sulfate levels may impact other recreational and fisheries activities within the Sandy/Pike River and the Dark River, as well as Pike Bay and Lake Vermilion more generally.

Alternative C: No Build (No Action)

Under this alternative, no further project actions would take place and seepage would continue to occur from the tailings basin. Under this scenario, the concentrations of dissolved solids in the tailings basin water would continue to increase over the long term, along with associated downstream impacts. Methylation of mercury may increase due to increasing sulfate concentrations in tailings basin seeps. It is expected that this, in turn, would continue to degrade the fishery resource, with related economic and social impacts.

Alternative D: Alternative Technologies

Tailing Basin Perimeter Dike Raising - this alternative would have similar impacts on surface water quantity as discussed under Alternative C above. However, increased methylation of mercury due to increased sulfate levels may occur and would likely also impact other recreational and fisheries activities within the Sandy/Pike Rivers and Dark River, as well as Pike Bay and Lake Vermilion.

Water Level Reduction - this alternative is focused on water recycling and as such would result in long-term increases in dissolved solids concentrations in the tailings basin water. There would be no impacts associated with surface water quantity, but surface water quality may be degraded and impact socioeconomic resources.

Water Level Reduction through Process Water Adjustment - There would be no impacts associated with surface water quantity, but surface water quality may be degraded and impact socioeconomic resources.

Alternative E: Design Alternative

Siphon Placement - if discharge water with a temperature different from the receiving water were released, thermal impacts to biota in the receiving system may occur. This, in turn, would have an impact on trout habitat and potentially on tourism.

Alternative F: Modified Scale or Magnitude Alternatives

Almost any additional discharge from the tailing basin would likely exceed water quality standards, as well as result in increased concentrations of dissolved constituents such as sulfate, in downstream waters that would place additional potential stress on remaining rice plant communities. Although basin and discharge sulfate concentrations will decrease with continued discharge from the basin, long term discharges would likely still have impacts on wild rice viability. Related socioeconomic impacts similar to those described above for the proposed project would be expected.

Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

It is concluded that the SPB system, while a potentially useful tool to reduce sulfate levels, would not, by itself, reduce those levels to meet wild rice growth and production criteria within the Sandy River. In addition, the system may result in increases in concentrations of other constituents. This alternative would, therefore, be likely to result in similar socioeconomic impacts as described under the proposed project.

MITIGATION MEASURES

Two mitigation scenarios have been developed to address impacts associated with the No Build and discharge alternatives, as briefly described below:

- Mitigation Scenario 1 - this mitigation scenario entails the continuous discharge of 8 cfs of SPB treated effluent directly to the St. Louis River Watershed via a Currently permitted discharge point (Permit No. MN0052493, Outfall SD001). Outfall SD001 discharges to an unnamed ditch that empties into the West Two River Reservoir. The reservoir subsequently discharges to the East Branch of the West Two River through a man-made spillway.. Implementation of this scenario would result in total sulfate mass loadings that are less than those associated with the current pit dewatering discharge to the south. This scenario would likely involve diverting some of the existing pit dewatering flow to Minntac for plant makeup water. In addition, under this scenario, SPB tertiary treatment would likely be required to address water quality issues. The primary benefits associated with Mitigation Scenario 1 include the following:

  - No major impact to baseline hydrology
  - Reduction in overall total sulfate mass loading
  - Decreased risk of mercury bioaccumulation
  - No impacts to downstream wild rice beds due directly to the discharge
  - No major impacts to socioeconomic resources

- Mitigation Scenario 2 - this mitigation scenario entails the continuous discharge of 8 cfs of tailings basin water through Outfall SD001 in conjunction with SPB treatment of wet scrubber effluent that is discharged to the tailings basin. Under this scenario, SPB tertiary treatment would also likely be required to address water quality issues. The primary benefits associated with Mitigation Scenario 2 include the following:

  - No major impact to baseline hydrology
  - \- No impacts to downstream wild rice beds due directly to the dischargeNo increase in overall total mercury mass loading.

Conclusions

An EIS is intended to provide information about the extent of potential environmental impacts of a proposed project and how they may be avoided or minimized. The EIS is not intended as a means to approve or disapprove a proposed project, but simply a source of information to guide the Responsible Governmental Unit (RGU) in this case the MPCA, on approval decisions. Occasionally, the EIS information results in an alternative site or design being selected. More commonly, the information helps the RGU with suggested changes or mitigative measures to minimize potential impacts that can later be imposed via governmental approvals. However, the legal basis for choosing an alternative other than the proposer's preference or for imposing mitigative measures comes from other statutory authorities. Again, the EIS can only point out problems and solutions, it cannot enforce them.

As indicated previously, MPCA can select one of the alternatives evaluated within the EIS or a combination of alternatives. In addition, MPCA can impose special conditions and/or additional mitigation strategies on the selection that may be ultimately permitted to insure protection of environmental and socioeconomic resources. Potential mitigation strategies, such as those outlined above, may be considered in the alternative selection process. MPCA may require additional site-specific evaluations prior to final design and implementation of the selected action.

The EIS did analyze seven alternative categories including the proposed project, with most all of the alternatives showing various degrees of environmental impact to the surrounding watersheds. Although there were some hydrologic impacts that were identified as being of concern, a majority of the negative impacts were related to water quality and the increase of constituent concentrations in the Dark and Sandy Rivers with the various discharge alternatives. Impacts of the proposed new discharge to the Dark and Sandy Rivers would diminish with time if pollutant concentrations in the tailings basin and tailings basin seepage are effectively reduced. The maximum downstream impacts generally would be most acute initially. The No Build (No Action) and non discharge-related alternatives will result in steadily increasing levels of dissolved minerals in the tailings basin water and seeps and continued degradation of the Dark and Sandy River Watersheds. The alternative with the least overall impact to the environment would likely be a scenario involving a discharge to mul watersheds at varying rates, and/or a discharge to the south to the West Two River/St. Louis R Watersheds.

1.0 LIST OF PREPARERS

This section provides the names and qualifications of the persons primarily responsible for the preparation of the *Minntac Water Inventory Reduction Project Environmental Impact Statement* (EIS) and related documents.

The Minnesota Pollution Control Agency (MPCA) is the lead agency responsible for the contents of this EIS document. MWH served as the EIS consultant, under the direction of the MPCA, and utilized a variety of subconsultant resource specialists in the preparation of this EIS. The academic background, experience, and responsibilities of contributors to this EIS are outlined below.

1.1 MINNESOTA POLLUTION CONTROL AGENCY

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- 4 years experience in environmental review/MPCA

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- 8 years experience in hydrogeologic and geochemical evaluations
- Surface water hydrology evaluations and impact assessment

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- 8 years experience in aquatic ecosystem evaluations incorporating biological, chemical, and physical parameters
- Aquatic macroinvertebrate (specifically fresh water mussels) evaluations and impact assessment

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- Upland vegetation evaluations and impact assessment

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- 30+ years of experience in environmental science and terrestrial ecology
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- B.S., Biology
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- Natural resources and aquatic ecosystem evaluations and impact assessments

Scott Harder (EFG), ***Socioeconomic Specialist***
- M.S., Civil Engineering
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- 24 years experience as an engineer, financial advisor, and management consultant serving the water and wastewater industry
- Socioeconomic evaluations and impact assessment

Chris Holm Ph.D. (Bois Forte Chippewa Tribe Water Program Director), ***Wild Rice Specialist***
- Ph.D., Forest Resources (Water Quality and Hydrology)
- M.S., Environmental Science (Aquatic Resource Management)
- B.S., Biology
- 18 years of professional and academic experience on in-lake acidification impacts, organic matter process modeling, and wild rice production. Coordinator of an *ad hoc* wild rice work group comprised of all Minnesota Chippewa Bands and non-tribal collaborators
- Wild rice evaluations and impact assessment

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- EIS preparation

Gary Van Riper Ph.D. (Van Riper Consulting), ***Mineral Processing Specialist***

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- B.S., Chemical Engineering
- 30 + years of diversified mining and mineral processing experience, including process evaluation, engineered risk assessments, permitting, regulatory compliance, auditing, due diligence, project reclamation, cyanide detoxification, acid mine drainage generation and treatment, industrial wastewater treatment, and hydrologic and geochemical impacts of mining and smelting operations
- Mineral processing procedures assessment

2.0 PROJECT DESCRIPTION

This section of the EIS presents a general introduction to the proposed Minntac Water Inventory Reduction Project (proposed project). It provides background information, discusses the project's regulatory framework, summarizes scoping activities and project issues, describes the existing facilities and operations, and outlines the proposed project. Discussions are contained in seven subsections, as follows:

- **Section 2.1, Introduction**, briefly introduces the proposed project and describes the project scope and objectives.
- **Section 2.2, Project Background**, presents a brief project history and outlines current operations.
- **Section 2.3, Regulatory Framework**, outlines the regulatory framework within which this EIS is being prepared and summarizes the status of the current discharge permit.
- **Section 2.4, Scoping Process and Project Issues**, describes the scoping process, including the Scoping Environmental Assessment Worksheet and Final Scoping Decision Document. In addition, it outlines issues identified by the public and agency participants during the scoping process
.
- **Section 2.5, Environmental and Socioeconomic Setting**, presents an overview of existing conditions within potentially affected environmental/socioeconomic resources. These resources include geology, water, wetlands, wild rice, aquatic resources, wildlife, upland vegetation, and socioeconomic resources.
- **Section 2.6, Existing Facilities and Operations**, describes current facilities and operations and includes an overview of the process water balance.
- **Section 2.7, Proposed Project**, further describes the proposal and presents a conceptual-level design schematic.

2.1 INTRODUCTION

This EIS was prepared by the MPCA on a proposal by U.S. Steel Minntac (Minntac) located on the Mesabi Range in the city of Mountain Iron, St. Louis County, Minnesota, as shown on Figure 2-1, *General Location Map*. Minntac, the largest taconite facility in North America, is a part of the U.S. Steel Corporation. Minntac mines and processes taconite, a mineral rock bearing 15 to 30 percent magnetic iron particles.

Minntac proposes to discharge water from its tailings basin. The proposed discharge would be approximately 5,000 gallons per minute (gpm). This equates to 11.1 cubic feet per second (cfs) or 7.2 million gallons per day (MGD). The tailings basin is located north of the Laurentian Divide on the Mesabi Range, as shown on Figure 2-2, *Regional Map*. The tailings basin drains to two watersheds: the Dark River watershed to the west, and the Sandy River watershed to the east. The proposed discharges would be located near two currently monitored seepage points that flow into the Dark River (Station 020) and Sandy River (Station 030), as shown on Figure 2-3, *Seepage Discharge Points*.

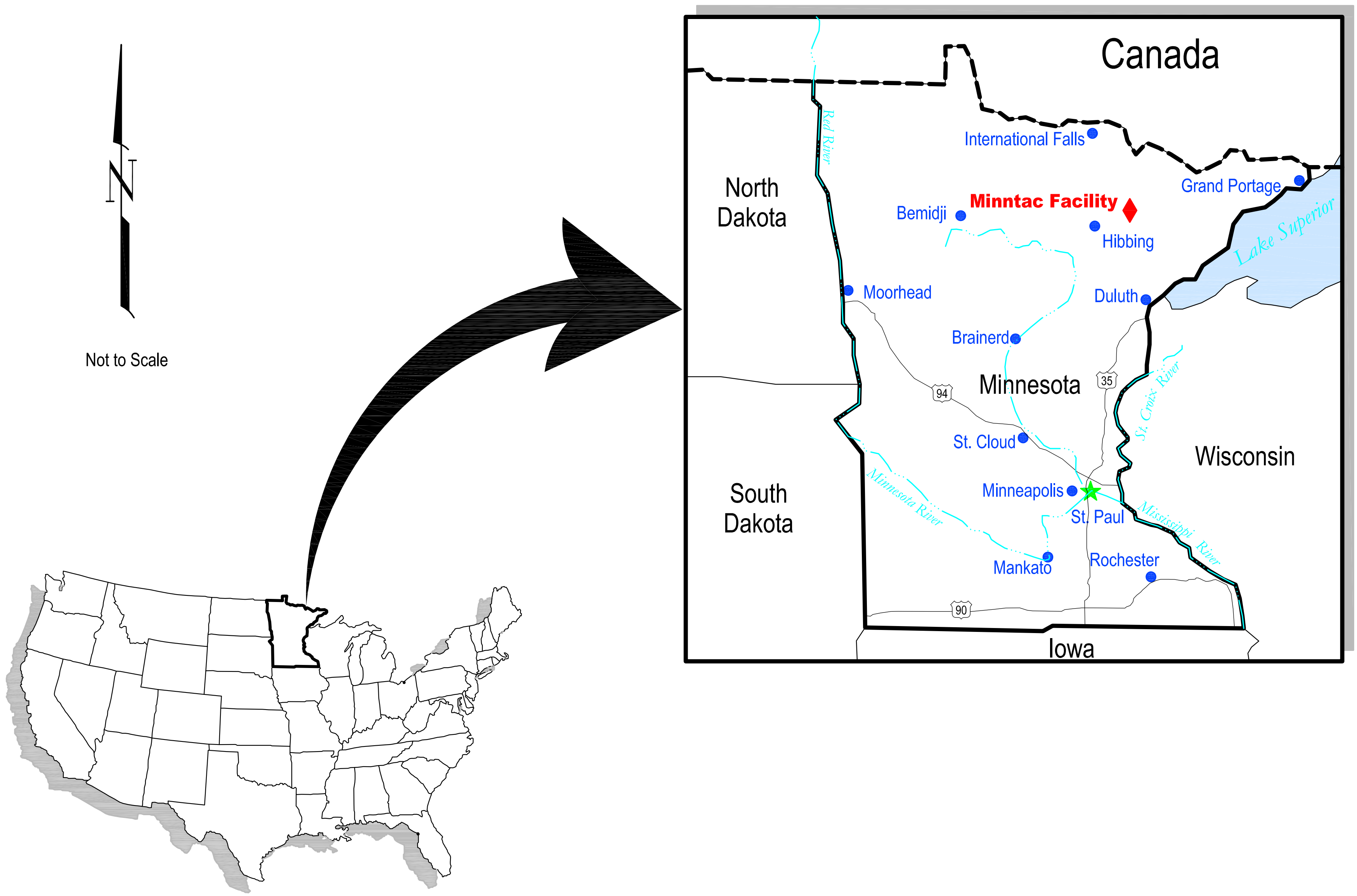


FIGURE 2-1
GENERAL LOCATION MAP

FILENAME: FIG 1-1-GEN LOC MAP.dwg

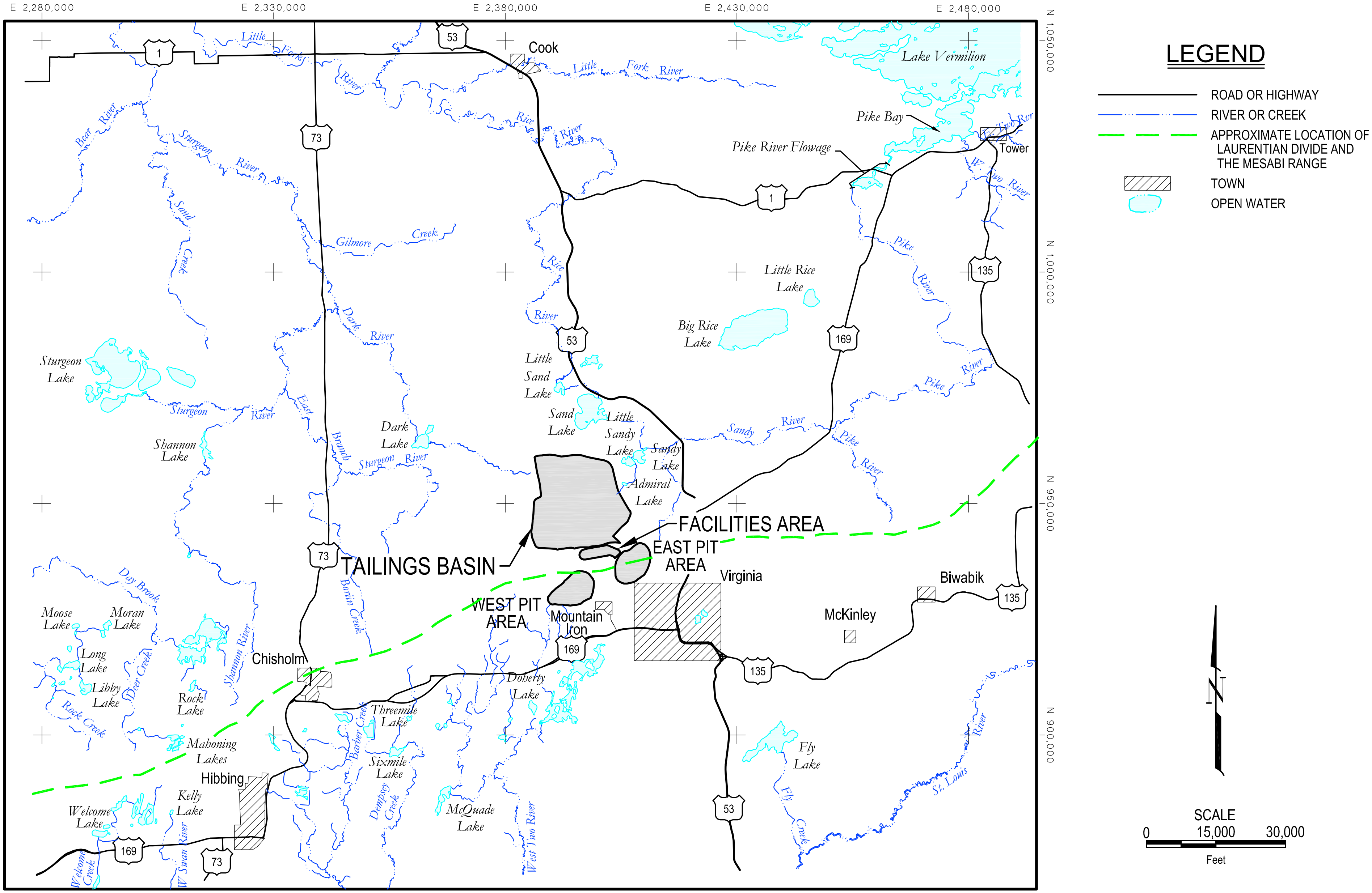


FIGURE 2-2
REGIONAL MAP

FILENAME: FIG 2-2-MINNTAC Regional Map.dwg

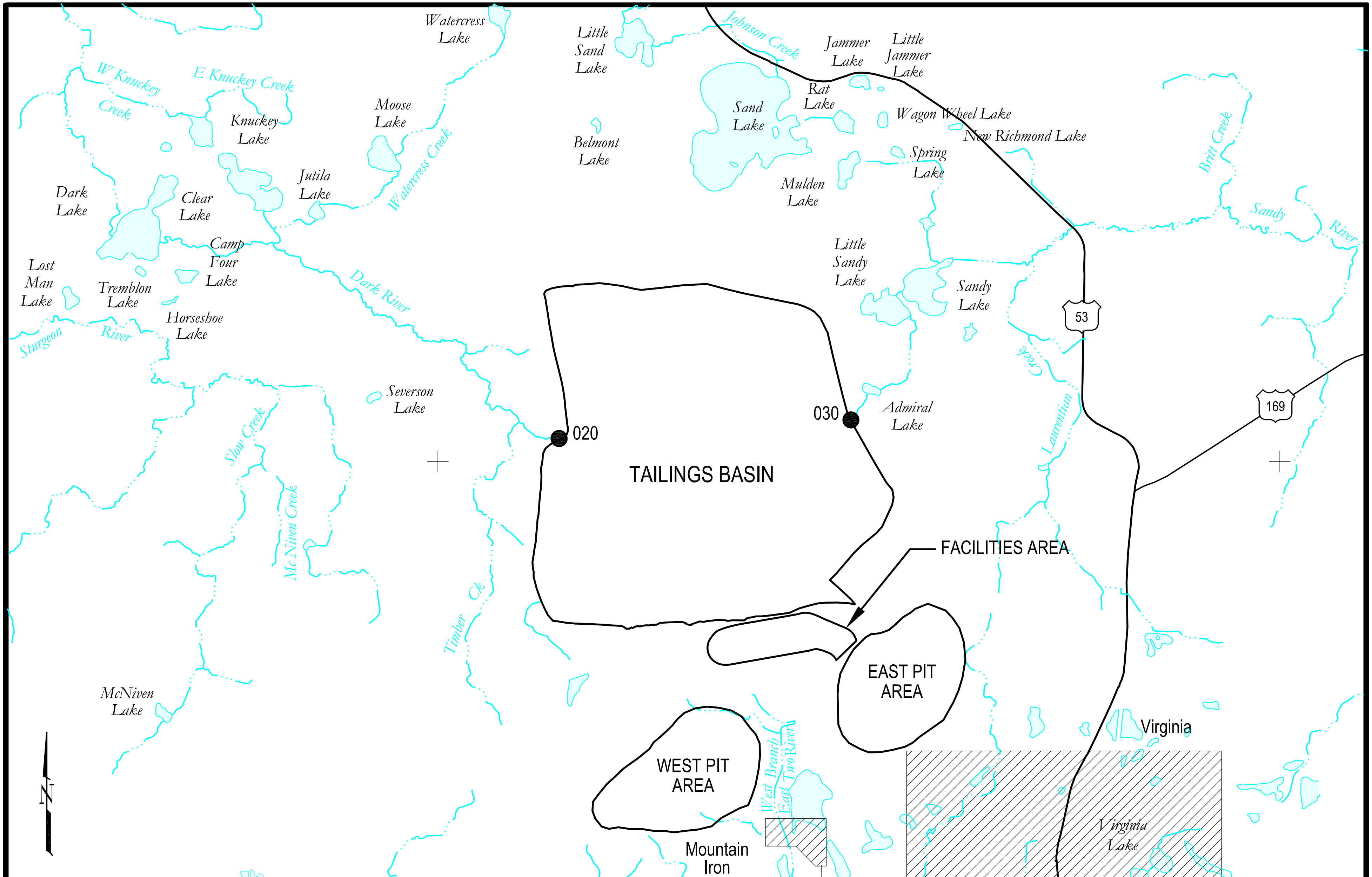


FIGURE 2-3
SEEPAGE DISCHARGE POINTS

FILENAME: Fig 2-3 Seepage Discharge Pnts.dwg

Minntac produces taconite pellets at its facility in Mountain Iron. The concentrated iron pellets are shipped offsite to steel manufacturers. The facility has the capability of producing over 14 million long tons of taconite pellets per year. Each 100 tons of taconite ore processed produces approximately 28 tons of coarse tails and 42 tons of fine tails. "Tails" or "tailings" refer to the gangue resulting from mineral processing in the production of the taconite pellets. An average of 7 million long tons of dry coarse tails and 15 million long tons of dry fine tails are disposed of each year in the basin (URS, 1999). The Minntac tailings basin stores fine and coarse tails, as well as process water for the taconite plant processing operations.

Due to the need to effectively manage process water at Minntac, a new siphon discharge of water from the tailings basin has been proposed. An engineered siphon system would actively move water from within the tailings basin to discharge point(s) in the Sandy River and/or Dark River watersheds. The objective would be to release water at a rate approximately equal to 11.1 cfs. This EIS evaluates potential impacts associated with this discharge to the Dark and/or Sandy Rivers. In addition, alternatives to this proposed project are assessed.

2.2 PROJECT BACKGROUND

The Minntac operations began in the 1960s and were later expanded during the 1970s. Permits issued allowed for construction of the tailings basin to serve as a disposal area for the tailings generated during the processing of taconite and to appropriate and store surface water for use at the facilities. The principal activity at the Minntac facility is taconite processing. The facility has the capability to generate over 14 million tons of taconite pellets annually. The Minntac processing plant consists of a series of crushers and screens, a concentrator, an agglomerator, and various auxiliary facilities. The concentrator utilizes a series of mills, magnetic separators, classifiers, hydrocyclones, hydroseparators, screens and thickeners, as well as a flotation process. The agglomerator receives the concentrate, which is dewatered using disc filters. The filter cake is then mixed with bentonite and formed into pellets in balling drums. The pellets are dried, heated and fired in a grate kiln and then loaded for rail transport. When flux pellets are produced, ground limestone and dolomite are added to the slurry prior to disk filtering. The plant uses approximately 250,000 gpm. Most of the process water (~95%) is recycled at the tailings thickeners. Approximately 32,000 gpm is recycled from the tailings basin. The remainder, or make-up water, is from the Mountain Iron Pit Reservoir. A small percentage of the water is consumed during mineral processing. The remainder is discharged as slurry by a gravity system from the plant to the tailings basin (Minntac, 2002).

The general purpose of the tailings basin is to dispose of fine tailings resulting from the processing. During the routine operation of the tailings basin, fine tailings are deposited and water is returned to the processing circuit. These tailings reduce the overall available volume of the tailings basin at a rate of approximately 25 acre-feet per day. Seepage discharges through the dike have been estimated at approximately 3,000 gpm. The water in the basin has elevated levels of dissolved solids, due in part to mineral buildup resulting from the process water being partially recycled for over 30 years. The minerals result from dissolution of the taconite rock, air pollution control scrubbers in the plant, and other chemicals and materials introduced during processing to make the taconite pellets. There is concern about the increasing concentrations of sulfate, chlorides, hardness, and specific conductance of the waters in the basin. These increasing concentrations are not only affecting the efficiency of the processing circuit, but also are detected in the Dark River and Sandy River watersheds downstream.

2.3 REGULATORY FRAMEWORK

Discharges from the seeps at Stations 020 and 030 are permitted under a National Pollutant Discharge Elimination System (NPDES) Permit (Permit No. MN0057207). Under this permit, Stations 020 and 030 are designated SD001 and SD002, respectively. This permit was issued by MPCA in 1987 and expired in 1992. Minntac applied for reissuance in a timely manner and is currently operating under the expired permit, as allowed under Minnesota Rule 7001.0160. The current permit requires Minntac

030 are designated SD001 and SD002, respectively. This permit was issued by MPCA in 1987 and expired in 1992. Minntac applied for reissuance in a timely manner and is currently operating under the expired permit, as allowed under Minnesota Rule 7001.0160. The current permit requires Minntac to monitor the discharges for sulfate and specific conductance. Based on reports submitted by Minntac as required under the permit, elevated levels of these constituents have been noted.

MPCA and Minntac entered into a compliance agreement in December 2001, under which Minntac agreed to evaluate technologies and process modifications to reduce sulfate, specific conductance, hardness, and chloride in the current seepage discharges and assess how efforts to reduce these constituents would be affected by the proposed siphon discharge. Information developed under the compliance agreement is incorporated into this EIS, and will be utilized by MPCA to develop a reissued permit governing discharges from the basin, regardless of whether the proposal that is the subject of this EIS proceeds (MPCA, 2001).

This EIS was prepared by MPCA as a discretionary EIS under the provisions of Minnesota Rule 4410.2000, subparagraph 3(B). A chronological list of primary events leading up to the release of the EIS follows.

- August 21, 2000: Based on Discharge Monitoring Report results submitted by Minntac, MPCA issued a Letter of Warning to Minntac for alleged violations of State water quality rules concerning sulfate and specific conductance in discharges from the tailings basin.

- April 23, 2001: Minntac requested a variance from water quality standards for sulfate, specific conductance, hardness, and chloride in discharges from the tailings basin.

- May 28, 2001: MPCA, acting as the Responsible Governmental Unit (RGU), released the *Draft Scoping Environmental Assessment Worksheet* (EAW) for a 45-day public review and comment period. The Draft Scoping EAW was prepared as the basis for the scoping process for the Minntac Water Inventory Reduction EIS.

- June 19, 2001: MPCA sent a letter to Minntac requesting additional information to complete the variance application.

- June 27, 2001: A public scoping meeting for the *Minntac Water Inventory Reduction EIS* was held.

- July 12, 2001: The public scoping period for the *Minntac Water Inventory Reduction EIS* ended and MPCA began preparation of the *Scoping Decision Document for the Minntac Water Inventory Reduction EIS*.

- October 19, 2001: Minntac submitted responses to the June 19, 2001 MPCA request for information.

- December 6, 2001: Minntac and MPCA entered into a Schedule of Compliance (SOC) agreement, which required that Minntac prepare a Focused Feasibility Study of technologies and process changes to reduce sulfate, specific conductance, hardness, and chloride in the current seepage discharges.

- December 18, 2001: MPCA requested that the MPCA Citizen Board approve the *Scoping Decision Document for the Minntac Water Inventory Reduction EIS*.

- December 21, 2001: The *Final Scoping Decision Document for the Minntac Water Inventory Reduction EIS* approval was signed.

- May 30, 2002: MPCA approved an extension to August 30, 2002 for Minntac to submit the Focused Feasibility Study.

- August 30, 2002: Minntac submitted the *Focused Feasibility Study in Support of Water Quality Standards Variance*.

- October 2002: Based on consideration of the August 2002 *Focused Feasibility Study in Support of Water Quality Standards Variance*, MPCA and Minntac agreed to enter into a new SOC centering on submerged packed-bed reactor (SPB) technology to meet the needs of the SOC and the EIS.

- June 2003: Preparation of Technical Memoranda not dependent on additional data collection related to the SOC commenced.

- October 2003: Minntac and MPCA finalized the new-amended SOC, which required that Minntac prepare a new *Focused Feasibility Study* centering on the SPB technology.

- February 28, 2004: Minntac submitted the SPB *Focused Feasibility Study of the Sulfate-Reducing Packed-Bed Technology in Support of Water Quality Standards Variance*, after which the project proceeded with the preparation of the remaining Technical Memoranda.

- June 2004: Preparation of the Draft EIS document was initiated.

- April 2005: The Draft EIS was released for public review.

Section 3.0 of this EIS further describes the status of the NPDES permit, as well as other government approvals and permits required for the proposed Minntac Water Inventory Reduction Project.

2.4 SCOPING PROCESS AND PROJECT ISSUES

MPCA initiated the project scoping process with notice of the availability of the *Draft Scoping EAW* in the *Minnesota Environmental Quality Board (EQB) Monitor* on May 25, 2001. The *Draft Scoping EAW* provided information about the proposed project and potential resource areas of concern and solicited comments from interested parties. A public scoping meeting was held at the Laurentian Environmental Center on June 27, 2001, during the 45-day comment period. Public comments and MPCA's responses to comments were summarized in the *Final Scoping Decision Document*, which was approved by the MPCA Citizen's Board on December 21, 2001.

Major issues identified during the scoping process and addressed within this EIS document are summarized below, by resource area.

Surface Water Hydrology

- Effects of increased flow rates and water level changes on flooding, overland flow, channel scouring, erosion and sedimentation in the affected drainages.

- Changes in magnitude and frequency of peak-flows.

- Impacts on bridges, pipes and culverts and other in-stream structures due to increased flows.

- Potential changes in groundwater flow as related to downstream surface water impacts.

Surface Water Quality

- Water quality impacts from the proposed discharge in the Dark River and Sandy River watershed focusing on concentrations of sulfate, chloride, hardness (calcium/magnesium) and total dissolved solids (TDS).

- Changes in general water quality parameters, including temperature, pH, specific conductance, turbidity, total suspended solids (TSS), dissolved oxygen (DO), alkalinity, and major ions.

- Downstream water quality impacts from trace or minor constituents including, nitrogen compounds (nitrate and ammonia), iron, manganese, mercury/methylmercury, arsenic, fluoride, molybdenum, cobalt, other heavy metals, and organic pollutants (including petroleum hydrocarbons), amines, and other taconite operation chemicals.

- Potential changes in groundwater quality as related to downstream surface water impacts.

- Impacts of proposed alternatives that discharge to drainages other than the Dark and Sandy Rivers directly, specifically, Laurentian Creek, West Two Rivers Reservoir, mine pit lakes, or other Lake Superior basin waters, which are possible discharge sites.

- Impact of water discharged from the SPB system as compared to untreated tailings basin water.

Wetlands

- Potential impacts to wetland vegetation located along streams, rivers, and lakes from hydrologic modifications resulting from the active discharge of water from the tailings basin.

- Potential impacts to wetland communities resulting from water quality changes in downstream waters (i.e., changes in sulfate, chloride, TDS, hardness, fluoride, manganese, mercury, pH, and temperature).

- Potential impacts to wetlands, particularly species in boggy areas, resulting from a possible rise in groundwater levels.

Wild Rice

- Current location and ecological status (distribution and abundance) of wild rice within the Sandy River.

- Reason(s) for decline and absence of wild rice in Twin Lakes.

- Effects of increased water level and flow rate on flooding of rice plants in the Sandy River if water is released directly from the tailings basin; potential physical movement and/or loss of rice seed from growing areas; potential sedimentation and covering of viable rice seeds.

- Timing of increased flow volumes and flow rates in relation to germination and growth impacts to existing wild rice beds in the Sandy and Pike Rivers.

- Effect of potential groundwater flow alteration on wild rice production in the Sandy and Pike Rivers.

- Effect of potential changes in water quality (pH, temperature, TDS, metals, DO, macro- and micronutrients, sulfate, organic pollutants) on wild rice growth and production in the Sandy and Pike Rivers, if the tailings basin acts as a source of these constituents.

- Projection of economic losses accompanying potential loss of wild rice production in the Sandy and Pike Rivers.

- Impact of water discharged from the alternative SPB system to wild rice in the Sandy and Pike Rivers as compared to untreated tailings basin water.

Aquatic Resources

- Available existing information on the aquatic communities of the downstream waters.

- Potential impacts on macroinvertebrates due to water chemistry, temperature, and flow rate and level changes.

- Potential impact on aquatic life species of concern, including the black sandshell, fluted shell creek heelsplitter freshwater mussels, northern brook lamprey, lake sturgeon, brook and brown trout.

- Impacts on trophic state of downstream waters.

- Changes in seasonal downstream water temperatures with respect to fisheries, especially Dark River trout waters and Pike Bay spawning habitat. This includes potential effects due to the relative flows of the proposed discharges versus downstream sources, such as springs.

Wildlife

- Potential effects of changes of water quality on the health of animals or their eggs (amphibians).

- Potential food chain effects of selected contaminants (notably mercury) on top-of-the-chain predator.

- Effects of the flows on foraging success of aquatic hunters.

Upland Vegetation

No upland vegetation scoping issues were identified during the project scoping process.

Socioeconomics

- Potential impact on the quality and quantity of resources and the subsequent influence on the economy.

- Potential long-term and worst-case socioeconomic impacts.

- Potential economic impacts associated with loss or decline of wild rice.

- Potential economic impacts resulting from loss or decline of agriculture.
- Potential impact to tourism resulting from a reduction in the trout population.
- Potential impacts on the tourism industry from changes in surface water hydrology and quality in the Dark/Sturgeon Rivers, the Sandy/Pike Rivers, Dark Lake or Lake Vermilion.
- Secondary impacts associated with potential population decline.
- Potential impacts to recreation along the Dark River Trail, the Little Fork River State Canoe and Boating Route, and other recreational areas.
- Potential impact to property values (residential and businesses) along the Dark/Sturgeon Rivers, the Sandy/Pike Rivers, Dark Lake or Lake Vermilion.
- Potential affects on current land use.

2.5 ENVIRONMENTAL AND SOCIOECONOMIC SETTING

This section presents an overview of the proposed project's environmental and socioeconomic setting. Discussions are presented within the following environmental/socioeconomic "resource areas": general location/land use, geologic resources, water resources, wetlands, wild rice, aquatic resources, wildlife, upland vegetation, recreation resources, and socioeonomic (sociological, employment, and economic) resources. More detailed discussions relating to the existing resource conditions and potential impacts associated with implementation of the proposed project or project alternatives are included in Section 5.0 of this EIS and in the following Technical Memoranda located in Volume 2 of this EIS:

- *Surface Water Hydrology and Quality Technical Memorandum*
- *Wetlands Technical Memorandum*
- *Wild Rice Technical Memorandum*
- *Mercury and Methylmercury Technical Memorandum*
- *Aquatic Resources Technical Memorandum*
- *Mineral Processing Technical Memorandum*
- *Tailings Basin Technical Memorandum*
- *Geotechnical Considerations Technical Memorandum*
- *Socioeconomics Technical Memorandum*

Additionally, Volume II includes the *Wildlife Technical Summary* and *Upland Vegetation Technical Summary*, developed for this EIS.

2.5.1 General Location and Land Use

Minntac is located on the Mesabi Range in the city of Mountain Iron, St. Louis County, Minnesota. The entire Minntac complex covers 37,000 acres including a mine that stretches for 10 miles along the Mesabi Range. The facility includes two mining areas, several processing plants, a heating and utility plant, a water reservoir, and a tailings basin.

The tailings basin is a large surface water and tailings impoundment located to the north of the taconite processing facility. The tailings basin is situated entirely within Township 59 North, Range

18 West. It covers all or part of Sections: 3-10 inclusive; 15-22 inclusive; and 28-30 inclusive. The basin has a present perimeter of 13.6 miles and occupies a total area of approximately 7,900 acres with an open water area of about 2,000 acres. The tailings basin is situated on the north flank of the Laurentian divide at the headwaters of two watersheds, the Dark River on the west and the Sandy River on the east.

The basin was originally permitted in May 1966, and construction of the perimeter dike began that year. Current land use as a tailings basin will not change as a result of the proposed project. The Minntac mine property is adjacent to the tailings basin and the land is used for industrial mining. The proposed project is compatible with the surrounding land use. Other directly surrounding areas are primarily undeveloped and/or used for water recreation. Recreational resources are further described below in Section 2.5.9.

2.5.2 Geologic Resources

This section describes the general geologic setting within the area of the proposed project. More detailed discussions are presented in the *Geotechnical Considerations Technical Memorandum* included within Volume 2 of this EIS.

2.5.2.1 Regional Geology

The Laurentian Divide of the Mesabi Range forms the original high ground and general southern limit of the tailings basin (USS, 1987). The divide trends north 73 degrees east and rises some 1,195 ft above Lake Superior and 323 ft above the 872 ft mean elevation of the bedrock floor in the basin. The Divide, known locally as the Giants Range, is composed on the east by the Ely Greenstone Formation, the oldest bedrock in the area. The greenstone is dense, blackish, dark green meta-basalt and meta-volcanics containing mafic flows with interbedded volcanic tuffs. Lying unconformably on this ancient greenstone is the 2.8 billion-year-old meta-sedimentary Knife Lake Formation. These meta-sediments are composed of steeply dipping (up to 90 degrees) highly deformed, dark greywackes, quartzites, sandstones, and siltstones. Interbedded in these rocks are meta-volcanics and included tuff beds. This mass of Pre-Cambrian country rock has been so heavily metamorphosed that determining whether it is Ely Formation or Knife Lake Formation is difficult to impossible. Both formations are well jointed, but permeability is minimal.

Intruded into these Pre-Cambrian country rocks is a massive, pink, quartz-feldspar-biotite granite, approximately 2.7 billion years old (USS, 1987), known as the Giants Range Algoman Granite. The granite forms steep and generally sharp contacts with the older enclosing rocks. Narrow, granitic dikes intrude into the bedrock adjacent to the granite. Tectonic disturbances after granite emplacement have produced several sets of tight joints. Based on diamond drill cores from numerous locations in the vicinity of the mine and the tailings basin, it is concluded that there are no major structural features in the bedrock beneath the basin area. The Giants Range Algoman Granite is considered impermeable to water flow.

In the southeast ¼ of Section 28, Township 59 North, Range 18 West, there is a steep angled, generally north-south trending fault that has cut off the metavolcanic and metasediment country rocks on the west. The pink Giants Range Algoman Granite west of this fault forms all of the core and highlands of the Laurentian Divide.

The massive pink feldspar granite forms the tight, impervious bedrock floor underlying the glacial and post-glacial sediments that make up 71 percent of the surficial deposits beneath the Minntac tailings basin area.

Two areas of the basin are underlain by the Ely Greenstone Formation and include some of the 180 acres in the southeast corner of the basin and a 325-acre tract in the northwest corner.

2.5.2.2 Local Geomorphic Setting

The bedrock surface beneath the tailings basin has the form of a wide, shallow east to west valley into which are incised several minor east to west trending depressions. The mean bedrock elevation beneath the basin ranges between approximately 846 feet Lake Superior Datum (LSD) to approximately 904 feet LSD.

2.5.2.3 Subsurface Conditions

Prior to development of the mine, approximately 158 boreholes were drilled using a roller bit along the alignment of the perimeter dam and within the proposed tailings basin area. A 2-inch outside diameter split tube was used to sample subsurface soil materials in each bore hole in accordance with the "Standard Penetration Test" (SPT) procedure which records the number of blows from a 140-lb. hammer required to advance the sampler a distance of 12 inches. Approximately eighty of these bore holes extended down to or into bedrock. In addition to the above drilling, hundreds of hand augered, Buda-drilled and hand penetration tests were obtained within the basin. The records of this work are on file in the Mine Engineering and Hydrology Departments at Minntac.

The existing tailings basin area has been glaciated and is located upon Pleistocene glacial deposits and post-glacial peats comprising sediments typical of a sandy outwash plain. Scattered across the basin are isolated clay-boulder knolls. These knolls are underlain by unstratified deposits of boulders and coarse gravel. The sands, silty sands and gravels were carried from glaciers by meltwater. The deposits are typically sorted into discontinuous and interfingered beds or stratified drift. The topography is generally flat, only slightly masking the gently rolling underlying bedrock surface.

The texture and grain size of the glacial deposits indicate, in general terms, the relative distance from the glacial face at the time of deposition. Much of the lower deposit is coarse and well washed, indicating relative closeness to the debris-laden melting ice. Probable re-advances of the glaciers into the outwash areas, introduced the boulder piles. Some of the abundant lower deposits of smaller boulders were probably ice rafted to their present location.

The melting ice front had receded some distance from the outwash plain when the upper silty deposits were laid down to cap the lower, well washed beds. Minor glacial and postglacial streams reworked the deposits into local, typical streambed deposits. Abandoned shallow glacial lakes are now found filled with swampy peat beds. Lake shorelines are composed of peat mixed with all varieties of glacial outwash material and ice-rafted boulders. With the exception of the clay-boulder knolls and the lowest boulder piles, the sediments are well to very well washed, thus producing a high rate of water permeability.

2.5.2.4 Tailings Basin Geologic Conditions

The natural topography in the vicinity of the tailings basin is subdued, gently rolling and heavily glaciated. The subsurface soils are high friction granular sands and gravels. There is no reported slope instability in the area and slope movement has never been reported on any of the dikes, which form the perimeter dam. The underlying granular soils and metavolcanic and metasedimentary bedrock is not susceptible to subsidence or the development of karst.

The soils are generally dense and coarse-grained and not susceptible to liquefaction or strain induced strength reduction. The United States Geological Survey Earthquake Hazards Program classifies the Mountain Iron area as one with very low seismicity. The design peak horizontal bedrock acceleration for the 475-year return period earthquake (10% probability of exceedance in 50 years) is 0.006 g. The design peak horizontal bedrock acceleration for the 1,000-year return period earthquake (5% probability of exceedance in 50 years) is 0.011 g.

The existing tailings basin is isolated from any surface stream inflows. The only sources of water are discharge from the tailings process and accumulation of rainfall and snowmelt within the basin area.

Major geotechnical constraints are not anticipated with implementation of the proposed project or project alternatives. Several geotechnical design considerations, however, are described within the *Geotechnical Considerations Technical Memorandum.*

2.5.3 Water Resources

This section presents a general description of water resources within the area of the proposed project. More detailed discussions are presented Section 5.0 of this EIS and in the *Surface Water Hydrology and Water Quality Technical Memorandum* included within Volume 2 of this EIS.

2.5.3.1 Watershed Description

The Minntac tailings basin lies at the headwaters of the Sandy River and Dark River, which are included in the regional Hudson Bay watershed. The tailings basin is located north of the Laurentian Divide. The terrain is relatively flat lying to gently sloping with areas of wetlands, lakes, and streams.

Dark River

The headwaters of the Dark River begin on the west edge of the tailings basin. The Dark River flows generally northwest through Dark Lake and subsequently into the Sturgeon River approximately 17 miles downstream. The Sturgeon River, in turn, drains into the Little Fork River, as shown in Figure 2-4, *Dark River Watershed*. A portion of the seepage from the tailings basin flows west into the Dark River watershed.

The Dark River watershed encompasses 51 square miles, including the tailings basin area. Construction of the tailings basin was completed in 1972 and consumed a total of 9.5 square miles (approximately 18 percent) of the entire Dark River watershed, effectively altering stream flow conditions (MDNR, 1987; Adams, 1983). The Sturgeon River, just below the confluence with the Dark River, drains a watershed area of approximately 266 square miles.

The Dark River watershed contains several lakes and wetland areas along the mainstem of the Dark River. In addition, a stretch of the Dark River, beginning approximately 3.5 miles downstream of Dark Lake and continuing to the confluence with the Sturgeon River, is a Designated Trout Stream, as discussed further in Section 2.5.6.

Sandy River

The headwaters of the Sandy River begin on the east edge of the tailings basin. The Sandy River continues for approximately 12 miles through Admiral Lake and through and past the Little Sandy and Sandy Lakes ("Twin Lakes"), to its confluence with the Pike River, as shown in Figure 2-5, *Sandy River Watershed*. The Pike River continues north and ultimately empties to Pike Bay of Lake Vermilion. A portion of the seepage from the tailings basin flows east into the Sandy River watershed.

The Sandy River drainage area totals 65 square miles, and the drainage area of the Pike River at Pike Bay totals 192 square miles. Approximately four square miles of the Sandy River watershed was consumed by the tailings basin (Adams, 1983).

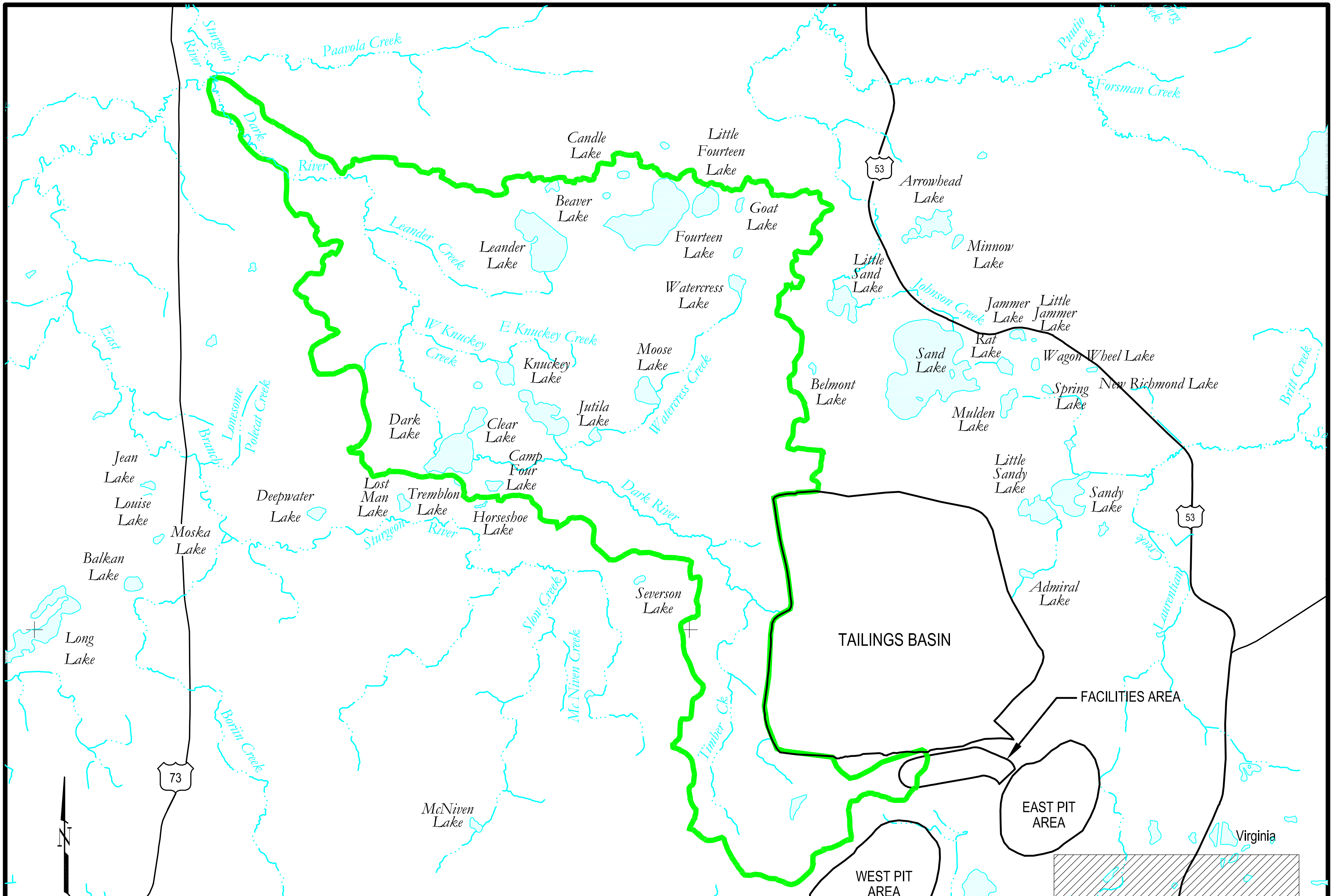


FIGURE 2-4
DARK RIVER WATERSHED

FILENAME: Fig 2-4 Dark Rvr Wtrshd.dwg

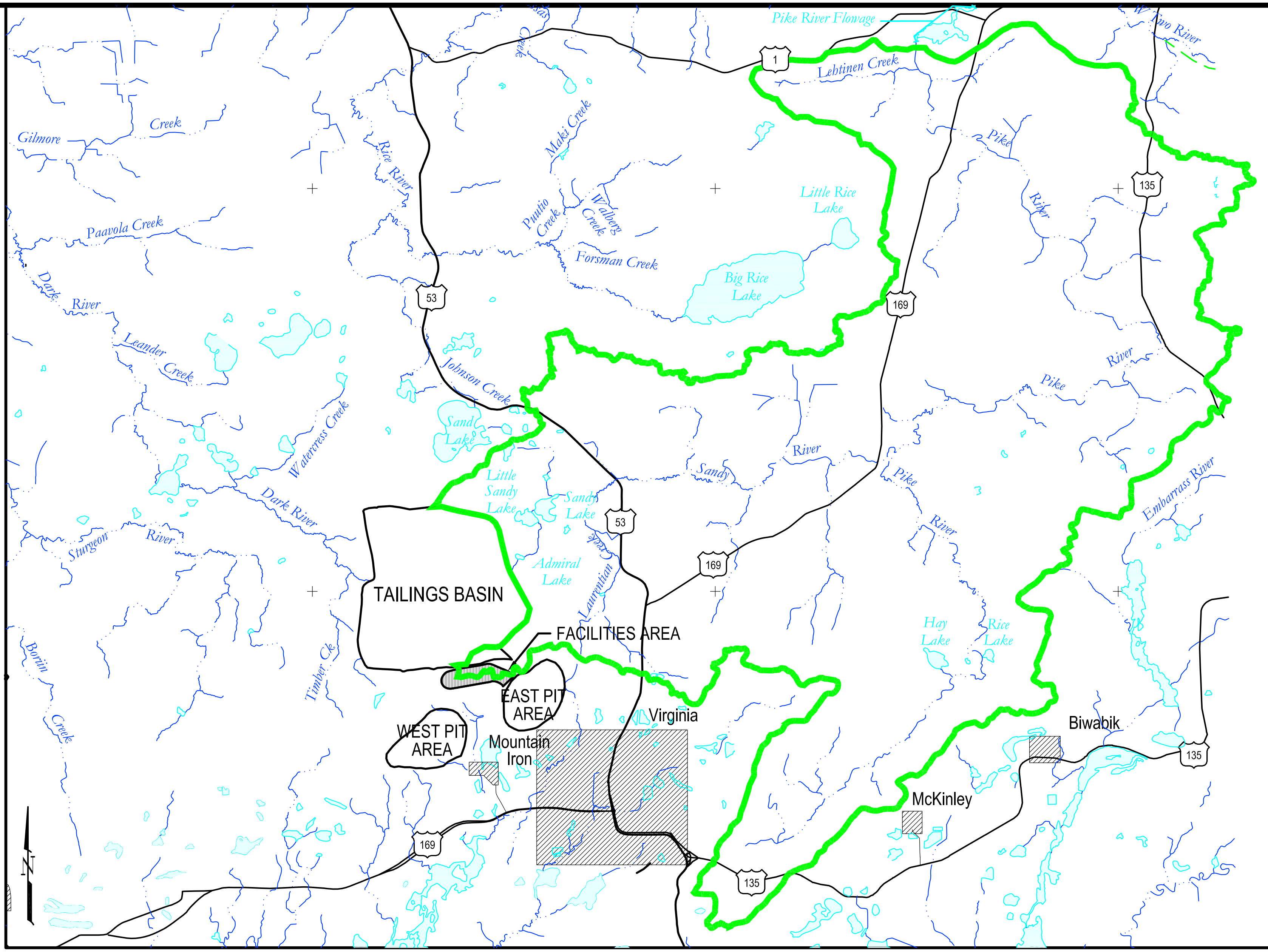


FIGURE 2-5
SANDY RIVER WATERSHED

FILENAME: Fig 2-5 Sandy Rvr Wtrshd.dwg

The character of the Sandy River is best defined as slow, non-flashy, dark-water stream flow. The Sandy River winds through extensive lowland vegetation, minerotrophic shrub swamp, and bog, along nearly its entire route to the Pike River. River width ranges from 2-3 feet in some locations near the headwaters to widths approximating 50-60 feet in lower reaches. Wetland areas in upper and mid-reaches of the Sandy River support limited wild rice production, as discussed further in Section 2.5.5.

2.5.3.1 Surface Water Hydrology Summary

Flow within the Dark River and Sandy River basins ranges seasonally with low-flow generally occurring in February and peak-flow generally occurring in April. Monthly average flows within the Dark River varied between 8.6 and 109 cfs at the gauging station at County Road 481. Monthly average flows at the Sturgeon River gauging station downstream of the confluence with the Dark River ranged between 24 and 367 cfs.

Flow within the Sandy River basin showed similar trends, with the monthly average flows within the Pike River ranging between 7 and 276 cfs at the gauging station along the Pike River downstream of Sandy River.

Hydrologic data from these watersheds are summarized in Section 5.0 of this EIS and further details are included in the *Surface Water Hydrology and Water Quality Technical Memorandum* (see Volume 2 of the EIS).

2.5.3.2 Water Quality Summary

In accordance with *Minnesota State Water Rules, Chapter 7050: Waters of the State*s, stream standards are applied to waters within the project area in accordance with the stream use and subsequent classification. Stream classifications and standards, as they pertain to the Dark River and Sandy River watersheds, are described in the *Surface Water Hydrology and Water Quality Technical Memorandum.*

In addition, Minnesota Rule 7052 also applies to discharges to the south of the Minntac facility (i.e., the Lake Superior basin). This rule contains additional mercury standards, which are described in the *Mercury and Methylmercury Technical Memorandum.*

General stream classifications within the potentially affected watersheds of the proposed project are outlined below:

- Class 1 - domestic consumption
- Class 2 - aquatic life and recreation
- Class 3 - industrial consumption
- Class 4 - agriculture and wildlife
- Class 5 - aesthetic enjoyment and navigation
- Class 6 - other designated public uses and benefits

Each of these classifications is further divided into a number of more specific sub-classifications and stream standards are applied in accordance with the specified use within a particular stream segment. A summary of the standards associated with key constituents within the Dark River and Sandy River watersheds (including sulfate, chloride, TDS, pH, fluoride, hardness, manganese, mercury, temperature, and specific conductance) is presented in Section 5.0 of this EIS.

Baseline data, reviewed and summarized in the *Surface Water Hydrology and Water Quality Technical Memorandum,* indicate exceedances of a number of water quality standards during certain flow regimes. Within the Dark River watershed, sulfate, hardness, specific conductance, and manganese standards have been exceeded. Within the Sandy River watershed, sulfate, chloride, hardness, and specific conductance standards have been exceeded.

Baseline data and potential impacts associated with implementation of the proposed project or project alternatives are discussed in more detail in Section 5.0 of this EIS and in the *Surface Water Hydrology and Water Quality Technical Memorandum*.

2.5.3.3 Current Watershed and Management Plans

Rainy River Basin Management Plan

The Rainy River Basin Management Plan (MPCA, 2004) covers goals, objectives, strategies, and indicators designed to maintain or improve the waters of the Rainy River basin, which includes the Vermilion River. The extent of the plan is shown in Figure 2-6, *Rainy River Basin Watershed Plan Area*. One of the goals of the management plan is to identify indicator wetlands for Phase 1 intensive monitoring and analysis, including chemical and biological monitoring. According to the Lake Vermilion Lake Assessment Program Report (MPCA, 2000), Lake Vermilion is a mesotrophic lake with a moderate phosphorous and chlorophyll-a concentration and a healthy fish community. Thus, the management plan for Lake Vermilion calls for development of a plan for protecting the water quality of the lake. Because of its nutrient status, Lake Vermilion would be sensitive to changes in trophic status with increases in the nutrient loading from watersheds.

Large Lake Program

Lake Vermilion is included in the statewide Large Lake Program, which provides for intensive fisheries management of the ten largest lakes in Minnesota. The lake is located in the Northern Lakes and Forests ecoregion and the Rainy River basin. It has an area of 40,557 acres with a maximum depth of 76 feet. The lake is point source impacted, and is only partially supporting its designated uses. The Minnesota Department of Natural Resources (MDNR) manages a walleye hatchery at the mouth of the Pike River where it flows into Lake Vermilion.

Lake Vermilion Land Use Plan

Lake Vermilion is also managed under the *Lake Vermilion Land Use Plan* (St. Louis County, 2004). The extent of Lake Vermilion is shown in Figure 2-7, *Lake Vermilion*. As one of the fastest developing lakes in St. Louis County and Minnesota, Lake Vermilion is experiencing similar development pressures experienced by lakes across the state and nation. These development pressures, along with resident and business concerns, and the *2001 Lake Vermilion Lake Assessment* report by the MPCA, compelled St. Louis County to undertake a planning process to establish a land use plan for lake development to update the current Lake Vermilion plan adopted in 1985. The updated plan will assess current conditions and help guide future development in order to preserve the lake character and quality. The goal of the *Lake Vermilion Land Use Plan* will be to develop a comprehensive lake management plan, including implementation strategies, utilizing available technical information. The *Lake Vermilion Land Use Plan* will provide a long-term framework to address the guiding principals and goals in the following areas:

- Maintain or improve water quality
- Balance development and preservation
- Preserve the "northern" character
- Develop government policy and management practices

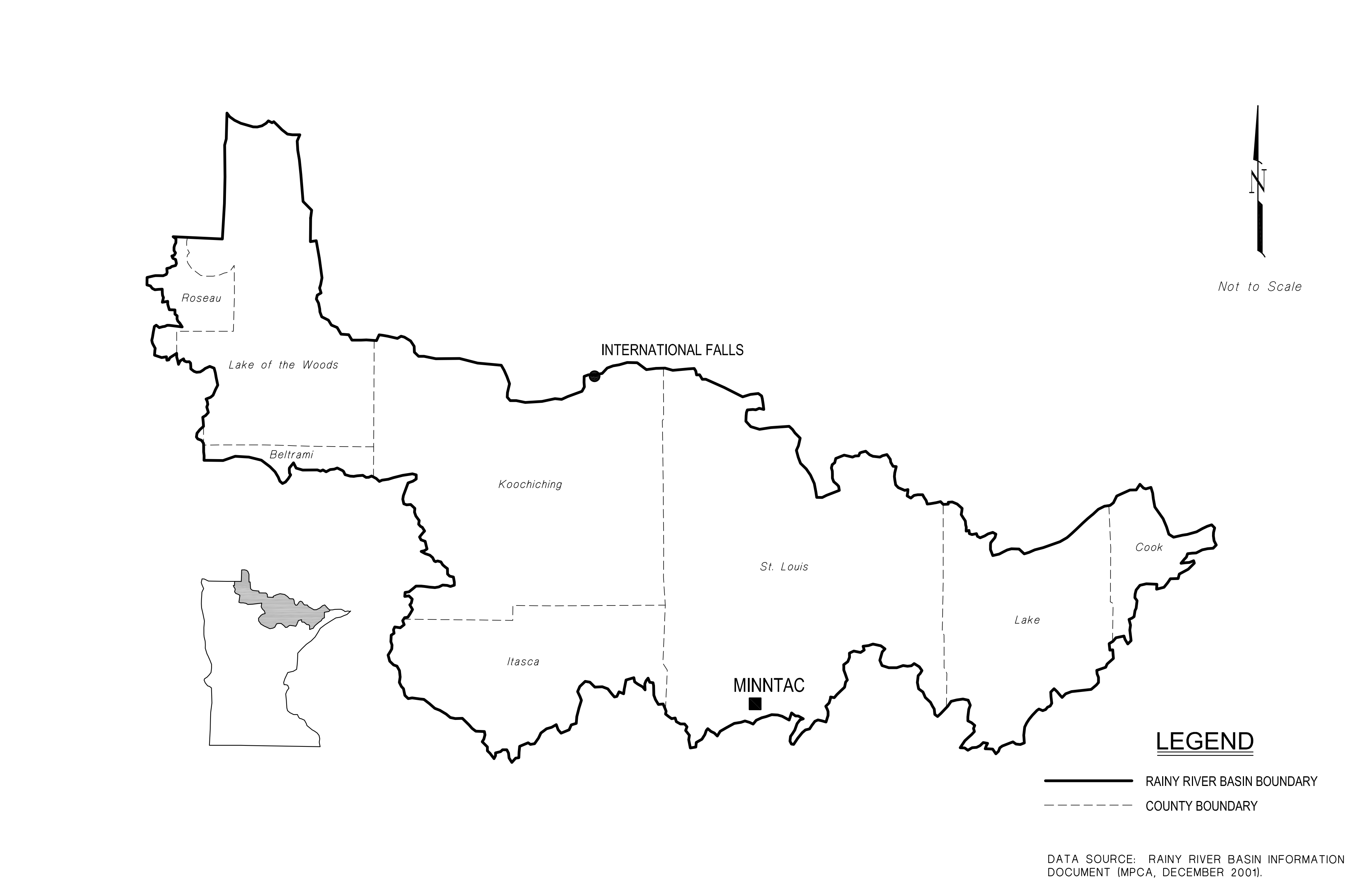


FIGURE 2-6
RAINY RIVER BASIN WATERSHED PLAN AREA

FILENAME: Fig 2-6 Rainy Wtrshd.dwg

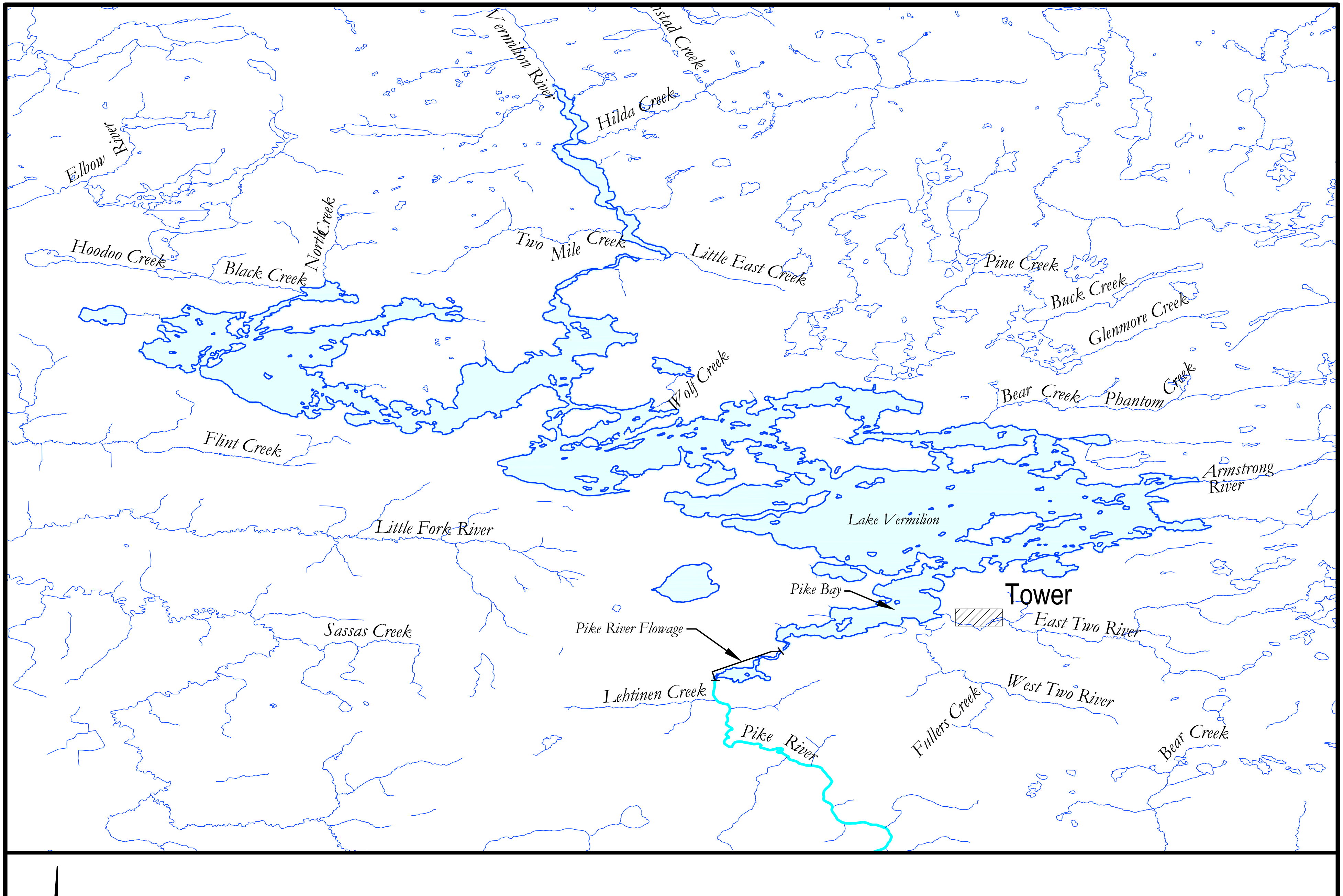


FIGURE 2-7
LAKE VERMILION

FILENAME: Fig 2-7 Vermilion Lake.dwg

Lake Management Plan for Dark Lake

MDNR has prepared a management plan to address resource issues associated with Dark Lake, including the aquatic resources. According to the *Lake Management Plan for Dark Lake* (MDNR, 2000), walleye and northern pike are identified as the primary species of management for Dark Lake, with bluegill and black crappie as secondary management species. Dark Lake has not attained an abundant walleye population, although walleye have been stocked fairly regularly for the past twenty years.

2.5.4 Wetlands

Wetland areas potentially impacted by the proposed project are briefly described below, and the general areas of existing wetlands are portrayed in Figure 2-8, *General Location of Wetland Areas*. More detailed discussions are presented in Section 5.0 of this EIS and in the *Wetlands Technical Memorandum*.

According to the wetland maps provided by St. Louis County, the areas bordering the Sandy River are composed primarily of shrub swamps and bogs. There are also some areas of wooded swamps, but this wetland type is not as abundant as are shrub swamps and bogs. There are also two areas where wet meadow occurs on the Sandy River. The areas bordering Sandy Lake and Little Sandy Lake are primarily shrub swamp and bogs. According to the wetland maps, there is a small area of wooded swamp near the southeast portion of Sandy Lake. Admiral Lake is bordered primarily by shrub swamp, with a small area of bog on the northern portion of the lake. The Pike River is bordered primarily by shrub swamp, with some wooded swamp also present.

The northernmost portion of Laurentian Creek, where it meets the Sandy River, is bordered by shrub swamp, wooded swamp, bog, shallow marsh, and wet meadow wetland communities. The upstream area is bordered primarily by shrub swamp and shallow marsh, with a small area of wooded swamp.

The areas adjacent to Dark River, from the tailings basin discharge area to Dark Lake, are primarily shrub swamps. There are also two areas where wet meadow occurs on the Dark River. Dark Lake is bordered by some shrub swamps, as well as a small area of wooded swamp. On the Dark River further downstream, from Dark Lake to the confluence with the Sturgeon River, there is a narrow strip of shrub swamp along the river and then mostly uplands. At and near the confluence of the Dark River and the Sturgeon River, there is a stretch of wooded swamps as. The Sturgeon River appears to be primarily bordered by upland vegetation.

The wetlands bordering the West Two Rivers Reservoir and its associated water bodies, south of the Laurentian Divide, consist primarily of shrub swamp, bog, and shallow marsh.

Descriptions of each type of wetland community occurring in St. Louis County, Minnesota are provided in the *Wetlands Technical Memorandum* and further discussion of baseline conditions and potential impacts associated with implementation of the proposed project or project alternatives are discussed in Section 5.0.

2.5.5 Wild Rice

Wild rice areas potentially impacted by the proposed project are located within the Sandy River watershed, as indicated in Figure 2-9, *General Location of Wild Rice Areas*.

Wetland characteristics of the Sandy and Pike River watershed make the Sandy and Pike Rivers suitable for production of wild rice. Water currents are mitigated by extensive stream sinuosity and surrounding wetland and bog habitat. These factors buffer the stream against flashiness that could flood and/or uproot immature wild rice plants, or mature plants with weak root systems.

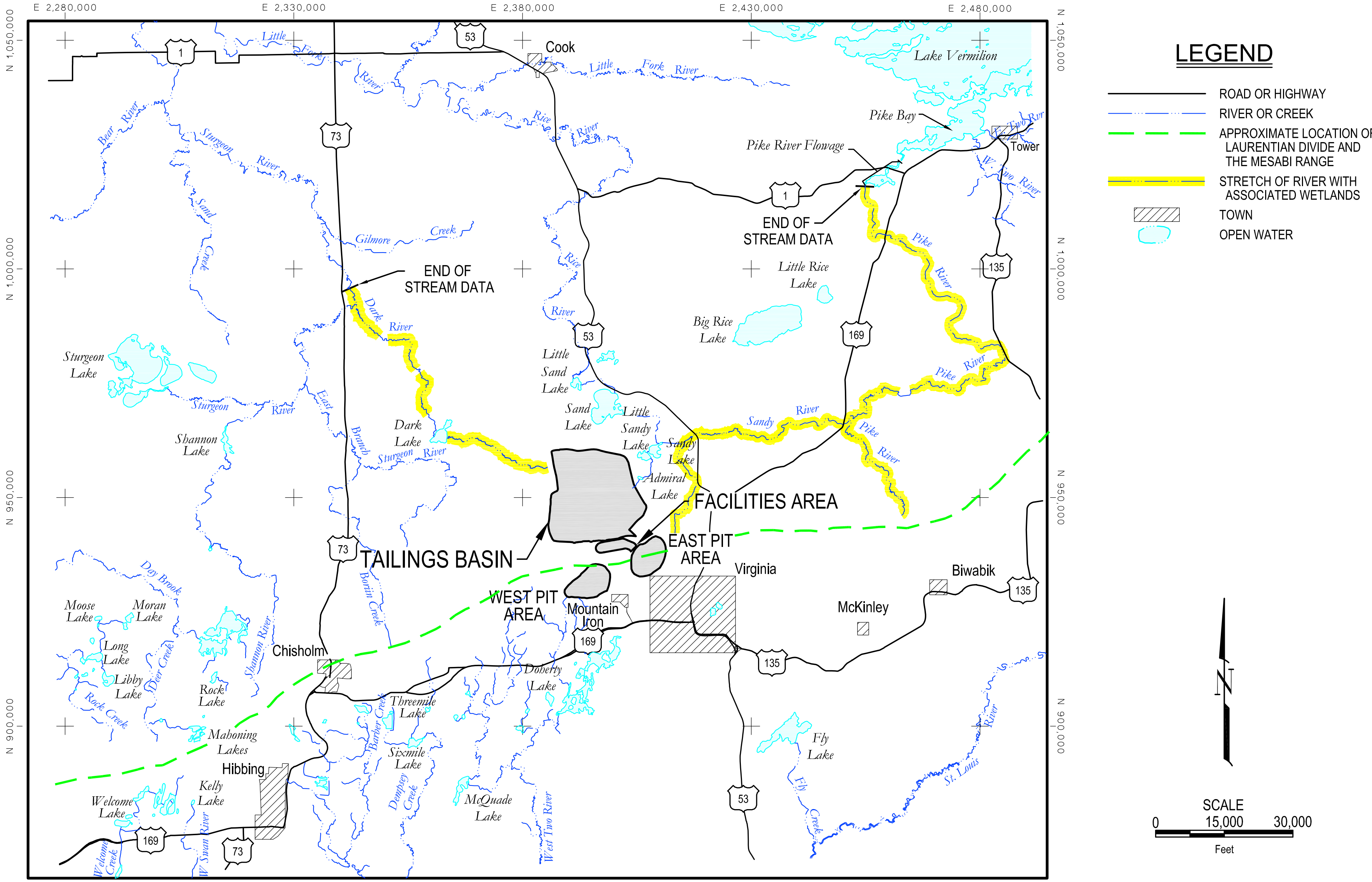


FIGURE 2-8
GENERAL LOCATION OF WETLAND AREAS

FILENAME: FIG 2-8-Genloc Wetlands.dwg

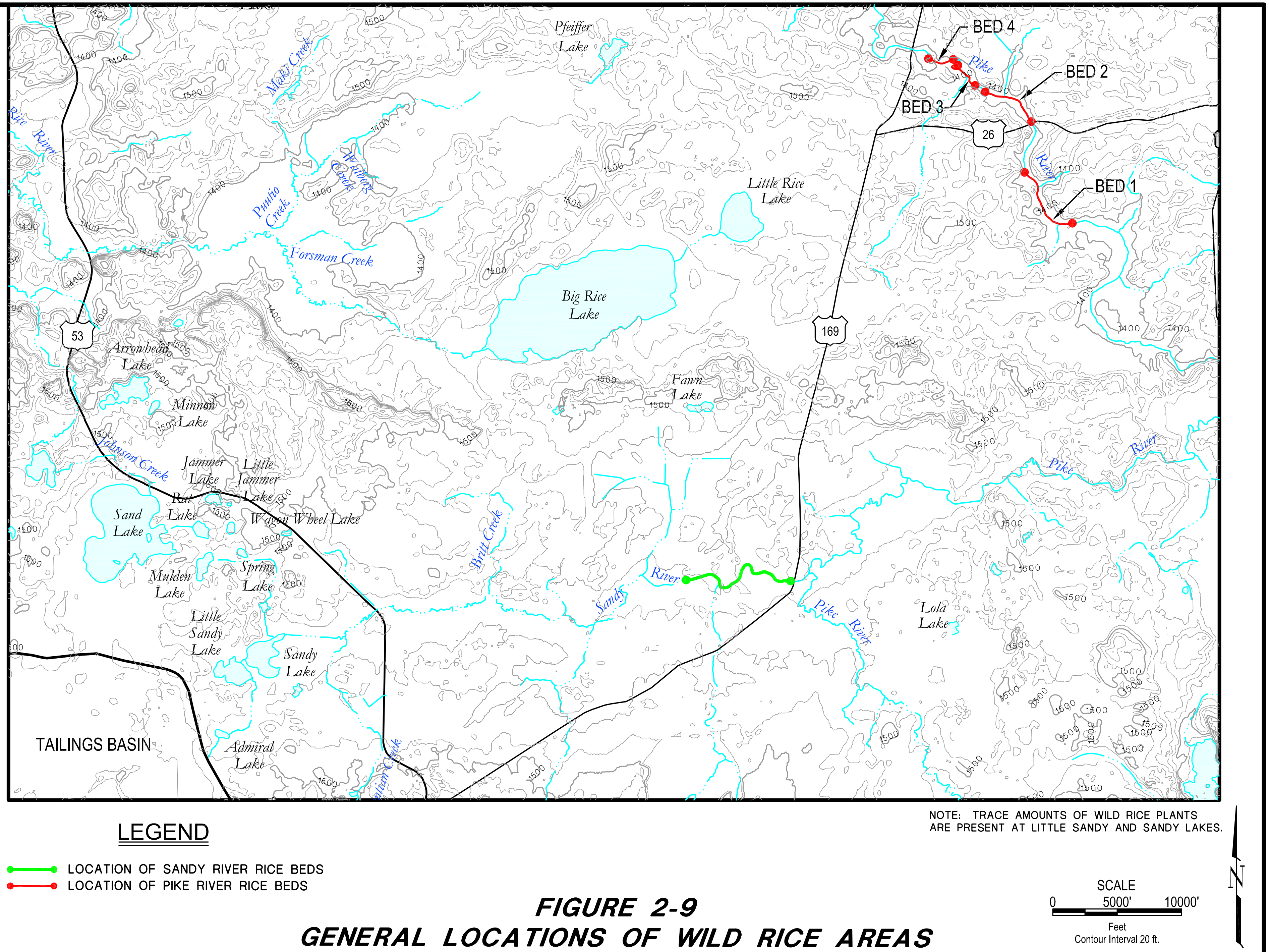


FIGURE 2-9
GENERAL LOCATIONS OF WILD RICE AREAS

FILENAME: Fig 2-9 Genloc Wild Rice.dwg

Slowed water flow also permits rice seed to settle in specific areas (typically in near-shore areas and other friction points of water flow in the stream course, such as river bends and oxbow areas) and establish root systems. Both the Sandy and Pike Rivers are typical northern Minnesota dark-water streams with extensive humic wetland vegetation borders. Annual humic vegetation and plant straw deposition and build-up acts as an insulator, protecting the mineral substrate from freeze-out in winter. This allows under-ice water and substrate temperatures suitable to maintain rice seed in dormancy, while also preserving it against desiccation through freezing.

More detailed discussions of wild rice conditions in the Sandy River basin and potential impacts to wild rice areas associated with implementation of the proposed project or project alternatives are presented in Section 5.0 of this EIS and in the *Wild Rice Technical Memorandum*.

2.5.6 Aquatic Resources

A general description of aquatic resources within the Dark River and Sandy River basins is provided below. More detailed discussions of aquatic resources within these watersheds and potential impacts to aquatic resources associated with implementation of the proposed project or project alternatives are presented in Section 5.0 of this EIS and in the *Aquatic Resources Technical Memorandum*.

The Dark River flows approximately 21 miles, originating from black spruce swamps at the base of the Laurentian Divide. The upper portion of Dark River, upstream of Dark Lake, is predominantly low bog with some flat to gently rolling topography. In this segment, the Dark River is a warm-water stream. Downstream of Dark Lake the topography changes from flat terrain to a steep rolling forested area. Stream temperatures begin to decrease below Dark Lake, and continue downstream. Near County Road 65, the river receives cold-water inputs from several tributaries and springs, lowering the water temperature in this segment. In the downstream portion, the gradient increases and the substrate changes to rock, cobble, and sand. In the lower portion, the stream slows and the substrate is composed mainly of sand.

The Dark River is unique to this part of Minnesota, with groundwater inputs in the lower portions sustaining a cold-water trout fishery, in comparison to the warm-water streams typical of the area. There is evidence that the groundwater inflows are more substantial further downstream of Dark Lake, with increasing numbers of intolerant fish and macroinvertebrate species that are sensitive to changes in water quality. The reach of the Dark River from County Road 65 to the confluence with the Sturgeon River is listed as a Designated Trout Stream under Minnesota Rule 6264.0050 subpart 4. (This section of the Dark River will be referred to as the "designated trout reach": throughout the remainder of this EIS document.) This reach is considered to be one of the best trout streams in the Grand Rapids Fisheries Management Area, and is a high management priority, with self-sustaining populations of brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta)*. The general location of this fishery is shown in Figure 2-10, *Location of Dark River Designated Trout Stream*. Brown trout and brook trout were stocked historically. However, a 1990 MDNR survey noted evidence of natural reproduction of brown and brook trout. Stocking was discontinued in 1991 when populations appeared to be self-supporting.

Other fish species typical of the Dark River basin include:

- Blackside darter
- Common shiner
- Creek chub
- Longnose dace
- Mottled sculpin
- White sucker
- Brown trout

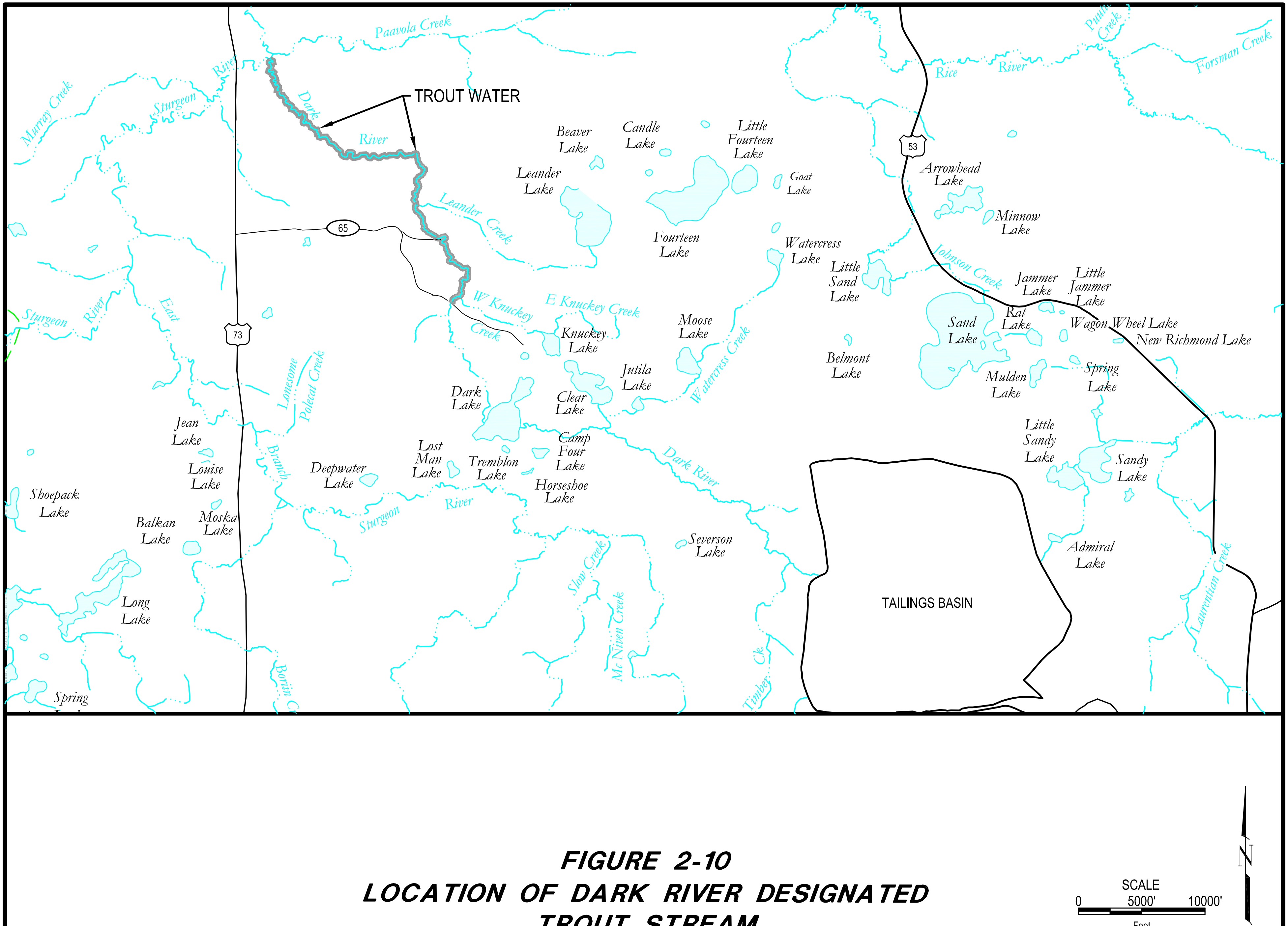


FIGURE 2-10
LOCATION OF DARK RIVER DESIGNATED TROUT STREAM

Fig 2-10 Genloc DRvrTrout.dwg

- Brook trout

The Sandy River is a warm-water stream with an unconsolidated silty substrate, and is more typical of streams in this part of Minnesota. It flows from the headwaters of Sandy and Little Sandy Lakes moving east approximately 7 miles where it drains into the Pike River. Upstream of Highway 53, the land is undeveloped with no residential development on or near the river; downstream of Highway 53, the existing land use is predominately residential, although the riparian areas remain intact and undeveloped. With the exception of the Minntac facility, there is no industrial development along the river.

The Sandy River flows through many local wetlands and lowland boggy areas; wetland shrubs and overhanging vegetation often dominate the riparian areas. During heavy rains, the transport of organic sediments to the stream from area wetlands occasionally results in problems with dissolved oxygen concentrations. The stream carries a high sediment load and is very discolored. By comparison with the lower Dark River, primarily warm-water fish species are found within the Sandy River. Typical species include:

- Johnny darter
- Blacknose dace
- Burbot
- Central mudminnow
- White sucker

2.5.7 Wildlife

Mammals, birds, reptiles, and amphibians found within the area are briefly described below. More detailed discussions of wildlife and potential impacts to wildlife associated with implementation of the proposed project or project alternatives are included in Section 5.0 of the EIS and in the *Wildlife Technical Summary*.

Fifty-three species of mammals are known to occur in the northeastern section of Superior National Forest (U.S.F.S., 2003a), nearly all of which may be assumed to be found within the project study area. Of these, 13 species are classified by MDNR as "species of concern," 16 as "furbearers," 5 as "small game," and 4 as "big game." Two species, the gray wolf and the lynx, are federally classified as "threatened."

J. C. Green (2003) notes that Superior National Forest, with 155 species of breeding birds, contains more species than any other national forest. She lists 223 species as occurring within Superior National Forest; the U.S. Forest Service (USFS, 2003a) lists 207 species of birds, including breeding and nonbreeding species. Although these two documents are not limited strictly to the project study area, most of the listed birds are likely to be found there, due to the variety of habitats represented. Among the 207 species of birds listed by USFS (2003a), two, the peregrine falcon and the common tern, are considered by MDNR to be "threatened" and one, the northern bald eagle is listed as of "special concern" by MDNR and "threatened" by the Federal government. A blue heron rookery and a bald eagle nest are located on an island in the tailings basin, approximately one mile from the proposed project location. These bird habitats were established after the mine began operation, and to date, normal mine and tailings basin operations and activities have not appeared to affect them (MPCA, 2001).

Seven species of reptiles are known to occur in the Subsection Forest Resource Management Plan (SFRMP) area of Superior National Forest. These include four turtles and three snakes. One turtle, the snapping turtle, is of “special concern” to MDNR, while two turtles, the wood turtle and the Blandings turtle are designated “threatened” by MDNR.

Four species of salamanders, one toad, and seven frog species occur in the eastern sector of Superior National Forest. None of these is considered threatened or endangered by State or Federal authorities, or "of concern" to the MDNR.

2.5.8 Upland Vegetation

Upland vegetation is briefly described in the following paragraphs. More detailed discussions of upland vegetation and potential impacts to upland vegetation associated with implementation of the proposed project or project alternatives are included in Section 5.0 of the EIS and in the *Upland Vegetation Technical Summary*.

Upland vegetation in the project area is a mosaic of forest types, including aspen, birch, black spruce, pine, spruce/fir, tamarack, cedar, and northern hardwoods. The project site is located in central St. Louis County in northeastern Minnesota. This area lies within the conifer – hardwood forest zone of Minnesota (Aaseng et. al., 1993) and is comprised of a number of overlapping sub-zones including deciduous forest, northern hardwood – conifer forest, white pine – hardwood forest, upland white cedar forest, jack pine forest, white pine forest, northern hardwood forest and oak forest.

The Dark River watershed has predominantly aspen and pine stands; the Sandy River watershed contains predominantly pine and black spruce stands with small areas of aspen (USFS). Available land cover data for the project area is not complete and not continuous along the primary discharge drainages potentially affected by the project.

The predominant forest type in the project area (from MDNR color aerial photography) appears to be aspen forest. Small stands of mixed spruce/fir, birch and black spruce are scattered throughout the area. Differentiation between aspen forest and aspen-birch forest types (Aaseng et. al., 1993) is not possible from the available images alone. The aspen forest canopy is comprised mainly of quaking aspen (*Populus tremuloides*); the understory is brushy and American hazelnut (*Corylus americana*) is a frequent species (Aaseng et. al., 1993). The aspen-birch forest canopy is a mixture of quaking aspen, bigtooth aspen (*Populus grandidentata*) and paper birch (*Betula papyrifera*). Understory species include beaked hazel (*Corylus cornuta*), mountain maple (*Acer spicatum*) and saplings of later successional species (Aaseng et. al., 1993).

Both aspen and aspen-birch forests are early successional and occur in areas of prior disturbance – fire, logging or wind throw. Aspen forest occurs in wetter localities with poorly drained soils.

The Superior National Forest has proposed management alternatives for the *Virginia Forest Management Project EIS*. Special Management Complexes (SMC) are proposed in the EIS. Proposed SMC 114 includes areas around Sandy and Little Sandy Lakes and the Sandy River; these areas in the Sandy River watershed lie within the potential impact area of the proposed project. Laurentian Creek from the confluence with the Sandy River to approximately one mile upstream lies within SMC 114. There are no SMCs in the Dark River watershed within the potential impact area.

2.5.9 Recreation Resources

Several important recreation resources are located within the Sandy River and Dark River watersheds. Two of particular interest, the North Dark River Trail and the Little Fork River State Canoe and Boating Route, are briefly described in the following paragraphs.

The North Dark River Trail is a 1.3 mile hiking trail located 11 miles northwest of the town of Virginia, as shown on Figure 2-11, *North Dark River Trail*. The Trailhead is located off County Road 668 in the Superior National Forest.

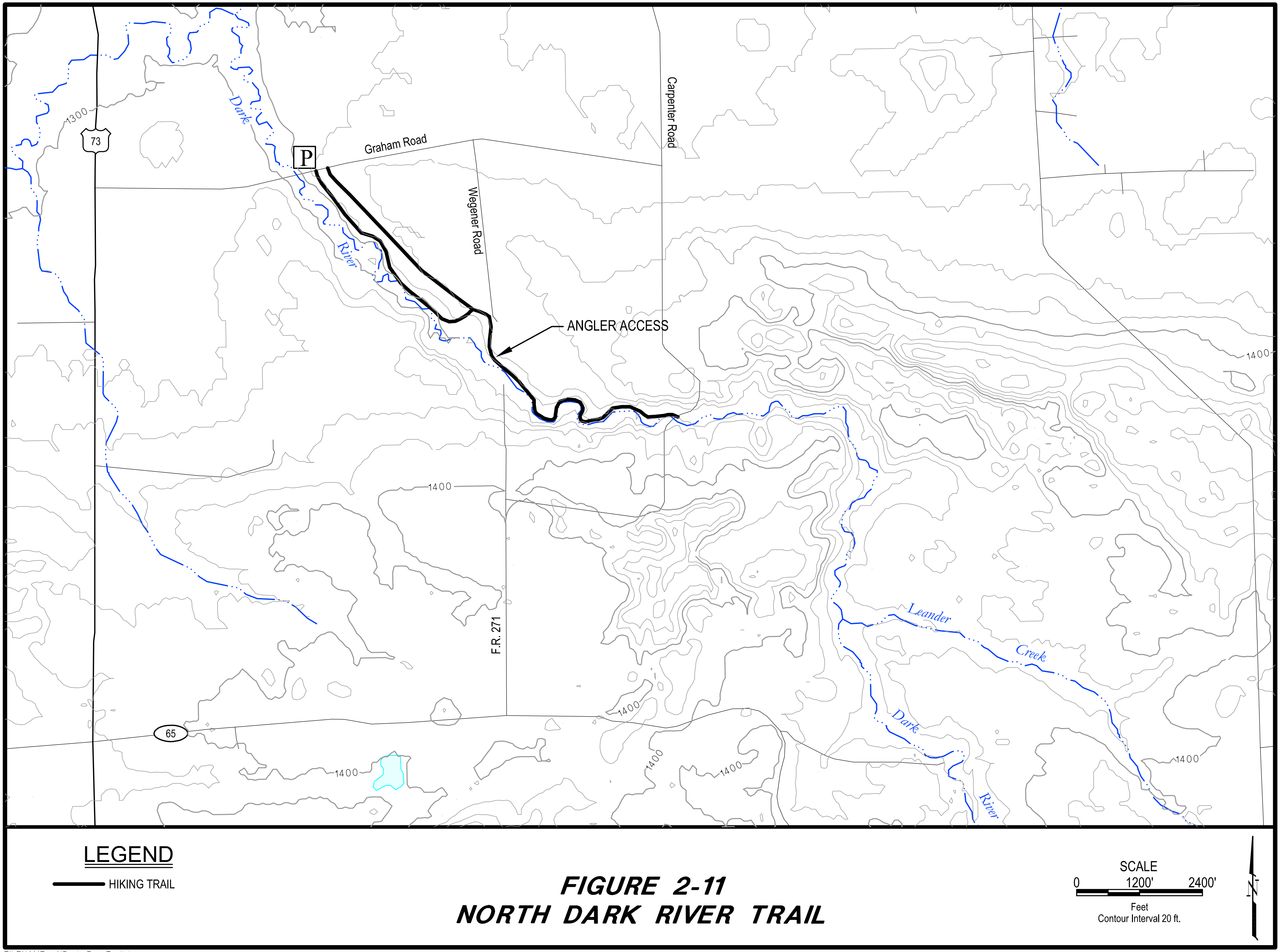


FIGURE 2-11
NORTH DARK RIVER TRAIL

FILENAME: NDark Rvr Trail.dwg

The trail follows the east bank of the Dark River through jack pine forest plantation and loops back on an old logging road. It is a scenic trail with views of the Dark River gorge and sandy valley.

The Little Fork River State Canoe and Boating Route is a 135-mile long State-designated canoe route along the Little Fork River that runs through farmland and the upper and lower reaches of the river, as shown on Figure 2-12, *Little Fork River State Canoe and Boating Route*. The 50 miles below the town of Silverdale is remote and primitive with thick forests and tamarack bogs. It is generally to be used by experienced whitewater canoeists only and includes short stretches of Class-II rapids separated by long stretches of quiet river. There is also abundant wildlife along the route.

2.5.10 Socioeconomic Conditions

A general description of the socioeconomic conditions in the vicinity of the proposed project is provided below. More detailed socioeconomic data and potential impacts to socioeconomic conditions associated with implementation of the proposed project or project alternatives are presented in Section 5.0 of this EIS and in the *Socioeconomic Technical Memorandum*.

The study area encompasses portions of St. Louis County located within the Dark River and Sandy River watersheds. These portions include the cities of Mountain Iron and the townships of Wuori, Sandy, Greenwood, Lake Vermilion, Pike, Embarrass, Kugler, Breitung, Great Scott, Sturgeon, Balkan, Linden, Morcom, and Willow Valley. Secondary impact areas include small portions of Koochiching and Itasca Counties.

The total population for St. Louis County is 200,568 (USBC, 2001). The area is very sparsely populated, with a density of 32.2 persons per square mile. Development within the area is characterized by clusters of largely single family dwellings located along rivers and streams, around lakes, and along some thoroughfares. There are many vacation homes and recreational cabins located in the area, particularly along the Dark River and along the Pike River toward Pike Bay and Lake Vermilion.

People in the area work primarily in the wood products, mining, tourism, and service industries. Two sectors, agriculture, (wild rice) and tourism, are of particular interest for purposes of assessing the impacts from the proposed project and alternatives. The vast majority of St. Louis County residents also work in the county, with some workers commuting to neighboring Itasca, Koochiching, Carlton, and Douglas County, Wisconsin. The average unemployment rate in the area is approximately six percent (USBC, 2001). Personal income in St. Louis County was $5.26 billion in 2000, providing a per capita personal income of $26,246 in that year.

2.6 EXISITNG FACILITIES AND OPERATIONS

This section provides an introduction to existing Minntac facilities and operations. More detailed discussions are included in the *Mineral Processing Technical Memorandum, Geotechnical Considerations Technical Memorandum* and *Tailings Basin Technical Memorandum*.

2.6.1 Mineral Processing

Minntac utilizes conventional mining and milling operations to process taconite in order to produce an iron concentrate. A schematic of the process is in Figure 2-13, *Mineral Processing Schematic Flow Chart*. The concentrate is pelletized and indurated to produce hardened iron pellets, which are shipped to steel manufactures. The facility has the capability to generate over 14 million long tons of taconite pellets per year. The Minntac plant consists of a series of crushers and screens, a concentrator, an agglomerator and various auxiliary facilities.

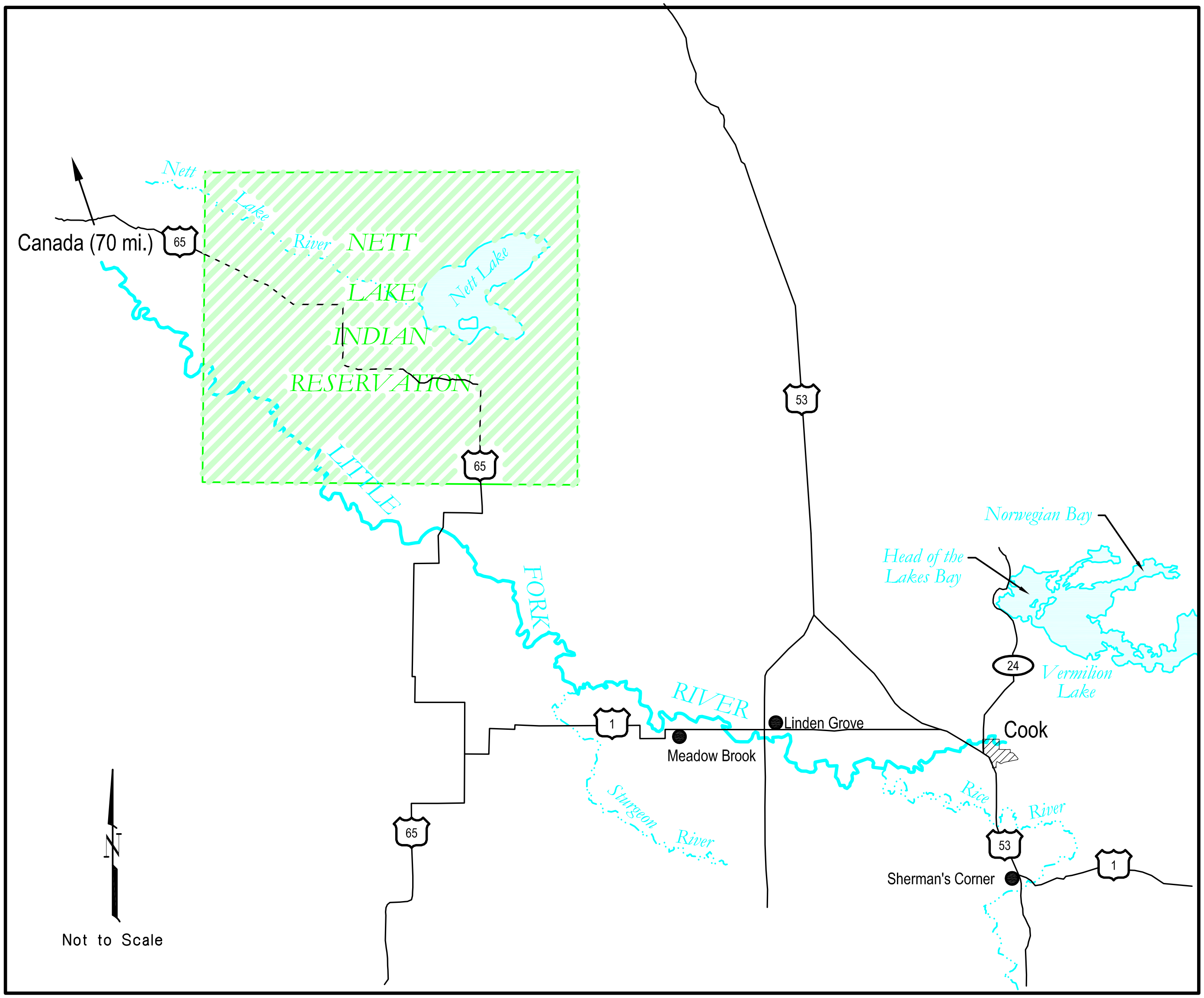


FIGURE 2-12
LITTLE FORK RIVER STATE CANOE AND BOATING ROUTE

FILENAME: Fig 2-12 Little Fork Canoe.dwg

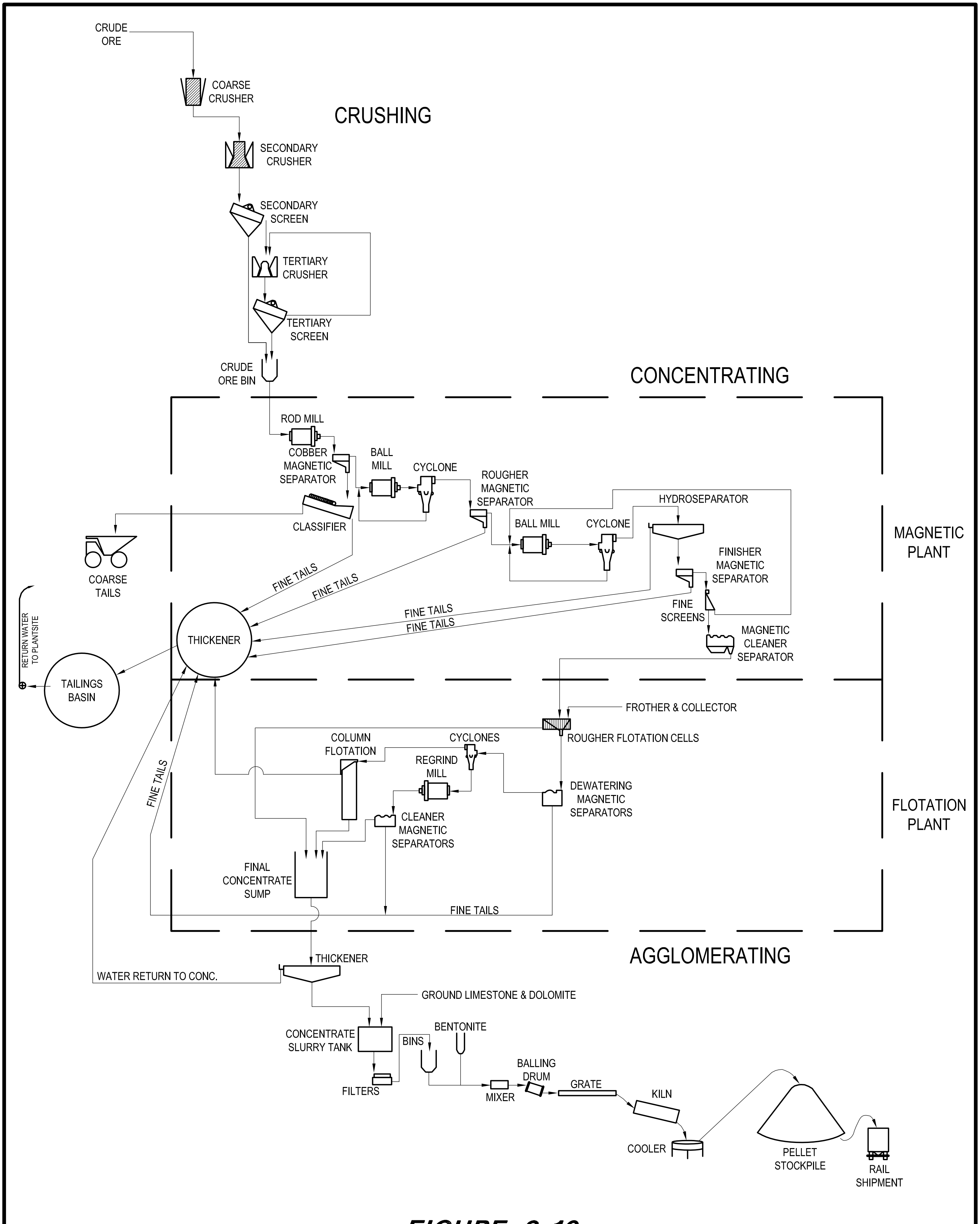


FIGURE 2-13
MINERAL PROCESSING SCHEMATIC FLOW CHART

SOURCE: USS-MINNTAC

FILENAME: FIG 2-13 Min Process Flow.dwg

The concentrator utilizes a series of mills, magnetic separators, classifiers, hydrocyclones, hydroseparators, screens and thickeners, as well as a flotation process. The production rate on a daily basis is approximately 143,000 tons of ore fed into the crushing end of the circuit. Minntac is a very large operation from a mining standpoint, and as such, even minor changes in process sequence, reagent usage, or water transport can represent major capital and operating cost differences. Water quality plays a major part in the overall taconite processing scheme, and since several of the processes represent high temperature operations, degradation in water quality can accelerate corrosion-related failures.

Taconite ore is processed through three stages of crushing: primary, secondary and tertiary. Product from the tertiary crusher is conveyed to a crude ore bin, which serves as the point of feed into the concentrator. Except for the purposes of controlling dust, water is not added to the process through crushing. The purpose of crushing is to initiate reduction in particle size in order to liberate the iron from the host rock.

Following three stages of crushing, the ore is fed to a rod mill for further size reduction. The product from the rod mill is passed through magnetic separators that make the first cut of separating the iron from the host rock. Reject from the primary magnetic separators (cobbers) is termed coarse tails and is sent to the tailings basin, although a significant portion of the coarse tailings is used in the mine operation. The magnetic fraction from the separators is sent through two stages of additional milling in ball mills, and the product from each series of ball mills is also magnetically separated as in the rod mill. Non-magnetic reject from each of the ball mill series is termed fine tails and is sent to a thickener and then to the tailings basin. The grinding process adds considerable energy to the process, which increases water temperature as the slurry advances through grinding. This temperature rise increases the impacts of corrosion on the grinding circuit.

Throughout the milling process, provisions are made to recycle oversized ore back into the grinding process at each of the grinding steps. This is accomplished via either hydrocyclones or screens. Once the desired particle size is achieved, the ore is advanced to the next unit process. The concentrate from the last series of ball mills is then upgraded in a flotation process. Chemicals, such as frothers and collectors are added in the flotation process to provide recovery of the iron and rejection of the gangue. Amines are the primary chemical used in the flotation process. The final float concentrate is pumped to the Agglomeration Plant.

For every 100 tons of taconite processed in the concentrator, approximately 28 tons of coarse tails, 42 tons of fine tails, and 30 tons of final iron concentrate are produced. Water serves as the main means of transport of material through the process once the ore enters the rod mills until it reaches the pelletization operation. Tailings slurry, at about 50 percent solids, flows from the thickener to the tailings basin and fills the tailings basin at the rate of approximately 25-acre feet per day. The process water portion of the slurry is recycled to the process circuit at the rate of about 55 MGD.

The agglomerator receives the concentrate as a slurry, which is then dewatered by disk filters. The filter cake is then mixed with bentonite and formed into pellets in balling drums. At this point in the process the pellets are termed green pellets, similar to the term in pottery manufacturing to describe pottery that has not yet been fired. The pellets are dried, heated and fired in a grate kiln. The firing process hardens the pellets for shipment to the steel mills. This firing process is termed induration.

The pellets produced in this process are called acid pellets. The plant can also produce what are termed fluxed pellets. When producing flux pellets, ground limestone and dolomite are added to the float concentrate slurry mentioned above prior to disk filtering.

The induration process is carried out at very high temperatures, ranging from 1,600 °F to 2,400°F, and any organics, such as float oils, are combusted in the process. Sulfides are converted to sulfur gases during induration.

There are wet scrubbers for all but one induration furnace and high volume water sprays in the scrubbers dissolve and remove not only the sulfur gases, but also other dust and some gases. Sulfur gas removal efficiencies vary between scrubbers, and also vary based upon the fuel source. When wood is being used as a supplemental fuel source, the alkaline ash increases the removal efficiency of sulfur dioxide. Removal efficiencies from about 50 to 70 percent have been documented. There is also an increase of sulfur gas removal efficiency when flux pellets are being produced, due to residual lime and dolomite that is carried as dust to the scrubbing process. Most sulfur gases that are removed during scrubbing are as sulfates, which enter the process water pool and contribute to the increase in sulfate concentration in the water pool.

With continued system operation, sulfate, chloride, TDS, fluoride, and hardness in the process water pool are expected to continue increasing over time. These increases in dissolved constituents are expected to negatively impact operations and to increase maintenance costs and capital costs to maintain current recovery levels, as described in the *Mineral Processing Technical Memorandum*. Specific operation impacts include:

- Increased scale buildup in process water piping;
- Increased corrosion in the secondary ball mill;
- Decreased recovery in the flotation circuit;
- De-rating of filtration capacity due to precipitation of gypsum and calcium fluorite;
- De-rating of induration capacity due to higher moisture green balls;
- Acceleration of induration grate corrosion due to higher re-circulating chlorides;
- Increased corrosion of scrubbing system components, and
- Increased corrosion of structural steel.

Minntac has estimated that these mineral processing water chemistry impacts increase facility operating costs by 3.0 million dollars per year.

2.6.2 Tailings Basin

2.6.2.1 General Description

The tailings basin is a large impoundment located north of the taconite processing facility. It serves to store fine and coarse tails waste from taconite processing and to provide a method for recycling process water for the taconite plant processing operations. During the routine operation of the tailings basin, fine tailings are deposited in a slurry and water is returned to the process. These tailings reduce the overall available volume of the basin at a rate of approximately 25 acre-feet per day. Seepage discharges through the dike have been estimated at approximately 3,000 gpm.

Construction of the tailings basin began in 1966 with the placement of the dike for Cell 1. The basin is constructed on an area of shallow bedrock covered by 10 to 55 feet of glacial and glaciofluvial deposits, which are primarily sand, gravel, and muskeg (peat). The tailings basin covers an area greater than 12 square miles north of the processing facility. The entire area of the tailings basin is enclosed on three sides, along approximately 48,000 feet (9.1 miles) of perimeter, by an impervious core dam and on the fourth side, along the remaining 24,000 feet (4.5 miles), by original high ground. The perimeter dam consists of two parallel coarse tails shells (embankments) with an impervious core of fine tails in between.

Prior to construction, the ground area to be occupied by the perimeter dike was to be stripped of peat and a 10-ft deep key-way was excavated into the underlying sand and gravel in the core area (see Figure 2-14, *Typical Cross-section of Minntac Tailings Basin Dike Construction),* but there are no data to confirm that this was done. The two coarse shells were then placed in 10-foot vertical lifts. The present top-of-dam elevation ranges from 900 to 910 feet LSD (Minntac, 1986). The ultimate top-of-dam considered in the original design (drawing Circa 1971) was at elevation 930 feet LSD (USS, 1981) with a minimum of five feet of freeboard being maintained. All coarse tails are hauled from the plant site by haulage truck and placed with the assistance of various crawler tractors, front-end loaders and graders. The average roadway width on top of the coarse tails shells is approximately 100 feet. Most of the perimeter dam for the tailings basin was constructed by spigotting a fine tailings slurry into the core between the parallel inner and outer tailings dikes. The exception is the perimeter dam on the southwest side of the basin, which was constructed in the same manner as the interior basin dikes. A detailed plan of the existing tailings basin is shown in Figure 2-15, *Minntac Tailings Basin Map.*

The exterior slope of the outside dike has an average inclination of 3H:1V and is between 10-ft and 70-ft high. The interior slope of the outside dike has an average inclination of 2H:1V. The perimeter spigot lines are located on the dry side of the core (on the outer dike). This creates a surface slope from the dry side down to the wet side, thus causing water from the slurry to pond on the wet side of the core and seep through the wet side dike to the retained water within the basin. Spigotting fine tails from the outside coarse tails shell allows the coarser particles to settle out and the finer particles to place themselves against the inside coarse tails shell. Spigotting occurs during the non-winter months only. The core varies in width between 70 feet and 100 feet.

Discussions with Minntac personnel indicate that there have never been any reported problems with the performance of the dike facilities. Small volumes of seepage have been noted on the west and east sides of the perimeter dam but this seepage is not considered to be detrimental to dam integrity and volumes are within permitted allowances.

An average of 15 million long tons of dry fine tailings and 7 million long tons of dry coarse tails are deposited annually.

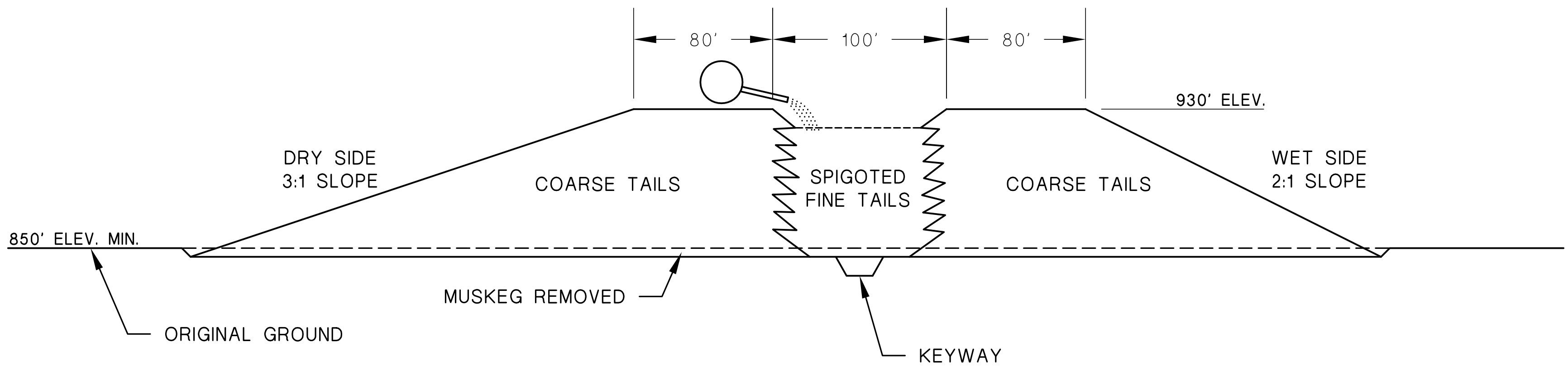
Each 100 tons of taconite ore processed produces approximately 28 tons of coarse tails and 42 tons of fine tails. The coarse tailings are generated from the classifier, following the first stage of milling and magnetic separation. The fine tailings are generated from the crusher thickener overflow and the tailings thickener underflow. Fine tailings are thickened and transported by slurry from the processing plant to the tailings basin, while the coarse tails are dewatered and hauled by truck from the processing plant to the tailings basin. The basin is segmented into several cells and the fine tailings discharge flow is periodically moved from one cell to another. A permanent pumping station located on the east side of the basin returns water to the plant site reservoir for reuse as process water.

The plant recycles approximately 32,000 gpm or 16,819 million gallons per year (MGY) of water from the tailings basinfor plant processes. Most of the water is discharged as slurry by a gravity system from the plant to the tailings basin. The majority of the water discharged to the tailings basin is recycled back to the process plant. The water that is lost from the tailings basin is made up by obtaining water from the Mountain Iron Pit Reservoir (make-up water). The amount of make-up water obtained from the Mountain Iron Pit Reservoir varies depending on tailings basin water levels and plant operations.

2.6.2.2 Sources of Water and Water Balance

Water Sources

The water contained in the tailings basin comes from two primary sources: direct precipitation (5,920 MGY) and mineral processing/fine tailings slurry discharge (17,470 MGY).



TYPICAL CROSS-SECTION OF MINNTAC
BASIN DIKE CONSTRUCTION

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FIGURE 2-14
TYPICAL CROSS-SECTION OF MINNTAC TAILINGS BASIN DIKE CONSTRUCTION

FILENAME: FIG 2-14-TYP SECTION-TAILINGS.dwg

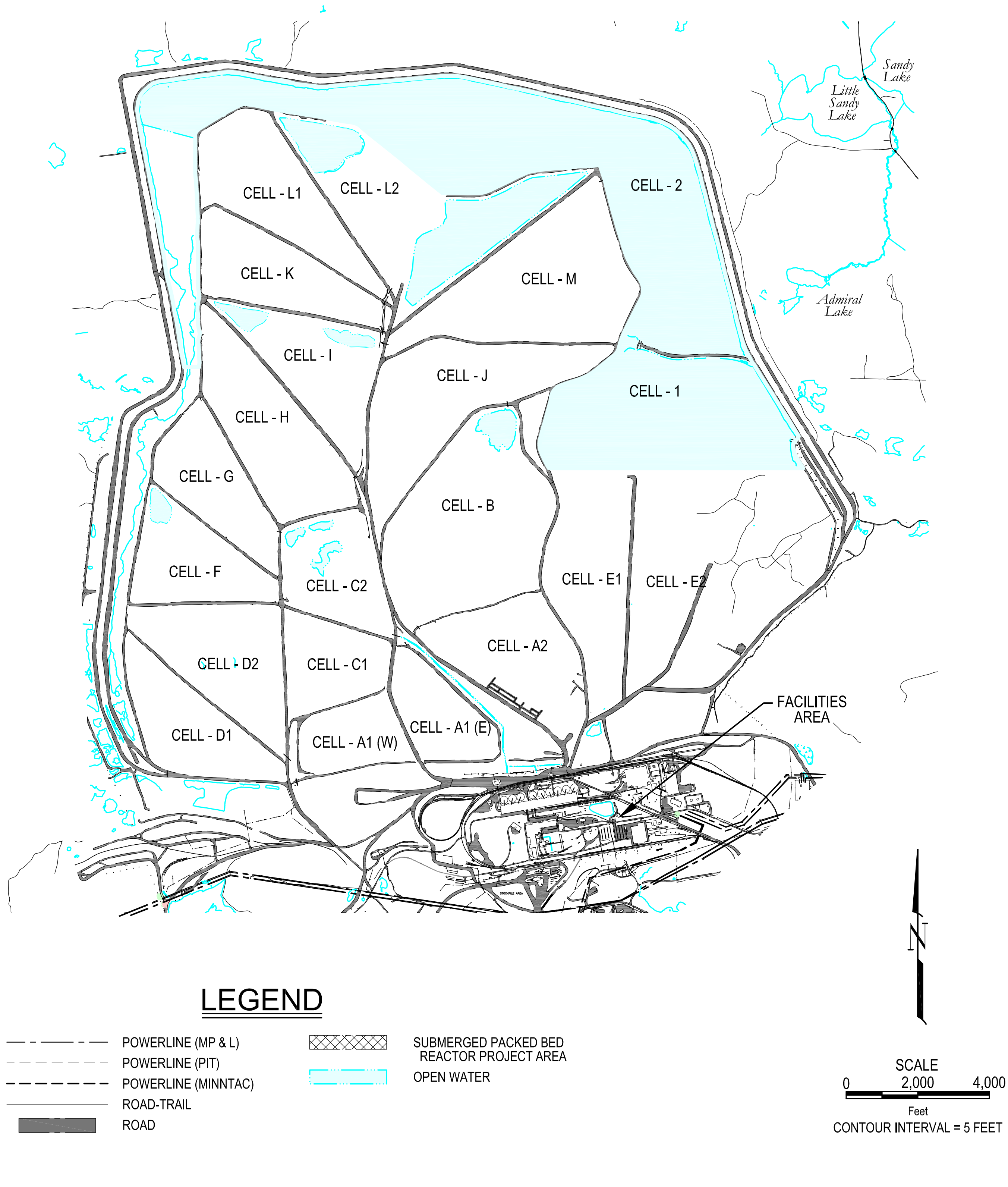


FIGURE 2-15
MINNTAC TAILINGS BASIN

FILENAME: FIG 2-15 Minntac Tailings Basin.dwg

The portion of water present in the tailings basin that is a direct result of precipitation was calculated by Minntac to be 5,920 MGY, using a long-term average of 26 inches of precipitation per year (USS - Minntac, 2002). Precipitation was applied to the total tailings basin watershed of 8,385 acres, which includes the plant area.

The primary source of tailings basin water is the fine tailings slurry discharge. Based on the annual water balance model that Minntac developed to reflect operating conditions, it was estimated that 17,470 MGY of water are discharged to the tailings pond (USS-Minntac, 2002). This slurry water is accumulated from a variety of secondary sources including return water, makeup water, crude ore feed, fluxstone moisture, and indurator combustion. Most of the water introduced into the process system is discharged to the tailings basin (96 percent). Less than three percent is lost through the indurator stacks, and about one percent leaves the plant in the taconite pellets or through the crusher dust collectors.

Water Balance

Minntac prepared a technical support document that includes a "Total Process Water Balance" (USS-Minntac, 2002). By regulation, the discharge cannot exceed the difference between precipitation minus evaporation (P-E). As indicated above, the tailings basin accumulates approximately 5,920 MGY and evaporation accounts for about 1,843 MGY of loss.

Using the P-E relationship:

5,920 MGY *(precipitation)* minus 1,843 MGY *(evaporation)* = 4,077 MGY *(excess precipitation)*

The 4,077 MGY equates to 7,757 gpm; therefore the proposed discharge of 5,000 gpm is realistic as far as the (P-E) water ratio is concerned based on the past approach of the MPCA in determining the annual net precipitation limits for similar tailings basin facilities. This ratio indicates that the tailings basin water volume should be increasing. However, the water balance associated with managing the tailings basin return water required for mineral processing is more complex.
The general tailings basin water balance is represented by the following equation:

$$\Delta S = INFLOWS - OUTFLOWS$$

where ΔS is the change in water storage or open water pond volume. The Minntac tailings basin water balance contains multiple inflows and outflows. Table 2.1, *Generalized Water Balance* is a general representation of the current tailings basin water balance.

TABLE 2.1
GENERALIZED WATER BALANCE

INFLOW	MGY	gpm
Tailings Discharge	17,470	33,329
Precipitation	5,920	11,263
TOTAL	23,390	44,592
OUTFLOW	**MGY**	**gpm**
Return Water	16,819	32,000
Evapotranspiration	2,457	4,675
Evaporation	1,843	3,506
Void Loss	1,650	3,139
Seeps	1,650	3,139
TOTAL	24,419	46,459
INFLOW (-) OUTFLOW	**-1,029**	**-1,867**

The results of this table indicate that the tailings basin is losing water under the current operational conditions. Minntac has stated (Minntac, 2002) that, "prior to 1998, the pond elevation was increasing at an average rate of approximately 0.5 feet per year. In 1998, the makeup water pumped from the Mountain Iron Reservoir was reduced from about 2,600 gallons per minute (gpm) to about 1,500 gpm. Also, in 1998, water was displaced with tailings in tailings basin cells that had coincidentally stored water. Consequently, the pond elevation has shown an average decrease of 1.2 feet per year since 1998 through 2001 under generally stable operating conditions." However, clear water pond elevation data for the period January 1998 to December 2003 indicate that the clear water pond level has now stabilized within a range between 892 and 886 feet.

This water balance assumes that the plant production rate is constant. If the production rate changes, this will directly impact the water balance. For instance, if the production rate decreases, the water inflow into the tailings facility will decrease, thereby further increasing the net negative water balance of the facility. Alternatively, if the production rate is increased above the existing throughput, this will affect the existing water balance.

A water balance sensitivity analysis was completed to ascertain the impact of incremental increases in precipitation. The sensitivity analysis, described in further detail in the *Tailings Basin Technical Memorandum,* considered precipitation of 26, 28, 30, and 32 inches. The sensitivity evaluation indicates that the tailings facility turns to a net positive water balance when precipitation reaches approximately 31 inches. Increased evaporation and/or seepage rates, however, may be associated with higher water levels in the tailings basin.

2.6.2.3 Inner Cell Operations

The basin is segregated into several cells and the fine tails discharge flow is periodically moved from one cell to another. Dikes separate the various cells, each constructed of a single berm of coarse tailings placed by truck and various pieces of auxiliary equipment in lifts. The perimeter dam spigot lines are located on the dry side of the core; this creates a surface slope from the dry side down to the wet side, thus causing the water from the slurry to pond on the wet side of the core and seep through the wet side dike to the retained water within the basin.

The fine tails slurry flows from the plant site to the intermediate cells through a gravity system of open ditches and launders (trough or flume). The slurry consists of approximately 50% solids. Approximately 25 acre-feet of volume are displaced each day by these tailings, based on 20 to 22 million long tons per year and a wet density of 120.7 lbs/ft^3. In order to maximize fine tailings capacity within the basin, intermediate cells are systematically constructed. The cells are built in series in a terraced manner. The highest cell starts at the plant discharge point and succeeding cells gradually drop in elevation to the north limit of the basin. The top elevation of each cell is determined by the minimum slope on which the fine tailings slurry will flow.

Fine tails are dewatered by passive sedimentation in the intermediate cells and water flows through the outlet culvert of the active intermediate cells and into the permanent clear water area of Cell 2 and then to Cell 1, where water is pumped back to the plant. Each intermediate cell receives tailings for approximately 13 months over a period of two to four years before being returned to dormancy. Inactive cells are seeded, fertilized, and mulched, resulting in approximately 60% of the tailings being vegetated for dust control. Cells often remain dormant for 8 to 10 years before being used again. As intermediate cell capacity via gravity flow through the launders is exhausted, the open launder system will be modified by extending the plant site fine tails discharge pipe lines to gain additional elevation over the entire inner intermediate cell areas. Eventually, pumping of the fine tails may be required to allow additional elevation gain.

Cell M is the last adjacent intermediate cell remaining to be filled with fine tailings. Because the maximum volume of water within the basin is fixed in this system, the elevation of the water surface tends to increase as fine tailings are added to these adjacent cells. In 1998, the makeup water pumped from the Mountain Iron Reservoir was reduced from about 2,600 gpm to 1,500 gpm. Cell M will be filled by the end of 2004.

2.6.2.4 Current Situation (Cell M Filling)

Minntac's basin operating plan includes using Cell M-1 for fine tailings disposal. Filling this cell will result in a change in area of the water pool and result in changes in the water balance. The current clear water pool area of 2,612 acres (August 2002) includes 529 acres in Cell M. When water in Cell M is displaced with tailings, total storage area for clear water will decrease. The water in Cell M is expected to be completely displaced by tailings by the end of 2004. Adding the Cell M water volume to Cells 1 and 2 would result in a surface elevation increase of 5.4 feet in the clear water pool.

In evaluating the risk of dam overtopping, it was concluded that after filling Cell M, the pond area would be reduced to about 2,083 acres. Even in this situation, there would be significant freeboard and the perimeter dam should be reasonably safe from overtopping. Pond levels may rise significantly as Cell M water is displaced, but the water levels can be managed adequately by controlling make-up water pumping activities.

2.6.2.5 Tailings Management Summary

As indicated above, current and projected future operations are not limited by the tailings basin capacity. A number of tailings basin design and operation considerations associated with the implementation of the proposed project or project alternatives are described in the *Tailings Basin Technical Memorandum*

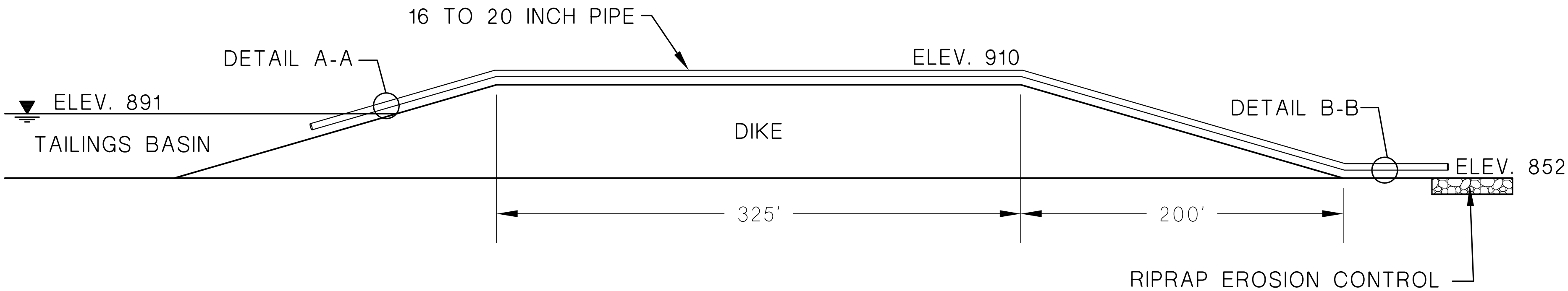
2.7 PROPOSED PROJECT

Due to the need to effectively manage process water at Minntac, a siphon discharge of water from the tailings basin has been proposed. To offset the continuing increase of water level in the tailings basin, a proposal has been submitted to augment the seepage release with an engineered siphon (piped) discharge system. An engineered siphon system would actively move water from within the tailings basin to the discharge point(s) in the Sandy River and/or Dark River watersheds. The objective would be to release water at a rate approximately equal to 25 acre-feet per day (5,000 gpm).

The proposed discharges would be located near current seepage points that flow to the Dark River and Sandy River. An engineered siphon system would be constructed to discharge the water. The siphon design would be similar to others in use at taconite processing facilities in the state for active discharge of water. A conceptual drawing of the siphon system is presented on Figure 2-16*, Conceptual Siphon Design.*

The water would be siphoned up and over the basin dike through two 16-inch to 20-inch diameter pipes. The flow from the pipes would be controlled with a gate valve and measured with a flow meter. The proposed discharge would be at a rate of about 5,000 gpm.

Primary construction components include the siphons and water lines. Only minimal physical disturbance of the basin dike and facility environment is anticipated during construction activities. There would be no modifications to existing equipment or industrial processes or significant demolition, removal, or remodeling of existing structures.



TYPICAL EXTERIOR DIKE CROSS-SECTION

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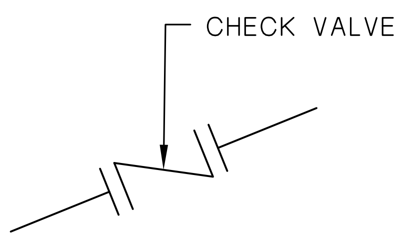

DETAIL A-A

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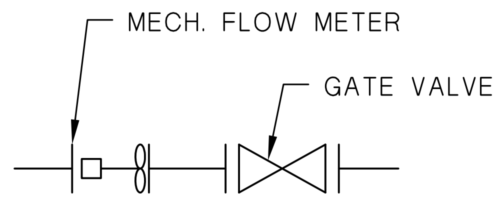


DETAIL B-B

N.T.S.

NOTES:

1. THE SIPHON SYSTEM WILL CONSIST OF TWO (2) 16"-20" DIA. PIPES.
2. FLOW WILL BE CONTROLLED BY USE OF THE GATE VALVE AND FLOW METER LOCATED AT THE DISCHARGE END OF THE PIPE. (DETAIL B-B')
3. THE INLET OF THE PIPE WILL BE LOCATED AT AN ELEVATION ABOVE 884 FT. AND IT WILL BE SCREENED TO PREVENT LARGE DEBRIS FROM ENTERING THE PIPE.
4. THE DISCHARGE END OF THE PIPE WILL BE SURROUNDED BY CRUSHED ROCK TO PREVENT EROSION.

FIGURE 2-16
CONCEPTUAL SIPHON DESIGN

Fig 2-16 Conc Siphon.dwg

3.0 GOVERNMENT APPROVALS

This section includes a list of known government approvals and permits required for implementation of the proposed project. It includes a description of the required permit, as well as identification of the governmental agency responsible for permit approval.

One of the objectives of Minnesota's environmental review process is to provide information regarding potential impacts of a proposal and encourage accountability in the decision-making process. A Record of Decision must be maintained identifying how this EIS was considered in reaching a decision regarding government approvals and permits. While the EIS provides information useful for permitting and approval decisions, it is not intended to provide all data and information required for these actions. The required permit applications and approval information will be developed and submitted independently of the EIS.

While some permit application review may occur concurrently with the EIS preparation, no permits may be issued until after the EIS process is completed. In the event that Minntac does not pursue the proposed project through permitting, or a permit is not granted for this project, the MPCA will use the information developed in this EIS in regard to reissuance of the current tailings basin NPDES/State Disposal System (SDS) Permit, or with regard to a variance application for the current tailings basin NPDES/SDS Permit (MPCA, 2001).

The following sections outline the approvals and permits required for the proposed project.

3.1 NPDES/SDS PERMIT

As discussed previously in Section 2.0, Minntac is currently operating under expired NPDES/SDS Permit No. MN0057207. Under the proposed project and discharge alternatives, the following would be required from MPCA:

- Re-issuance of the existing NPDES/SDS Permit for seep discharges;
- Issuance of a new NPDES/SDS Permit for siphon discharge; and
- Possible variance applications for the existing and/or new discharges that do no meet water quality standards.

3.2 WATER USE PERMIT

A water use permit from DNR would also be required for the proposed project and discharge alternatives. A water use or water appropriation permit from DNR Water is required for all users withdrawing or discharging more than 10,000 gallons of water per day or one million gallons per year. Since the proposed project and discharge alternatives entail discharging greater than these specified quantities, Minntac would be required to submit a Permit Application for Appropriation of Waters of the State.

3.3 ENDANGERED SPECIES ACT SECTION 7 CONSULTATION

A number of Federal threatened and endangered species have been identified within the study area, as discussed further in Section 5.6.1. Site-specific surveys, however, have not been conducted as part of the EIS process to verify precise locations. Based upon available information, impacts to threatened and endangered species are not expected as a result of implementation of the proposed project or project alternatives. As such, Section 7 Consultation with the U.S. Fish and Wildlife Survey is not anticipated.

4.0 ALTERNATIVES

This section briefly describes the project proposal and alternatives, including a No Build alternative. Potential impacts associated with the implementation of these alternatives are discussed in Section 5.0 of this EIS.

4.1 ALTERNATIVE TYPES

The Environmental Quality Board (EQB) rules require that an EIS evaluation address at least one alternative from each of the following alternative types, or provide a concise explanation of why an alternative from a particular alternative type is not evaluated. Alternative types include:

- Proposed Project (Proposed Action)
- Alternative Sites
- No Build (No Action)
- Alternative Technologies
- Design Alternatives
- Modified Scale or Magnitude Alternatives
- Alternatives Incorporating Reasonable Mitigation Measures
- Mitigation Suggested Through Comments

At least one alternative from each alternative types is evaluated within this EIS. The following section describes the proposed project and alternatives considered within this EIS, by alternative type.

4.2 ALTERNATIVE DESCRIPTIONS

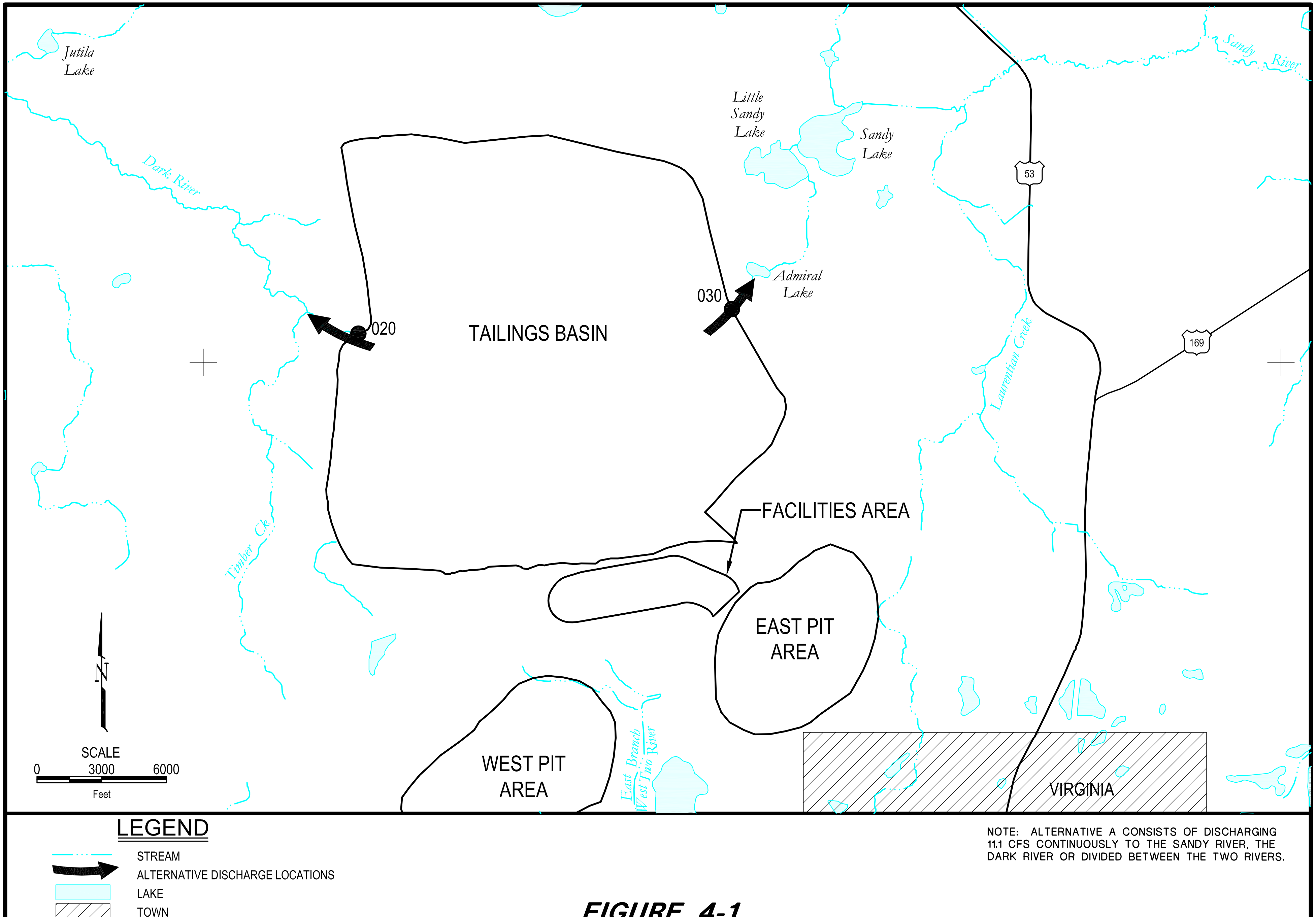
4.2.1 Alternative A: Proposed Project (Proposed Action)

Minntac is proposing new/expanded siphon discharges from the existing tailings basin to the Dark River watershed or the Sandy River watershed or both watersheds. The proposed discharges would be located near current seepage points (Stations 020 and 030) that flow to the Dark and Sandy Rivers. An engineered siphon system would be constructed to discharge the water. The siphon design would be similar to others in use at taconite processing facilities in the State for active discharge of water. The water would be siphoned up and over the basin dike through two 16-inch to 20-inch diameter pipes, as shown in Figure 4-1, *Alternative A*. The flow from the pipes would be controlled with a gate valve and measured with a flow meter. The proposed discharge would be at an average rate of about 11.1 cfs. The construction of the project would involve minimal physical disturbance of the basin dike.

Optional discharge locations considered under Alternative A include:

- **Sandy River Discharge**: Water from the tailings facility would be siphoned and discharged at a rate of 11.1 cfs continuously to the Sandy River at the location of the current seep. This scenario would have a siphon located on the east side of the tailings basin, which would discharge to the headwaters of the Sandy River. The headwaters of the Sandy River begin on the east edge of the tailings basin and flow generally east through Admiral Lake, the Little Sandy and Sandy Lakes (Twin Lakes) and after about 12 miles join the Pike River, which in turn drains into Pike Bay of Lake Vermilion.

- **Dark River Discharge:** Water from the tailings facility would be siphoned and discharged at a rate of 11.1 cfs continuously to the Dark River at the location of the current seep.



NOTE: ALTERNATIVE A CONSISTS OF DISCHARGING 11.1 CFS CONTINUOUSLY TO THE SANDY RIVER, THE DARK RIVER OR DIVIDED BETWEEN THE TWO RIVERS.

FIGURE 4-1
ALTERNATIVE A

Fig 4-1 Alternative A.dwg

This scenario would have a siphon located on the west side of the tailings basin, which would discharge to the headwaters of the Dark River. The headwaters of the Dark River begin on the west edge of the tailings basin and flow generally northwest through Dark Lake and after about 17 miles empty into the Sturgeon River, which in turn drains into the Little Fork River.

- **Combination of Sandy River and Dark River Discharge**: Water from the tailings basin would be siphoned and discharged continuously to both points described above, splitting the 11.1 cfs discharge between the two points. The appropriate discharge rate to each site would be determined at the time of discharge.

4.2.2 Alternative B: Alternative Sites

This alternative would incorporate primary elements of the Proposed Action, but would include discharge to alternative sites, as shown in Figure 4-2, *Alternative B* and described below.

- **Laurentian Creek (Sandy River Watershed) Discharge:** This option would examine siphon and discharge of 11.1 cfs continuously to Laurentian Creek. This scenario would have a siphon located on the east side of the tailings basin, which would discharge basin water via pipeline to Laurentian Creek, a tributary that enters the Sandy River below the Sandy and Little Sandy Lakes.

- **Lake Superior Watershed Discharge:** This option would require pumping 2.6 billion gallons per year continuously to the south over the Laurentian Divide for discharge into the West Two Rivers Reservoir, mine pit lakes, or other Lake Superior basin waters.

- **Multiple Watersheds Discharge**: This option would divide the 11.1 cfs continuous discharge and/or controlled intermittent (including possible seasonal limitations) discharge, between the receiving waters described above under Alternatives A and B.

4.2.3 Alternative C: No Build (No Action)

Under the No Action Alternative, the proposed discharge would not be permitted and the current tailings deposition and basin water recycle operations would continue. Evaluation of this alternative is further considered in the *Tailings Basin Technical Memorandum*, in which the tailings basin capacity is assessed.

4.2.4 Alternative D: Alternative Technologies

This alternative would evaluate whether the life of the tailings basin could be extended by modification to the existing basin operating and management design. The modifications to be considered are:

- **Tailings Basin Perimeter Dike Raising:** This option would include raising the crest of the perimeter dikes to extend the life of the tailings basin, as shown in Figure 4-3, *Alternative D – Tailings Basin Perimeter Dike Raising Option.* The level to which the current dikes could be raised would be dependent on geotechnical analyses to estimate stability and safety factors.

- **Water Level Reduction through Operational Use:** This option would include reduction in water levels in the basin for use in other purposes, such as dust suppression of facility haul roads and exposed tailings beaches.

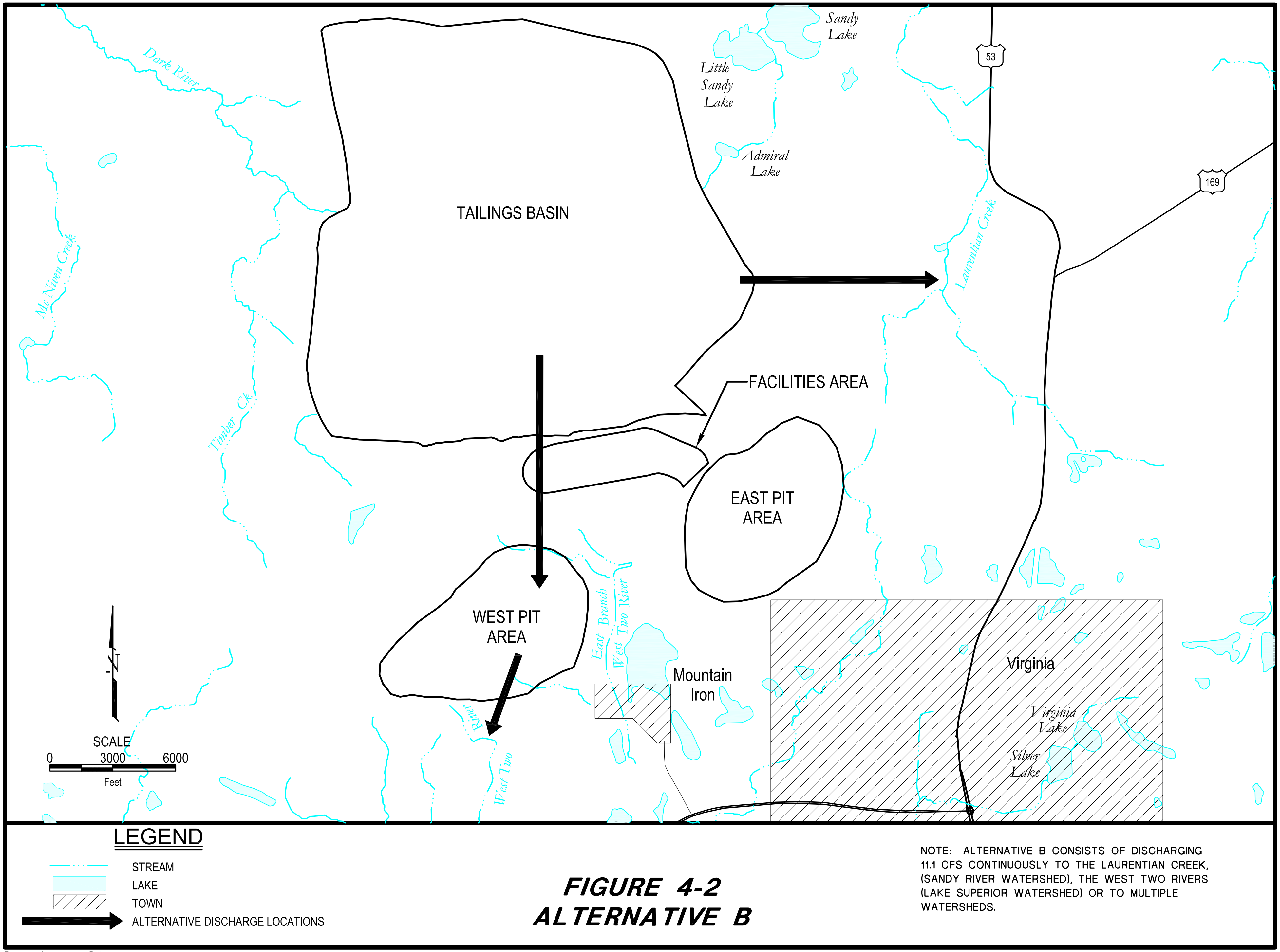
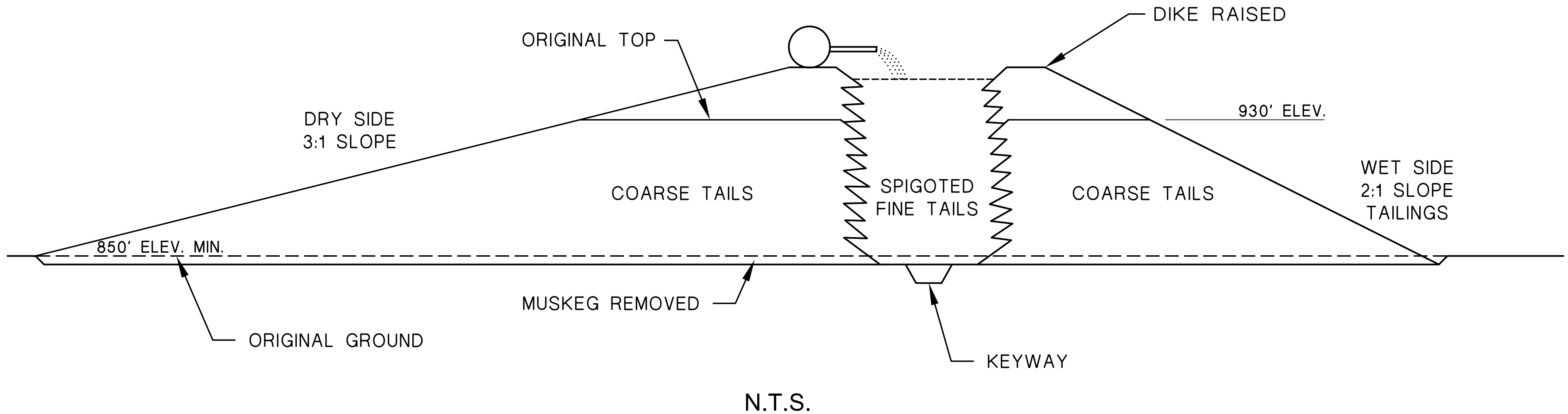


FIGURE 4-2
ALTERNATIVE B

NOTE: ALTERNATIVE B CONSISTS OF DISCHARGING 11.1 CFS CONTINUOUSLY TO THE LAURENTIAN CREEK, (SANDY RIVER WATERSHED), THE WEST TWO RIVERS (LAKE SUPERIOR WATERSHED) OR TO MULTIPLE WATERSHEDS.

Fig 4-2 Alternative B.dwg



NOTE: THE LEVEL TO WHICH THE CURRENT DIKES COULD BE RAISED WOULD BE DEPENDENT ON GEOTECHNICAL ANALYSES TO ESTIMATE STABILITY AND SAFETY FACTORS.

FIGURE 4-3
ALTERNATIVE D - TAILINGS BASIN PERIMETER DIKE RAISING OPTION

FILENAME: FIG 4-3 Alternative D.1.dwg

- **Water Level Reduction through Process Water Adjustment:** This option would address whether water levels could be reduced by adjustments in make-up water and process water recycling.
- **West Tailings Basin Expansion:** This option would address the potential for construction of another tailings basin to the west of the existing facility, as shown in Figure 4-4, *Alternative D – West Tailings Basin Expansion Option*. Minntac has set aside an area as a potential future location for a tailings basin. This site, however, would require a separate EIS evaluation prior to approval.

4.2.5 Alternative E: Design Alternatives

Through the EAW Scoping process, two potential design alternatives were identified.

- **Siphon Placement:** This option would include the design and placement of a new siphon discharge with the location determined by potential effects on the discharge water temperature from tailings basin.
- **Dark Lake Effluent:** This option would include monitoring and/or management of the water leaving Dark Lake to potentially regulate temperature of downstream waters.

4.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Under this alternative, the scale or magnitude of the proposed discharge would be modified to examine whether potential environmental impacts from the proposed project could be avoided or mitigated. For example, some of the objectives of the project might be met with a reduced flow in combination with other mitigation strategies and alternatives.

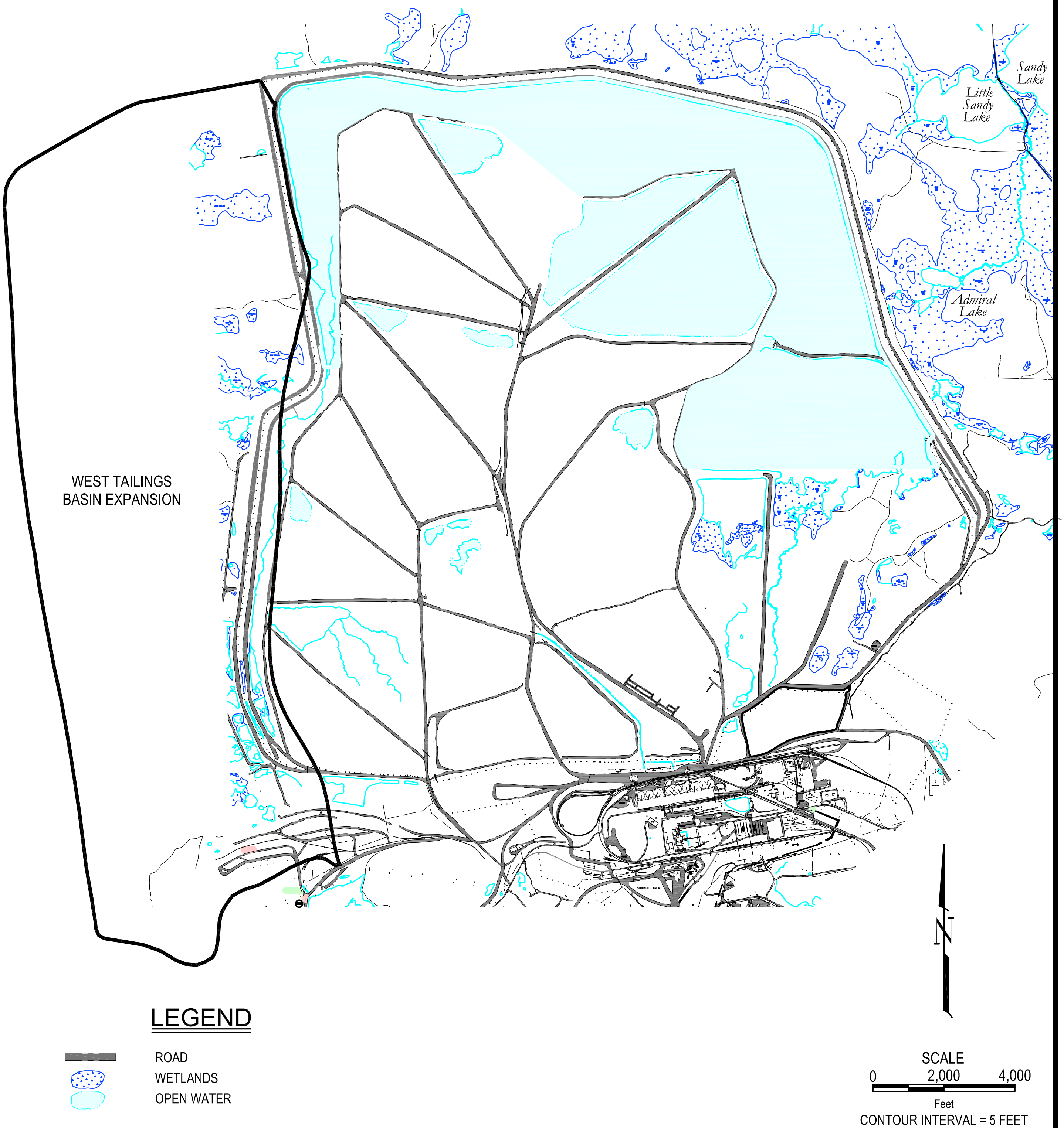
4.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

4.2.7.1 SPB Treatment System

This alternative would include treatment of tailings basin water prior to discharge. An SPB system would be incorporated into the proposal to reduce the levels of sulfate in the waters of the State downstream of the tailings basin. The proposed SPB treatment technology would include a submerged anaerobic filter system using a unique packed-bed design. A schematic of the SPB system is shown in Figure 4-5, *Alternative G*. The SPB would be designed to remove sulfate and dissolved solids by biological reduction to an iron sulfide precipitate. The primary operations would include addition of a carbon and nutrient source (for example, ethanol), to the process water feeding the biological reaction unit and tertiary polishing and clarification operations as needed. The SPB system would be designed to treat the process water effluent, which is the largest source of pollutant mass loading to the overall Minntac wastewater disposal system for dissolved solids, including sulfate, chloride, and hardness. Under this alternative, a total of 11.1 cfs of SPB-treated water would be discharged continuously to one or more of the optional discharge sites described previously under Alternatives A and B.

4.2.7.2 SPB Treatment Options

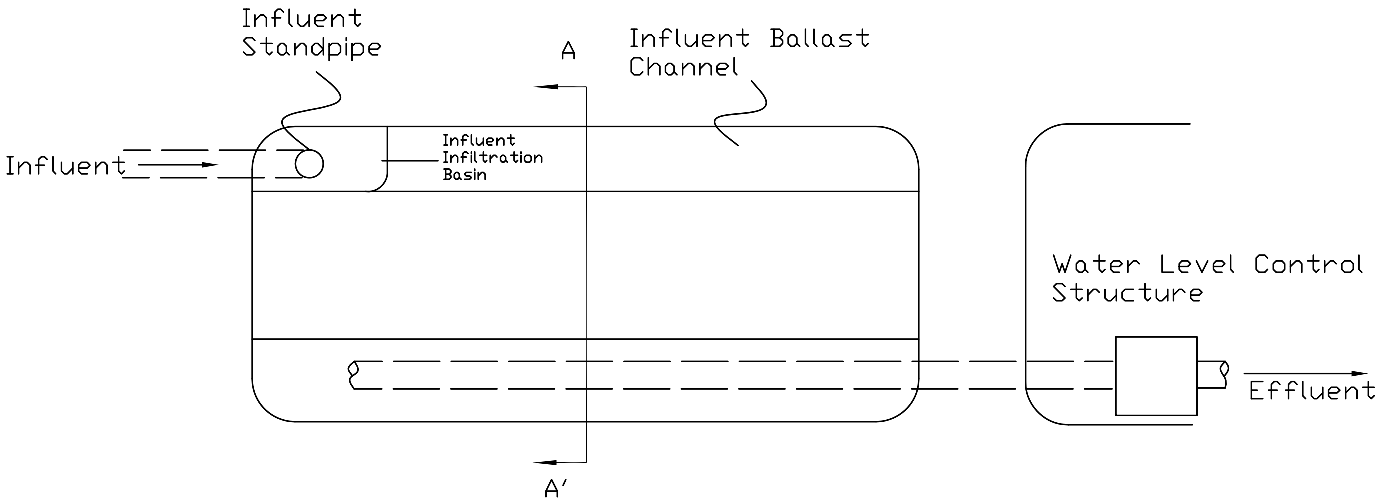
In addition to the discharge scenarios described above, Minntac has evaluated the options of: (1) discharging 11,000 gpm (24.5 cfs) treated plant water to the tailings facility without a direct discharge; and (2) the discharge of 2,400 gpm of treated plant effluent to the tailings facility with a managed discharge (HCR) of 11.1 cfs to the Sandy River. As stated above, primary effluent from the SPB will be further treated in tertiary polishing steps to remove residual organics, nutrients and suspended solids, prior to discharge to the tailings basin reservoir or downstream receiving bodies.



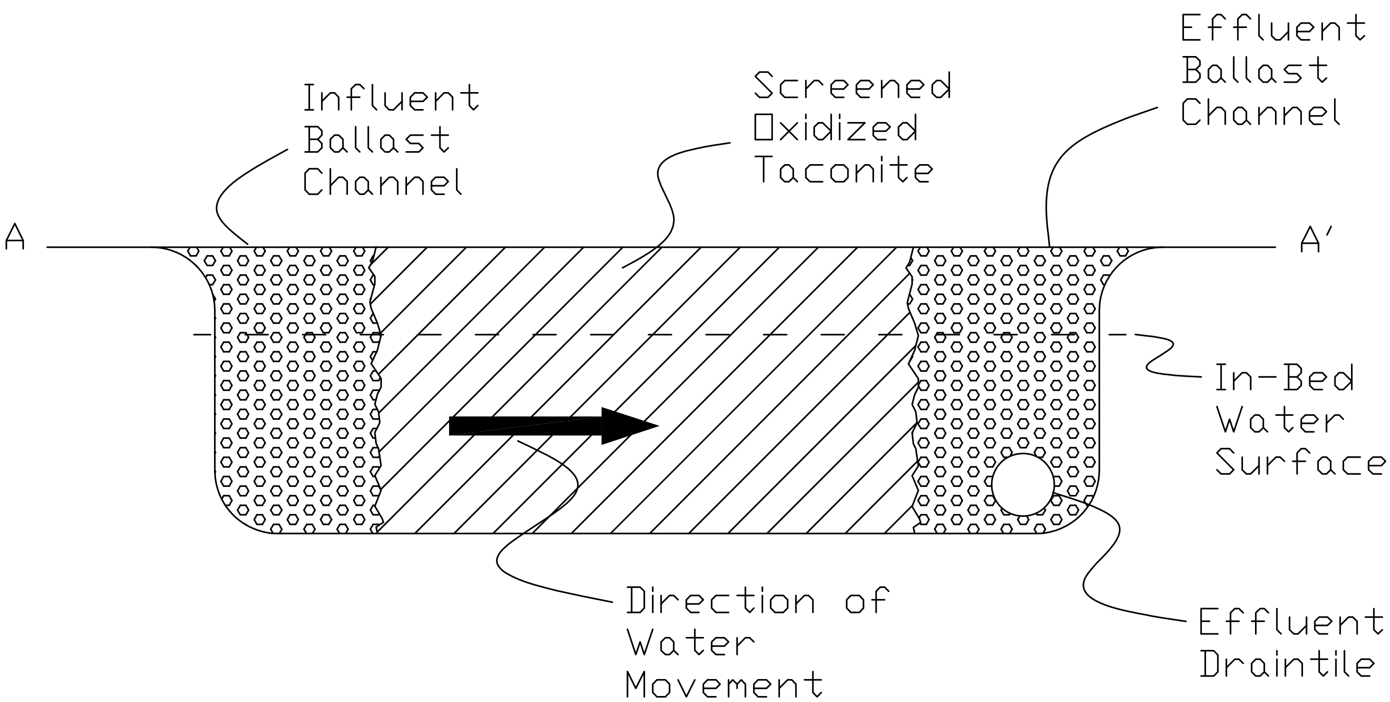
NOTE: ALTERNATIVE D.4 CONSISTS OF CONSTRUCTING ANOTHER TAILINGS BASIN TO THE WEST OF THE CURRENT TAILINGS BASIN.

FIGURE 4-4
ALTERNATIVE D - WEST
TAILINGS BASIN EXPANSION OPTION

FILENAME: Fig 4-4 Alternave D.4.dwg



PLAN VIEW



SECTION VIEW

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Alternative G-SPB Treatment	**10/8/04**
US Steel Minntac	**Figure** 1

10-08-04 1=1 DIR:W:\ww\94154\Alternative G-SPB Treatment 5.dwg

TGP

4.2.7.3 Other Treatment/Discharge Alternatives

Several other treatment/discharge alternatives to reduce sulfate, chloride, conductivity, and hardness concentrations were identified in the *Final Scoping Decision Document* including the following:

- Revision of mine plan to avoid high sulfide zones in the crude ore, and reduce mass of sulfur inputs through ore feed
- Treatment of post-production tailings through flotation separation and separate disposal of sulfides
- Treatment of ore concentrate prior to agglomeration by flotation separation and separate disposal of sulfides
- Reduction of chloride mass inputs in fluxstone and pellet binders (beyond current efforts)
- Reduction of sulfur mass inputs per BTU burned in agglomerator fuels (beyond current efforts)
- Reduction of sulfur mass inputs through changes in makeup water supply (beyond current efforts)
- Closed loop agglomerator scrubber wastewater system, with the option of treatment of low flow blowdown wastewater
- Treatment of agglomerator scrubber wastewater by reverse osmosis with evaporation of concentrates
- Treatment of agglomerator scrubber wastewater by calcium sulfate precipitation
- Treatment of agglomerator scrubber wastewater by low rate anaerobic technology (such as wetlands)
- Spray irrigation of tailings pond wastewater (to facilitate uptake by plants in the tailings basin area

As a result of the SOC process, MPCA staff made a preliminary determination that the SPB system showed promise to reduce pollutant levels downstream and, therefore, eliminated the other alternatives from evaluation within the EIS.

4.2.8 Alternative H: Mitigation Suggested through Comments

The EQB rules require consideration of mitigation measures identified through comments on the scope or draft EIS. MPCA has considered the comments received during the Scoping process and has included appropriate alternatives to address the comments within Alternatives A through G, described above

4.3 HYDROGRAPHICALLY CONTROLLED RELEASE

With detailed evaluation, another variation on the discharge to Sandy and Dark Rivers and/or the Lake Superior watershed could be developed whereby the rate of total discharge is varied and the split between the watersheds is varied. This management strategy is termed "hydrographically controlled release" or HCR. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River watershed during periods of temperature extremes to protect the trout habit. Similarly, flow could be directed from the Sandy River, or routed down Laurentian Creek during periods critical for wild rice production. These types of discharge scenarios could result in less adverse impacts when compared to the proposed alternative. However, the process to design and implement this type of discharge strategy is complex and requires an extensive monitoring network, and still may not allow Minntac to meet the objectives of discharging an average of 11.1 cfs without adverse impact.

4.4 COMBINED ALTERNATIVES

Throughout the EIS process, a number of combined alternatives have been identified. These include:

- Portioning untreated tailings water discharge (equally or in unequal proportions) between the Sandy River, the Dark River, Laurentian Creek, and the West Two Rivers, effectively also proportionally dividing the mass of key constituents, namely chloride, TDS, conductivity hardness, conductivity, and the aforementioned metals.

- Use of the SPB system alone to treat all effluent prior to discharge in to Sandy River, Dark River, West Two Rivers, or a combination thereof.

- Use of the SPB in conjunction with a managed schedule of direct, untreated tailings discharge.

- Siphon placement and differential untreated tailings water discharge, either seasonally to a watershed, split between watersheds, or both.

- Use of the SPB system with discharge to the south (West Two Rivers) and potentially diverting existing pit dewatering flow from the south to use for Minntac plant makeup, effectively reducing both the total mercury and total sulfate mass loadings.

MPCA can select one of the alternatives evaluated within the EIS or a combination of alternatives, such as those outlined above. In addition, MPCA can impose special conditions and/or additional mitigation strategies on its selection to insure protection of environmental and socioeconomic resources.

4.5 ALTERNATIVES SUMMARY

Alternatives evaluated within this EIS are summarized below:

- **Alternative A: Proposed Project (Proposed Action) -** Siphon discharge of 5,000 gpm of tailings basin water to the Dark River watershed, Sandy River watershed, or a combination of the Dark River and Sandy River watersheds.

- **Alternative B: Alternative Sites -** Siphon discharge of 5,000 gpm of tailings basin water to optional sites including Laurentian Creek, Lake Superior watershed, or multiple watersheds.

- **Alternative C: No Build (No Action) -** No discharge, with remaining life at status quo.

- **Alternative D: Alternative Technologies –** Non- discharging alternatives including tailings basin perimeter dike raising, water level reduction through operational use, water level reduction through process water adjustment, or tailings basin west expansion.

- **Alternative E: Design Alternatives -** Siphon discharge of 5,000 gpm through alternate siphon placement modification or management of Dark Lake effluent discharge.

- **Alternative F: Modified Scale or Magnitude Alternatives –** Siphon discharge of reduced volume.

- **Alternative G: Alternatives Incorporating Reasonable Mitigation Measures:** Discharge of 5,000 gpm of SPB-treated water: to Sandy River, Dark River, a combination of the Sandy and Dark Rivers, Laurentian Creek, Lake Superior watershed, or multiple watersheds.

- **Alternative H: Mitigation Suggested through Comments:** MPCA has considered the comments received during the scoping process and has included appropriate alternatives incorporating suggested mitigation measures in the above alternative scenarios.

5.0 ENVIRONMENTAL, ECONOMIC, EMPLOYMENT, AND SOCIOLOGICAL IMPACTS

This section presents a discussion of potential impacts associated with the implementation of the proposed project or project alternatives, described previously in Section 4.0 of the EIS. Baseline conditions and potential impacts are disclosed by resource area, as follows:

- **Section 5.1: Surface Water Hydrology**
- **Section 5.2: Surface Water Quality**
- **Section 5.3: Wetlands**
- **Section 5.4: Wild Rice**
- **Section 5.5: Aquatic Resources**
- **Section 5.6: Wildlife**
- **Section 5.7: Upland Vegetation**
- **Section 5.8: Socioeconomics**

As prescribed in the EAW and *Scoping Decision Document,* this section of the EIS is presented only in sufficient detail to disclose potential significant issues associated with project implementation. More detailed discussions relating to the existing resource conditions and potential impacts associated with implementation of the proposed project or project alternatives are included in the following Technical Memoranda located in Volume 2 of this EIS:

- *Surface Water Hydrology and Quality Technical Memorandum*
- *Mercury and Methylmercury Technical Memorandum*
- *Wetlands Technical Memorandum*
- *Wild Rice Technical Memorandum*
- *Aquatic Resources Technical Memorandum*
- *Socioeconomics Technical Memorandum*
- *Geotechnical Considerations Technical Memorandum*
- *Tailings Basin Technical Memorandum*
- *Mineral Processing Technical Memorandum*

Additionally, Volume II includes the *Wildlife Technical Summary* and the *Upland Vegetation Technical Summary*.

5.1 SURFACE WATER HYDROLOGY

This section describes surface water hydrology baseline conditions (Section 5.1.1) and potential impacts (Section 5.1.2) within the Dark River and Sandy River watersheds associated with implementation of the proposed project or project alternatives. General watershed characteristics were described previously in Section 2.5.3.1 and shown in Figures 2-4 and 2-5. Detailed surface water hydrology discussions, evaluations, and data sets are contained within the *Surface Water Hydrology and Quality Technical Memorandum* included in Volume II of this EIS.

5.1.1 Surface Water Hydrology Baseline

Baseline conditions within the Dark River watershed are discussed in Section 5.1.1.1 and those within the Sandy River watershed are described in Section 5.1.1.2.

5.1.1.1 Dark River Watershed Baseline Hydrology

Hydrologic flow data for the Dark and Sturgeon Rivers are available at five monitoring stations and various tributaries, as shown on Table 5.1, *Dark River Watershed Available Hydrologic Flow Data.*

TABLE 5.1
DARK RIVER WATERSHED
AVAILABLE HYDROLOGIC FLOW DATA

Station	Location	Available Flow Data	Source
020	Seep west of tailings basin. Headwaters of Dark River.	Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac
D-1	Dark River downstream of County Road 668	Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac
DLO	Dark River below outlet of Dark Lake.	Continuous flow measurements (Aug – Oct 2000)	MDNR
		Instantaneous flow measurements (Apr 1999 - Apr 2001)	
D-2	Dark River at USGS Station 05131000 near County Rd 481.	Continuous flow measurements (1942 – 1979)	USGS
		Continuous flow measurements (May – Oct 1999; May - Oct 2000)	MDNR
		Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac
ST-1	Sturgeon River upstream of Dark River at USGS Station 05130500	Continuous flow measurements (1942 – 2002)	USGS
Tributaries	Various Tributaries to Dark River	Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac

Notes:
1. Stations listed from upstream to downstream.
2. Station locations are shown on Figure 5-1.

These five monitoring stations plus three additional locations (D-65, D-688 and ST-2) are used for the evaluation on the Dark and Sturgeon River watersheds. These stations are listed from upstream to downstream, as follows:

- Station 020: Seep west of tailings basin, headwaters of the Dark River
- Station D-1: Dark River downstream at County Road 668
- Station DLO: Dark River below the outlet of Dark Lake
- Station D-65: Dark River at County Road 65
- Station D-2: Dark River at the former USGS Station 05131000
- Station D-688: Dark River at County Road 688, upstream of the Sturgeon River
- Station ST-1: Sturgeon River at USGS Station 05130500, upstream of the Dark River
- Station ST-2: Sturgeon River downstream of the confluence with the Dark River

The water monitoring locations in this watershed are shown on Figure 5-1, *Flow and Water Quality Monitoring and Modeling Locations.*

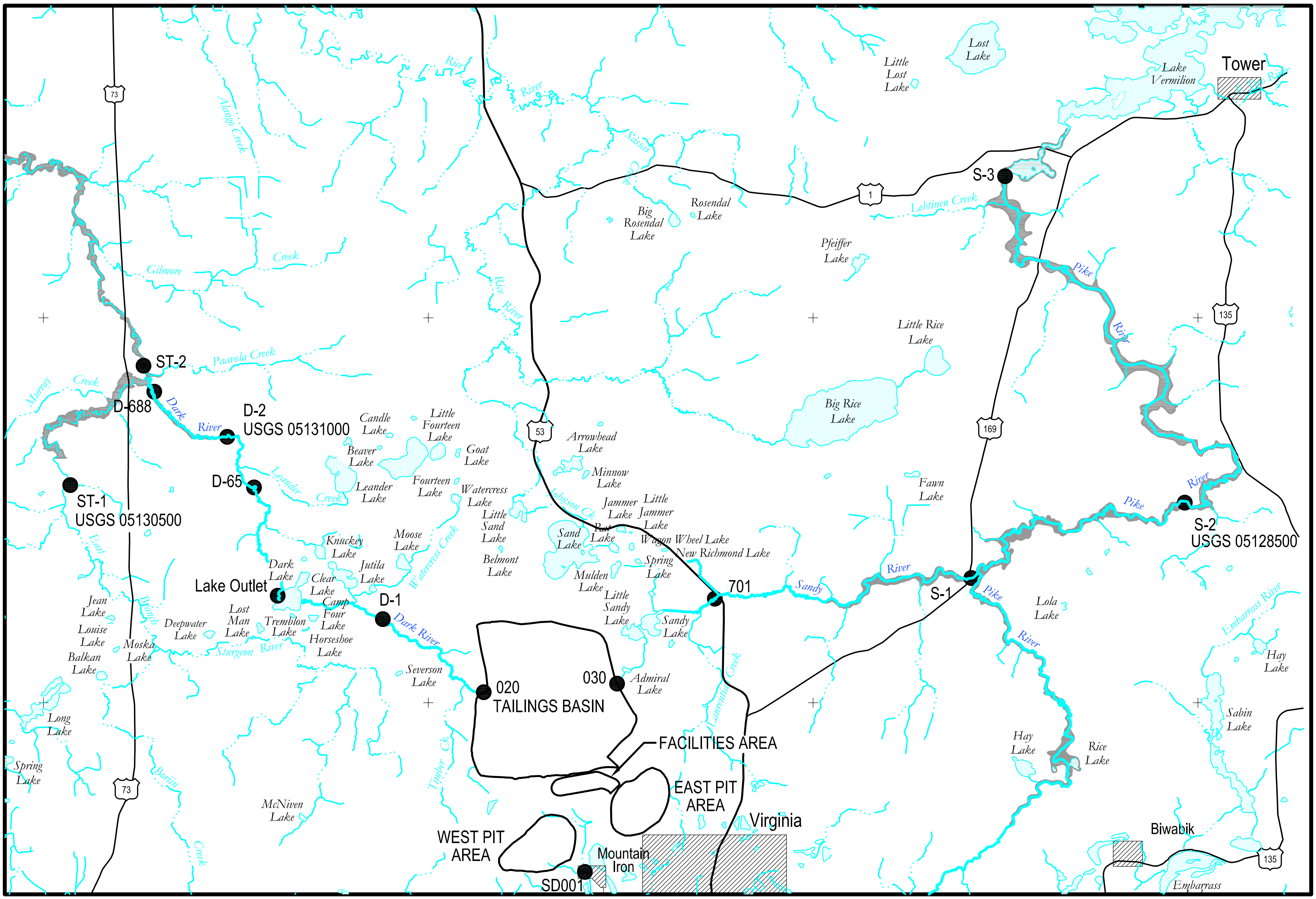


FIGURE 5-1
FLOW AND WATER QUALITY MONITORING AND MODELING LOCATIONS

Fig 5-1 Flow WQ.dwg

Continuous flow data are available from the USGS for the current USGS Station #05130500 on the Sturgeon River (Station ST-1) and the former USGS Station # 05131000 on Dark River (Station D-2). Selected statistical flow data for these stations have been calculated and are shown on Table 5.2, *Dark River Watershed Monthly Flow Data Statistics Based on USGS Gauging Data*. Annual peak flow data is also available from these gauging stations presented in the "Surface Water Hydrology and Quality Technical Memorandum" and is discussed below.

TABLE 5.2
DARK RIVER WATERSHED
MONTHLY FLOW DATA STATISTICS BASED ON USGS GAUGING DATA
(cfs)

Station:	D-1			D-2			D-688		
Period of Record: Drainage Area:	Calculated [1] 22.7 mi^2			1942 – 1979 50.6 mi^2			Calculated [2] 52 mi^2		
Month	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
October	14	1.1	105	31	2.4	234	32	2.5	240
November	11	2.1	93	25	4.6	207	25	4.7	213
December	6.2	2.3	21	14	5.2	46	14	5.3	47
January	4.4	1.9	10	10	4.2	23	10	4.3	24
February	3.9	0.7	8.5	8.6	1.6	19	9	1.6	20
March	7.3	1.6	140	16	3.6	312	17	3.7	321
April	49	2.9	340	109	6.5	758	112	6.7	779
May	39	2.0	502	86	4.5	1120	89	4.6	1151
June	24	2.7	155	53	6.0	346	55	6.2	356
July	16	0.8	103	35	1.8	229	36	1.8	235
August	10	0.3	82	23	0.6	182	24	0.6	187
September	12	1.0	237	27	2.2	528	28	2.3	543

Station:	ST-1			ST-2		
Period of Record: Drainage Area:	1942 – 2002 180 mi^2			Calculated [3] 266 mi^2		
Month	Mean	Min	Max	Mean	Min	Max
October	121	4.9	1920	153	7.3	2154
November	96	6.5	656	121	11.1	863
December	51	4.1	235	64	9.3	281
January	30	3.8	76	39	8.0	99
February	24	3.8	199	33	5.4	218
March	51	5.0	973	67	8.6	1285
April	367	12	2370	476	18.5	3128
May	299	16	3530	385	20.5	4650
June	183	9.1	1680	237	15.1	2026
July	125	2.5	2280	160	4.3	2509
August	74	6.5	827	97	7.1	1009
September	91	4.0	1060	118	6.2	1588

Notes:
1. Data for Station D-1 are calculated based on drainage area and data from USGS Station 0513100 (Dark River, D-2).
2. Data for Station D-688 are calculated based on drainage area and data from USGS Station 0513100 (Dark River, D-2).
3. Data for Sturgeon River Station ST-2 are calculated based on the sum of statistics for USGS Stations 05130500 (Sturgeon River, ST-1) and 05131000 (Dark River, D-2).

According to these data, the lowest monthly average flows in the watershed occur during February and the highest occur in April. Monthly average flows at Dark River Station D-2 varied from 8.6 to 109 cfs, and monthly average flows at Station ST-1 varied between 24 and 367 cfs. Monthly average flows at upstream Station D-1 were estimated to range between 4.4 and 49 cfs, and average flows at the downstream Station ST-2 were estimated to range between 33 and 476 cfs. Peak annual flows ranged from 106 cfs (in 1973) to 1170 cfs (in 1950) at Dark River Station D-2, between 246 cfs (1998) and 3630 cfs (1950) at Sturgeon River Station ST-1, and estimated at between approximately 648 cfs (1958) and 4800 cfs (1950) at downstream Sturgeon River Station ST-2.

The 7Q10 values represent the 7-day average low-flow value based on a 10-year recurrence interval. These values are shown on Table 5.3*, Dark River Watershed 7Q10 Low-Flow Values for Selected Stations*. Values for Stations D-1 (0.91 cfs), DLO (2.0 cfs) and D-2 (3.0 cfs) were agreed upon based on discussions between MPCA and Minntac (MPCA, 2003b and Barr, 2003). The 7Q10 value for Station D-65 (2.4 cfs) was calculated using the specific discharge rate of 0.0593 cfs/square mile at 7Q10 conditions (MPCA, 2003b) and an approximate watershed area of 40.8 square miles. Similarly, the 7Q10 value for Station D-688 (3.1 cfs) was calculated based on a watershed size of 52 square miles. Estimates for 7Q10 low-flows were not available for Stations ST-1 and ST-2; therefore, the minimum 7-day average flow value over the period of record at Station ST-1 was used for the low-flow value (3.0 cfs). This value for Station ST-1 added to the 7Q10 value at Station D-2 was used as a low-flow estimate for Station ST-2 (6.0 cfs).

TABLE 5.3
DARK RIVER WATERSHED
7Q10 LOW-FLOW VALUES FOR SELECTED STATIONS

Station	Watershed Area (mi^2)	7Q10 Low-Flow [1,2] (cfs)
D-1	22.7	0.91
DLO	32.5	2.0
D-65	40.8	2.4
D-2 (USGS 5131000)	50.6	3.0
D-688 [3]	52	3.1
ST-1 (USGS 5130500)[4]	180	3.0
ST-2[5]	266	6.0

Notes:
1. The 7Q10 values represent the 7-day low-flow for a 10-year recurrence interval.
2. The 7Q10 values presented for Stations D-1, DLO, and D-2 have been agreed upon based on discussions between MPCA and USS-Minntac (MPCA, 2003 and Barr, 2003).
3. The 7Q10 values for Stations D-688 and D-65 are calculated using the specific discharge rate of 0.0593 cfs/square mile at 7Q10 conditions (MPCA, 2003).
4. The value presented for Station ST-1 is the 7-day average low-flow over the period of record at USGS Station 05130500 (ST-1).
5. The value presented for Station ST-2 is the sum values for Stations ST-1 and D-2.

Instantaneous flow measurements were collected by Minntac in 1999 and 2000 at Stations 020, D-1, D-2, and selected tributaries of the Dark River for preparation of a water quality and flow model. Additional flow measurements were collected monthly between May and August 2003 at Stations 020, D-1, D-2 and the tributaries for validation of this model. Also, some instantaneous flow measurements were collected by MDNR during 1999 through 2001 at the DLO station and Station D-2 for the development of a flow and temperature model. MDNR also collected continuous stage height data (with some data gaps) at the DLO station between September 1998 and September 2001, and at the Dark River Station D-2 between May 1999 and April 2001. These data are presented in Appendix A of the *Surface Water Hydrology and Quality Technical Memorandum.* Rating curves were developed by MDNR to calculate flows for some of the stage height data. These rating curves are included in the Technical Memorandum.

Instantaneous flow measurement summary statistics are shown on Table 5.4, *Dark River Watershed Instantaneous Flow Measurement Summary*. Measured flows at Station 020 ranged from 0.12 to 0.25 cfs; flows at Station D-1 ranged from 1.5 to 26 cfs; flows at DLO ranged from 9.1 to 48 cfs; and flows at Station D-2 ranged from 15 to 115 cfs.

TABLE 5.4 DARK RIVER WATERSHED INSTANTANEOUS FLOW MEASUREMENT SUMMARY (1999 – 2003) (cfs)				
Station	**020**[1]	**D-1**[2]	**DLO**[3]	**D-2**[1]
Minimum	0.12	1.5	9.1	15
Maximum	0.25	26	48	115
Mean	0.18	10	24	34

Notes:
1. Data for Stations 020 and D-2 (1999/2000) are from Barr, 2002 (modified from URS, 2001).
2. Data for Stations D-1 (1999/2000) are from URS, 2001.
3. Data for DLO are from MDNR.

Peak storm flow estimates were generated by modeling for the 2-, 5-, 10-, 25-, 50-, and 100-year events for several stations in the Dark River basin and compared with estimates derived from actual historic flow data at USGS Stations D-2 and ST-1. Details pertaining to the peak flow analysis are contained within the *Surface Water Hydrology and Water Quality Technical Memorandum.* In general, the calculated peak flow estimates were consistent with actual flow data. Peak flow data are presented for Stations D-2 and ST-2 in the following figures: Figure 5-2, *Peak Annual Flows on Dark River at Station D-2,* and Figure 5-3, *Estimated Peak Annual Flows on Sturgeon River at Station ST-2.*

5.1.1.2 Sandy River Watershed Baseline Hydrology

Hydrologic flow data for the Sandy River and Pike River are available at several monitoring stations and various tributaries, as shown on Table 5.5, *Sandy River Watershed Available Hydrologic Flow Data.*

TABLE 5.5 SANDY RIVER WATERSHED AVAILABLE HYDROLOGIC FLOW DATA			
Station	**Location**	**Available Flow Data**	**Source**
030	Seep east of tailings basin, Headwaters of Sandy River.	Instantaneous flow measurements (Jan 1995 – Dec 2002; May – Aug 2003)	Minntac
701	Sandy River at Hwy 53	Instantaneous flow measurements (Jan 1995 - Oct 2002; May – Aug 2003)	Minntac
S-1	Sandy River at Hwy 169 upstream of Pike River confluence	Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac
S-2	Pike River downstream of Sandy River at USGS Station 05128500	Instantaneous flow measurements (Apr 1999 – Feb 2000)	Minntac
		Continuous flow measurements (1954 – 1979)	USGS
Tributaries	Various Tributaries to Sandy River	Instantaneous flow measurements (Apr 1999 – Feb 2000; May – Aug 2003)	Minntac

Notes:
1. Stations listed from upstream to downstream.
2. Station locations are shown on Figure 5-1.

These monitoring stations are listed from upstream to downstream, as follows:

- Station 030: Seep east of tailings basin, headwaters of the Sandy River
- Station 701: Sandy River downstream of Sandy Lake at Highway 53
- Station S-1: Sandy River at Highway 169, upstream of the Pike River

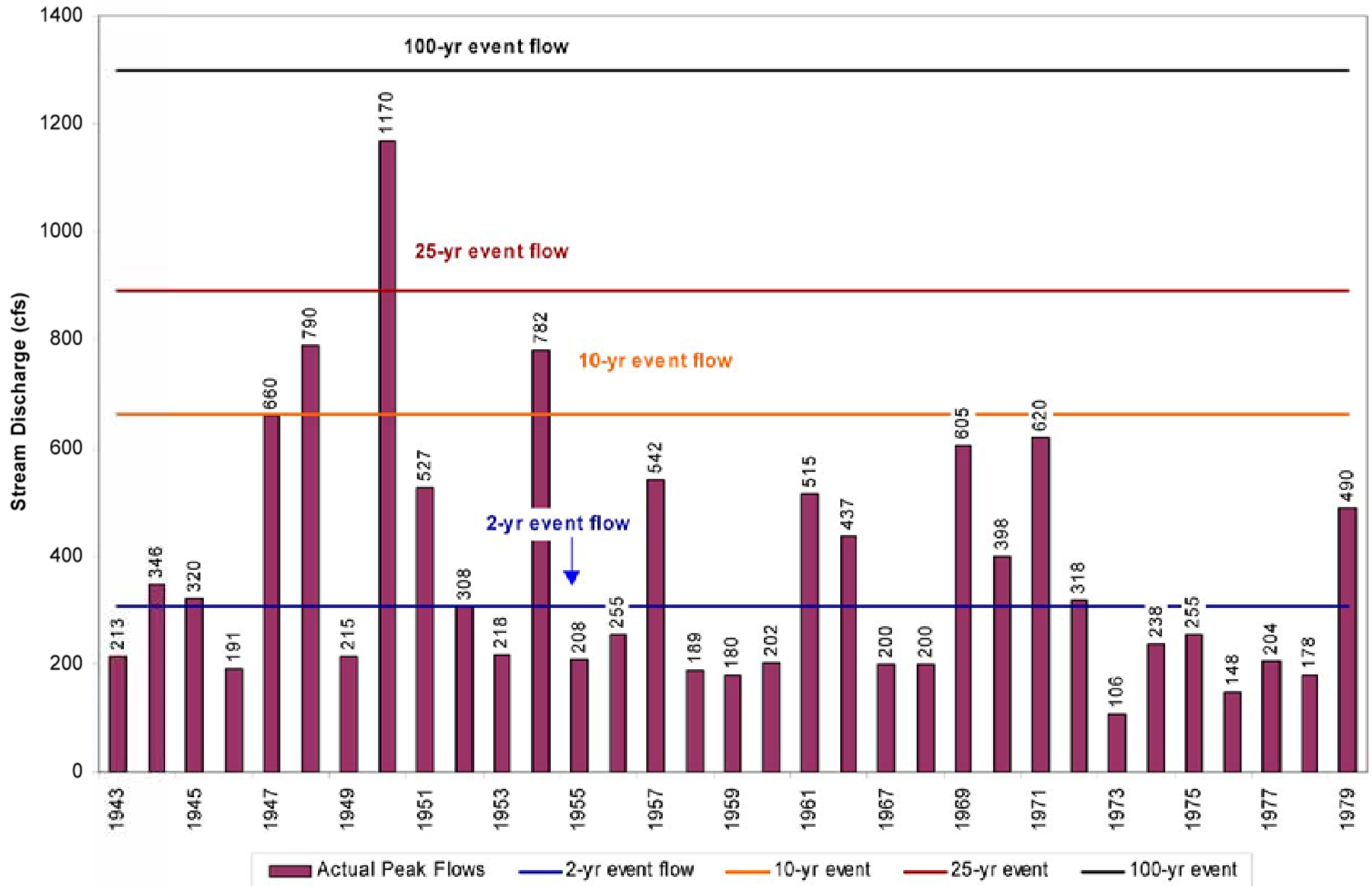
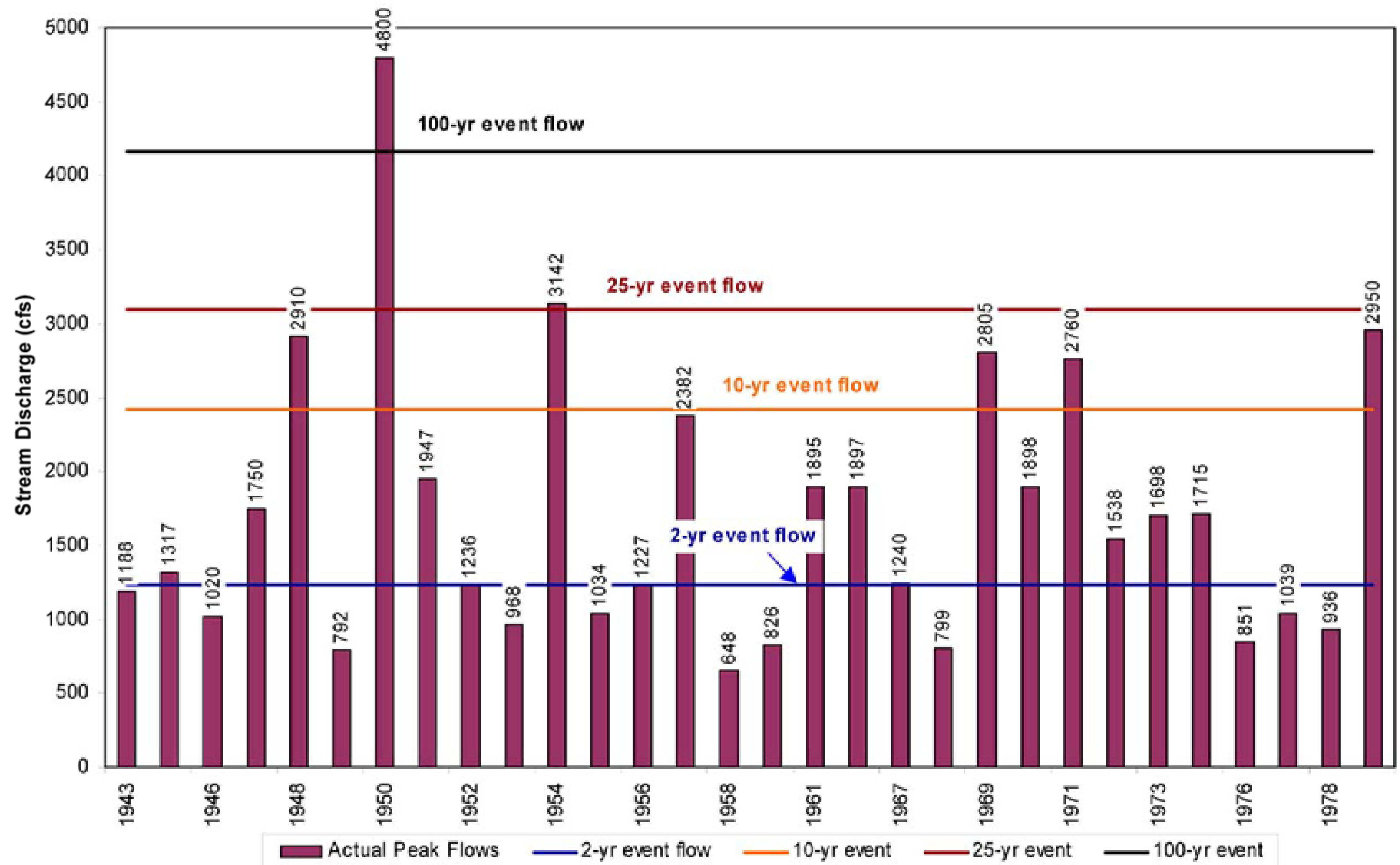


FIGURE 5-2
PEAK ANNUAL FLOWS ON
DARK RIVER AT STATION D-2

FILENAME: Fig 5-2 Flows D2.dwg



Peak flows estimated based on sum of data from USGS Stations 05130500 and 05131000

FIGURE 5-3
ESTIMATED PEAK ANNUAL FLOWS ON STURGEON RIVER AT STATION ST-2

FILENAME: Fig 5-3 Flows ST2.dwg

- Station S-2: Pike River at former USGS Station 05128500, downstream of Sandy River
- Station S-3: Pike River near its confluence with the Pike River flowage.

The water monitoring locations in this watershed are shown on Figure 5-1.

Continuous flow data are available from the USGS for the former USGS station on the Pike River (Station S-2). Monthly flow statistics and peak annual flow data were also reported by the USGS for the gauged station. Selected statistical flow data for this station were calculated and are presented in Table 5.6, *Sandy River Watershed Monthly Flow Data Statistics Based on USGS Guaging Data*. According to USGS data, the lowest monthly average flow of 7.0 cfs occurred in January and February, and the highest average flow of 267 cfs was in April. Peak annual flows ranged from 337 cfs (in 1958) to 2400 cfs (in 1950) at this station.

TABLE 5.6
SANDY RIVER WATERSHED
MONTHLY FLOW DATA STATISTICS BASED ON USGS GAUGING DATA
(cfs)

Station:	701			S-2		
Period of Record Drainage Area:	Calculated [1] 23.2 mi^2			1954 – 1979 118 mi^2		
	Mean	Min	Max	Mean	Min	Max
October	10	1.5	56	53	7.6	287
November	8.9	2.2	49	45	11	250
December	3.6	0.6	18	18	3.3	92
January	1.8	0.1	6.5	9.0	0.4	33
February	1.4	0.1	3.5	7.0	0.4	18
March	2.8	0.3	42	14	1.5	214
April	53	0.7	342	267	3.5	1740
May	44	1.5	147	226	7.8	746
June	24	1.7	98	122	8.7	497
July	15	1.0	85	75	4.9	432
August	8.1	0.6	85	41	3.3	433
September	15	0.8	88	75	4.0	448

Notes:
1. Data for Station 701 are calculated based on drainage area and data from USGS Station 05128500 (Pike River, S-2).

The 7Q10 low-flow values are shown on Table 5.7, *Sandy River Watershed 7Q10 Low-Flow Values for Selected Stations*. Values presented for Stations 701 (0.27 cfs), S-1 (0.83) S-2 (1.5 cfs) and S-3 (2.5 cfs) have been agreed upon based on discussions between MPCA and Minntac (MPCA, 2003b and Barr, 2003).

TABLE 5.7
SANDY RIVER WATERSHED
7Q10 LOW-FLOW VALUES FOR SELECTED STATIONS

Station	Watershed Area (mi^2)	7Q10 Low-Flow [1,2] (cfs)
701	23.2	0.27
S-1	64.6	0.83
S-2 (USGS 5128500)	118	1.5
S-3	192	2.5

Notes:
1. The 7Q10 values represent the 7-day low-flow for a 10-year recurrence interval.
2. The 7Q10 values presented for Stations 701, S-1, S-2 and S-3 have been agreed upon based on discussions between MPCA and USS-Minntac (MPCA, 2003 and Barr, 2003).

During 1999 and 2000, Minntac collected instantaneous flow measurements at Stations 030, 701, S-1, S-2 and selected tributaries for preparation of a chemical/flow model. Additional flow measurements were collected monthly between May and August 2003 at Stations 030, 701, S-1 and various tributaries for validation of this model.

A summary from the instantaneous flow measurements collected between 1999 and 2003 for the main stream stations are shown on Table 5.8, *Sandy River Watershed Instantaneous Flow Measurement Summary (1999-2003)*. Measured flows at Station 030 ranged from 0.30 to 0.59 cfs, flows at Station 701 ranged from 0.70 to 59 cfs; flows at Station S-1 ranged from 23 to 307 cfs; and flows at Station S-2 ranged from 61 to 675 cfs.

TABLE 5.8
SANDY RIVER WATERSHED
INSTANTANEOUS FLOW MEASUREMENT SUMMARY (1999 – 2003)
(cfs)

Station	030	701[1]	S-1[2]	S-2[1]
Minimum	0.30	0.70	23	61
Maximum	0.59	59	307	675
Mean	0.45	21	100	321

Notes:
1. Data for Stations 701 and S-2 (1999/2000) are from URS, 2001.
2. Data for Station S-1 (1999/2000) are from Barr, 2002 (modified from URS, 2001).

Data collected at various stations during 2003 are from Barr, 2003.

Peak storm flow estimates were generated by modeling for the 2-, 5-, 10-, 25-, 50-, and 100-year events for several stations in the Sandy River basin and compared with estimates derived from actual historic flow data at USGS Station S-2. Details pertaining to the peak flow analysis are contained within the *Surface Water Hydrology and Water Quality Technical Memorandum*. In general, the calculated peak flow estimates were consistent with actual flow data. Peak flow data are presented for Station S-2 in Figure 5-4, *Peak Annual Flows on the Pike River at Station S-2*.

5.1.1.3 Additional Watershed Information

Additional watershed information, collected in support of the hydrologic impact analysis, included USGS 7.5-minute topographic maps of the area, FEMA flood zone maps, and other general site maps. The FEMA maps for the area present the 100-year floodplain zone for the Dark River and Sandy River watersheds. This zone is shown as a shaded area along the streams on Figure 5-1. In addition, the rating curves for relating stage height to stream discharge at the gauging stations on the Sturgeon River (ST-1), Dark River (D-2), and Pike River (S-2) were obtained from USGS. These data are included in Appendix B of the *Surface Water Hydrology and Water Quality Technical Memorandum*.

Information related to design of in-stream structures such as bridges, pipes and culverts along the Dark River and Sandy River was obtained from the St. Louis County Engineer's Office. According to the Bridge Engineer at the St. Louis County Engineer's Office (Personal Communication, 12/15/03), current in-stream structures (bridges, pipes, culverts, etc) are designed for a 100-year storm event flow. The first engineered structure on the Dark River is the bridge at County Road 668, which is located at Station D-1. The first engineered structure on the Sandy River is the bridge at Highway 53, which is located at Station 701.

5.1.2 Surface Water Hydrology Impacts

This section documents the potential impacts, both quantitatively and qualitatively, to the surface water hydrologic system under the Proposed Project, No Build Alternative, and the Action Alternatives described previously in Section 4.0.

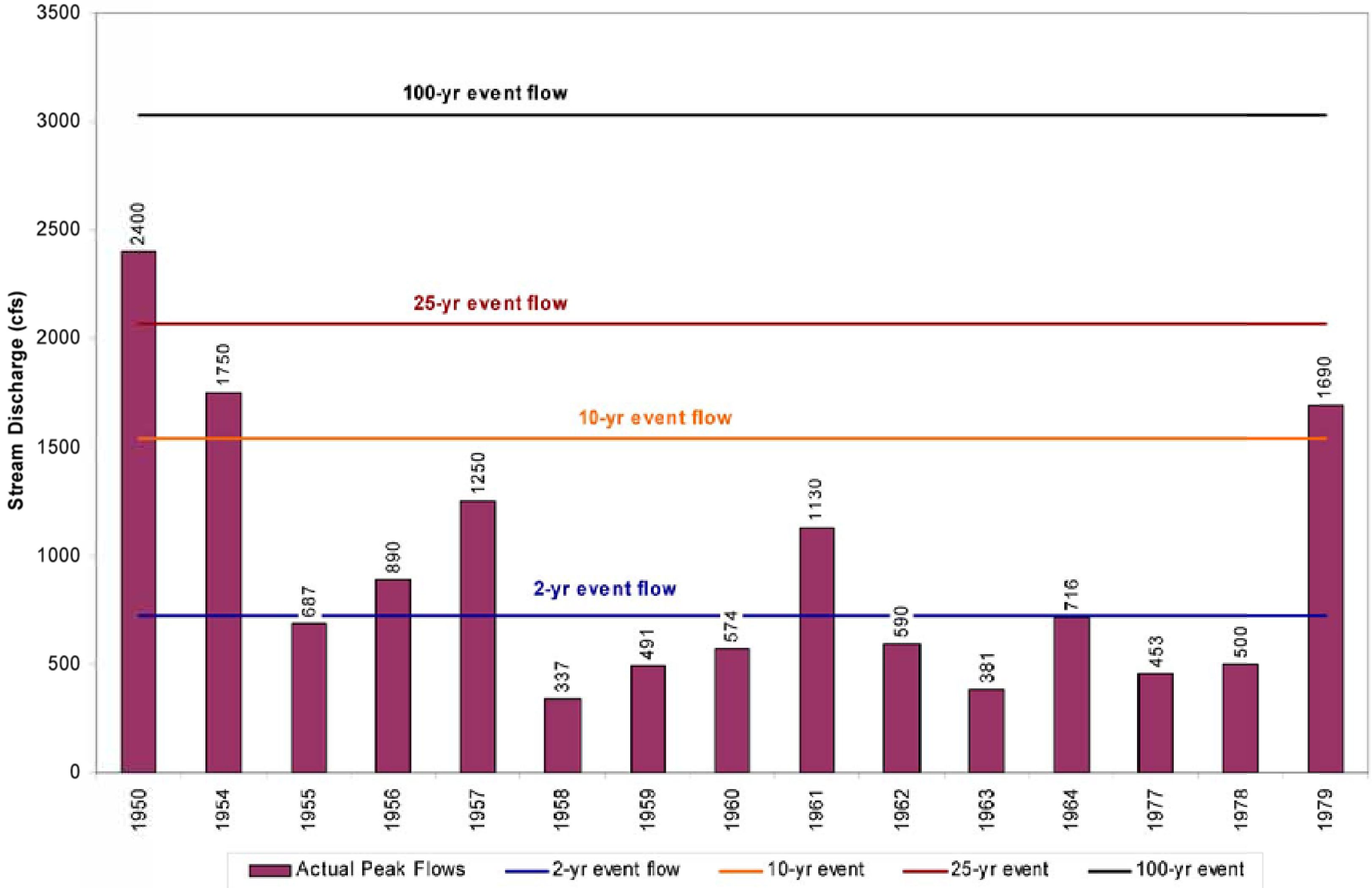


FIGURE 5-4
PEAK ANNUAL FLOWS ON
PIKE RIVER AT STATION S-2

FILENAME: Fig 5-4 Flows S2.dwg

Further details pertaining to potential hydrologic impacts are included in the *Surface Water Hydrology and Quality Technical Memorandum.*

5.1.2.1 Alternative A: Proposed Project (Proposed Action)

A hydrologic impact analysis was performed to evaluate potential effects of the proposed project and project alternatives to the baseline hydrologic conditions of the Dark River and Sandy River watersheds. The effects of the proposed discharge on the hydrologic systems were assessed in terms of the following:

- Relative percent increase to historic flows
- Potential increased water depths, flooding and overland flow
- Potential increased channel scouring, erosion and sedimentation
- Potential impacts to in-stream structures (bridges, pipes, culverts)
- Potential for changes in groundwater flow to streams

Relative Percent Flow Increases

The additional discharge that would contribute to stream flow as a result of the proposed project was added to statistical, estimated and measured stream flows to quantitatively determine resulting flows at discrete locations along streams. The hydrologic impact analyses determined the relative percent increases in flows as a result of increased flows from the proposed project for the following:

- Monthly average flow
- 7Q10 minimum flow
- Peak storm flow

Potential impacts under these three flow regimes are described in the following paragraphs.

Monthly average flow: Baseline flow data shown on Table 5.2 for the Dark River watershed and Table 5.6 for the Sandy River watershed were used as a reference for evaluating relative impacts of the additional flow volumes of 5.6 cfs or 11.1 cfs to each watershed. The monthly average flows at Stations D-2, ST-2, and S-2 for baseline conditions and for Alternative A with 5.6 cfs discharge and 11.1 cfs discharge are shown in the following tables: Table 5.9, *Effects of Minntac Tailings Basin Discharge on Dark River Flow at Monitoring Station D-2,* Table 5.10, *Effects of Minntac Tailings Basin Discharge on Sturgeon River Flow at Monitoring Station ST-2,* and Table 5.11, *Effects of Minntac Tailings Basin Discharge on Pike River Flow at Monitoring Station S-2.* These data are shown graphically on Figure 5-5, *Monthly Average Flows on Dark River at Station D-2,* Figure 5-6, *Monthly Average Flows on Sturgeon River at Station ST-2* and Figure 5-7, *Monthly Average Flows on Pike River at Station S-2,* which present the resulting total flows by month.

Analysis of effects of discharge on hydrology was reported in the *Surface Water Hydrology and Quality Technical Memorandum* and these data are reviewed here. Data shown in Tables 5.9 through 5.11 and in Figures 5-5 through 5-7 illustrate the effect of increases in water flow with additional discharge from the tailings basin. Percent flow of receiving water bodies increases with additional discharge of 5.6 or 11.1 cfs and varies by month and by river size. In general, during high-flow periods the impact of tailings basin discharge on flow is much lower than during low-flow periods. In addition, impacts to rivers becomes greater with increasing proximity to the discharge point.

**TABLE 5.9
EFFECTS OF MINNTAC TAILINGS BASIN DISCHARGE ON DARK RIVER FLOW
AT MONITORING STATION D-2**

Date	Average flow (cfs)	Flow +5.6 cfs	Percent Increase	Flow +11.1 cfs	Percent Increase
January	10	15	56	21	111
February	9	15	62	20	123
March	16	22	35	27	69
April	109	115	5	120	10
May	86	92	6	97	13
June	53	59	10	64	21
July	35	41	16	46	32
August	23	29	24	34	48
September	27	33	21	38	41
October	31	37	18	42	36
November	25	31	22	36	44
December	14	20	40	25	79
Average	37	43	15	48	30

**TABLE 5.10
EFFECTS OF MINNTAC TAILINGS BASIN DISCHARGE ON STURGEON RIVER FLOW
AT MONITORING STATION ST-2**

Date	Average flow (cfs)	Flow +5.6 cfs	Percent Increase	Flow +11.1 cfs	Percent Increase
January	39	45	14	50	28
February	33	39	17	44	34
March	67	73	8	77	17
April	476	482	1	487	2
May	385	391	1	396	3
June	237	243	2	248	5
July	160	166	3	171	7
August	97	103	6	108	11
September	118	124	5	129	9
October	153	159	4	164	7
November	121	127	5	132	9
December	64	70	9	75	17
Average	162	169	3	173	13

**TABLE 5.11
EFFECTS OF MINNTAC TAILINGS BASIN DISCHARGE ON PIKE RIVER FLOW
AT MONITORING STATION S-2**

Date	Average flow (cfs)	Flow +5.6 cfs	Percent Increase	Flow +11.1 cfs	Percent Increase
January	9	15	62	20	123
February	7	13	80	18	158
March	14	20	40	25	79
April	267	273	2	278	4
May	226	232	2	237	5
June	122	128	5	133	9
July	75	81	8	86	15
August	41	47	14	52	27
September	75	81	8	86	15
October	53	59	11	64	21
November	45	51	12	56	25
December	18	24	31	29	62
Average	79	85	7	90	14

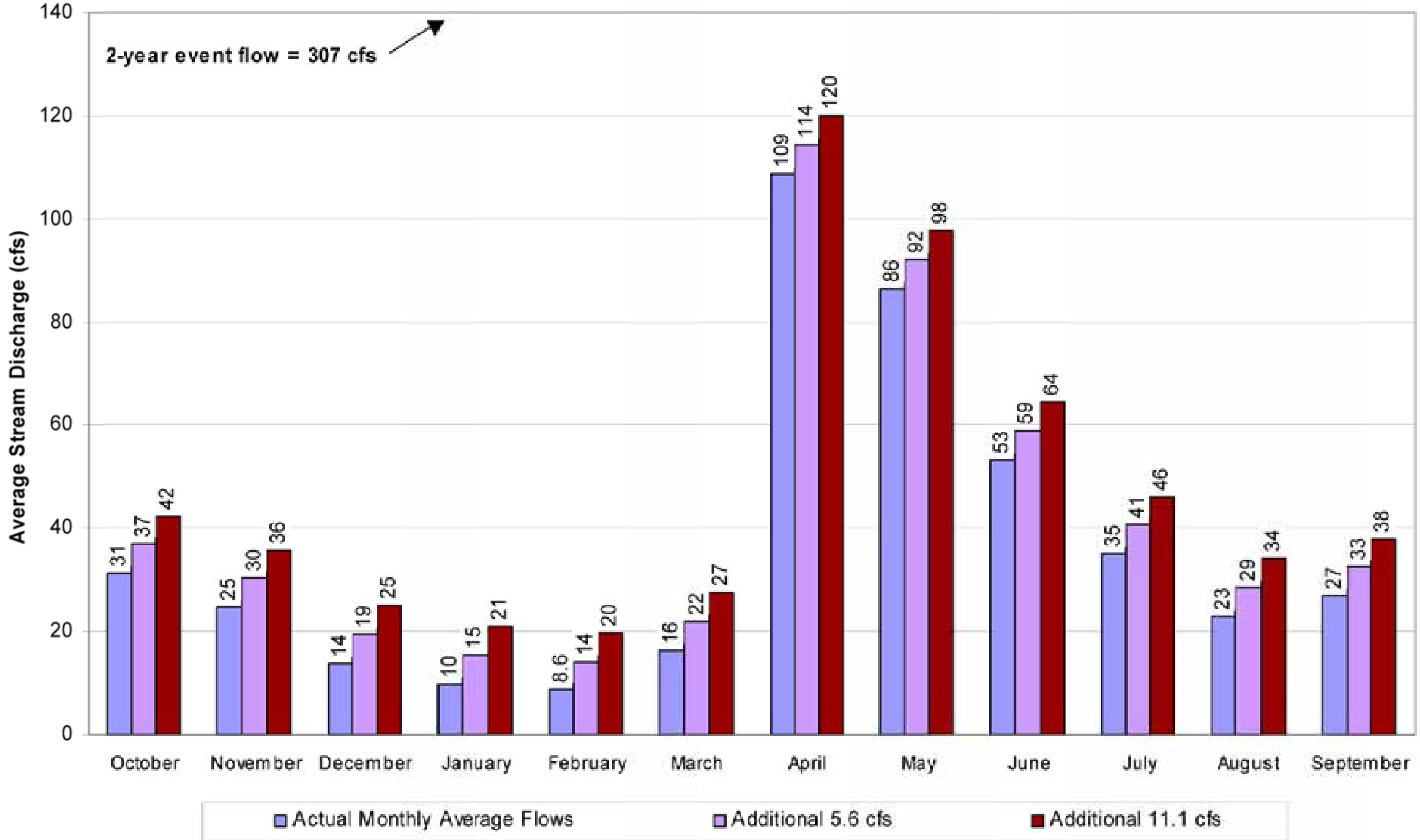


FIGURE 5-5
MONTHLY AVERAGE FLOWS ON
DARK RIVER AT STATION D-2

FILENAME: Fig 5-5 Flows D2.dwg

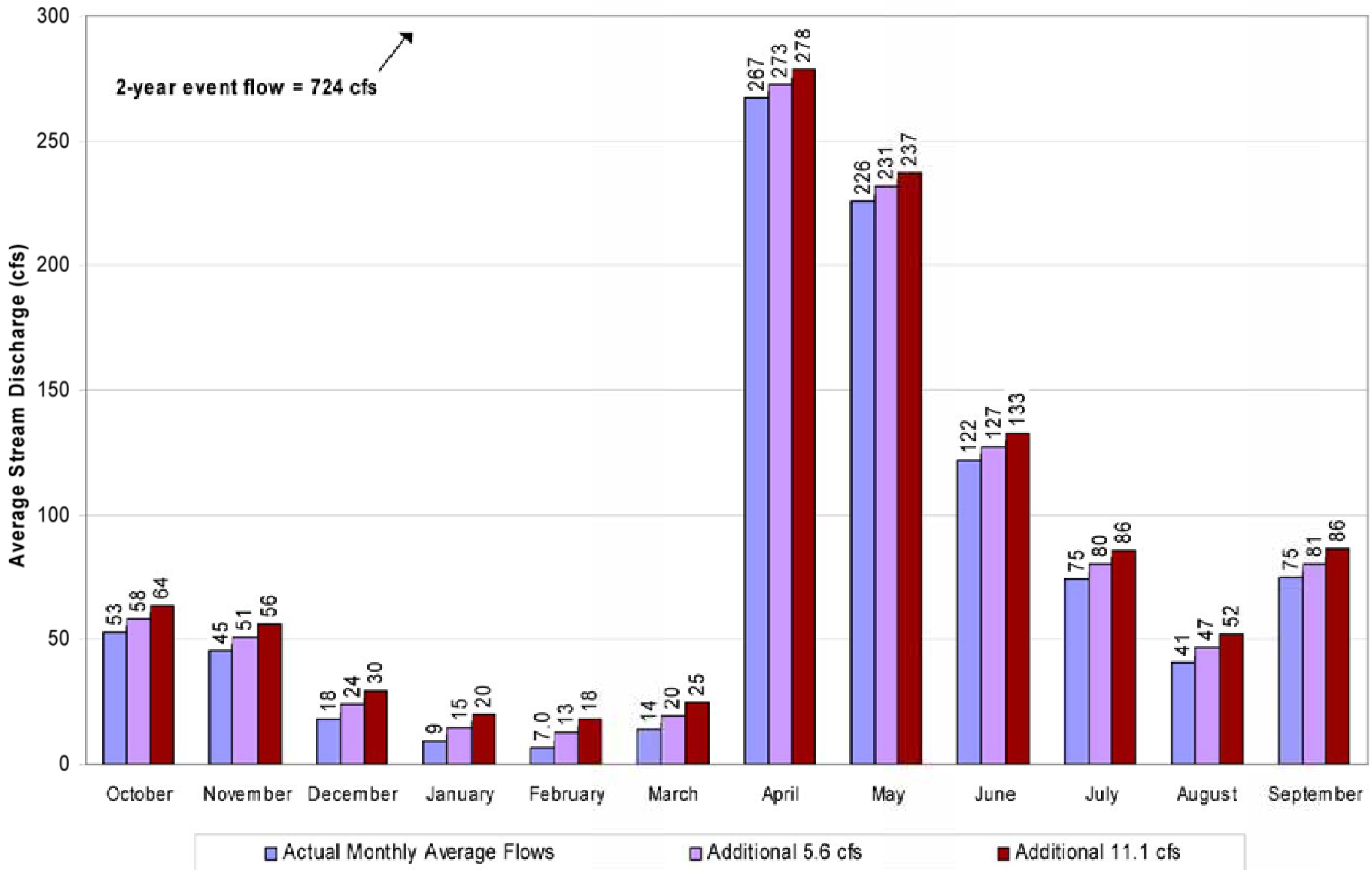


FIGURE 5-6
MONTHLY AVERAGE FLOWS ON
STURGEON RIVER AT STATION ST-2

FILENAME: Fig 5-3 Flows ST2.dwg

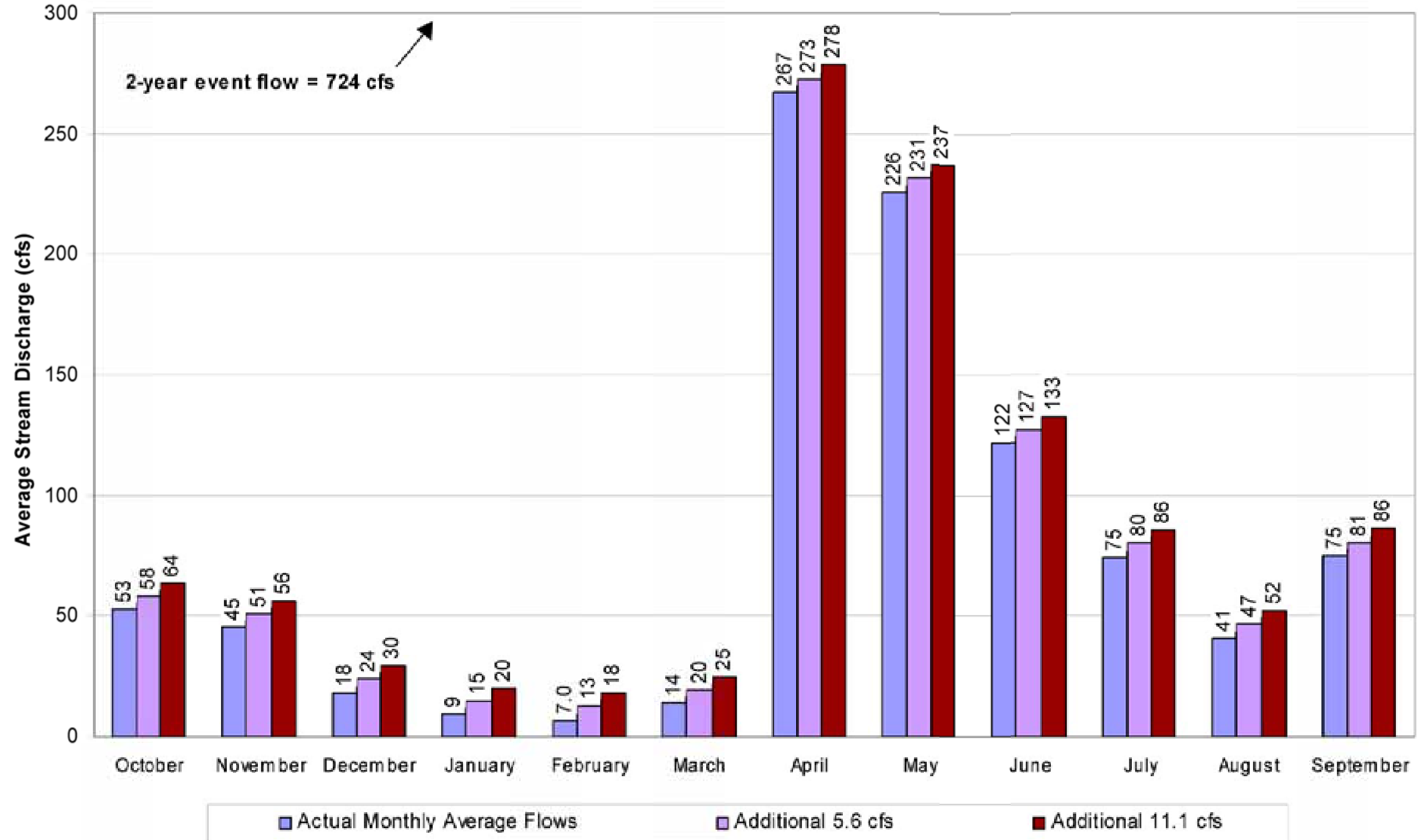


FIGURE 5-7
MONTHLY AVERAGE FLOWS ON
PIKE RIVER AT STATION S-2

FILENAME: Fig 5-7 Flows S2.dwg

As indicated by the data, the natural hydroperiod of all impacted rivers peaks in April and declines throughout the summer where it remains low from August to March (Barr, 2001). February is typically the low-flow month in both the Dark River and Sandy River basins.

As was noted in the *Surface Water Hydrology and Water Quality Technical Memorandum*, the mean flow at the seeps located to the west (Station 020) and east (Station 030) of the tailings basin are 0.18 and 0.45 cfs, respectively. Although discharge will not be directly into these areas, seeps may receive additional water through backflow and/or flooding. The average flow at the point of discharge from the tailings basin from February 1999 to April 2000 (the time period when data were available) was 0.76 cfs on the east (Sandy River) and 1.02 cfs on the west (Dark River)(URS Corporation, 2001). Average flow, with an additional 11.1 cfs, would increase 1,360 and 988 percent at the point of discharge on the Sandy and Dark rivers, respectively. With an additional 5.6 cfs, flows would increase 637 and 450 percent on the Sandy and Dark rivers, respectively. Thus, an increase in discharge of up to 11.1 cfs from either of these points would greatly increase river flows. Admiral Lake, Sandy Lake, and Little Sandy Lake may help buffer the effects of the discharge on the Sandy River and Dark Lake may buffer these effects on Dark River.

Table 5.12, *Projected Annual Average Minimum, Maximum, and Mean Flows at Selected Stations*, presents annual summary information, including the minimum, maximum, and mean flows expected at Stations D-2, ST-2, and S-2 as a result of adding additional flow. Data are presented both in terms of total resulting flow volumes and relative percent increases.

TABLE 5.12
PROJECTED AVERAGE ANNUAL MINIMUM, MAXIMUM AND MEAN FLOWS AT SELECTED STATIONS

	Average Flow (cfs)	+ 5.6 cfs		+ 11.1 cfs	
		Total Flow (cfs)	% Increase	Total Flow (cfs)	% Increase
Station D-2					
Min (February)	9	15	62	20	129
Max (April)	109	114	5	120	10
Annual Mean	37	43	15	48	30
Station ST-2					
Min (February)	33	39	17	44	34
Max (April)	476	482	1	487	2
Annual Mean	162	168	3	173	7
Station S-2					
Min (February)	7	13	80	18	159
Max (April)	267	273	2	278	4
Annual Mean	79	85	7	90	14

In terms of percent increase, the lowest relative percent increase would occur during the higher flow months (April-June), and the highest percent increase would occur during the lower flow months (January-March). Specifically, the lowest percent increases would occur in April at Station D-2 (5% or 10% for an additional 5.6 or 11.1 cfs, respectively), Station ST-2 (1% or 2%), and Station S-2 (2% or 4%). The highest average percent increases would occur during the month of February at Station D-2 (62% or 129%), Station ST-2 (17% or 34%), and Station S-2 (80% or 159%). This illustrates that throughout the watersheds, the low-flow periods would be affected by the additional flow to a greater degree than the high-flow periods when evaluated based on percentage increase in flow.

The total resulting flows were also compared to the predicted 2-year storm event flows at each station. According to the *Surface Water Hydrology and Quality Technical Memorandum*, the average stream flows predicted to result from the additional discharge of 11.1 cfs would fall well below the estimated 2-year peak storm flow volumes in both the Dark River (Stations D-2 and ST-2) and Sandy River

(Station S-2). These data indicate that, on average, the additional flow volume would not significantly impact the hydrologic system.

7Q10 minimum flow: The potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 7Q10 minimum flow was modeled and details are presented in the *Surface Water Hydrology and Water Quality Technical Memorandum.* Increases to the low-flow values were calculated throughout the watersheds from the upstream to downstream stations. In contrast to the 2-year storm event discussed above, relative percent increases during the low-flow periods would be large throughout the watersheds, from the headwater stations to the downstream stations on the Pike and Sturgeon Rivers. Thus, low-flow periods would be affected to a greater relative degree by additional flow than would high-flow periods. Table 5.13, *Percent Increase in 7Q10 Low-Flow Values for Rivers Receiving Additional Tailings Basin Discharge,* shows the degree to which the average river flows may be increased during low-flow periods. Although these increases are predicted to be large in the upper portions of both the Dark and Sandy Rivers, the percent change decreases as the distance from the discharge point increases.

TABLE 5.13
PERCENT INCREASE IN 7Q10 LOW-FLOW VALUES FOR RIVERS RECEIVING ADDITIONAL TAILINGS BASIN DISCHARGE

Station	7Q10 Low-Flow (cfs)	+5.6 cfs		+11.1 cfs	
		Total flow (cfs)	% Increase	Total flow (cfs)	% Increase
Dark/Sturgeon River Watershed					
D-1	0.9	6.5	622	12.0	1233
Lake Outlet	2.0	7.6	280	13.1	555
D-2	3.0	8.6	187	14.1	370
D-688	3.1	8.7	181	14.2	358
ST-2	6.1	11.7	92	17.2	182
Sandy/Pike River Watershed					
701	0.3	5.9	2074	11.4	4111
S-1	0.83	6.4	674	11.9	1337
S-2	1.5	7.1	373	12.6	740
S-3	2.5	8.1	224	13.6	444

The data indicate more than a thousand percent increase in flow in the upstream stations and on the order of a hundred percent increase in flow on the downstream stations in both watersheds. These calculations are based on the conservative assumption that the additional flow volume is added to the 7Q10 low-flow value. It is more realistic that some component of the additional flow volume would be attenuated into the storage capacity (e.g., lakes and wetland areas) of the watersheds. In addition, it should be noted that the absolute increases in flows would be well below the average stream flows in the channels.

Peak storm flow: The potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 2-, 5-, 10-, 25-, 50- and 100-year storm event flows were also modeled and details are presented in the *Surface Water Hydrology and Water Quality Technical Memorandum.* Relative impacts to 2-year event peak flows in both the Dark River and Sandy River watersheds are shown in Figure 5-8*, Relative Percent Impacts on 2-Year Peak Storm Flow Estimates.* As shown in this figure, increases to peak flows would range from approximately 3 to 6 percent at the upstream locations for 5.6 cfs and 11.1 cfs additional flow, respectively. At the downstream stations, peak flows would range from less than 1 percent to slightly greater than 1 percent for 5.6 cfs and 11.1 cfs additional flow, respectively. Percent increases from the proposed project flow to the larger storm event flows (5-, 10-, 25-, 50- and 100-year event flows) are between 0.3 and 4 percent for all locations evaluated.

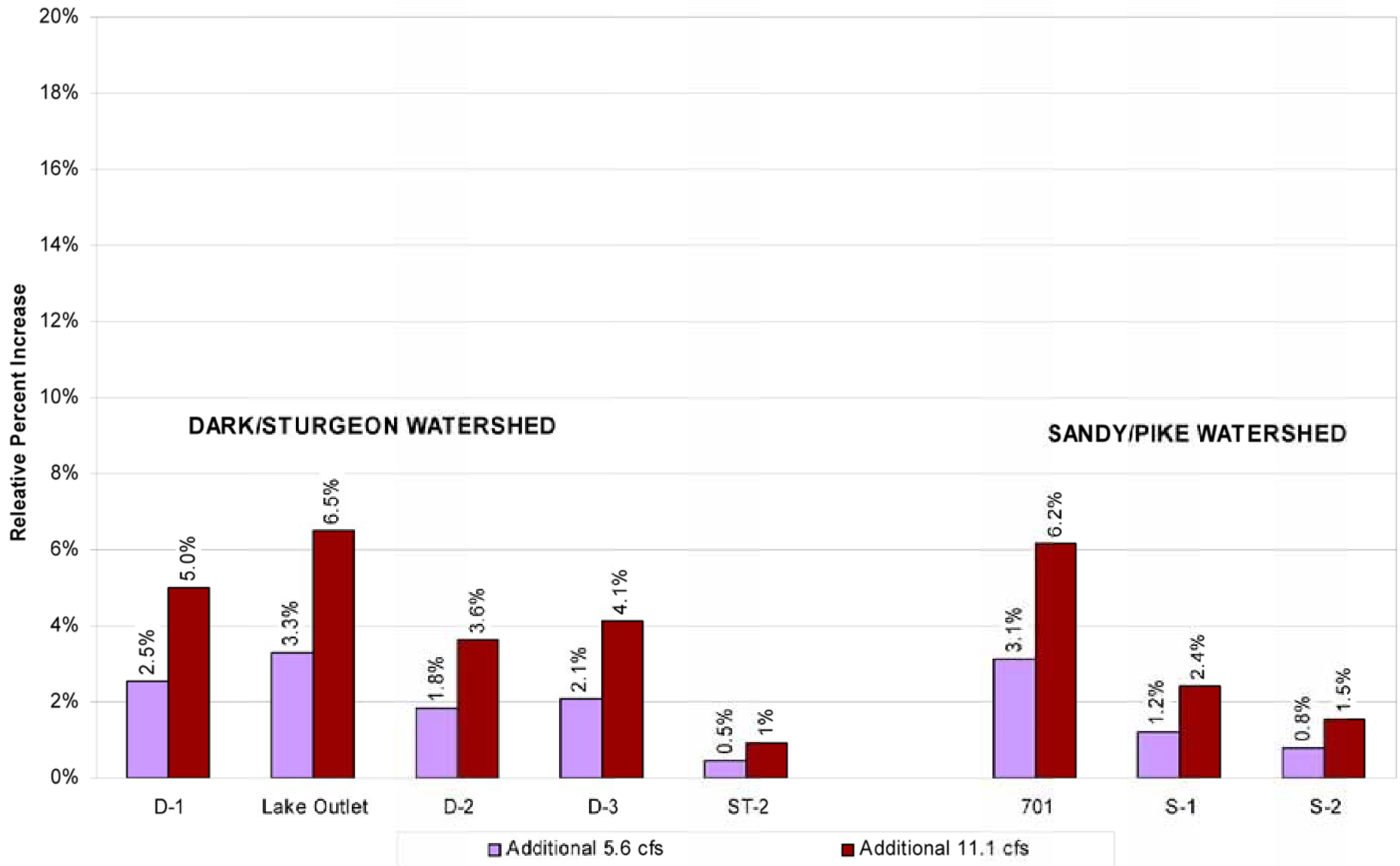


FIGURE 5-8
RELATIVE PERCENT IMPACTS ON 2-YEAR PEAK STORM FLOW ESTIMATES

FILENAME: Fig 5-8 Peak Flow Estimates.dwg

Water Levels, Flooding and Overland Flow

Rating curves developed by the USGS to relate water depth to stream flow at the USGS stations on the Pike, Sturgeon and Dark Rivers were used to estimate increases in water levels due to proposed increased flow. The rating curves are included in Appendix B of the *Surface Water Hydrology and Water Quality Technical Memorandum*. These estimates were determined for discrete locations in the channel (the USGS stations) and were dependent on the channel morphology at that location; therefore, the estimated water level changes were only representative of the channel at that specific location and possibly along that immediate stream reach. Projected water level increases at USGS stations in the Dark River and Sandy River watersheds are shown in Table 5.14, *Projected Water Level Increases During Average Annual Minimum and Maximum Flows and Two-year Storm Events at Selected Locations.*

TABLE 5.14
PROJECTED WATER LEVEL INCREASES
DURING AVERAGE ANNUAL MINIMUM AND MAXIMUM FLOWS AND 2-YEAR STORM EVENTS AT SELECTED STATIONS

	Average Flow (cfs)	Additional 5.6 cfs Total Flow (cfs)	Projected Water Level Increase (ft)	Additional 11.1 cfs Total Flow (cfs)	Projected Water Level Increase (ft)
Station ST-1					
Min (February)	33	39	0.08	44	0.17
Max (April)	476	482	0.01	487	0.03
2-Year Storm	1,230	1,236	<0.01	1,241	<0.01
Station D-2					
Min (February)	9	15	0.20	20	0.35
Max (April)	109	114	0.04	120	0.09
2-Year Storm	307	313	0.04	318	0.08
Station S-2					
Min (February)	7.0	13	0.18	18	0.31
Max (April)	267	273	0.04	278	0.09
2-Year Storm	724	730	0.01	735	0.03

Station ST-1: According to the rating curve for the Sturgeon River Station ST-1, additional flow volumes of 5.6 cfs and 11.1 cfs would result in increases in the water levels (stage height) by 0.08 and 0.17 feet, respectively, during an average February flow rate of 33 cfs; and by approximately 0.01 and 0.03 feet during an average April flow of 476 cfs. Water level increases during a 2-year flow event of 1,230 cfs would be less than 0.01 feet combined with the additional 5.6 or 11.1 cfs of proposed project flow.

Station D-2: According to the rating curve for the Dark River Station D-2, additional flow volumes of 5.6 cfs and 11.1 cfs would result in increases in the water levels (stage height) by 0.20 and 0.35 feet, respectively, during an average February flow rate of 8.6 cfs; and by approximately 0.04 and 0.09 feet during an average April flow of 109 cfs. Water level increases during a 2-year flow event of 307 cfs would be approximately 0.04 and 0.08 feet, respectively, due to the additional 5.6 or 11.1 cfs of proposed project flow.

Station S-2: According to the rating curve for the Pike River Station S-2, additional flow volumes of 5.6 cfs and 11.1 cfs would result in increases in the water levels (stage height) by 0.18 and 0.31 feet, respectively, during an average February flow rate of 7.0 cfs; and by approximately 0.04 and 0.09 feet during an average April flow of 267 cfs. Water level increases during a 2-year flow event of 724 cfs would be approximately 0.01 and 0.03 feet combined with the additional 5.6 or 11.1 cfs of proposed project flow, respectively.

The potential for increased flooding and overland flow at these locations is minimal based on the relatively small changes in water levels resulting from the increased flows. However, the locations of these ratings are relatively far downstream of the proposed discharge point. Therefore, it is likely that smaller channels further upstream and the headwater areas may be prone to higher degrees of flooding and overland flow; this could not be evaluated based on available data. To generally characterize potential areas of flooding, FEMA maps were used to define the 100-year floodplain along the stream channels, as shown on Figure 5-1. The additional proposed discharge is insignificant when compared to the predicted 100-year flow volumes; therefore the 100-year flood plain should define any areas of maximum potential flooding.

According to a study by MDNR, conducted in 1983, the water levels in Dark Lake were reduced as a direct result of tailings basin construction, which decreased the watershed size at Dark Lake from 32 square miles to 22.5 square miles (9.5 square miles of watershed were impounded by the tailings basin). This 30 percent reduction in watershed size resulted in an average water level reduction in Dark Lake of 0.4 feet, and average high lake water levels were reduced by up to 1.5 feet (Adams, 1983). To evaluate potential effects of the proposed discharge on Dark Lake water levels, the following analysis has been made: the proposed additional discharge of 11.1 cfs at Station D-1 (located upstream of Dark Lake) would increase the flow from 222 cfs to 233 cfs during a 2-year storm event. This additional flow represents a five percent increase in flow volume (which may be approximately equated to a five percent increase in watershed size). Because the actual reduction in watershed size due to basin construction (30 percent) was greater than the proposed increase in flow (five percent), it may be presumed that the potential increase in Dark Lake water levels would result in a relatively smaller change than the original impact.

Channel Scouring, Erosion and Sedimentation

Potential effects of scouring, erosion and sedimentation would be the most significant at the most upstream locations of the watersheds, where the discharge would be introduced (near the tailings basin seeps). The proposed discharge poses an increase in flow when compared with the current seepage rates. The discharge of an additional 5.6 cfs to 11.1 cfs of flow to the current seep locations could potentially cause adjustments in the plan and profiles of the channels as the channels must down-cut and widen to accommodate the increased flow volumes. Stream velocities, channel boundary stresses and stream power would all increase, translating into a combination of increased bank erosion, increased sediment scouring and stream morphology changes downstream of the tailings basin.

Increased flows would potentially destabilize the channels and could result in increased sediment flux and TSS concentrations, and the potential to violate turbidity water quality standards for some distance downstream as the stream adjusts to the increased flow volume. Sediment accumulation data for Dark Lake indicate accelerated rates that may represent channel equilibrium disruptions due to the tailings basin construction during the 1960s and 1970s (MPCA, 2001). This may suggest that scouring–related sedimentation due to increased discharge could translate as far downstream as Dark Lake, and perhaps equivalent distances on the Sandy River.

The relative percentage of increased flow at discrete locations further downstream was used to qualitatively evaluate the potential increases in channel scouring, erosion and sedimentation in the channels at these locations. Because these effects would most likely occur during higher flow periods, the relative percent increases during the estimated 2-year event flows were considered. As shown on Figure 5-8, increases to peak flows would range from approximately six percent at upstream locations (Stations D-1 and 701 on the Dark and Sandy Rivers, respectively) to less than one percent at downstream locations when combined with 11.1 cfs of additional flow. And increases would be approximately 3 percent to 0.5 percent when combined with 5.6 cfs of additional flow. The percentage increases during larger storm event flows (5-, 10-, 25-, 50- and 100-year event flows) would be sequentially less. These impacts are considered to be minimal, and therefore the degree of channel scouring, erosion and increased sedimentation are considered to fall within the normal hydrologic conditions at these locations. It should be noted that typically 1-year flow events are considered to represent channel-forming flows; therefore the relative impacts to 2-year event flows may underestimate potential impacts.

In-Stream Structures

Information on the in-stream structure designs was obtained to verify whether any of these structures would be affected by the increased flows. According to the Bridge Engineer at the St. Louis County Engineer's Office (Personal Communication, 12/15/03), the first structure on the Dark River is the bridge at County Road 668 and the first structure on the Sandy River is the bridge at Highway 53. Current in-stream structures (bridges, pipes, culverts, etc.), including these two bridges, are designed for a 100-year storm event flow. Therefore, the additional proposed discharge was cumulatively added to the estimates of 100-year event flows at discrete locations to evaluate the additional impact (as a percentage) under the proposed discharge scenarios. The potential impacts of adding 5.6 cfs or 11.1 cfs of additional flow to the 100-year storm event flow was modeled and details are presented in the *Surface Water Hydrology and Water Quality Technical Memorandum*. Relative percent impacts to the estimated 100-year storm events are less than two percent combined with 11.1 cfs of additional flow, and less than or equal to one percent combined with 5.6 cfs of flow. Therefore, impacts to in-stream structures are not expected as a result of the additional discharge.

Groundwater

Changes in groundwater inflows to streams have been evaluated by MDNR with regard to temperature modeling. It was determined, based on this modeling, that changes in the relative percentage of groundwater flows would likely occur as a result of the increased discharge. This issue is discussed with regard to mitigation measures related to surface water quality in Section 5.2 and in the *Surface Water Hydrology and Water Quality Technical Memorandum.*

5.1.2.2 Alternative B: Alternative Sites

Alternate discharge sites include Laurentian Creek, the outfall to West Two Rivers Reservoir, the mine pit lakes, or other Lake Superior basin waters.

Discharge to Laurentian Creek would create similar impacts to those described for the Sandy River watershed with the primary difference that there would be no additional impacts to the headwaters of Sandy River (near Station 030), Admiral Lake, Little Sandy Lake or Sandy Lake. However, there would be hydrologic impacts to Laurentian Creek as a result of this alternative. There are no existing flow data for locations on Laurentian Creek and, therefore, a quantitative analysis of impacts could not be made. However, it may be qualitatively noted that the size of the watershed for Laurentian Creek at the assumed discharge location is approximately three square miles, which is similar to the watershed size for the headwaters of Sandy River prior to the tailings basin construction (Adams, 1983; MDNR, 1987). Therefore, it may be presumed that the relative hydrologic impacts to Laurentian Creek would be similar to those discussed for upstream Sandy River. Also, it should be noted that there are some wetland areas located in Laurentian Creek that may be affected. These wetland areas would help attenuate the increased flow through this area, although not to the same degree that the upstream lakes on Sandy River (Admiral, Sandy and Little Sandy Lakes) would attenuate the additional flow volume. Potential wetland impacts are discussed further in Section 5.3 and in the *Wetlands Technical Memorandum.*

Discharge to the Lake Superior watershed would most likely occur via Minntac's permitted discharge points (MN0052493 Outfall SD001) located south of the tailings basin and adjacent to the West Pit Area in the city of Mountain Iron. The outfall is used for discharging mine pit water and is permitted for an average discharge of 5.0 MGD (7.5 cfs) and maximum discharge of 33.2 MGD (49.8 cfs).

According to NPDES monitoring reports, the monthly average discharge through this outfall between December 1999 and December 2002 was 8.2 cfs, with a maximum monthly average of 23.3 cfs. Therefore, it may be concluded that this outfall location could accommodate the additional proposed discharge of 11.1 cfs with respect to the maximum permitted amount. However, the average proposed flow at this location (11.1 cfs) would be greater than the current average flow (8.2 cfs) or the permitted average flow (7.5 cfs); therefore, relative hydrologic impacts as a result of this increased flow may be expected. As discussed with regard to the proposed project, hydrologic impacts may include increased channel scouring and erosion, water level increases and overland flow, and increased sediment flux and TSS concentrations downstream.

Data are not available to assess the hydrologic impacts to the mine pit lakes.

5.1.2.3 Alternative C: No Build (No Action)

Under the No Build Alternative, the proposed discharge would not be permitted and the current tailings deposition and basin water recycle operations would continue. Potential hydrologic impacts associated with this alternative are anticipated to be minimal.

5.1.2.4 Alternative D: Alternative Technologies

An alternate technology under consideration is to raise the perimeter dikes on the tailings basin. With regard to hydrologic impacts, this alternative would result in conditions generally similar to the No Build Alternative. There may, however, be some potential for additional seepage as a result of the increased water level in the basin.

5.1.2.5 Alternative E: Design Alternatives

The proposed design alternative related to siphon placement in the tailings basin would not result in any changes to the hydrologic impact analysis, because it does not change the flow rate downstream of the discharge points. Another potential design alternative is related to managing the flow from Dark Lake into the Dark River in order to regulate stream temperature. This mitigation alternative would generally be designed to discharge higher flows during the high spring flow periods in order to allow smaller discharges during the summer and winter low-flow periods. This action would result in slightly greater hydrologic impacts during the high-flow periods.

5.1.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Reduction in the magnitude of discharge to either watershed would accordingly reduce the associated impacts. However, the volume of discharge required to meet some of the objectives of the project would likely have impacts on the order of those discussed in the impact analysis for the proposed project.

5.1.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

This alternative is concerned with operation of the SPB system, which is currently under review by Minntac. The objective of the SPB system operation is related to improvement of water quality prior to discharge and, as such, would have no different impact to the hydrology of the watersheds than has been discussed for the proposed Alternative A. However, in addition Minntac has evaluated alternatives of discharging 11,000 gpm (24.5 cfs) treated plant water to the tailings facility without a direct discharge, or discharging 2,400 gpm of treated plant effluent to the tailings facility with a HCR managed discharge averaging 5,000 gpm (11.1 cfs) to the Sandy River. Minntac did not propose the minimum or maximum allowable flows under the HCR or managed discharge scenario. The proposed discharge rates under the HCR scenario would have to be closely evaluated with regard to the effects that higher discharge rates would have on channel scouring, erosion, water level changes, etc., especially at the upstream discharge locations. Therefore, the general evaluation of this action is that any discharge above 5,000 gpm would have proportionally greater impacts than those discussed for the proposed Alternative A. Another consideration is that the upstream-most structures on the Dark and Sandy Rivers (bridges at County Road 668 and Highway 53, respectively) would have to be protected. These structures are designed for 100-year storm events, which have been estimated at approximately 933 cfs (419,000 gpm) and 565 cfs (254,000 gpm) for the Dark and Sandy Rivers, respectively.

5.2 WATER QUALITY

This section describes surface water quality baseline conditions (Section 5.2.1) and potential impacts (Section 5.2.2) within the Dark River and Sandy River watersheds associated with implementation of the proposed project or project alternatives. General watershed and water quality characteristics were described previously in Section 2.5.3. Detailed water quality discussions, evaluations, and data sets are contained within the *Surface Water Hydrology and Quality Technical Memorandum* and the *Mercury and Methylmercury Technical Memorandum.*

As described in the Technical Memorandum, key constituents were identified for the water quality evaluation. These constituents include the following:

- Sulfate
- Chloride
- TDS
- pH
- Fluoride
- Hardness
- Manganese
- Mercury
- Temperature
- Conductivity
- Molybdenum

MPCA has adopted stream standards for each of these constituents, based upon the stream use and classification, as summarized previously in Section 2.5.3 of this EIS. Stream standards applicable to the Dark River and Sandy River watersheds are outlined below. Except where noted, the standards are the same for the potentially impacted streams in these watersheds.

- **Sulfate:** The State of Minnesota has adopted the U.S. Federal Secondary Drinking Water Standard of 250 mg/L for sulfate, which is based on taste, as a Class 1 Standard for drinking water in Lake Vermilion and the section of the Dark River from County Road 65 to the confluence with the Sturgeon River, which is listed as a Designated Trout Stream (and referred to in this document as the "designated trout reach"). In addition to the Class 1 standard of 250 mg/L, which is based on aesthetic effects, health-based advisory levels are also considered where drinking water supply is a potential use. The U.S. Environmental Protection Agency (EPA) has a health-based value of 500 mg/L, and the Minnesota Department of Health (MDH) recommends a limit of 400 mg/L for infant formula water supply. There is also a State of Minnesota Class 4 Standard (agricultural use) of 10 mg/L for sulfate that is relevant to the wild rice beds in the Sandy and Pike Rivers and other Class 4A-designated water bodies with wild rice beds; this standard is effective during periods when the rice may be susceptible to damage by high sulfate levels, generally between the months of April through September. Potential issues with respect to wild rice are discussed in detail in the *Wild Rice Technical Memorandum.* Although not a listed numerical water quality standard, the MPCA has identified a sulfate criterion of 1,000 mg/L as a numeric representation of the Class 4B narrative standard for livestock and wildlife watering, per EPA regulations (40 CFR 122.44 (d)). The Class 4B level of concern applies to all water bodies in the Dark and Sandy River watersheds.

- **Chloride:** The Dark, Sandy and Pike Rivers are designated as Class 3B for industrial use, which carries with it a 100 mg/L standard for chloride. If a variance was obtained for this standard, then the Class 1 standard of 250 mg/L may apply to specific stream segments with these designations. However, the Class 2A/2B standard of 230 mg/L is more restrictive and applies throughout the Dark, Sandy and Pike Rivers, and further downstream.

- **TDS:** The TDS standard for the Dark River designated trout reach and Lake Vermilion is the Class 1 standard for drinking water of 500 mg/L. Another consideration for TDS is its association with conductivity, which is discussed below.

- **pH:** The pH standards that apply to the Dark, Sandy and Pike Rivers include the Class 1, Class 2A and B, and Class 4A standards, which have an upper limit of 8.5 or 9.0 and a lower limit of either 6.0 or 6.5, depending on classification. The 6.5 standard is more restrictive and is applied to all waters in the study except wetlands. For wetlands, the Class 2D standard applies, which is "maintain background".

- **Fluoride:** The applicable fluoride standard is the U.S. Federal Secondary Drinking Water Standard of 2 mg/L, which has been adopted by the State of Minnesota as a Class 1 Standard for the Dark River designated trout reach and Lake Vermilion.

- **Hardness:** The Dark, Sandy and Pike Rivers are designated as Class 3B for industrial use, which carries with it a 250 mg/L standard for hardness.

- **Manganese:** The U.S. Federal Secondary Drinking Water Standard of 50 μg/L has been adopted by the State of Minnesota as a Class 1 standard for manganese. This standard applies to the Dark River designated trout reach and Lake Vermilion. The use of the 50 μg/L standard based on aesthetic effects is conservative. The MDH recommends a value of 1000 μg (1.0 mg/L) when assessing potential risk to drinking water receptors (MPCA, 1999).

- **Mercury:** The mercury standard for the Dark, Sandy and Pike Rivers is the Class 2B standard (aquatic life and recreation) of 0.0069 μg/L (6.9 parts per trillion [ppt]). For discharges to the Lake Superior watershed, a more restrictive Class 2 standard of 0.0013 μg/L is applied. Specific portions of the downstream watersheds are on the 303(d) list of impaired water bodies due to fish consumption advisories for mercury. On the Dark River side of the tailings basin, this includes Dark Lake and downstream in the Sturgeon River. On the Sandy River side, Little Sandy Lake, the Pike River and Lake Vermilion are listed. To the south of the site in the Lake Superior watershed, West Two Rivers Reservoir, and the Saint Louis River are listed on the 303(d) list.

- **Temperature:** The temperature standard for the Dark, Sandy, and Pike Rivers is the Class 2B standard for aquatic life and recreation. Class 2B states that the monthly average of maximum daily temperature shall not change by more than three degrees Fahrenheit (°F) above natural in lakes and 5°F above natural in streams as a result of a discharge. Additionally, in no case shall the temperature exceed the daily average of 86°F. The standard for a Class 2A waterbody, such as the Dark River designated trout reach, is "no material increase".

- **Conductivity:** Conductivity (or "specific conductance") has a Class 4A standard of 1,000 micromhos per centimeter at 25 degrees Celsius (µmhos/cm). The evaluation relies in part on a TDS threshold of 546 mg/L, which, although not a listed numerical water quality standard, was determined for the purposes of this EIS to be a surrogate value approximately equivalent to the class 4 conductivity standard of 1,000 µmhos/cm. The Class 4A standard applies to all water bodies.

- **Molybdenum:** There is currently no listed Minnesota water quality standards for Molybdenum. However, Molybdenum was identified as a key constituent, with the average concentration in the tailings basin exceeding a number of health advisory levels such as the USEPA Life-time Advisory Level of 40 µg/L. The State of Minnesota also has a Health-based Value (HBV) established for molybdenum by the MDH of 30 µg/L. However, because of the difficulty in establishing a molybdenum concentration value that is low enough that it will not cause toxic effects in any person, but not so low as to deprive some people of essential requirements, MDH currently does not recommend that the MPCA rely on the established HBV for molybdenum for human health. Based on concentrations measured in the tailings basin, molybdenum is included as a key constituent, but is not compared to a specific standard in the impact analysis.

5.2.1 Water Quality Baseline

Baseline conditions within the Dark River watershed are discussed in Section 5.2.1.1 and those within the Sandy River watershed are described in Section 5.2.1.2. Surface water monitoring stations are shown on Figure 5-1.

5.2.1.1 Dark River Watershed Baseline Water Quality

Baseline water quality data for the Dark River are available at the four primary monitoring stations: Stations 020, D-1, DLO, and D-2. The data were collected in 1999/2000 and 2003 and consist of general water quality parameters and metals. The complete water quality data set is included in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*. Additionally, more recent data (into 2004) are included for reference in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*, but were not used in the impact analysis.

Two tributaries, Knuckey Creek and Leander Creek, are located between Stations D-1 and D-2. Water quality data for these locations are also shown in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*. Due to their locations upstream of potentially impacted water in the Dark River, data from the tributaries are considered representative of background conditions.

Dark River Baseline Data

A statistical summary of the analytical results for the key constituents are shown on Table 5.15, *Dark River Baseline Water Quality Data - Key Constituents* and include minimum, maximum, and mean concentrations.

TABLE 5.15 DARK RIVER BASELINE WATER QUALITY DATA - KEY CONSTITUENTS				
CONSTITUENTS	**020 Min – Max (Mean)[1]**	**D-1 Min – Max (Mean)[1]**	**DLO Min – Max (Mean)[1]**	**D-2 Min – Max (Mean)[1]**
Chloride (mg/L)	63.8 – 91.2 (82.3)	22.3 –36.2 (28.5)	NM	11.9 – 14.9 (13.7)
Fluoride (mg/L)	1.3 – 2.2 (1.5)	0.4 – 0.7 (0.5)	NM	0.2 – 0.4 (0.3)
Hardness (mg/L)	1,440 – 1,600 (1,513)	538 –785 (667)	NM	246 –346 (289)
Manganese (µg/L)	740 – 880 (836)	20 – 140 (63)	NM	100 – 220 (144)
Mercury (Total) (µg/L)	<0.2 - <0.2 (<0.2)	<0.2 - <0.2 (<0.2)	NM	<0.2 - <0.2 (<0.2)
Low-level Mercury (Total) (ppt)[3]	1.17	1.12	NM	1.66
Low-level Mercury (Dis) (ppt)[3]	1.33	NM	NM	NM
Methyl Mercury (Total) (ppt)[3]	<0.008	0.091	NM	0.056
pH (S.U.)	7.09 – 7.46 (7.28)	7.40 – 8.25 (7.74)	NM	7.50 – 8.06 (7.81)
Sulfate (mg/L)	703 – 1,050 (897)	188 – 726 (387)	89 – 216 (165)	79 – 221 (140)
Temperature (°C)	4.0 –13.9 (10.8)	1.5 – 21.0 (13.2)	NM	0.5 – 21.5 (13.7)
TDS (mg/L)	1,380 – 1,960 (1,811)	400 – 1,530 (789)	NM	33 – 492 (306)
Notes: 1. Sampling period: 1999/2000 and 2003. 2. NM: not measured 3. Sampled once on 11/11/99 (URS Corporations, 2001a)				

Baseline water quality data indicate that water in the Dark River has relatively high concentrations of hardness, alkalinity, and conductivity and neutral pH values. In addition, the water is high in TDS and sulfate concentrations.

These data further indicate that several of the key constituents are currently elevated above background (when compared with the data from Knuckey Creek and Leander Creek) in the downstream waters of Dark River. For instance, background sulfate levels are typically less than 10 mg/L (Knuckey and Leander Creeks), while at Stations 020, D-1, DLO, and D-2, sulfate ranged from 79 to 1,050 mg/L. Concentrations above 50 µg/L for manganese were measured at the background locations.

Baseline data for some additional downstream locations are included in Appendix C.3 of the *Surface Water Hydrology and Quality Technical Memorandum*. Limited data (2000, 2001 and 2003) are available for several stations on the Sturgeon River (from near the confluence with the Shannon River to downstream at Highway 1), as well as the Little Fork River (downstream of the Sturgeon River and near Cook, Minnesota). These data indicate that:

- Sulfate was measured five times on the Sturgeon River (9.3 to 38 mg/L) and six times on the Little Fork River (<5 to 18 mg/L), with no clear temporal trends.

- Conductivity ranged from 60 to 250 µmhos/cm on the Sturgeon River and 82 to 275 µmhos/cm on the Little Fork River, with no clear temporal trends.

Data are also available on the Dark River at Station Dark-65 (2000 to 2003), which indicate that sulfate ranged from 140 to 220 mg/L (three data points) and conductivity ranged from 320 to 1,030 µmhos/cm. Conductivity data at Stations Dark-668 and Dark-688 were 320 to 1,284 µmhos/cm (2000 and 2001, see Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*). The 1,284 µmhos/cm value was measured at Station Dark-668, upstream of Dark Lake.

There is at least one other source of permitted discharge to nearby surface waters and that is the Hibbing Taconite tailings basin. This permittee (NPDES Permit #MN0049760) discharges to the Shannon River (west of the Minntac tailings basin), which in turn discharges to the Sturgeon River, upstream of Station ST-1. As such, baseline data associated with Stations D-1, DLO, and D-2 are on the Dark River and not impacted by the Hibbing Taconite tailings basin discharge. However, water downstream of the confluence of the Dark and Sturgeon Rivers, which eventually reaches the Little Fork River, may be impacted by this other permitted discharge.

Comparison to Standards

The 1999/2000 and 2003 water quality data for the Dark River were compared to applicable Minnesota and Federal water quality standards, as discussed in the following paragraphs. Concentrations in the Dark River that exceeded the standards are shown in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*.

Sulfate: The average sulfate concentration at Station 020 was 897 mg/L and the average concentration at Station D-1 was 387 mg/L. Some sulfate data were greater than 1,000 mg/L. The baseline concentrations did not exceed the 250 mg/L standard at Station D-2 below Dark Lake. For sulfate, the Class 1 standard applies to the designated trout reach of the river (from near Dark-65 to Station D-2 to the confluence with the Sturgeon River). Sulfate was measured as high as 220 mg/L (February 2002; see Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*) at Station Dark-65. The average sulfate concentrations at the Knuckey Creek and Leander Creek tributary stations were 1.1 mg/L and 1.7 mg/L, significantly below the standard of 250 mg/L. Both of these tributaries enter the Dark River within the reach of trout water and provide a source of dilution. Therefore, it should be noted that, at the head of the designated trout reach at County Road 65, water quality is more sensitive to flow from the Minntac facility, and sulfate standards are more likely to be exceeded.

Chloride: None of the locations on the Dark River exceeded the Class 3B standard of 100 mg/L for chloride. The average concentration at Station 020 in the Dark River headwater was 82.3 mg/L.

TDS: The average TDS concentrations at Stations 020 and D-1 were 1,811 mg/L and 789 mg/L, respectively. The TDS standard was not exceeded at Station D-2, but based on concentrations at D-1 could be exceeded at the head of the designated trout reach.

pH: None of the samples from the Dark River contained pH values that exceeded the upper limit of 8.5 or were below the lower limit of 6.5.

Fluoride: The average fluoride concentrations were below the fluoride standard of 2 mg/L at all stations on the Dark River. However, one sampling event in June 2003 reported a fluoride concentration of 2.2 mg/L at Station 020.

Hardness: Almost all sample results for hardness exceeded the Class 3B standard of 250 mg/L at Stations 020, D-1 and D-2 in 2003. Data on hardness are not available for the 1999/2000 sampling events. The average hardness concentration was 1,513 mg/L for Station 020, 667 mg/L for Station D-1 and 289 mg/L for Station D-2.

Manganese: Manganese data are available for Stations 020, D-1 and D-2. The average concentrations for all three locations, from upstream to downstream were 836 μg/L, 63 μg/L and 144 μg/L. At Station D-2, the manganese standard was exceeded in all samples.

Mercury: Mercury was sampled once in 1999. All results were less than the standard of 0.0069 μg/L, in the Dark and Sandy Rivers.

Temperature: The average temperatures for Stations 020, D-1 and D-2 were 10.8, 13.7 and 13.2° Celsius (°C) (51.4, 56.7 and 54.8°F). The difference between minimum and maximum temperatures was as high as 21°C (37.8 °F).

<u>Historic Data Trends</u>

Historic data from the primary stations on the Dark River (i.e., in addition to the 1999/2000 and 2003 sampling events) are available from three primary sources and time periods, as follows:

- USGS Gauging Stations, 1955 to 1979 (Stations D-2 and ST-1)
- Storet data, 1975 to 1980 (Station D-2)
- Minntac, 1984 to 1989 (Stations 020 and D-2), sulfate only

These data are presented in Appendix D of the *Surface Water Hydrology and Quality Technical Memorandum*, and show that, in general, concentrations of key constituents were below applicable standards. Mercury was not analyzed during any of the monitoring periods listed above. The data are summarized below.

Between 1955 and 1972: Eight of the key constituents were analyzed (no mercury) from Station D-2 (Dark River) and Station ST-1 (Sturgeon River). All of these key constituents were less than their applicable standards and none showed any obvious trends, with the exception of manganese. Manganese (dissolved) was detected twice at 21 and 50 μg/L in April 1958 and October 1972, respectively from Station D-2. The Class 1 standard for manganese is 50 μg/L. Manganese (dissolved) was also detected once at ST-2 at 40 μg/L (October 1972).

Between 1975 and 1980: Four of the key constituents (sulfate, chloride, hardness, and manganese) were analyzed from Station D-2 on the Dark River. All of the key constituents were less than applicable standards and none showed any obvious trends, with the exception of manganese. Manganese (total) was sampled five times between August 1975 and May 1976. During that time it was detected between 48 and 106 μg/L; the Class 1 standard is 50 μg/L.

Sulfate Trend: Sulfate was also analyzed from Stations 020 and D2 between October 1984 and January 1998. These data, along with the 1999/2000 and 2003 data indicate that sulfate was consistently below the standard at Station D2. It can also be seen that the concentrations of sulfate at Station 020 steadily increased. Sulfate ranged from 12 to 140 mg/L between 1987 and 1989, and from 79 to 221 mg/L in 1999/2000 and 2003, suggesting that concentrations may be increasing at Station D2.

Conductivity Trends: Conductivity ranged between 55 and 128 μmhos/cm from 1955 to 1972 (74 μmhos/cm in 1955 and 128 μmhos/cm in 1972), with no clear increasing or decreasing trend. Between 1976 and 1980, it ranged from 20 and 225 μmhos/cm at Station D-2, with no clear increasing or decreasing trend. Between April 1999 and September 2003, it ranged from 306 to 804 µmhos/cm, again with no clear increasing or decreasing trend. However, collectively these three data sets suggest that there may be an increasing trend: the average conductivity concentrations throughout the three time periods were 74 µmhos/cm, 149 µmhos/cm and 489 µmhos/cm, respectively. As conductivity is likely caused by the two major ions (calcium and sulfate), this suggests that there is also an increase in concentrations of the major ions. These increases in concentrations are consistent with the development of the tailings basin and associated discharge of waters with high concentrations of the same ions (e.g., sulfate). More recent data collected along the Dark River (e.g., Station D-2) are consistent with these other historic data.

5.2.1.2 Sandy River Watershed Baseline Water Quality

Baseline water quality data and a comparison to standards for stations on the Sandy River watershed are summarized in this section. Surface water monitoring stations are shown on Figure 5-1.

Baseline water quality data for the Sandy River are available at the four primary monitoring stations: Stations 030, 701, S-1 and S-2. The data were collected in 1999/2000 and 2003 and consisted of general water quality parameters and metals. The complete water quality data set is included in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*.

Two tributaries, Britt Creek and an unnamed Creek at Highway 169, are located downstream of Sandy Lake. Water quality data for these locations are shown in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*. Due to their locations upstream of potentially impacted water in the Sandy and Pike Rivers, data from these tributaries are considered to be representative of background conditions.

Sandy River Baseline Data

A statistical summary of the analytical results for the key constituents is shown on Table 5.16, *Sandy River Baseline Water Quality Data - Key Constituents* and includes minimum, maximum, and mean concentrations. Baseline water quality data for the Sandy and Pike Rivers indicate high concentrations of TDS, sulfate, hardness, alkalinity, and conductivity and neutral pH values.
These data indicate that several of the key constituents are already elevated above background (as indicated by data from Britt and unnamed creeks) in the downstream waters of the Sandy and Pike Rivers. For instance, sulfate background levels are typically less than 10 mg/L (Britt and unnamed creeks), while at Stations 030 and 701 sulfate ranged from 32 to 885 mg/L. At Stations S-1 and S-2, sulfate ranged from 5 to 608 mg/L. Concentrations above 50 µg/L for manganese were measured at the background locations.

TABLE 5.16
SANDY RIVER BASELINE WATER QUALITY DATA - KEY CONSTITUENTS

CONSTITUENTS	030 Min – Max (Mean)[1]	701 Min – Max (Mean)[1]	S-1 Min – Max (Mean)[1]	S-2 Min – Max (Mean)[1]
Chloride (mg/L)	150 – 171 (158)	26 – 67 (48)	19 – 38 (27)	NM[2]
Fluoride (mg/L)	2.3 – 3.2 (2.5)	0.3 – 0.9 (0.7)	0.3 – 1.0 (0.5)	NM
Hardness (mg/L)	1,070 – 1,190 (1,119)	108 – 428 (304)	100 –193 (148)	NM
Manganese (µg/L)	1,840 – 2,190 (2,006)	20 – 130 (164)	10 – 90 (41)	NM
Mercury, total (µg/L)	<0.2 - <0.2 (<0.2)	<0.2 - <0.2 (<0.2)	<0.2 - <0.2 (<0.2)	<0.2 - <0.2 (<0.2)
Low-level Mercury (total) (ppt)[3]	0.44 – 0.54 (0.49)	1.30 – 3.56 (2.43)	2.19 – 3.85 (3.02)	2.82

Low-level Mercury (dissolved) (ppt)[3]	0.27 – 0.70 (0.48)	NM	NM	NM
Low-level Methylmercury (diss) (ppt)[3]	<0.008-0.003 (0.18)	0.089 – 0.670 (0.38)	0.162	0.238
pH (S.U.)	7.14 – 7.60 (7.36)	6.68 – 7.58 (7.19)	6.48 – 7.17 (6.93)	6.45 – 7.32 (6.88)
Sulfate (mg/L)	633 – 885 (757)	32 – 713 (223)	10 – 608 (108)	5 – 261 (64)
Temperature (°C)	4.6 – 14.6 (11.3)	0.3 – 18.3 (11.8)	0.0 – 20.5 (12.3)	NM
TDS (mg/L)	1,300 – 1,640 (1,500)	190 – 1,300 (467)	132 – 1,250 (317)	42 – 543 (219)
Notes: 1. Sampling period: from 1999/2000 through 2003. 2. NM is not measured 3. Sampled twice on 9/22/99 and 11/1/99 (URS Corporation, 2001a)				

Baseline data for Lake Vermilion and two other stations on the Pike River are included in Appendix C.3 of the *Surface Water Hydrology and Quality Technical Memorandum*. The Lake Vermilion data are from the 2000 Lake Vermilion *Lake Assessment Program* (MPCA, 2001). The data are average values for the lake at various locations (Pike Bay, Big Bay, Wakemup Bay and the outlet of the lake) sampled during summer 2000. These data indicate that sulfate averaged 15.2 mg/L in Pike Bay and <5 to 16 mg/L in the other bays. In addition, conductivity averaged 139 μmhos/cm in Pike Bay and 55 to 136 μmhos/cm in the other bays. The lowest concentrations were detected in Wakemup Bay and the highest concentrations were detected in Pike Bay and Big Bay.

Data are also available from four stations on the Pike River. Sulfate was measured twice at 57 and 60 mg/L, while conductivity was measured five times and was between 54 and 462 μmhos/cm. Conductivity was also measured at Stations Sandy-53 and Sandy-169 (580 to 1,400 μmhos/cm). Sulfate was measured once at 470 mg/L. These data indicate that concentrations of sulfate decrease downstream of the tailings basin and into Lake Vermilion.
There are at least three other sources of permitted discharge to nearby surface waters:

- Ispat-Inland Minorca Tailings Basin: NPDES Permit #MN0055964
- Tower Publicly-owned Treatment Works (POTW): NPDES Permit #MN0056618
- Soudan State Park (Department of Natural Resources): NPDES Permit #MN0060151

Both the Tower POTW and Soudan State Park, discharge to the East Two Rivers, which in turn discharges to Pike Bay of Lake Vermilion. The Ispat-Inland Minorca tailings basin discharges to Wouri Creek, which in turn discharges to the Sandy River upstream of Station S-1. As such, baseline data associated with Stations S-1 and S-2 include existing impacts from the Ispat-Inland Minorca tailings basin. However, since the East Two Rivers discharges to Lake Vermilion, baseline data at Stations S-1 and S-2 are not impacted by the Tower POTW or Soudan State Park.

Comparison to Standards

The 1999/2000 and 2003 water quality data for the Sandy and Pike Rivers were also compared to both existing Minnesota and Federal water quality standards, as discussed in the following paragraphs. Concentrations in the Dark River that exceeded the standards are shown in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum*.

Sulfate: The average sulfate concentrations for Stations 030, 701, S-1 and S-2 were 757 mg/L, 223 mg/L, 108 mg/L and 64 mg/L, respectively. When the four locations on the Sandy and Pike Rivers are compared to the more stringent sulfate standard of 10 mg/L relative to wild rice, 97 percent of the samples exceeded the standard. The wild rice beds are located in the Little Sandy and Sandy Lakes and downstream along the Sandy and Pike River watersheds. However, the Class 1 standard for drinking water is the primary standard considered in the impact evaluation in Section 5.0. The *Wild Rice Technical Memorandum* further discusses potential impacts to wild rice.

Chloride: At Station 030, all sample results exceeded the 3B standard of 100 mg/L for chloride. At Station 701, none of the samples exceeded the Class 3B standard (an exception occurred in data collected by Minntac during preparation of this report in February 2004 when a concentration of 103 mg/L was measured). None of the locations downstream of the Sandy River (Stations S-1 and S-2) exceeded the Class 3B standard.

TDS: The average TDS concentration was 1,500 mg/L in samples collected from Station 030.

pH: None of the locations on the Sandy River reported a pH value that exceeded the upper limit of 8.5 or were below the lower limit of 6.5. Two sample locations, S-1 and S-2, reported pH values of 6.48 and 6.45, respectively in July of 1999. These values are slightly below the limit of 6.5, but are within the error range for a pH measurement.

Fluoride: The average fluoride concentrations at Stations 701, S-1, and S-2 on the Sandy River were below 2 mg/L. The average fluoride concentration at Station 030 was 2.5 mg/L.

Hardness: The average hardness concentrations at Stations 030 and 701 exceeded the standard of 250 mg/L in 2003, while none of the samples at Station S-1 exceeded the hardness standard. (Data collected during the winter of 2004 by Minntac during preparation of this report indicated hardness concentrations up to 518 mg/L at Station S-1, thus exceeding the standard be more than two times. Data on hardness are not available from 1999/2000 or at Station S-2.

Manganese: Manganese analytical data are available for only Stations 030, 701 and S-1 from 2003 monitoring. The average concentration at Station 030 was 2,006 μg/L and the average concentration at Station 701 was 64 μg/L. The average concentration at Station S-1 did not exceed the manganese standard.

<u>Historic Data Trends</u>

Available historic data from Stations 030, 701 and S-1 are summarized briefly in this section. Historic data (i.e., in addition to the 1999/2000 and 2003 sampling events) are available from three primary sources and time periods, as follows:

- USGS Gauging Stations, 1955 to 1979 (Stations 701 and S-2)
- Storet data, one data point from 1983 (Station S-3)
- Minntac, 1984 to 1989 (Stations 030 and D-2), sulfate only

The available data are presented Appendix D of the *Surface Water Hydrology and Quality Technical Memorandum*. These data show that, in general, concentrations of key constituents were below applicable standards and did not show any obvious trends (e.g., long-term increases or decreases or seasonal trends), with a few exceptions. Mercury was not analyzed during any of the monitoring periods listed above. The data are summarized below.

Between 1955 and 1972: Six of the key constituents (not TDS, mercury or temperature) were analyzed from Stations 701 and S-2. The key constituents were less than their applicable standards and none showed any obvious trends, with the exception of manganese and pH. Manganese (total) was sampled twice at Station 701 and was non-detect (August 1960) and 50 μg/L (May 1961). pH was consistently greater than 6.0 and less than 8.5, except once at Station 701 (4.9 in June 1959).

August 1983: Station S-3 was sampled once in August 1983 for only one of the key constituents (chloride). Chloride was detected at 7.2 mg/L, well below the Class 3B standard of 100 mg/L.

Sulfate Trend: Sulfate was also measured from Stations 030 and 701 between October 1984 and January 1998. It can also be seen that the concentration of sulfate at Station 030 steadily increased. No trends in the data are evident for Station 701.

Conductivity Trend: Conductivity averaged 64 µmhos/cm in 1960 to 1961 and averaged 738 µmhos/cm in 2003 at Station 701. These data suggest that conductivity has increased over time and, since it is likely caused by the two major ions (calcium and sulfate), suggests that there has also been an increase in concentrations of the major ions. These increases in concentrations are consistent with the development of the tailings basin and associated discharge of waters with high concentrations of the same ions (e.g., sulfate). More recent data (i.e., 2004) collected along the Sandy and Pike Rivers (e.g., Station 701) are consistent with these other historic data.

5.2.2 Water Quality Impacts

This section documents the potential impacts, both quantitatively and qualitatively, to water quality under the proposed Alternative A, No Build Alternative, and the Action Alternatives described previously in Section 4.0. Further details pertaining to potential water quality impacts are included in the *Surface Water Hydrology and Quality Technical Memorandum* and the *Mercury and Methylmercury Technical Memorandum.*

5.2.2.1 Alternative A: Proposed Project (Proposed Action)

Under the proposed project, Minntac would discharge flow from the tailings facility to the Dark River and/or Sandy River at the currently permitted seepage discharge locations. The proposed project would entail either of these two scenarios:

- Discharge of 5,000 gpm (11.1 cfs) tailings basin water directly to the Sandy River or Dark River.

- Splitting the discharge between the Sandy River and Dark River drainages and discharging at a rate of 2,500 gpm (5.6 cfs) to both basins.

This section summarizes the potential impacts to water quality in the Sandy River and Dark River watersheds associated with the proposed project. Detailed evaluations and discussions are contained within the *Surface Water Hydrology and Quality Technical Memorandum*.

<u>General Water Quality Impacts Summary</u>

As discussed in the previous section, the current tailings basin seepage results in elevated concentrations of some key constituents in both watersheds. Under some flow conditions, standards are already exceeded. Due to the elevated baseline concentrations in the Dark River and Sandy River, any substantial additional discharge from the Minntac tailings basin would likely result in additional impact to surface water quality in these basins.

Table 5.17, *Summary of Predicted Water Quality Impacts to the Dark River and Sandy River Based on Historic Data,* summarizes predicted water quality standard exceedances of key constituents at Station D-2 on the Dark River and Station S-1 on the Sandy River. Station D-2 was chosen for this summary, because it is located within the designated trout reach and has the most restrictive water quality standards. Station S-1 was chosen because it is located near a wild rice bed area and also has more restrictive standards.

The number of exceedances of water quality standards for sulfate, TDS, specific conductance, and hardness are anticipated to increase at Station D-2 with the proposed 5.5 cfs or 11.1 cfs discharge. Manganese, which is currently exceeding standards, would continue to do so under either of the proposed discharge scenarios. Similarly, the data indicate that Station S-1 would also experience increases in the numbers of exceedances of chloride, specific conductance, and hardness water quality standards. Based on these data, the Dark River and Sandy River do not have sufficient capacity to assimilate some key constituents without exceeding standards.

As indicated in the Table 5.17, the percentage of water quality exceedances increases with increasing flow discharges from the tailings facility. The relative magnitude of the impact associated with the split discharge scenario, therefore, is less than the magnitude associated with discharging the full flow volume to either of the rivers exclusively. This is due to a 50 percent reduction in the mass of the key constituents that would be discharged to the individual drainages under the split discharge scenario. Impacts would be reduced, but would still exceed some standards. In addition, under the split discharge scenario, both the Dark River and Sandy River would be impacted by additional discharge from the tailings facilities.

TABLE 5.17
SUMMARY OF PREDICTED WATER QUALITY IMPACTS TO THE SANDY RIVER AND DARK RIVER BASED ON HISTORIC DATA

STATION D-2 (Dark River)								
	Baseline[1]		**11.1 cfs Proposed Discharge**				**5.6 cfs Proposed Discharge**	
	Average Concentration (mg/L)	%of Events Exceeding Standards	Average Concentration (mg/L)	%of Events Exceeding Standards	% Change in Exceedances	Average Concentration (mg/L)	% of Events Exceeding Standards	%Change in Exceedances
Sulfate	140	0	318	81	81	249	63	63
Chloride	14	0	56	0	0	40	0	0
TDS	324	0	654	75	81	526	56	56
Hardness	289	86	541	100	14	447	100	14
Fluoride	0.3	0	1.23	0	0	0.88	0	0
Manganese	0.14	100	0.20	100	0	0.18	100	0
STATION S-1 (Sandy River)								
	Baseline[1]		**11.1 cfs Proposed Discharge**				**5.6 cfs Proposed Discharge**	
	Average Concentration (mg/L)	%of Events Exceeding Standards	Average Concentration (mg/L)	%of Events Exceeding Standards	% Change in Exceedances	Average Concentration (mg/L)	% of Events Exceeding Standards	%Change in Exceedances
Sulfate	112	0	239	0	0	191	0	0
Chloride	24	0	56.1	14	14	45	0	0
TDS[3]	304	12	543	38	26	457	25	13
Hardness	148	0	392	100	100	301	57	57
Fluoride	0.63	na	1.32	na	na	1.08	na	na
Manganese	0.04	na	0.21	na	na	0.20	na	na

Notes:
1. Baseline data presented herein differ slightly from data included in Table 5.15 and 5.16. Baseline concentrations within this table were derived from data points with both flow and concentration values to allow for load calculations.
2. Mercury impact analysis is not presented because mercury concentrations in the tailings basin are lower than concentrations in the receiving waters.
3. Evaluation based on TDS threshold of 546 mg/L as equivalent to 1,000 µmhos/cm conductivity standard.

It should be noted that, for comparison purposes, the table uses average baseline and projected concentrations at Station D-2 and Station S-1. During low-flow scenarios, it is anticipated that the concentrations of these key constituents would be even higher and greater exceedances would be expected. Similarly, the most upstream locations on both rivers, which have the lowest flow volumes, would generally experience the greatest concentration increases associated with tailings discharge.

Direct adverse impacts are not predicted on mercury concentrations as a result of the tailings basin discharge, because concentrations in the tailings basin water are lower than the baseline water quality in the Dark River and Sandy River. This applies to total, dissolved and methylmercury. Indirect impacts, however, may occur due to potentially higher sulfate concentrations. This is discussed briefly in the following paragraphs and evaluated in more detail in the *Mercury and Methylmercury Technical Memorandum*.

It has been well established that increased concentrations of sulfate in water and sediments can increase the rate at which mercury is converted to methylmercury. Other factors influence the fate of mercury in the aquatic environment. Many of these factors can be correlated to factors that promote the activity of sulfate-reducing bacteria. For example, the activity of sulfur-reducing bacteria is enhanced by environmental factors such as increased temperature, low dissolved oxygen and redox conditions. Therefore, methylmercury concentrations will be correlated to these factors.

Dissolved organic carbon (DOC) also influences the fate of mercury in the environment. Mercury in all forms tends to have a high affinity to DOC. Therefore in the aquatic environment, high DOC concentrations can correlate with higher mercury concentrations. Areas where organic sediments tend to accumulate will also tend to accumulate higher concentrations of mercury.

Hydrologic factors can also be an important influence on the fate of mercury. Areas that are periodically inundated with water tend to have increased production of methylmercury (Heyes et al. 1994). This increase is thought to be due to higher levels of anaerobic microbial activity brought on by decaying organic material.

Increased methylmercury concentrations in both surface waters and sediment pore water are also correlated with high flows, usually occurring with rain events, which can increase the flow of pore water in surface sediments. Fowle et al. (1994) reported that methylmercury concentrations increased about 4-fold in surface waters and about 30-fold in sediment pore water after a storm event. Similar increases were also reported after rain events by Jeremiason et al (2003). Because higher methylmercury concentration would be expected in aquatic sediment pore water, factors that increase scouring and erosion would also be expected to increase total and methylmercury concentrations downstream.

Available data indicate that impacts due to mercury are widespread across the County, and the rest of the State, and also suggest that there is the potential that an increased impact may be occurring downstream of the Minntac tailings basin. The available data do not clearly identify a cause-effect relationship. However, based on recent research, it is suspected that the presence of sulfate promotes the methylation of mercury. Summer season sampling of the Sandy and Pike Rivers conducted by MPCA in August 2001 showed relatively high methylmercury concentrations. This observation tends to support the conclusion that high sulfate concentrations are currently resulting in high methylmercury concentrations downstream of the tailings basin seepage points. Sampling of sulfate and sulfide concentrations in the sediments of the Sandy River suggest that sulfate concentrations in water are not a good predictor of sulfate concentrations in sediments, nor a good predictor of the potential for methylmercury production. Therefore, it is speculated that increased sulfate concentration associated with the proposed project would result in an increase in the pool of sulfate available to enter the sediments where methylation occurs, leading to an increase in methylmercury concentrations in the impacted downstream waters.

In addition, the proposed discharge may increase the mercury content of sport fishes and fish consumed by fish-eating wildlife. It is not known if the increase would be significant, in terms of incremental increase in the percentage of the resource that exceed health-based thresholds. It is also not known to what extent increased mercury impacts to sports fishes and fish consumed by fish-eating wildlife may occur. However, under several of the alternatives, an analysis of the mercury impacts in Sandy and Little Sandy Lakes suggest that the "standard" size northern pike (NP_{55}) concentrations would increase from 0.59 mg/kg to about 0.93 mg/kg mercury, a concentration in this "standard" fish that exceeds the MDH one meal/week threshold for the general population (0.65 mg/kg). Therefore, it is concluded that a larger portion of the fish in downstream lakes could exceed health standards. Potential impacts to aquatic resources are further discussed in Section 5.5 of this EIS and in the *Aquatic Resources Technical Memorandum.*

The following paragraphs summarize projected water quality impacts at key locations within the Dark River and Sandy River watersheds at the onset of discharge. Projected water quality impacts within the Dark River and Sandy River watersheds may decrease over time with discharge.

Dark River Watershed

General Watershed: Table 5.18, *Predicted Increases in Water Quality Constituents on the Dark River Due to Discharge from Minntac's Tailings Basin*, presents a summary of potential impacts to water quality within the Dark River basin that would result from implementation of the proposed project.

TABLE 5.18
PREDICTED INCREASES IN WATER QUALITY CONSTITUENTS ON THE DARK RIVER DUE TO DISCHARGE FROM MINNTAC'S TAILINGS BASIN

	Baseline Average Concentration[1] (mg/L)	+11.1 cfs Discharge		+5.6 cfs Discharge	
		Average Concentration (mg/L)	% Increase Over Baseline Concentration	Average Concentration (mg/L)	% Increase Over Baseline Concentration
Outfall 020 (Dark River)					
Sulfate	897	717	-20	722	-20
Chloride	82.3	121	47	120	46
TDS	1811	1394	-23	1406	-22
Fluoride	1.5	2.7	78	2.6	76
Manganese	0.84	0.295	-65	0.31	-63
Hardness	1513	946	-37	964	-36
pH	7.3	8.3	---	8.2	---
Station D-1 (Dark River)					
Sulfate	387	563	47	516	35
Chloride	29	99	241	86.2	197
TDS	789	1114	41	1030	31
Fluoride	0.5	2.16	315	1.87	260
Manganese	0.06	0.23	283	0.20	233
Hardness	667	860	29	823	23
pH	7.17	7.8	---	7.7	---
Station D-2 (Dark River)					
Sulfate	140	318	127	249	78
Chloride	14	56	300	40	186
TDS	324	654	102	526	62
Fluoride	0.3	1.23	339	0.88	214
Manganese	0.14	0.20	43	0.18	29
Hardness	289	541	87	447	55
pH	7.8	na	---	na	---

Notes:
1. Baseline data presented herein differ slightly from data included in Table 5.15. Baseline concentrations within this table were derived from data points with both flow and concentration values to allow for load calculations.
2. Mercury impact analysis is not presented because mercury concentrations in the tailings basin are lower than concentrations in the receiving waters.

na = analysis was not conducted because upstream impacts were minor and did not result in additional exceedances of relevant standards.

Modeling results for sulfate, chloride, TDS, fluoride, manganese, hardness, and pH are presented for three stations, from upstream to downstream. Detailed discussions of methodology and results are included within the *Surface Water Hydrology and Quality Technical Memorandum.* As indicated in the previous paragraphs, water quality impacts would generally be greater with the greater discharge volume of 11.1 cfs. In addition, impacts would generally diminish from upstream to downstream stations. In most cases, analytes that are currently exceeding standards would continue to do so, and the magnitude and frequency of exceedances would likely increase for the body of water that receives the discharge.

Further discussions pertaining to potential impacts to wetlands, wild rice, aquatic resources, wildlife, and upland vegetation associated with the projected increases in analyte concentrations are presented in Sections 5.3, 5.4, 5.5, 5.6, and 5.7 of this EIS and in the associated resource technical memoranda.

Several areas of interest within the Dark River watershed were further evaluated, as discussed within the *Surface Water Quality and Hydrology Technical Memorandum.* These include the designated trout reach located downstream of Dark Lake and the Dark Lake Management Area, which are described briefly in the following paragraphs. More detailed discussions pertaining to aquatic resources are included Section 5.5 of this EIS and in the *Aquatic Resources Technical Memorandum.*

Designated Trout Stream: The Designated Trout Stream starts upstream of Station D-2 at County Road 65. Two tributaries, located between the head of the trout reach and Station D-2, provide dilution. Impacts in the upper portion of the trout reach, therefore, are anticipated to be greater than those predicted as Station D-2, especially during low-flow conditions. Station D-2 is more closely predictive of average impacts in the designated trout reach.

The more protective Class 1 drinking water standards apply to the designated trout reach. Based on evaluations primarily at monitoring Station D-2, the Class 1 standards for sulfate and TDS would be exceeded and water quality adversely impacted in the designated trout reach under certain flow conditions. Projected changes in sulfate and TDS concentrations are presented, respectively, in Figure 5-9, *Sulfate Concentrations Resulting from Tailings Basin Discharge* and in Figure, 5-10, *TDS Concentrations Resulting from Tailings Basin Discharge.*

Manganese concentrations already exceed the Class 1 standards in baseline conditions and the proposed discharge would further increase the manganese concentrations. Current data indicate, however, that manganese concentrations increase between Stations D-1 and D-2. At the upstream Station, D-1, the manganese concentrations were 50 μg/L during 43 percent of the 2003 sampling events, but downstream at Station D-2 the class 1 Manganese standard it was exceeded in 100 percent of the 2003 baseline samples. This is likely due to a source of manganese other than the tailings basin seeps. Alternatively, variable hydrochemical conditions (e.g., redox) could be affecting the chemistry of manganese.

Temperature is also a key constituent on the Dark River because of its potential impact to trout habitat. The temperature of Dark Lake is the critical factor in determining temperature in the designated trout reach. Due to the long residence time within the lake, it is not anticipated that the temperature of the tailings basin discharge would affect the designated trout reach.

In addition, the Class 3 industrial use hardness standard is exceeded in baseline data during all but one event at Station D-2. With the addition of the proposed discharge, the standard would be exceeded during all events.

Rainy River Basin and Dark Lake Management Plans: The proposed project is not consistent in the short-term with these management plans that have a goal of improving or maintaining water quality. However, it is anticipated that over the long-term, seepage from the tailings basin would be reduced and a subsequent improvement in downstream water quality would be anticipated.

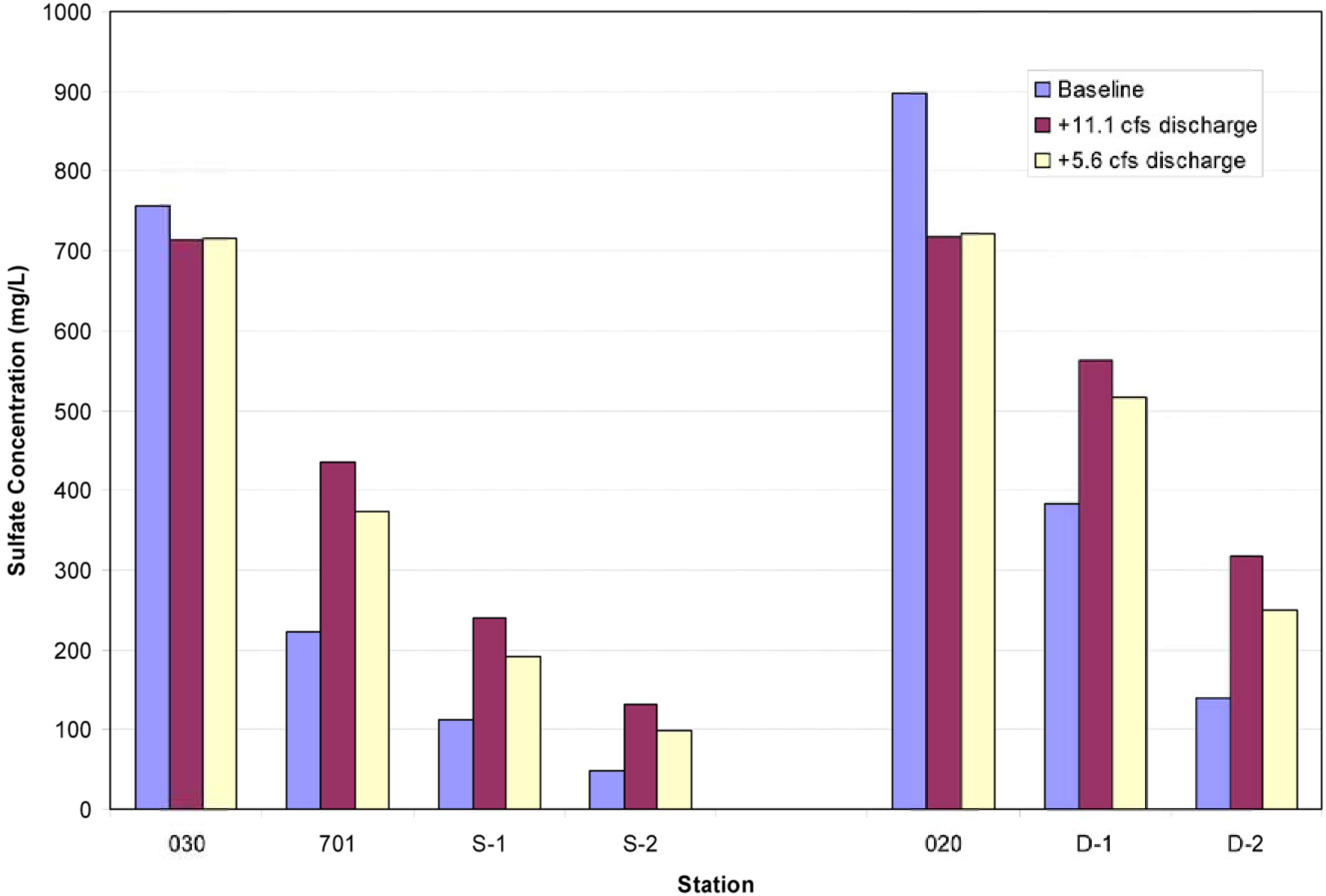


FIGURE 5-9
SULFATE CONCENTRATIONS RESULTING FROM TAILINGS BASIN WATER DISCHARGE

FILENAME: Fig 5-9 Sulfate Conc.dwg

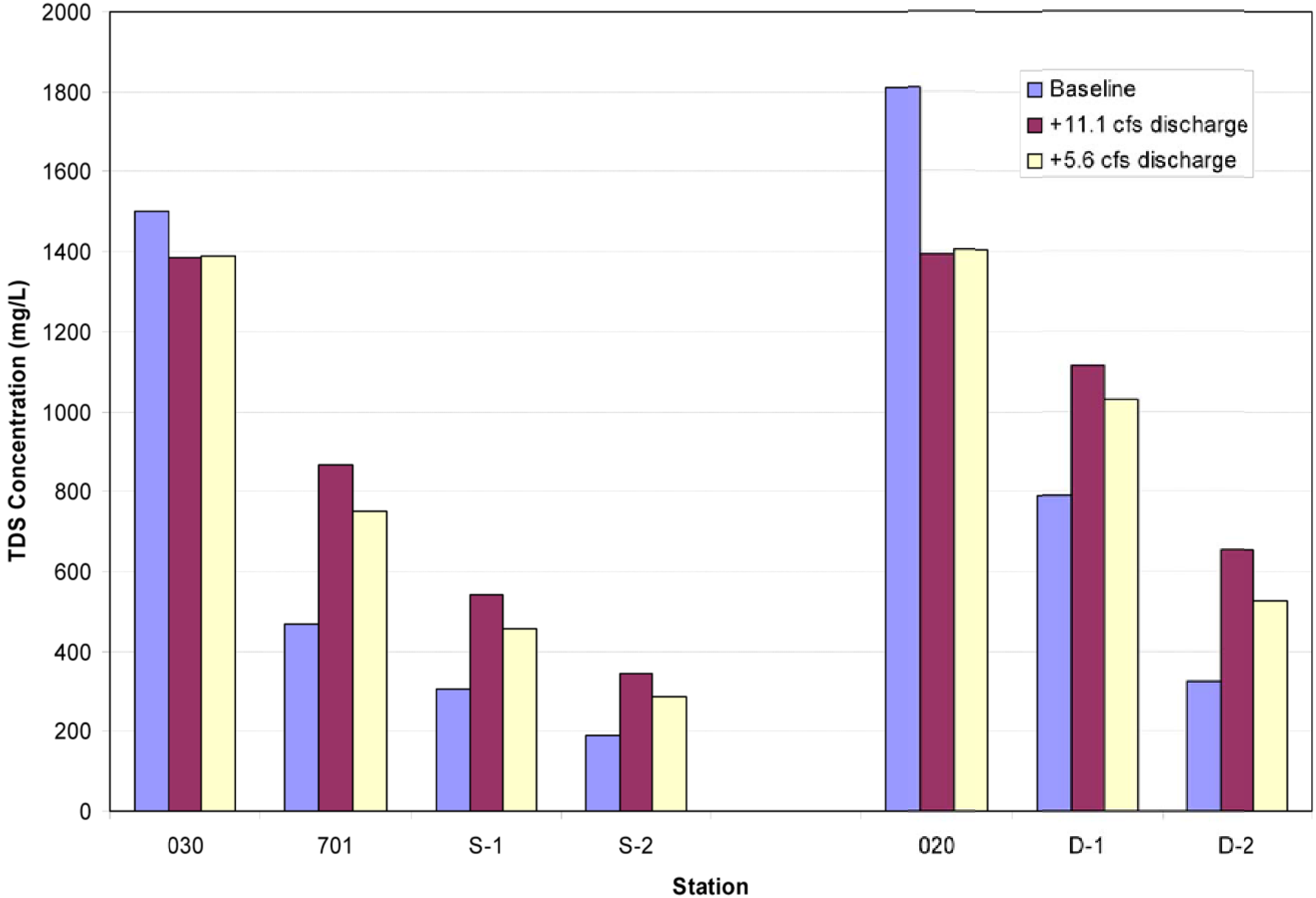


FIGURE 5-10
TDS CONCENTRATIONS RESULTING FROM TAILINGS BASIN WATER DISCHARGE

FILENAME: Fig 5-10 TDS Conc.dwg

Sandy River Watershed

General Watershed: Table 5.19, *Predicted Increases in Water Quality Constituents on the Sandy River Due to Discharge from Minntac's Tailings Basin*, presents a summary of potential impacts to water quality within the Sandy River basin that would result from implementation of the proposed project.

TABLE 5.19
PREDICTED INCREASES IN WATER QUALITY CONSTITUENTS ON THE SANDY RIVER DUE TO DISCHARGE FROM MINNTAC'S TAILINGS BASIN

	Baseline[1]	+11.1 cfs Discharge		+5.6 cfs Discharge	
	Average Concentration (mg/L)	Average Concentration (mg/L)	% Increase Over Baseline Concentration	Average Concentration (mg/L)	% Increase Over Baseline Concentration
Outfall 030 (Sandy River)					
Sulfate	757	713	-6	715	-6
Chloride	158	124	-22	125	-21
TDS	1500	1385	-8	1390	-7
Fluoride	2.5	2.7	8	2.7	8
Manganese	2.01	0.35	-82	0.42	-79
Hardness	1119	936	-16	944	-16
pH	7.4	8.3	---	8.2	---
Station 701 (Sandy River)					
Sulfate	223	436	96	374	68
Chloride	48	92	92	81.9	71
TDS	467	868	86	752	61
Fluoride	0.7	1.89	170	1.62	131
Manganese	0.06	0.18	200	0.15	150
Hardness	304	676	122	591	94
pH	7.2	7.4	---	7.4	---
Station S-1 (Sandy River)					
Sulfate	112	239	113	191	71
Chloride	24	56	133	45	88
TDS	304	543	79	457	50
Fluoride	0.63	1.32	110	1.08	71
Manganese	0.04	0.21	425	0.20	400
Hardness	148	392	165	301	103
pH	6.9	na	---	na	---
Station S-2 (Pike River)					
Sulfate	49	132	169	99	102
Chloride	nd	nd	---	nd	---
TDS	188	346	84	287	53
Fluoride	nd	nd	---	nd	---
Manganese	nd	nd	---	nd	---
Hardness	nd	nd	---	nd	---
pH	nd	nd	---	nd	---

Notes:
1. Baseline data presented herein differ slightly from data included in Table 5.16. Baseline concentrations within this table were derived from data points with both flow and concentration values to allow for load calculations.
2. Mercury impact analysis is not presented because mercury concentrations in the tailings basin are lower than concentrations in the receiving waters.

nd = data not available for impact analysis at this station.
na = analysis was not conducted because upstream impacts were minor and did not result in additional exceedances of relevant standards.

Modeling results for sulfate, chloride, TDS, fluoride, manganese, hardness, and pH are presented for four stations, from upstream to downstream. Detailed discussions of methodology and results are included within the *Surface Water Hydrology and Quality Technical Memorandum.* As indicated in the previous paragraphs (under "General Water Quality Impacts Summary"), water quality impacts would generally be greater with the greater discharge volume of 11.1 cfs. In addition, impacts would generally diminish from upstream to downstream stations. In most cases, analytes that are currently exceeding standards would continue to do so, and the magnitude and frequency of exceedances would likely increase.

Further discussions pertaining to potential impacts to wetlands, wild rice, aquatic resources, wildlife, and upland vegetation associated with the projected increases in analyte concentrations are presented in Sections 5.3, 5.4, 5.5, 5.6, and 5.7 of this EIS and in the associated resource technical memoranda.

Several areas of interest within the Sandy River watershed were further evaluated, as discussed within the *Surface Water Quality and Hydrology Technical Memorandum.* These include the wild rice beds, Lake Vermilion, wetlands, the Rainy River Basin Management Plan Area, and Lake Vermilion. These are described briefly in the following paragraphs.

Wild Rice Beds: Sulfate is a primary constituent of concern for wild rice and has an associated water quality standard of 10 mg/L. Currently, baseline conditions commonly exceed this standard in the Sandy River and Pike River. The proposed discharge would further increase the sulfate concentrations, as summarized above in Table 5.19 and shown in Figure, 5-9. The potential impact of this increase in sulfate concentration to wild rice is further discussed below in Section 5.4 and is evaluated in more detail in the *Wild Rice Technical Memorandum*.

Lake Vermilion: Lake Vermilion is used as a drinking water source and, therefore, Class 1 drinking water standards apply. The potential impact to concentrations of sulfate, chloride, TDS, manganese, and fluoride concentrations in Lake Vermilion was evaluated and compared with the Class 1 standards. The impact evaluation indicates that the Class 1 standard at the Pike Bay inlet would likely be exceeded for sulfate, TDS, and manganese under low-flow conditions. However, it should be noted that, while impacts to Lake Vermilion (in particular Pike Bay) would occur, dilution in Lake Vermilion would be substantial, and exceedances at specific drinking water intakes are not likely. Only under extremely prolonged low-flow conditions would sufficient tailings basin water enter Pike Bay to result in exceedances of water quality standards.

Wetlands: The impact of the tailings basin on pH in the receiving rivers is predicted to be minor. However, because the pH standard for wetlands is "maintain background", if a particular low-pH wetland has a large interaction with a river containing the discharge, the increased pH load could alter the pH in the wetland. The pH in the wetland would likely increase over background due to the above neutral pH of the tailings basin. Potential impacts to wetlands associated with changes in pH are discussed further in Section 5.3 of this EIS and detailed evaluations are contained within the *Wetlands Technical Memorandum.*

Rainy River Basin Management Plan and Lake Vermilion Land Use Plan: The proposed project is not consistent in the short-term with basin management plans that have a goal of improving or maintaining water quality in the basin. However, it is anticipated that over the long-term, seepage from the tailings basin will be reduced and a subsequent improvement in downstream water quality would be anticipated.

Additional Potential Exceedances: Other standards likely impacted by increasing concentrations resulting from the proposed discharge include the Class 4 conductivity standard, and Class 3 standards for chloride and hardness.

5.2.2.2 Alternative B: Alternative Sites

Under this alternative, water from the tailings basin would be discharged to alternate locations. Alternate discharge sites include Laurentian Creek, locations in the Lake Superior watershed, and multiple watersheds, as described in the following paragraphs.

Laurentian Creek Discharge

The purpose of discharging water to Laurentian Creek would be to bypass Sandy and Little Sandy Lakes and associated wild rice beds. Laurentian Creek flows into the Sandy River just upstream of monitoring Station 701. As such, possible impacts at Station 701 and downstream Stations S-1, S-2 and Lake Vermilion would be similar to those of the proposed project. Laurentian Creek would be impacted, however, since the discharge would occur near the creek headwater and the creek has a relatively small watershed. Therefore, dilution would be limited and most standards that are exceeded in the Sandy River headwaters also would be exceeded in Laurentian Creek. The wild rice beds upstream of the Laurentian Creek/Sandy River confluence would not be further impacted by the discharge.

However, the Minnesota Class 4 sulfate standard for wild rice would still be exceeded due to seepage from the tailings basin. The goal of the Laurentian Creek alternative would be to prevent additional exceedances of standards in the wild rice beds associated with Sandy and Little Sandy Lakes and this could be achieved. However, Laurentian Creek would be highly impacted by the tailings basin discharge. It is assumed that the creek is currently not impacted by seepage from the tailings basin. Impacts downstream of the Sandy River/Laurentian Creek confluence would be similar to those of the proposed alternative.

Lake Superior Watershed Discharge

The most probable location for a discharge to the south in the Lake Superior watershed (which includes West Two Rivers and West Two Rivers Reservoir) is through one of Minntac's existing NPDES discharge points for mine pit dewatering. Specifically, NPDES-permitted Outfall SD001 (Permit #: MN0052493) is the most favorable based on its location in proximity to the tailings basin. Currently, this outfall is permitted for a daily maximum 33.2 MGD (49.8 cfs) of mine pit water discharge. The average permitted discharge is 5.0 MGD (7.5 cfs). Table 5.20, *Evaluation of Proposed Tailings Basin Discharge at Minntac Outfall SD001 in Lake Superior Watershed* compares actual concentrations observed in the SD001 outfall discharge with the tailings basin water quality for the key constituents.

In addition, Table 5.20 compares water quality for three example mixtures of tailings basin water and the existing permitted discharge water:

- Average Outfall SD001 discharge rate (7.4 cfs) with the full proposed 11.1 cfs tailings basin discharge for a total discharge of 18.5 cfs

- Maximum Outfall SD001 discharge rate (22.6 cfs) with the full proposed 11.1 cfs tailings basin discharge for a total discharge of 33.7 cfs

- Average Outfall SD001 discharge rate (7.4 cfs) with one-half the proposed tailings basin discharge (5.6 cfs) for a total discharge of 13 cfs. This case is used to evaluate the scenario where the discharge is split between the Lake Superior watershed and another discharge point.

TABLE 5.20
EVALUATION OF PROPOSED TAILINGS BASIN DISCHARGE AT MINNTAC OUTFALL SD001 IN LAKE SUPERIOR WATERSHED

Key Constituent (mg/L)	Water Quality Standard/Class	Outfall SD001 Permit Limits	Outfall Water Quality		Average Tailings Basin Water Quality	Mixed Water Quality 18.5 cfs [1]	Mixed Water Quality 33.7 cfs [2]	Mixed Water Quality 13.0 cfs [3]
Sulfate	1000/4B[4]	Monitor	313	a	711	552	444	483
Chloride	100/3B	---	23.8	a	122	83	56	66
TDS	NS	---	670	a	1380	1096	904	974
Fluoride	NS	---	0.55	a	2.71	1.85	1.26	1.48
Manganese	NS	Monitor	0.11	a,t	0.277	0.21	0.17	0.18
Mercury[6] (μg/l)	0.0013/2-Superior	Monitor	0.0010	e,t	0.011	0.0011	0.0011	0.0010
Iron	NS	2.0	0.06	d	0.09	0.08	0.07	0.07
Hardness	250/3B	Monitor	483	a,c	928	750	630	674
pH	6.5 – 8.5/4A	6.5 - 8.5	7.8	b	8.3	8.1	8.0	8.0
Molybdenum	NS	---	0.0184	a,t	0.085	0.058	0.040	0.047

Notes:
1. Average SD001 Discharge and Full Tailings Basin Discharge: Total Flow = 18.5 cfs
2. Maximum SD001 Discharge and Full Tailings Basin Discharge: Total Flow = 33.7 cfs
3. Average SD001 Discharge and Split Tailings Basin Discharge: Total Flow = 13.0 cfs
4. Criterion based on Class 4B narrative standard.
5. Units in mg/L, unless otherwise noted
6. μg/l

a report as maximum concentration (1 analysis)
b average
c calculated from calcium and magnesium concentrations
d MPCA Permit MN0052493, reissued January 7, 2004
e Mean of March 2004 mercury data collected at nearby mine pit dewatering (similar source water) outfalls
t total metals fraction
--- not applicable
EPA Advisory: EPA Health-Based Advisory Level for drinking water (USEPA, 2002 Edition of the Drinking Water Standards and Health Advisories).
NS – No Standard.

Another scenario, in which the discharge through the Outfall SD001 is 100 percent tailings basin water, is represented in Table 5.20 by the "Average Tailings Basin Water Quality" column. These concentrations represent current conditions, which will change over time.

Numerical water column water quality standards would likely be exceeded at the discharge point for specific conductance and hardness. With the tailings basin discharge representing 100 percent of the discharge, the chloride standard would also likely be exceeded. Impacts downstream of the discharge, however, would likely be mitigated to some degree by additional dilution from tributaries and groundwater baseflow.

As discussed in the *Mercury and Methylmercury Technical Memorandum,* the more restrictive Class 2 standards for mercury apply to the Lake Superior watershed. Specifically, a standard of 0.0013 μg/L applies (verses 0.0069 μg/L). As noted in the *Mercury and Methylmercury Technical Memorandum*, of seven low-level mercury analyses of tailings basin water (both total and dissolved), only one exceeded 0.0013 μg/L. A sample collected in September 1999 contained 0.00154 μg/L mercury. All of the other samples were less than 0.001 μg/L. Based on these results, exceedance of the mercury standard in the discharge could occur, but appears unlikely given any dilution.

Multiple Watershed Discharge and HCR

The most viable alternative for discharge to multiple watersheds is discharge to both the Sandy River and Dark River watersheds. This evaluation was discussed previously under Alternative A. However, with detailed evaluation, another variation on this scenario could be developed whereby the rate of total discharge is varied and the split between the watersheds is varied. This alternative would be a variation of the HCR, discussed previously. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River watershed during periods of temperature extremes to protect the trout habit. Similarly, flow could be directed from the Sandy River, or routed down Laurentian Creek during periods critical for wild rice production. These types of discharge scenarios could result in less adverse impacts when compared to the proposed project. However, the process to design and permit this type of discharge strategy is complex and requires an extensive monitoring network, and still may not allow Minntac to meet the objectives of discharging an average of 11.1 cfs without adverse impact.

5.2.2.3 Alternative C: No Build (No Action)

The No Build Alternative would result in additional impacts to the surface water system over the long-term. Data indicate that, with continued use of the tailings basin, the water quality would continue to degrade as a result of the design and operation of the mineral processing facility and tailings basin. This will result in increased concentrations of solutes in the seepage from the tailings basin and the subsequent increase in concentrations in the Sandy River and Dark River.

At closure, the water quality would begin to improve with removal of major pollutant sources, and precipitation and continued seepage loss from the impoundment. However, for required final impoundment closure, eventual discharge of the water could still be needed. If discharge occurs at a later date, after an extended period of use, the water quality could be more concentrated and result in greater impacts to in-stream water quality or require substantially greater levels of treatment.

5.2.2.4 Alternative D: Alternative Technologies

Several alternatives incorporating design or operational changes were considered. These focus on extending the life of the tailings basin such that the 11.1 cfs discharge of tailings basin water would not be required in the near future. Perimeter dike raising and water level reduction alternatives are briefly described below. In both cases, potential impacts would not be due to a new discharge, but to changes in the existing seepage discharge.

Tailings Basin Perimeter Dike Raising

Raising the tailings basin perimeter dike would continue to adversely impact water quality in the Sandy and Dark Rivers. This alternative would not address the water quality in the tailings basin and, thereby, the basin seepage. The tailings basin water would continue to evapo-concentrate and concentrations of regulated constituents would continue to increase. In addition, increased water levels in the tailings basin could increase seepage rates due to higher hydraulic heads. The combination of higher concentrations and discharge rates would result in higher concentrations of sulfate and other key constituents downstream in the Dark River and Sandy River. Such an alternative would reduce the short-term impact associated with discharging 11.1 cfs of tailings basin water; however, it would result in increased loading from seepage. In addition, it would not address the issue of long-term water quality improvement, and would potentially result in additional impacts when the water eventually has to be discharged to allow for closure and reclamation.

of long-term water quality improvement, and would potentially result in additional impacts when the water eventually has to be discharged to allow for closure and reclamation.

Water Level Reduction

Several options are proposed that could reduce the level of water in the tailings basin through operational changes. Such a reduction could reduce seepage rates and improve water quality in the Sandy River and Dark River, if the improvements are not off-set by increasing constituent concentrations in the tailings basin. However, it is probable that the reduced water level would be accompanied by a further degradation of the water quality in the basin. It, therefore, is likely that no net improvement would be seen in the rivers, and the long-term water quality issues at closure would remain. This alternative is addressed in more detail in the *Tailings Basin Management Technical Memorandum* included in Volume II of this EIS.

5.2.2.5 Alternative E: Design Alternatives

Two potential design alternatives for the tailings basin discharge were evaluated. Both of these were largely focused on mitigating temperature impacts in the trout reach on Dark River. The first addresses the temperature of the tailings basin discharge (siphon placement), and the second addresses the temperature of water flowing from Dark Lake.

Siphon Placement

Siphon placement could be altered to help mitigate direct impacts due to temperature immediately downstream of the tailings basin. During May through August, the lower few feet of the tailings basin water column is cooler than the more surficial water, as shown on Figure 5-11, *Temperature Profiles in the Minntac Tailings Basin*. Similarly, in mid-winter the temperature of the deeper water is slightly warmer. However, discharge of this water would not directly affect the water temperature in the trout reach in the Dark River. The relative temperature differences between the tailings basin water and the 1999-2000 Dark River monitoring stations are shown on Figure 5-12, *Comparison of Tailings Basin and Dark River Temperatures*. As discussed in association with the proposed project, the temperatures of stations below D-2 would not be directly affected by the temperature of the proposed tailings basin discharge due to the buffering effect of Dark Lake. In addition, other considerations such as dissolved oxygen concentration may be of key consideration. The dissolved oxygen level can drop to less than one mg/L in the bottom of the tailings basin lake in the summer when stratification occurs. The discharge of water with such depressed dissolved oxygen levels could adversely affect aquatic communities immediately downstream of the tailings basin. However, the maximum extent of this effect would likely be limited, due to re-oxygenation of the water, to the sections between the discharge points and Dark Lake and Little Sandy Lakes. Potential impacts to aquatic resources are further discussed in Section 5.5 of this EIS and in the *Aquatic Resources Technical Memorandum*.

Dark Lake Effluent

Hydraulic control of the Dark Lake outflow could mitigate the temperature impact on the trout reach in the Dark River. By reducing flow from Dark Lake during warm periods, the cooler groundwater baseflow to the stream would help maintain preferred temperatures for the trout. Flow from the lake would have to be regulated during July though September.

It is possible that excess water could be discharged when air temperatures are lower (e.g., at night). A detailed engineering/hydraulic analysis would be required to determine if there is capacity in Dark Lake to store sufficient water to allow for this type of flow regulation.

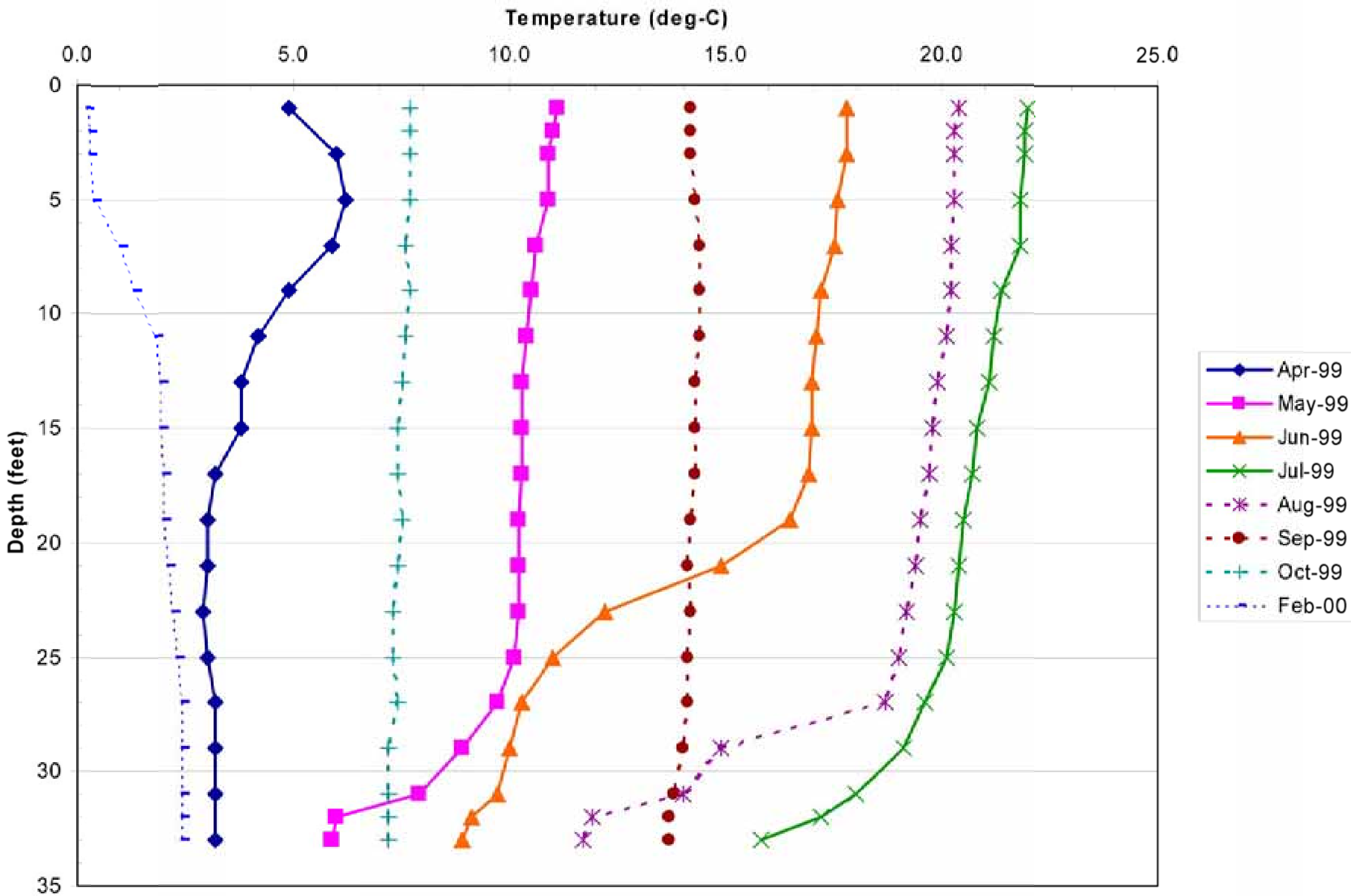


FIGURE 5-11
TEMPERATURE PROFILES IN THE MINNTAC TAILINGS BASIN

FILENAME: Fig 5-11 Temps MTB.dwg

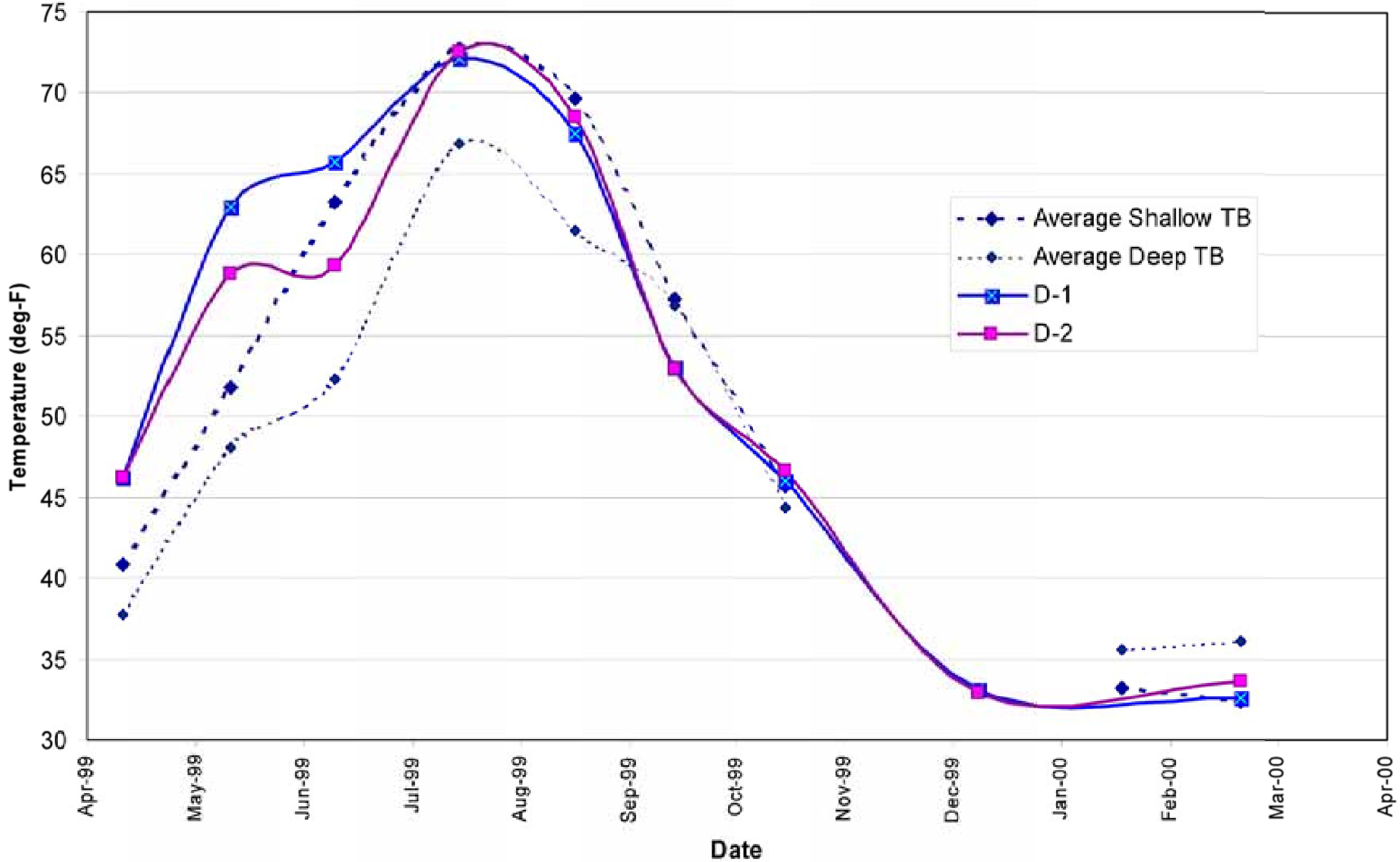


FIGURE 5-12
COMPARISON OF TAILINGS BASIN
AND DARK RIVER TEMPERATURES

FILENAME: Fig 5-12 TB DR Temps.dwg

5.2.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Reduction in the magnitude of discharge to either watershed would accordingly reduce the associated impacts. However, the volume of discharge required to meet some of the objectives of the project would likely have impacts on the order of those discussed in the impact analysis for the proposed project.

The project is complicated by ongoing exceedances of water quality standards in the Sandy River and Dark River, apparently due to seepage from the tailings basin. Because of the elevated baseline conditions, practically any additional discharge from the tailings basin could result in additional exceedances and further increases in concentrations in these Rivers. Therefore, it is not practical to assume that any discharge to the Sandy River or Dark River large enough to significantly reduce concentrations in the tailings basin and associated seepage would not have some adverse impact. This conclusion is supported by the analysis of the proposed project, where the impacts of the full discharge of 11.1 cfs and the split discharge of 5.6 cfs are evaluated. Even when discharge is one-half of the proposed flow rate, and one-half the tailings basin sulfate concentration is assumed (as described under Alternative G), adverse impacts are still predicted. Therefore, any reduction in discharge rates will reduce the impact, but it is not likely that an adequate discharge can occur to the Sandy River or Dark River that would not result in additional exceedances of water quality standards.

This alternative would be more effective if the discharge was piped to a relatively unimpacted watershed. For example, the flow volume to the south discharge (Lake Superior Watershed – evaluated in Alternative B) could be modulated to reduce impacts.

5.2.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Minntac is evaluating an SPB system to reduce sulfate concentrations in the proposed discharge. In a report submitted to MPCA in February 2004, Minntac presented the result of the pilot testing of the SPB system and evaluation of several discharge alternatives that include versions of the SPB system (Minntac, 2004). Two of the alternatives are comparable to alternatives presented in the EIS scoping document. The Minntac report evaluated the alternatives' ability to meet the sulfate drinking water standard at Lake Vermilion during discharge and the sulfate water quality improvement objectives for the tailings basin seepage, as well as Minntac's desire to reduce chloride and hardness in the water recycled to the plant.

General Review of SPB Options

SPB Option 1: As a baseline, the SPB report (Minntac, 2004) evaluated Alternative A, the discharge of 11.1 cfs of tailings basin discharge. As discussed previously, this alternative has limitations in meeting water quality standards during the discharge. The direct discharge of 11.1 cfs of SPB-treated discharge may reduce the impacts on the Dark River and Sandy River watersheds compared to the extent of those impacts from a new discharge without SPB treatment. However, the discharge of 11.1 cfs of SPB-treated water would similarly not result in a sufficient level of sulfate reduction. The water quality impact of the direct SPB-treated discharge is evaluated below in this section as an alternative similar to Alternative A, but with a level of mitigation.

SPB Option 2: Minntac also evaluated a system whereby there would be no additional discharge from the tailings impoundment, but an SPB system would be used to treat water in the tailings system. It was concluded that, while this system could be used to reduce sulfate concentrations in the seepage, concentrations of most of the other key constituents would continue to build up in the tailings basin and subsequent seepage. Furthermore, it was concluded that this would result in additional impacts to water quality in the Sandy River and Dark River watersheds. This alternative does not appear to be a viable alternative to address most of the water quality issues. It is, therefore, not evaluated further.

SPB Option 3: The final alternative presented by Minntac includes a combination of an 11.1 cfs direct siphon discharge from the tailings impoundment with discharge of 5.3 cfs of SPB- treated plant effluent to the tailings facility. Included in this alternative would be other plant water management strategies to help improve water quality. In addition, the 11.1-cfs would be a managed (HCR) discharge limiting discharge during low-flow periods and increasing it during high flow periods, and thereby reducing the likelihood of water quality standard exceedances. Minntac qualified the evaluation of the sizing of the SPB and flow rates, which would require further analysis. It is agreed that if this alternative were selected, further analysis of specific components would be required. However, for the evaluation of this alternative, the data given are sufficient, and this alternative is discussed further in this section.

<u>**SPB Treatment System Observations**</u>

The following general observations can be made about the proposed SPB system based on general observations about systems that rely on biological sulfate reduction and Minntac's pilot testing:

- Some metals in the tailings basin water are already low, but could be further reduced as the result of sulfide precipitation or absorption (most notably molybdenum and mercury; (see Table 5.21*, Metal and Metalloid Analyses from Cell 2 of the SPB System*).

TABLE 5.21
METAL AND METALLOID ANALYSES FROM CELL 2 OF THE SPB SYSTEM

Constituent[1]	Influent			Cell 2 Effluent		
	12/29/03	1/22/04	Average	12/29/03	1/22/04	Average
Aluminum	410	180	295	230	29	129.5
Antimony	<4	<4	<4	<4	<4	<4
Arsenic	<3	<3	<3	16	8	12
Barium	85	84	84.5	86	90	88
Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	190	190	190	190	180	185
Cadmium	<1	<1	<1	<1	<1	<1
Chromium	7	<2	---	<2	<2	<2
Cobalt	<1	<1	<1	<1	<1	<1
Copper	1	<1	---	<1	<1	<1
Lead	6	<5	---	<5	<5	<5
Manganese	200	150	175	3,200	800	2,000
Mercury[2]	0.0435	0.158	0.101	0.0172	0.0296	0.0234
Molybdenum	73	78	75.5	12	11	11.5
Nickel	3	3	3	<2	<2	<2
Selenium	9	9	9	5	<5	---
Silver	<1	<1	<1	<1	<1	<1
Thallium	<5	<5	<5	<5	<5	<5
Titanium	14	8	11	2	<2	<2
Zinc	<5	<5	<5	<5	<5	<5

Notes:
1. All concentrations in μg/L and are total metals analyses
2. Total mercury sample dates are 9/10/02 and 12/29/03

However, as the result of reductive dissolution and other reactions other metal concentrations could increase (most notably arsenic and manganese).

- Methylmercury may increase due to increased methylation associated with sulfate reduction (a slight increase from an average of 0.0015 to 0.0072 μg/L was observed).

- While the SPB system would most directly reduce concentrations of sulfate, TDS concentration and conductivity can also exhibit a slight reduction in concentration.
- Alkalinity should increase and could result in carbonate precipitation and a slight reduction in hardness.

Chloride concentrations are not affected by the SPB system.

The discharge of the SPB system may contain several constituents that may be of concern that are not an issue in the direct discharge from the tailings basin. These include:

- Chemical Oxygen Demand (COD): typically greater than 100 mg/L in SPB discharge compared to typically less than 20 mg/L in tailings basin water.
- Biochemical Oxygen Demand (BOD): typically greater than 100 mg/L in SPB discharge compared to less than 15 mg/L and commonly less than 2 mg/L in tailings basin water.
- Ammonia: greater than 1 mg/L and up to 7.1 mg/L compared to less than 0.2 mg/L in tailings basin water.
- Sulfide: up to 192 mg/L in the SPB discharge.

Some data have also indicated that phosphorus may be slightly elevated as the result of the SPB system, but this data does not appear conclusive. In addition, because of the nature of the system total organic carbon (TOC) could also be elevated in the effluent. Due to the strong influence of TOC on the methylation and transport of mercury, increased TOC concentrations could lead to increase methylmercury and fish tissue mercury levels in the impacted downstream waters.

Sufficient data from the SPB system study do not exist to further evaluate these additional constituents. Minntac has proposed that an aeration and settling basin would be used to polish the discharge from the SPB system. It is likely that this system would reduce the concentrations of COD, BOD, ammonia, sulfide, TOC and phosphorus. However, this has not been demonstrated for this specific system which was optimized for sulfate removal. The discharge from the settling basin could also be discharged to the tailings basin, where further reduction and dilution of SPB-related constituents could occur. For example, aquatic plants could further reduce the concentrations of nutrients such as nitrogen compounds and phosphorus. To address the above concerns, primary effleint from the SPB would be treated in tertiary polishing steps to bring down the BOD.

While the demonstration system indicated that a consistent 50 percent reduction of sulfate could be obtained, reductions of TDS, conductivity, and hardness were slight, if they occurred at all. Therefore, the primary impact of the SPB would be to reduce sulfate in the effluent discharged to the Sandy River and/or the Dark River.

SPB Treatment System Independent Review

An independent review of the SPB report indicated the following:

- Nutrient optimization showed promise in improving the performance of the bench-scale studies.
- The chemical balance model inputs reportedly were overestimated, which underestimate future water quality improvements. This would affect the timeline for improvement.

- The use of different carbon sources may generate different biological populations, which may affect the performance of the system with respect to sulfate removal. No biology information was presented in the SPB report.

- Manganese release through the system may cause downstream water quality issues, since the secondary treatment level is 50 μg/L.
- Insufficient data exist in the SPB system report to estimate the life expectancy of the system and the SPB system substrate.

SPB Option 1: Direct 11.1 cfs SPB Effluent Discharge to Sandy or Dark Rivers

To evaluate the impact of sulfate concentration in the SPB effluent on the Dark River and Sandy River watersheds, mass balance calculations for the Dark River and Sandy River (to Lake Vermilion) were conducted, as reported in the *Surface Water Hydrology and Quality Technical Memorandum*. Optimally, the SPB appears to discharge water with sulfate concentrations of approximately 400 to 450 mg/L based on an 800 to 900 mg/L influent concentration (a 50% reduction) (Minntac, 2004). These values are assumed in the mass balance model. The mass balance analysis also assumed a constant discharge rate of 11.1 cfs. (In Minntac's evaluation of the SPB-system, however, it was proposed that an HCR discharge be used to discharge water from the tailings basin to the Sandy River only, such that drinking water standards would not be exceeded at the Pike River inlet to Lake Vermilion. This remains an option for mitigating impacts identified in this evaluation.) Mass balance model results are described in the following paragraphs.

At Station 701 on the Sandy River, the average sulfate concentration for the 1999 to 2003 sampling events would have increased from 223 to 288 mg/L with the addition of the SBP-treated discharge, as indicated in Table 5.22, *Summary of Sulfate Impacts from SPB Discharge.* However, the concentrations would be less than those associated with the full-tailings basin discharge (436 mg/L), and the split discharge (374 mg/L), as discussed in Section 5.2.1.1. Similar to the direct discharge, the 10 mg/L wild rice standard would still be exceeded, and the 1,000 mg/L Class 4 criterion would not likely ever be exceeded.

The average for the previous sampling events at Stations S-1 and S-2 would have increased from 112 to 173 mg/L sulfate for Station S-1 and 49 to 93 mg/L for Station S-2. A concentration of 250 mg/L sulfate was only exceeded during events where flow was less than 10 cfs at these stations, excluding the events where the baseline data exceeded 250 mg/L. It is estimated that, for the historical sampling events, the 11.1 cfs SPB discharge would not have resulted in an exceedance of the 250 mg/L drinking water standard at the Pike River inlet to Lake Vermilion. Barr (2003) estimated the 7Q10 low-flow at the Pike River inlet to be 2.5 cfs. If this flow was assumed to have a conservative baseline concentration of 50 mg/L, a sulfate concentration of 336 mg/L would result at the lake inlet.

TABLE 5.22
SUMMARY OF SULFATE IMPACTS FROM SPB DISCHARGE

Station	Baseline Concentration (mg/L)	Concentration with 11.1 cfs SPB Discharge (mg/L)	Concentration with 5.6 cfs SPB Discharge (mg/L)
Sandy River Discharge			
701	223	288	267
S-1	112	173	151
S-2	49	93	74
Pike Bay Inlet[1]	no data[2]	62	49
Dark River Discharge			
D-1	383	376	374
D-2	140	220	189

Notes:
1. Sulfate concentrations are estimated at Pike Bay Inlet to Lake Vermilion based on concentrations at Station S-2 and downstream watershed yield. Baseline data are not available.
2. Data were not available at the time of evaluation

Therefore, even SPB-treated water would cause an impact that exceeds standards at 7Q10 flows. However, Minntac's proposed HCR discharge would mitigate this impact by reducing the discharge rate during low flows, and increasing it during high flows.

At Station D-1 on the Dark River, the 400 mg/L sulfate SPB discharge would have the impact of leveling out concentrations. The baseline concentrations greater than 400 mg/L would be reduced, while the events with concentrations less than 400 mg/L would see elevated concentrations. The net effect on the baseline data would be a reduction in average concentration from 383 mg/L down to 376 mg/L (11.1 cfs) or 374 mg/L (5.6 cfs). The SPB discharge would provide sufficient sulfate mass to result in new exceedances of the drinking water standard in 25 percent of the baseline data at Station D-2. The average concentration would have increased from 140 mg/L to 220 mg/L at Station D-2.

The scenario where the SPB discharge is split between the Dark River and Sandy River is also considered. The maximum estimated concentration at the Pike River inlet to Lake Vermilion would be 177 mg/L sulfate. On the Dark River side, the impact of splitting the SPB effluent would result in one exceedance of the Class 1 standard at Station D-2 or a six percent increase.

As discussed further below, alkalinity, aluminum, arsenic, manganese, and methylmercury concentrations are higher in the SPB effluent than in the tailings basin. Therefore, potential impacts associated with these constituents are possible in waters receiving discharge directly from the SPB system. The effects of Minntac's proposed aeration/settling pond have not been evaluated, therefore, a quantitative evaluation of these impacts is not possible. Impacts from COD, BOD, ammonia and sulfide, and possibly phosphorus and TOC would also be possible, thus requiring the use of tertiary treatment aeration/sedimentation steps.

SPB Option 2: As indicated previously Minntac also evaluated a system whereby there would be no additional discharge from the tailings impoundment, but an SPB system would be used to treat water in the tailings system. It was concluded that, while this system could be used to reduce sulfate concentrations in the seepage, concentrations of most of the other key constituents would continue to build up in the tailings basin and subsequent seepage. Furthermore, it was concluded that this would result in additional impacts to water quality in the Sandy River and Dark River watersheds. This alternative does not appear to be a viable alternative to address most of the water quality issues. It is, therefore, not evaluated further.

SPB Option 3: Discharge of 11.1 cfs of Tailings Basin Water through HCR Release, Treatment of 5.3 cfs of Discharge to Tailings Basin and Other Measures

As discussed previously, the HCR release of the tailings basin water is an option that could reduce impacts to water quality in streams receiving tailings basin discharge. Under the HCR approach, discharge would be curtailed during low-flow periods when exceedances are most likely to occur. Minntac (2004) evaluated the HCR-release of tailings basin water averaging 11.1 cfs on an annual basis and concluded that it would be possible to discharge sufficient water to the Sandy River without exceeding the sulfate drinking water standard at the Pike River inlet on Lake Vermilion. Constituents other than sulfate were not evaluated. In addition, while from a water quality position the HCR discharge to the Sandy River may not impact the sulfate standard, the added flow volume during high flow periods may impact the hydrology of the rivers, as discussed previously. The HCR-discharge to multiple watersheds could facilitate the discharge without impacts to non-wild-rice sulfate water quality standards. Further detailed monitoring and watershed modeling would be required to develop the criteria for this type of discharge.

The discharge of tailings basin water at an average rate of 11.1 cfs would not allow Minntac to obtain the necessary level of sulfate reduction to meet the sulfate mitigation goal (Minntac, 2004). In order to obtain the mitigation goal, it has been proposed by Minntac (2004) that a discharge of 5.3 cfs from the SPB system to the tailings basin supplement the direct discharge from the tailings basin, and that the discharge also be supplemented with other unspecified water management procedures. According to Minntac, the combined alternative would allow for a direct "managed" HCR siphon discharge and for the reduction of sulfate concentrations in the tailings basin sufficient to meet the mitigation goals.

Minntac indicated that the SPB discharge would be routed to an aeration and settling pond and then discharged to the tailings basin to reduce or eliminate impacts from SPB-specific constituents (i.e., elevated COD, BOD, ammonia or sulfide). Additional constituents of concern in the SPB effluent, however, must also be addressed. These are identified in Table 5.23, *Additional Constituents of Concern in SPB Discharge,* and discussed further in the following paragraphs.

TABLE 5.23
ADDITIONAL CONSTITUENTS OF CONCERN IN SPB DISCHARGE

Constituent	SPB Influent Concentration (mg/L)	SPB Effluent Concentration (mg/L)
Manganese	0.175	2.0
Aluminum[1]	0.295	0.130
Arsenic	<0.003	0.0125
Alkalinity	114	540

Notes:
1. While aluminum concentrations decrease through the SPB system, relevant standards would still be exceeded.

Manganese has been identified as a key constituent and has been observed to increase in concentration through the SPB system (Minntac, 2004). The influent to the SPB system averaged 0.175 mg/L, slightly less than the 1999-2000 tailings basin average concentration of 0.277 mg/L, and while the downstream manganese appears slightly elevated, it is still generally less than 0.030 μg/L. However, the effluent from the SPB system averaged 2.0 mg/L (Minntac, 2004). The Class 1 standard for manganese that applies to Lake Vermilion and the trout reach on the Dark River is 0.050 mg/L. The effects of the aeration and tailings basin have not been tested to determine if a reduction in manganese concentrations would occur. It is possible that oxidation could reduce the concentration through precipitation of a manganese oxide. However, if operation of the SPB system results in an increase in tailings basin manganese concentrations, then it could become another parameter to consider in the HCR discharge, so that standards are not exceeded in the Class 1 waters. Similarly mitigation in the seepage may become important if manganese concentration increase in the tailings basin.

For the remainder of the key constituents, the discharge of SPB effluent is not likely to have further impact. The proposed system of SPB treatment discharge to the tailings basin and a direct HCR discharge to the Sandy River, would have a positive impact of reducing constituent concentrations in tailings basin seepage over the long-term. Methylmercury is a possible exception that is evaluated in the *Mercury and Methylmercury Technical Memorandum*. Because the SPB system removes sulfate from the water, due to the activity of sulfate-reducing bacteria, the potential exists for mercury contained within the substrate of the bed to be converted to methylmercury and, therefore, be mobilized as methylmercury. Data provided in Minntac (2004) indicate that this is occurring with up to 0.0072 μg/L in the SPB discharge. This slightly exceeds the relevant standard of 0.0069 μg/L in the Sandy and Dark River watersheds. With the SPB discharge, the methylmercury loading to the receiving water would increase over baseline conditions and Alternative A. However, this may be offset to some degree. Lower sulfate concentrations in the discharge could result in decreased mercury methylation downstream compared to a direct siphon discharge of tailings basin water.

Three constituents not listed as key constituents may be a concern in the SPB effluent. These are aluminum, arsenic and alkalinity. The average aluminum concentration in the SPB effluent was 0.130 mg/L. The Class 2A (aquatic) standard for aluminum is 0.087 mg /L; this standard is applicable at the trout reach. It is notable that the pilot SPB system was directly treating scrubber water and the influent aluminum concentration averaged 0.295 mg/L, so better than a 50 percent reduction in aluminum concentration was actually observed. The average in the tailings basin was 0.025 mg/L in 1999-2000. Assuming the aluminum concentration in the process flows have not significantly changed, this suggests that further reduction in aluminum concentration in the tailings basin occurs either due to dilution with other inflows or chemical attenuation. Therefore, the SPB system may supplement the reduction in aluminum concentrations observed in the tailings basin, and an impact on the aluminum standards in the Sandy or Dark Rivers would not be expected.

Arsenic concentrations increased through the SPB system and the average arsenic concentration in the SPB effluent was 0.0125 mg/L. The effects of the proposed aeration/settling basin have not been evaluated during the pilot testing program, and neither have the effects of discharging the SPB effluent to the tailings basin. It is likely that the effect of rain/snow water dilution in the aeration and tailings basins would reduce the arsenic concentration sufficiently such that the arsenic concentration would not exceed the Class 1 standard in the direct discharge. Regardless, the arsenic concentration would not likely ever exceed the Class 1 standards where they apply if the HCR discharge is utilized. Similarly, the Class 2A and 2Bd standards of 0.002 mg/L only apply to the Dark River trout reach and Lake Vermilion. So under an HCR discharge scenario, it is not likely that the standard would be exceeded. The Class 2B standard of 0.053 mg/L applies to most other waters downstream of the tailings basin, and is higher than the average SPB effluent concentration by several times.
Alkalinity is elevated in the SPB effluent as a natural result of the biological reaction in the system. The average effluent concentration is 540 mg/L compared to an average influent concentration of 114 mg/L (Minntac, 2004). This is compared to a total alkalinity concentration of approximately 183 mg/L in the tailings basin. If the total alkalinity is mostly bicarbonate alkalinity, which is reasonable given the observed pH, then a Class 4 standard (agriculture (irrigation) water use) of 5 meg/L (305 mg/L) is relevant. If the SPB system results in an increase in bicarbonate alkalinity, then the system may impact the industrial use standard.

5.2.3 Cumulative Impacts

In addition to permitted discharges associated with the Minntac facility, several additional permitted discharges exist within the Dark River and Sandy River watersheds, as shown in Figure 5-13, *Location of Other NPDES Discharges Within the Study Area*. There are at least four other permitted discharges:

- Soudan State Park (Department of Natural Resources): NPDES Permit #MN0060151
- Tower Publicly Owned Treatment Works (POTW): NPDES Permit #MN0056618
- Hibbing Taconite Mine: NPDES Permit #MN0049760
- Ispat-Inland Minorca Tailings Basin: NPDES permit #MN0055964

The Tower POTW includes a treatment plant that discharges to the East Two Rivers, and limits and monitors for typical sewage wastewater pollutants like phosphorus, solids, BOD, fecal coliform and pH. The Soudan State Park de-waters its mine workings to a series of small wetlands flowing into the East Two Rivers. Pollutants such as cobalt, copper, solids, sulfate and pH are tested in the Soudan State Park discharge. Both the Soudan State Park and Tower POTW discharge to the East Two Rivers, which in turn discharges to Pike Bay of Lake Vermilion.

Analytical results for the key constituents from the Soudan State Park and Tower POTW dischargers are not available, except pH. During 2003 and 2004, pH ranged from 7.3 to 7.9, and 7.3 to 8.8 in the discharge water from the Soudan State Park and Tower POTW, respectively. These pH values are all within the standards, except the maximum of 8.8 from Tower POTW. Since the East Two Rivers discharges to Lake Vermilion, the Tower POTW and Soudan State Park discharges do not impact the Sandy or Pike Rivers.

The Hibbing Taconite (Hibbing) mine discharges to the Shannon River, which drains into the Sturgeon River, just upstream of Forest Road 278 about seven miles upstream of the confluence of the Sturgeon and Dark Rivers. Review of the Discharge Monitoring Report (DMR) data from Hibbing (MPCA, 2004) for 2003 and 2004, revealed that the maximum concentration of sulfate measured in the Hibbing discharge was 140 mg/L. Their monthly average flow rate in 2004 was 14 cfs (MPCA, 2004). The actual concentration of sulfate at the confluence of the Sturgeon and Dark Rivers as a result of discharge from Hibbing would likely be significantly lower than 140 mg/L due to dilution from other water sources. The average concentration of sulfate at Station D-2 resulting from the proposed 11.1 cfs discharge from Minntac was estimated to be 318 mg/L. If one assumes that the concentration of sulfate just downstream of the confluence of the Dark and Sturgeon Rivers would be similar to D-2, then the addition of a maximum of 140 mg/L (likely much lower) of sulfate from Hibbing would represent a source of dilution to discharges from Minntac. However, without water quality data from ST-1 indicating the actual concentrations of sulfate (or other key constituents) resulting from Hibbing discharges, it is not possible to estimate the resultant concentration in the Sturgeon River due to the cumulative impact from these two discharges. It is apparent that the discharge from Hibbing has likely increased the sulfate loading and concentration in the Sturgeon River and a discharge from Minntac would further increase sulfate loading.

The Ispat-Inland Minorca Tailings Basin (Ispat) discharges to Wouri Creek, which in turn discharges to the Sandy River upstream of Station S-1.

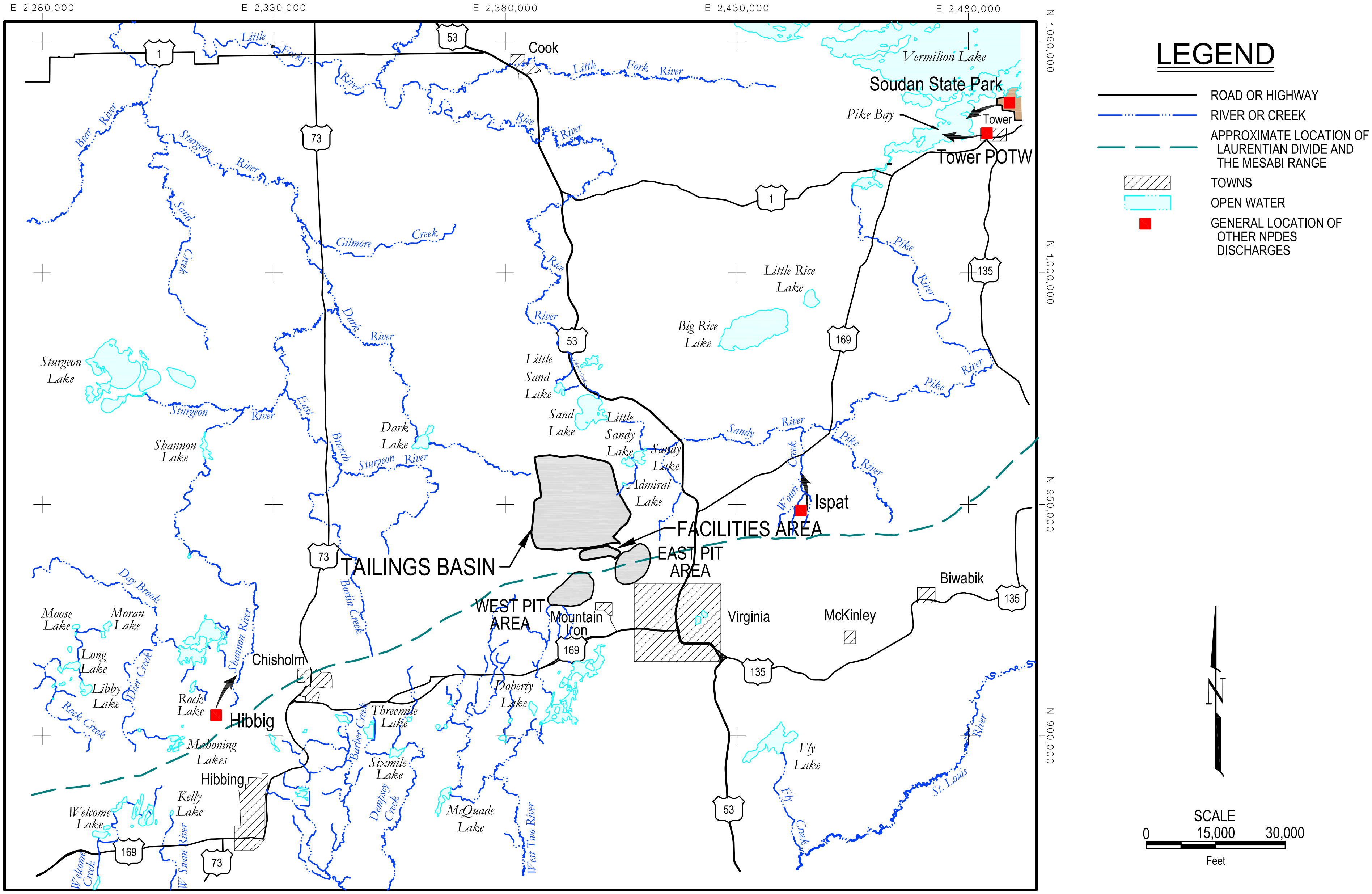


FIGURE 5-13
LOCATIONS OF OTHER NPDES DISCHARGES WITHIN STUDY AREA

FILENAME: Fig 5-13 NPDES Locs.dwg

Review of the DMR data from Ispat (MPCA, 2004) for 2003 and 2004, revealed that the maximum concentration of sulfate discharged was 54 mg/L. Their monthly average flow rate in 2004 was 22 cfs (MPCA, 2004). The average baseline concentration at Station S-1 was 108 mg/L, while the average concentration of sulfate resulting from the proposed 11.1 cfs discharge from Minntac was estimated to be 239 mg/L. Since maximum concentrations of sulfate discharged from Ispat are significantly lower than both the baseline and projected impact concentrations of sulfate at Station S-1, the Ispat discharge would represent a source of dilution to discharge from Minntac.

Since Ispat discharge flows into the Sandy River upstream of Station S-1, baseline data associated with Stations S-1, S-2, and S-3 include existing impacts from Ispat. This would also be the case during 7Q10 flows; however, monitoring data during 7Q10 flows are not available. The addition of a maximum of 54 mg/L from Ispat would represent a source of dilution for the Minntac discharge that may not otherwise be present during 7Q10 flows, and could therefore improve water quality during 7Q10 flows compared to 7Q10 with Minntac only discharge. However, the total receiving water load would increase, which could then increase concentrations in Lake Vermilion above those if Ispat discharge were not occurring.

In terms of flow, if one assumes that Ispat discharges at maximum allowable flow during peak flow of the Sandy River, then the flow from Ispat could increase the maximum flow at S-1. This then would increase potential cumulative impacts during peak flow. Similarly, if Ispat were to discharge water during 7Q10 low-flows, it could cause flows in the Pike River to be higher than the typical 7Q10 flow.

5.3 WETLANDS

This section describes wetland baseline conditions (Section 5.3.1) and potential impacts (Sections 5.3.2 and 5.3.3) within the Dark River and Sandy River watersheds associated with implementation of the proposed project or project alternatives. General wetland characteristics were described previously in Section 2.5.4 and general locations of wetland areas are shown in Figure 2-8, *General Locations of Wetland Areas.* Detailed wetland discussions, evaluations, and data sets are contained within the *Wetlands Technical Memorandum.*

5.3.1 Wetland Baseline Conditions

The following paragraphs describe the primary types of wetland communities occurring in St. Louis County, Minnesota and the project study area. Within some of the community types, there are subtypes, which are described within the *Wetlands Technical Memorandum*. This information was compiled primarily from the MDNR (2003) publication "Wetlands in Minnesota", MDNR (2003) publication "Field Guide to the Native Plant Communities of Minnesota: the Laurentian Mixed Forest Province", and Aaseng et al., 1993, except where specific authors are noted.

Wetland community types in the area, and described below, include the following:

- Shrub swamp
- Bogs
- Hardwood swamp forests
- Conifer swamp forest
- Wet Meadow/Fen
- Emergent marsh

In addition, aquatic communities, including aquatic river communities and aquatic lake communities are described.

5.3.1.1 Shrub Swamp

Shrub swamps are minerotrophic (receiving water that has passed through mineral soil), tall-shrub communities, most often present on mucks and shallow peat in the deciduous forest-woodland and conifer-hardwood forest zones of Minnesota. The major shrub species are speckled alder, willows (especially pussy willow, slender willow, and Bebb's willow), and red-osier dogwood.

Shrub swamp communities are relatively stable in areas where water table fluctuations are small because the loss or gain of woody vegetation in many wetland areas is linked to particularly dry or wet cycles that affect seedling establishment, flooding, windthrow, and fire frequency. Two shrub swamp community types exist in Minnesota, Alder Swamp and Willow Swamp as follows:

- **Alder Swamp:** Speckled alder is the most abundant shrub species in the canopy although the combined cover of willows, dogwood, poison sumac or other canopy shrubs may exceed the cover of alder.

- **Willow Swamp:** Willows or red-osier dogwood are the most abundant shrub species in the canopy; speckled alder may be present but is not the single most abundant shrub species.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum.*

5.3.1.2 Bogs

Bogs have a nearly continuous mat of moss dominated by *Sphagnum* species (especially *Sphagnum fuscum* and *Sphagnum angustifolium*), and an impoverished vascular flora. A forest canopy of black spruce may or may not be present. Tall shrubs are absent. The ground layer is dominated by low ericaceous shrubs (Labrador tea, leatherleaf, swamp laurel, or bog-rosemary), sedges (*Carex* spp.), or cotton grasses (*Eriophorum* spp.). Although there are no indicator species of bogs, bogs can be identified by their paucity of minerotrophic species (they usually have at most two minerotrophic species present, with very low coverage).

Bogs are late-successional communities that develop in peatlands where the surface substrate has become isolated from groundwater flow because of peat accumulation. A minimum of one meter of peat, with a surface composed of poorly decomposed minerotrophic sphagnum mosses, must develop before acidophilus sphagnum mosses dominate a bog. The bog surface is usually raised or domed, but can sometimes appear flat. Most bogs on glacial lake plains succeed from sphagnum-dominated Black Spruce Swamps.
Soil in bogs is usually waterlogged and has a spongy covering of mosses. Because bogs receive most (if not all) of their water and nutrients from rainfall, the surface water in bogs is oligotrophic or ombrotrophic. Surface waters are extremely acidic (pH <4.4) with low concentrations of dissolved nutrients (e.g., [Ca^{2+}]< 2.2 mg/l). The water table in bogs is near the surface during the spring, but generally falls through the summer. There are two bog community types, a forested bog and an open (non-forested) bog:

- **Black Spruce Bog:** Tree cover >30 percent, strongly dominated by black spruce; groundlayer with few or no minerotrophic species; water chemistry: pH <4.6, [Ca^{2+}] <6 mg/l.

- **Open Sphagnum Bog:** Tree cover <30 percent; groundlayer with few or no minerotrophic species; water chemistry: pH <4.6, [Ca^{2+}] <6 mg/l; often a transitional area between forested bog and fen in patterned peatlands; includes extremely poor fen.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum*.

5.3.1.3 Hardwood Swamp Forests

Hardwood swamp forests are minerotrophic wetland communities that occur on wet muck and shallow peat substrates. They have tree canopies dominated by broad-leaved deciduous species, including black ash, paper birch, yellow birch, red maple, American elm, slippery elm, green ash, quaking aspen, or, rarely, balsam poplar. Tamarack is sometimes the most abundant tree species present in a stand, but never forms more than 50 percent of the total tree cover (if so, the swamp is classified as a Tamarack Swamp). White pines or white cedars also occur in the community on occasion. The tree canopy cover ranges from dense (especially in even-aged or drained stands) to sparse, but there is always at least 30 percent cover by trees over 5 meters tall.

Hardwood swamp forests form fairly distinct, often narrow zones at the margins of wetland basins or along streams. They form more extensive stands in shallow, poorly drained depressions or lake basins and in groundwater seepage areas on level terrain at the bases of hills or terrace slopes. Hardwood swamp forests often are long-lived communities on nutrient-rich low-disturbance sites. Flooding (especially that caused by beaver dams) and windthrow occasionally kill canopy trees in Hardwood swamp forests, causing regression to shrub swamps or wet meadows. Hardwood swamp forests also grade into tamarack swamp but tamaracks tend to dominate swamp forests where the organic substrate is poorer in nutrients, thicker, less decomposed, more acidic, or more continuously saturated. Hardwood swamp forests differ from floodplain forests and from lowland hardwood forests by having an organic substrate and continuously or nearly continuously saturated soils during normal years.

There are two types of swamp forest:

- **Black Ash Swamp:** Canopy with >50 percent cover by black ash.
- **Mixed Hardwood Swamp:** Canopy a mixture of broad-leaved deciduous trees, with <50 percent cover by black ash.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum*.

5.3.1.4 Conifer Swamp Forest

Conifer swamp forests occur mainly in the conifer-hardwood forest zone, but also occasionally in the deciduous forest-woodland zone. The tree canopy is dominated by black spruces, tamaracks, or white cedars. The density of the shrub, herb, and moss layers varies greatly, depending on the density of the tree canopy, on soil nutrients, and on the level of the water table. Conifer swamp forests tend to develop on sites with wet mineral or poorly drained organic soils. There is often standing or barely moving water within the community. However, the water table usually drops below the tree rooting zone in mid to late summer so the upper soil layers are aerated for at least part of the growing season. Often, conifer swamp forests are associated with springs or seepage areas. The surface waters within conifer swamp forests range from circumneutral to moderately acidic.

White cedars usually grow on nutrient-rich mineral or shallow peat soils in areas protected from fire. Sites with these characteristics are common at the edges of peatlands or along gentle slopes with subsurface groundwater flow. Tamaracks and black spruces occur on nutrient poor-peat soils, with tamaracks tending to occur on the more minerotrophic sites and sites with higher water tables. Black spruces are tolerant of extremely acidic conditions, so black spruce swamp often grades into black spruce bog. There are three recognized conifer swamp forest community types:

- **White Cedar Swamp:** Canopy mostly white cedar, often with some balsam fir and sometimes with black spruce or tamarack; Sphagnum spp. mostly absent.

- **Tamarack Swamp:** Canopy mostly tamarack, often mixed with paper birch or black ash; groundlayer typically of minerotrophic species; Sphagnum spp. present or absent.

- **Black Spruce Swamp:** Canopy strongly dominated by black spruce, with minor amounts of tamarack, white cedar, and hardwoods; Sphagnum spp. or feathermosses present.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum.*

5.3.1.5 Wet Meadow/Fen

Wet meadow/fen is a broad class of community types whose main shared characteristic is a closed canopy of mid-height graminoids. Dominant species include grasses (e.g., bluejoint (*Calamagrostis canadensis*), prairie cordgrass (*Spartina pectinata*)), sedges (e.g., wiregrass sedge (*Carex lasiocarpa*), lake-bank sedge (*Carex lacustris*), tussock sedge (*Carex stricta*)), and rushes (e.g., *Scirpus cespitosa*). Although there may be significant shrub cover, especially from willow species and bog birch, a continuous matrix of graminoid species in the understory differentiates the communities of this class from shrub swamp communities. Obligate aquatic species are mostly absent, however facultative aquatic species are often present in the subcanopy. Mosses are present in some of the wet meadow/fen community types, but sphagnum mosses are absent or have low cover compared with other (Amblystegiaceae) mosses. Wet meadow/fen community types occur on wet mineral or peat soils with seasonally standing or flowing water at the ground surface. Generally, they occur on sites too wet for significant invasion by woody species or on sites that burn frequently.

Seven wet meadow/fen community types are recognized in Minnesota, including wet prairie, fen, and wet meadow, and subsets of these. Wet prairie communities included

- **Wet Brush Prairie:** Groundlayer dominated by prairie grasses and forbs and shrub cover >30 percent.

- **Wet Prairie:** Groundlayer dominated by prairie grasses and forbs and shrub cover <30 percent.

Fens have a groundlayer dominated by wetland graminoids or half-shrubs rather than prairie grasses and forbs. The forb cover and diversity is low; peat depth generally >0.5m; lateral movement of groundwater often visible or inferable from vegetation patterns (e.g. teardrop islands or strings) or from species associated with groundwater movement (e.g., grass of Parnassus (*Parnassia* spp.), *Scirpus cespitosus*). There are three types of fens:

- **Poor Fen:** Sphagnum cover interrupted to continuous; groundlayer of weakly minerotrophic species, pH <5.9, [Ca2+] <13 mg/l.

- **Rich Fen:** Sphagnum cover patchy to absent; groundlayer of minerotrophic to highly minerotrophic species, pH >5.9, [Ca2+] >10 mg/l; source of water not obviously springs; spring features and surface-flow features absent; groundlayer composed of minerotrophic to highly minerotrophic species.

- **Calcareous Seepage Fen:** Source of water from springs or zones of discharge; springs or spring features evident; water with circumneutral to high pH; groundlayer often composed of species associated with soils high in dissolved (especially Ca2+-containing) salts.

Wet meadows have a groundlayer dominated by wide-leafed graminoids (leaves wider than 3 mm), especially lake-bank sedge (*Carex lacustris*), tussock sedge (*Carex stricta*), and bluejoint (*Calamagrostis canadensis*). There are two types of wet meadows:

- **Wet Meadow:** Groundwater generally stagnant or, if flowing, flow is weak and not concentrated in obvious rivulets or streams (i.e., springs); water generally at or near air temperature.

- **Seepage Meadow:** Forb cover diverse; peat depth generally <0.5 m; groundwater moving; rivulets and spring heads or obvious zones of groundwater discharge present; water cold; forb cover high where skunk cabbage (*Symplocarpus foetidus*) and angelica (*Angelica atropurpurea*) are present.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum.*

5.3.1.6 Emergent Marsh

Emergent Marshes are shallow-basin wetlands that have standing water present during most of the year. They occur throughout Minnesota, typically in association with lakes, ponds, and streams. Marsh bottoms have mineral soils or relatively inorganic sediments, although marshes dominated by cattails often contain floating, peaty mats. Marsh vegetation is composed of tall, erect, rooted herbaceous hydrophytes that are present for most of the growing season during years of normal rainfall. Emergent marshes often have zones of vegetation related to soil or sediment type, to the depth and permanence of standing water, and to groundwater influence. The dominant emergent species in marshes are usually graminoids such as cattails (*Typha latifolia* and *T. angustifolia*), common reed grass (*Phragmites australis*), bulrushes (*Scirpus* spp.), rushes (*Juncus* spp.), spike-rushes (*Eleocharis* spp.), and some umbrella sedges (*Cyperus* spp.). Common herbs associated with the emergent graminoids are broad-leaved arrowhead (*Sagittaria latifolia*), swamp milkweed (*Asclepias incarnata*), willow-herbs (*Epilobium* spp.), bulb-bearing water-hemlock (*Cicuta bulbifera*), and several species of *Polygonum*. Obligate aquatic plants (including *Potamogeton*, *Elodea*, *Ceratophyllum*, and *Myriophyllum*) often are present at the bases of the emergent species.

There are two recognized Emergent Marsh community types:

- **Cattail Marsh:** Cover mostly cattails.

- **Mixed Emergent Marsh:** Cover mostly a mixture of bulrushes, common reed grass, and graminoids other than cattails.

The vegetation and hydrology associated with these community types are described in the *Wetlands Technical Memorandum.*

5.3.1.7 Aquatic Communities

Aquatic river and aquatic lake communities are briefly described below.

Aquatic River Community

Aquatic River Communities are present in rivers and streams throughout Minnesota. They have less than 30% cover by persistent vegetation and sparse to continuous cover by nonpersistent vegetation. The vegetation fluctuates greatly in percent cover and species composition because of the erosion and deposition of sediment caused by changes in water levels and currents. There is one recognized Aquatic River Community type:

- **River Bed:** Characterized by few persistent emergent plants, cover mostly submergent and rooted floating-leafed aquatics.

The vegetation and hydrology associated with this community type is described in the *Wetlands Technical Memorandum.*

Aquatic Lake Community

Aquatic Lake Communities are present in lakes throughout Minnesota. They have less than 30% cover by persistent vegetation and sparse to continuous cover by nonpersistent vegetation. There is one recognized Aquatic Lake Community type:

- **Lake Bed:** Characterized by few persistent emergent plants, cover mostly submergent and rooted floating-leafed aquatics).

The vegetation and hydrology associated with this community type are described in the *Wetlands Technical Memorandum.*

5.3.1.8 Threatened or Endangered Species

A species is considered endangered if it is threatened with extinction throughout all or a significant portion of its range within Minnesota. A species is considered threatened if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range within Minnesota. A species is considered to be of special concern if, although the species is not endangered or threatened, it is extremely uncommon in Minnesota, or if it has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations.

A complete list of the wetland vascular plants that occur in St. Louis County, MN is shown in Appendix C of the *Wetlands Technical Memorandum* and a complete list of the threatened, endangered, and special concern species that occur in Minnesota is shown in Appendix D of that technical memorandum. The two lists were compared against one another to determine what threatened, endangered, and special concern wetland species of Minnesota occurred in St. Louis County. The results are shown in Table 5.24, *Wetland Species Occurring in St. Louis County, Minnesota that are Endangered (E), Threatened (T), or of Special Concern (SC).*

Carex exilis is listed in relevant data from the MDNR as occurring in poor fen sedge communities. It was the only endangered, threatened, or special concern species documented in this releve data. Habitat for all species are shown in Table 5.25, *Habitat of Wetland Species Occurring in St. Louis County, Minnesota that are Endangered (E), Threatened (T), or of Special Concern (SC),* along with the source of the data. Knowledge of each species habitat is important to determine how it will be affected by changes in hydrology.

The effects of additional tailings basin discharge on threatened, endangered, and special concern species will be discussed in Section 5.3.2.

TABLE 5.24
WETLAND SPECIES OCCURRING IN ST. LOUIS COUNTY, MINNESOTA THAT ARE ENDANGERED (E), THREATENED (T), OR OF SPECIAL CONCERN (SC)

Species	Common Name	Endangered Species Status	Wetland Indicator Status[1]	Life Form[2]
Caltha natans	Floating marsh-marigold	E	Obl	PNZF
Allium schoenoprasum	Wild chives	T	Fac+	PNF
Cypripedium arietinum[3]	Lady's slipper, ram's head	T	Facw+	PNF
Subularia aquatica	Water awlwort	T	Obl	ANZF
Carex exilis	Coast sedge	SC	Obl	PNGL
Fimbristylis autumnalis	Slender fimbry	SC	Facw+	GL
Juncus stygius	Moor rush	SC	Obl	PNGL
Muhlenbergia uniflora	Bog muhly	SC	Obl	PNG
Potamogeton vaginatus	Sheathed pondweed	SC	Obl	PNZF
Potamogeton vaseyi	Vasey's pondweed	SC	Obl	PNZF
Rhynchospora fusca	Brown beakrush	SC	Obl	PNGL
Salix pellita	Satiny willow	SC	Facw	NS
Xyris montana	Northern yellow-eyed grass	SC	Obl	PNEF

Notes:

1. Wetland indicator status includes: Obl (Obligate wetland) = species occurs >99 percent of the time in wetlands; Facw (Facultative wet wetland) = species occurs 67 to 99 percent of the time in wetlands but occasionally found in nonwetlands; Fac (Facultative wetland) = species is equally likely to occur in wetlands or nonwetlands. A positive (+) sign indicates a frequency toward the higher end of the category (more frequently found in wetlands).

2. Life form descriptions include: A = annual, E = emergent, F = forb, G = grass, GL = grasslike, N = native, P = perennial, S = shrub, Z = submerged.

3. Although Ownbey and Morley (1991) do not list *Cypripedium arietinum* as occurring in St. Louis County, it is listed by the Minnesota Natural Heritage Database as occurring within 100 meters of the Pike River drainage. It is a threatened species that occurs within an upland stand of *Populus tremuloides* and *Abies balsamea*.

TABLE 5.25
HABITAT OF WETLAND SPECIES OCCURRING IN ST. LOUIS COUNTY, MINNESOTA THAT ARE ENDANGERED (E), THREATENED (T), OR OF SPECIAL CONCERN (SC)

Species	Habitat	Source
Caltha natans	Floating or on moist mud, ponds, lakes, & slow-moving rivers & streams	Flora Online – Flora of North America
Allium schoenoprasum	No information found	
Cypripedium arietinum	White cedar swamps; black spruce swamps & bogs	Michigan Natural Features Inventory
Subularia aquatica	Lake margins	Washington Native Plant Society
Carex exilis	Open sedge sphagnum bogs & sphagnum bogs	Minnesota Department of Natural Resources
Fimbristylis autumnalis	Shores, stream banks, and wet meadows	USGS Aquatic & Wetland Vascular Plants of Northern Great Plains
Juncus stygius	Patterned peatlands, cold wet mossy bogs, marshes, shallow ponds	Wisconsin Department of Natural Resources
Muhlenbergia uniflora	Bogs, wet shores	USGS Northeast Wetland Flora
Potamogeton vaginatus	Deep water of cold, clear lakes	USGS Aquatic & Wetland Vascular Plants of Northern Great Plains
Potamogeton vaseyi	No information found	
Rhynchospora fusca	Bogs and marshes	New York Flora Association
Salix pellita	No information found	
Xyris montana	Bogs	New York Flora Association

5.3.2 Wetland Impacts Associated With Surface Water Hydrology Changes

One of the major factors affecting zonation, composition, germination, and survival of freshwater wetland species along lakes and rivers is water depth, flooding duration, and frequency of inundation (Cosgriff, 1999). These three aspects of river or lake hydrology will also affect other components of the wetland ecosystem such as organic matter decomposition, nutrient concentrations, and sedimentation. Changes in water levels can kill existing vegetation and allow species present as seeds in the seed bank that are more tolerant of high water levels to become established (Adamus and Brandt, 1990). Alteration of water levels may also cause a shift in dominant species. Thus, changes in hydrology affect species composition and alter competition dynamics. In a situation such as the proposed project, where additional water would be discharged into rivers, creeks, etc., it is important to determine how much (if any) the water levels will change and what wetland species are present in the areas that will be affected. Many species have reproductive strategies that take advantage of the natural recession of water levels in spring. These seeds require receding water at or near the soil surface to germinate. Therefore, disruptions in natural flow patterns could reduce germination and recruitment.

The potential impacts of increased flow and changes in hydrology on wetland vegetation include:

- Decrease in seed germination and recruitment due to lack of suitable habitat and to changes in normal water regime.
- Increase in vegetation mortality and conversion of wetland habitat to aquatic habitat.
- Decrease in wetland species diversity.
- Shift in species composition to those species more tolerant of inundation.

This section documents the potential impacts associated with surface water hydrology modifications, both quantitatively and qualitatively, to area wetlands under the Proposed Project, No Build Alternative, and the Action Alternatives described previously in Section 4.0. Further details pertaining to potential wetland impacts are included in the *Wetlands Technical Memorandum.*

5.3.2.1 Alternative A: Proposed Project (Proposed Action)

Sandy River Watershed Impacts Occurring to Wetlands with Changes in Surface Water Hydrology

The Sandy River watershed contains several different wetland types, with shrub swamp and bogs occupying the greatest percentage of wetland area. Table 5.26, *Summary of Characteristics of Wetland Communities Located on or Near Impacted Water Bodies in the Sandy River Watershed*, lists wetland community types along water bodies in the Sandy River watershed and their hydrology and water quality characteristics. Because each wetland type has a different hydrology, each may respond differently to changes in river flows due to increased discharge.

From photographs, the seep areas adjacent to the tailings basin appear to contain cattail marsh and other emergent vegetation. Some woody vegetation is present further away from the seep as well. Cattails are highly adaptable to disturbed areas and generally tolerate deeper water than most other emergent species (Adamus and Brandt, 1990). If this area is affected by flooding from discharge and slight increases in water levels or length of inundation occur, invasive emergents such as cattails should adapt. If large increases occur and the area is covered by permanent standing water, the vegetation may succeed to rooted submergent and floating plant communities.

TABLE 5.26
SUMMARY OF CHARACTERISTICS OF WETLAND COMMUNITIES LOCATED ON OR NEAR IMPACTED WATER BODIES IN THE SANDY RIVER WATERSHED

Wetland Type	Location	Hydrology	pH	Nutrients	Mineral Content
Sandy River					
Shallow marsh	Near discharge area and in seep area	1	7	Med - High	High
Shrub swamp	All along Sandy River	2	7	Medium	High
Bog	Along and near Sandy River	3	<4.4	Low	Low
Wet meadow	Small areas on river west of Hwy 303	4	6 - 8	High	High
Wooded swamp	Areas adjacent to bogs; Not along river	5	>5.5	Varies	Varies
Aquatic River Community	Edges of river	6	7	Varies	Varies
Sandy Lake/Little Sandy Lake					
Shrub swamp	Adjacent to lakes	2	7	Medium	High
Bog	Adjacent to and near lakes	3	<4.4	Low	Low
Aquatic Lake Community	Edges of lakes	6	7	Varies	Varies
Admiral Lake					
Shrub swamp	Adjacent to lake	2	7	Medium	High
Bog	Near lake, beyond shrub swamp	3	<4.4	Low	Low
Aquatic Lake Community	Edges of lake	6	7	Varies	Varies
Pike River					
Shrub swamp	All along Pike River	2	7	Medium	High
Wooded swamp	Along Pike River	5	>5.5	Varies	Varies
Aquatic River Community	Edges of river	6	7	Varies	Varies

Hydrology Descriptions:
1. Standing water for most of the year.
2. Hydrology is closely tied to the river surface water dynamics. Water table can fluctuate but remains at or near the ground surface for much of the year.
3. Soils usually waterlogged. Separated from groundwater so receives most of water from rainfall.
4. Standing water is present in the spring and after heavy rains, but the water table is generally below the surface soil for most of the growing season.
5. Varies with wooded swamp type. Can have continuously saturated soils with as much as 1 ft of water on surface or have fluctuating water tables that are aerated for part of the year.
6. Hydrology is closely tied to the river or lake surface water dynamics.

With an additional discharge of 11.1 cfs, the average flow at the point of discharge would increase 1,360 percent. Although not quantified, it is most likely that such an increase in flow would impact water levels. Wetlands located near the discharge are shallow marsh. Marsh communities are adapted to longer periods of saturation than many wetland types. However, periodic low water periods are important for vegetation growth and nutrient dynamics. Zonation in marshes is usually along water depth gradients (Mitsch and Gosselink, 1993). In addition, seed banks and fluctuating water levels interact in complicated ways to produce vegetation communities (Mitsch and Gosselink, 1993). If water level is increased in the marsh or the soil surface becomes continually flooded, changes in vegetation will occur. The area may succeed to rooted submergents and floating vegetation.

With an additional discharge of 11.1 cfs, flows are predicted to increase 812% and 21% in February and April, respectively, at monitoring Station 701. The average percent increase over the entire year is estimated to be 35% with additional 5.6 cfs and 69% with an additional 11.1 cfs. Again, although not quantified, it is likely that such an increase in flow would have a pronounced impact on water levels. This station is located approximately four miles from the discharge point. Between the discharge point and this station, the vegetation is primarily shrub swamp and bog, with aquatic lake vegetation in Admiral, Sandy, and Little Sandy lakes.

The increase in flow at Station 701 may cause rises in water levels and an increase in the area that is flooded with surface water. Depending on the discharge regime and topography, the increase in water level may cause flooding to occur during the entire growing season. This can cause death of vegetation or the wetland community boundaries may move further up the slope to less inundated river margins. However, the effects of flooding on vegetation will depend on flooding depth, frequency, duration, water velocity, and other factors (Adamus and Brandt, 1990). Deviations from normal hydrologic regimes in wetlands (i.e., annual cycles of flooding and drawdown) can cause changes in plant communities and may reduce plant species richness (Adamus and Brandt, 1990).

Increased water depth and length of flooding can cause mortality in vegetation located in shrub swamps. While plants in shrub swamps, such as willow and alder, are adapted to waterlogged soils, if the root crown is flooded for long periods of time mortality can result (Keddy, 2000). Because seeds of alder and willow species need bare moist soil to germinate, increased flooding will also interfere with reproduction and, eventually, cause changes in community structure due to competition and invasion of more flood-tolerant species (Tallent-Halsell, 2002; NRCS, 2003).

According to the wetland community description in Minnesota (Aaseng et al., 1993), bogs have become isolated from groundwater flow due to peat accumulation. Because of their raised or domed shape, small increases in surface water flows will probably not affect either the black spruce or open sphagnum bogs. Large increases in surface water levels, however, could cause a rise in groundwater that could affect the bog hydrology. However, unless the bog is inundated in the actively growing sphagnum zone or is flooded so that sphagnum (and other vegetation) is covered by water or the root crown of the black spruce (and other vegetation) is inundated for a prolonged period of time, no impacts should occur due to a change in hydrology. If surface water is channeled onto treed areas of black spruce bog, black spruce and tamarack may be stunted or killed and the area may then develop into open sphagnum bog.

Changes in water levels may occur in Admiral Lake, Little Sandy Lake, and Sandy Lake. An increase in flooded areas could negatively affect shrub swamps and bogs located on lake margins. In open water bodies and along lakeshores, rooted submerged aquatic vegetation can induce petiole elongation to keep up with rising water levels (Groeneveld and Voesenek, 2003; Summers et al., 2000). Thus, with small changes in water levels, rooted submergents and floating vegetation (for example, *Potamogeton* sp.) can readily adapt. With larger, more rapid changes, rooted submergents may be harmed if petiole elongation rates are much lower than water level increases. Extent of damage, including mortality, depends on water clarity, elongation rates, and energy reserves of the plants.

According to the State of Minnesota Stormwater Advisory Group (1997), sedge meadows, open bogs, coniferous bogs, calcareous fens, and lowland hardwood swamps are highly susceptible to impacts from storm-water drainage. Adverse impacts to these wetland types can occur due to inundation and changes in water chemistry due to stormwater inputs. Shrub carrs, alder thickets, wet meadows and marshes are considered moderately susceptible to impacts from storm-water. Shrub carrs, alder thickets, and wet meadows can tolerate inundation, from 6 to 12 inches for short periods of time. Marshes can tolerate up to 12 inches of inundation but are adversely impacted by sediment and/or nutrient loading and prolonged high water levels. Floodplain forests, wet meadows dominated by reed canary grass, and marshes dominated by reed canary grass, cattail, giant reed, or purple loosestrife are only slightly susceptible to impacts from storm-water runoff. In addition, native wetland plant communities that are impacted by storm-water runoff can convert to monotypes of invasive and non-native species such as cattail and reed canary grass.

The changes in surface flow and water levels due to discharge from the tailings basin reported at monitoring Stations S-2 would not be significant enough to harm vegetation or cause changes in reproduction success or competition. Along the Pike River the vegetation is primarily shrub swamps and wooded swamps. At most, water levels along this stretch of the Pike River would increase 3.7 inches in February with an added discharge of 11.1 cfs. Because this increase would occur during a time when most vegetation is dormant, it would likely have no effect (Drew and Stolzy, 1996). Flows are much higher on this river in April due to snowmelt and water level will increase only 1.1 inches in the Pike River with an additional discharge of 11.1 cfs. This increase in water level should not have a negative impact on vegetation in shrub or forested swamps.

The large percent increases in flow during the 7Q10 low-flow periods due to additional discharge illustrate the great impact that the additional discharge would have on this river during times when flow is at a minimum. This difference in water flow may have a major impact on vegetation, based on impacts discussed previously.

Within the Sandy River watershed and the Superior National Forest is Potential Candidate Special Management Complex (SMC) #114. This complex is located north of the Sandy River at T59N, R18W and consists of Sections 1, 2, 3, 10, 11, and 12 (Bob Berrisford, Personal Communication). This area is 24% wetland, with the majority in scrub-shrub and forested wetlands. The purpose of SMCs will be to protect areas of forests, wetlands, bogs, lakes and streams and provide landtype associations that will be managed to provide ecosystems that are decreasing in size and becoming increasingly uncommon. However, this SMC is most likely not to receive a designation as a candidate research natural area and, therefore, is not of special concern to this impact assessment (Bob Berrisford, Personal Communication). In addition, the relevant wetland types that would be impacted by changes to the Sandy River hydrology have already been discussed in this section.

Dark River Watershed Impacts Occurring to Wetlands with Changes in Surface Water Hydrology

The Dark River watershed contains several different wetland types, with shrub and wooded swamps occupying the greatest percentage of wetland area. Table 5.27, *Summary of Characteristics of Wetland Communities Located on or Near Impacted Water Bodies in the Dark River Watershed,* lists wetland community types along water bodies in the Dark River watershed and their hydrology and water quality characteristics. Because each wetland type has a different hydrology, each may respond differently to changes in hydrology due to increased discharge.

From photographs, the seep area located on the west side of the tailings basin appears to contain cattail marsh and other emergent vegetation. Some woody vegetation is present further away from the seep as well. Cattails are highly adaptable to disturbed areas and generally tolerate deeper water than most other emergents (Adamus and Brandt, 1990). If this area is affected by flooding from discharge and slight increases in water levels or length of inundation occur, cattails should adapt. If large increases occur and the area is covered by permanent standing water, the vegetation most likely would succeed to rooted submergent and floating plant communities.

With an additional discharge of 11.1 cfs, average flow at the point of discharge is expected to increase 988%. Vegetation at the discharge point is primarily shrub swamp, according to the St. Louis County wetlands maps. As discussed previously, vegetation in shrub swamps can be adversely affected by prolonged inundation of the root crown. Increased flooding would also interfere with growth and reproduction and cause invasion by more flood-tolerant species.

With an additional discharge of 11.1 cfs, flows are predicted to increase 287% and 22% in February and April, respectively, at monitoring Station D-1. The average percent increase over the entire year is estimated to be 34% with additional 5.6 cfs and 68% with an additional 11.1 cfs. This station is located approximately 3.5 miles from the discharge point.

TABLE 5.27 SUMMARY OF CHARACTERISTICS OF WETLAND COMMUNITIES LOCATED ON OR NEAR IMPACTED WATER BODIES IN THE DARK RIVER WATERSHED					
Wetland Type	**Location**	**Hydrology**	**pH**	**Nutrients**	**Mineral Content**
Dark River					
Shrub swamp	All along Dark River; discharge area	2	7	Medium	High
Wooded swamp	Areas adjacent to shrub swamps; Near confluence with sturgeon River	5	>5.5	Varies	Varies
Aquatic River Community	Edges of river	6	7	Varies	Varies
Dark Lake					
Shrub swamp	Adjacent to lake	2	7	Medium	High
Wooded swamp	Adjacent to lake	5	>5.5	Varies	Varies
Aquatic Lake Community	Edges of lake	6	7	Varies	Varies
Sturgeon River					
Shrub swamp	Along river	2	7	Medium	High
Wooded swamp	Along river	5	>5.5	Varies	Varies

Hydrology Descriptions:
2: Hydrology is closely tied to the river surface water dynamics. Water table can fluctuate but remains at or near the ground surface for much of the year.
5: Varies with wooded swamp type. Can have continuously saturated soils with as much as 1 ft of water on surface or have fluctuating water tables that are aerated for part of the year.
6: Hydrology is closely tied to the river or lake surface water dynamics.

Between the discharge point and this station, the vegetation is primarily shrub swamp. The large increase in flow at Station D-1 may cause substantial rises in water levels and an increase in the area that is flooded with surface water. Depending on the discharge regime, the increase in water level may cause flooding to occur during the entire growing season. The effects of flooding on vegetation would depend on flooding depth, frequency, duration, water velocity, and other factors (Adamus and Brandt, 1990). Deviations from normal hydrologic regimes in wetlands (i.e., annual cycles of flooding and drawdown) could cause changes in plant communities and may reduce plant species richness (Adamus and Brandt, 1990). As discussed in the previous section on the Sandy River, increased water depth and length of flooding could cause mortality in vegetation located in shrub swamps in these areas.

Changes in water levels may also occur in Dark Lake and an increase in flooded areas may negatively affect shrub swamp located on lake margins. As discussed in the previous section on the Sandy River, the extent of damage to these plants and submergents located on river and lake margins depends on the magnitude and duration of change in water depth, petiole elongation thresholds, and plant species.

The changes in water level and surface flow caused by discharge from the tailings basin reported at monitoring Stations ST-2 and D-2 would not be significant enough to harm vegetation or cause changes in reproduction success or competition. At most, water levels along these stretches of the Sturgeon River and Dark River would increase 2.0 and 4.2 inches, respectively, in February with an added discharge of 11.1 cfs. Vegetation along this stretch of the Dark and Sturgeon Rivers is primarily shrub swamp and wooded swamp. Because these increases would occur during a time when most vegetation is dormant, they would likely have no effect (Drew and Stolzy, 1996). Flows are much higher on both rivers in April due to snowmelt and water level would increase only 0.4 and 1.1 inches in the Sturgeon and Dark rivers, respectively, with an additional discharge of 11.1 cfs. This increase in water level should not have a negative impact on vegetation in shrub swamps or forests located along these rivers.

Minnesota Rule 7050.0210 subp. 13a protect wetlands against chemical and physical pollution that will cause significant adverse impacts to biological diversity and wildlife habitat. Impacts associated with flow increase could result in violation of these rules. In addition, Minnesota Rules 7050.0150 subp. 3 and 6 and 7050.0222 subp. 6 protect Class 2 waters against pollution, which will degrade habitat or increase undesirable species, including physical or hydrological alterations of the streambed.

Impacts Occurring to Wetlands with Increased Channel Scour, Erosion, and Sedimentation

The potential impacts of channel scouring include an increase in sedimentation, turbidity, and a reduction in dissolved oxygen, along with changes in carbon and nutrient loading. Two concerns regarding the impacts of an increase in sedimentation on wetland vegetation are vegetation burial and a decrease in water depth that may lead to a shift in species composition (Adamus and Brandt, 1990). An increase in turbidity causes a decline in water clarity and may cause community shifts in vegetation to more shade-tolerant, non-emergent herbaceous species (Adamus and Brandt, 1990). An increase in carbon and subsequent reduction in dissolved oxygen can cause a shift in wetland species to those more tolerant of anoxic conditions (Mitsch and Gosselink, 1993). Increases in nutrients can cause an increase in primary productivity and may favor fast-growing, invasive species over slower-growing species (Keddy, 2000). If an increase in scouring does occur along rivers receiving additional discharge, impacts would most likely occur in shrub swamps because this is the wetland type most commonly located along the impacted rivers and within river channels. Other wetland types, such as bogs, fens, and swamps are not located in areas where they would be directly impacted by an increase in river discharge.

According to the *Surface Water Hydrology and Quality Technical Memorandum*, the relative percentage of increased flow at discrete locations was used to qualitatively evaluate the potential increases in channel scouring, erosion and sedimentation in channels. Because these effects would most likely occur during higher flow periods, the relative percent increases during the estimated 2-year event flows were considered. As discussed in the *Surface Water Hydrology and Quality Technical Memorandum*, increases to peak storm flows would range from approximately six percent at upstream locations (Stations D-1 and 701) to less than one percent at downstream locations (Stations D-2, ST-2, S-2) when combined with 11.1 cfs of additional flow. Increases would be approximately 3 percent to 0.5 percent when combined with 5.6 cfs of additional flow. The percentage increases during larger storm event flows would be sequentially less. These impacts are considered to be minimal and, therefore, the degree of channel scouring, erosion and increased sedimentation is considered to fall within the normal hydrologic conditions at these locations.

According to the *Surface Water Hydrology and Quality Technical Memorandum*, at the most upstream locations where the discharge would be introduced (near the tailing basin seeps), the effects would be greater. The proposed discharge would cause a substantial increase in flow, which could potentially cause adjustments in the channels due to down-cutting and widening to accommodate the excess flow. Stream velocities, channel boundary stresses and stream power could all increase, translating into a combination of increased bank erosion, increased sediment scouring, and stream morphology changes downstream of the tailings basin. Increased flows could destabilize the channels and could result in increased sediment flux and TSS concentrations for some distances downstream as the stream adjusts to the increased flow volume. Sediment accumulation data for Dark Lake indicate accelerated rates that may represent channel equilibrium disruptions due to the tailings basin construction during the 1960s and 1970s. This may suggest that scouring-related sediment, due to increased discharge, could translate as far downstream as Dark Lake, and perhaps equivalent distances on the Sandy River. Thus, it may be qualitatively stated that the greatest impacts with regard to channel scouring, erosion and increased sedimentation would occur at the upstream discharge points. These effects may be exacerbated due to the presence of peat substrate in the channels at these locations (Epstein, 2002).

The seep areas contain emergent cattail marshes that are able to withstand many disturbances, including increased sedimentation. However, increased sedimentation can favor invasive species such as cattail and reed canary grass, to the exclusion of other, more diverse communities (Adamus and Brandt, 1990).

Impacts Occurring to Wetlands with Changes to Groundwater Hydrology

Although a change in the relative percentage of groundwater flows would likely occur as a result of the increased discharge, this change has not been quantified. Changes in groundwater inflows to streams have been evaluated by MDNR with regard to temperature modeling. It was determined, based on this modeling, that changes in the relative percentage of groundwater flows would likely occur as a result of the increased discharge. If the change in groundwater causes an increase in the area, depth and length of flooding, sensitive species in swamps, fens, wet meadows and bogs would be affected. Death of these species and succession to more flood tolerant or disturbance-tolerant species would occur. However, groundwater data do not exist to allow for an extensive evaluation of these potential impacts.

Impacts to Threatened or Endangered Wetland Plant Species

Although specific locations of the species listed as endangered, threatened or special concern have not been identified within St. Louis County, it is possible to speculate impacts of discharge based on habitat type. *Caltha natans* and *Subularia aquatica* are rooted submergents that occupy lake margins. If change in water level is not too fast or greater than each plant's threshold for petiole elongation, these plants should adjust well to small changes in water depth due to additional discharge. If wave action of the lake is increased, however, additional discharge could have a detrimental impact on rooted submergent vegetation in Admiral Lake, Sandy Lake and Little Sandy Lake (Adamus and Brandt, 1990). The two *Potamogeton* species of Special Concern are floating plants that should not be affected by changes in water level.

Many of the species occupy bog habitat, including *Cypripedium arietinum*, *Carex exilis*, *Juncus stygius*, *Muhlenbergia uniflora*, *Rhynchospora fusca*, and *Xyris montana* and, thus, may be growing in bogs adjacent to the Sandy River and associated lakes. This habitat type is highly susceptible to disturbance because it is a late-successional community that develops with a balance between water inputs and accumulation of organic matter. Changes in water level can disrupt this fine balance and cause invasion by more opportunistic vegetation species. In addition, bogs are generally separated from groundwater and receive most, if not all, water from rainfall. Small changes in the surface water of nearby rivers should not affect this ecosystem type or the species that inhabit it. However, if increased water to rivers causes an increase in surface water runoff or depth to groundwater, bogs may be negatively impacted if they are inundated or saturated more than normal. Although Lake Admiral, Sandy Lake, and Little Sandy Lake may help mitigate the effects of discharge in the upper reaches of the Sandy River, bogs located around edges of lakes can be affected by even small changes in water levels.

Fimbristylis autumnalis occupies shores, stream banks, and wet meadows and, as such, is most likely adapted to seasonal rising and falling water tables. Although no information was found for *Salix pellita*, based on other members of this genus it most likely occupies stream banks. Thus, it too is adapted to seasonal water level fluctuations. Because these two species require periodic water drawdowns, changes in the natural hydrologic regime can adversely affect plant growth. If the extra discharge causes inundation of roots and/or root crown during periods when they are typically growing in unsaturated soils, these species may die or experience reduced growth/stress.

This reduction in vegetation health and/or growth can allow more flood-tolerant species to invade. This invasion can lead to a decrease in species diversity and loss of habitat as well.

5.3.2.2 Alternative B: Alternative Sites

Laurentian Creek

This alternative would result in Laurentian Creek receiving 5,000 gpm of untreated tailings basin water. The water would bypass Sandy and Little Sandy Lakes and flow into Sandy River upstream of monitoring Station 701. There are no existing flow data for any locations on Laurentian Creek but, according to the *Surface Water Hydrology and Quality Technical Memorandum*, discharge to Laurentian Creek would create similar impacts to those described for the Sandy River watershed. However, it may be noted that the size of the watershed for Laurentian Creek at the assumed discharge location is similar to the watershed size for the headwaters of Sandy River prior to the tailings basin construction. Therefore, it may be presumed that the relative hydrologic impacts to Laurentian Creek would be similar to those discussed for upstream Sandy River.

The wetlands on Laurentian Creek are shallow marsh, shrub swamp, wet meadow, bog, wooded swamp, and aquatic river plants, as shown on Table 5.28, *Summary of Characteristics of Wetland Communities Located on or Near Laurentian Creek*. If hydrologic conditions are similar on the Laurentian Creek and the Sandy River, these wetlands can be expected to be affected in the same ways as those previously discussed for the Sandy River.

According to the St. Louis County wetland maps, there are several areas where Laurentian Creek widens and contains shallow marsh and wet meadow that would attenuate the creek flow. Although these areas may reduce the impacts of the discharge by attenuating excess flow, vegetation in these communities may be negatively impacted. As discussed previously, increases in water depth and duration of flooding in wetlands can cause plant mortality, reduction in primary productivity and reproductive success, and succession to other communities.

TABLE 5.28
SUMMARY OF CHARACTERISTICS OF WETLAND COMMUNITIES LOCATED ON OR NEAR LAURENTIAN CREEK

Wetland Type	Location	Hydrology	pH	Nutrients	Mineral Content
Shallow marsh	Northern portion of creek	1	@7	Med - High	High
Shrub swamp	All along creek	2	@7	Medium	High
Bog	Near confluence with Sandy River	3	<4.4	Low	Low
Wet meadow	Near Interstate 53	4	6 - 8	High	High
Wooded swamp	Northern portion of creek	5	>5.5	Varies	Varies
Aquatic River Community	Edges of creek	6	@7	Varies	Varies

Hydrology Descriptions:
1: Standing water for most of the year.
2: Hydrology is closely tied to the river surface water dynamics. Water table can fluctuate but remains at or near the ground surface for much of the year.
3: Soils usually waterlogged. Separated from groundwater so receives most of water from rainfall.
4: Standing water is present in the spring and after heavy rains, but the water table is generally below the surface soil for most of the growing season.
5: Varies with wooded swamp type. Can have continuously saturated soils with as much as 1 ft of water on surface or have fluctuating water tables that are aerated for part of the year.
6: Hydrology is closely tied to the creek surface water dynamics.

Lake Superior Watershed

Minntac's permitted discharge point (NPDES Permit # MN0052493 - Outfall SD001) would be used for discharge to the Lake Superior Watershed. The outfall is used for discharging mine pit stormwater and is permitted for an average discharge of 5.0 MGD (7.5 cfs), with a maximum discharge of 33.2 MGD (49.8 cfs). The changes to discharge with this alternative would change baseline conditions. Baseline conditions are considered to be 100% mine pit dewatering discharge, while the alternative to this is 100% tailings basin discharge with no mine pit water discharge or some blend of water.

According to NPDES monitoring reports, the monthly average discharge through this outfall between December 1999 and December 2002 was 8.2 cfs, with a maximum monthly average of 23.3 cfs. According to the *Surface Water Hydrology and Water Quality Technical Memorandum*, it may be concluded that this outfall location could accommodate the additional proposed discharge of 11.1 cfs during the typical range of flow conditions. However, the average proposed flow at this location (11.1 cfs) would be greater than the current average flow (8.2 cfs) or the permitted flow (7.5 cfs). Relative hydrologic impacts as a result of this increased flow may be expected, such as increased channel scouring and erosion, water level increases and overland flow, and increased sediment flux and TSS concentrations downstream

Table 5.29, *Summary of Characteristics of Wetland Communities Located on or Near Impacted Water Bodies in The West Two Rivers Watershed,* lists the wetland community types in the watershed south of the tailings basin. The impacts to vegetation are similar to those discussed previously, with effects varying according to changes in water flow, depth, and duration of flooding.

It is anticipated that the impacts to wetlands due to hydrology with this "south" discharge alternative are likely to be less than impacts associated with the "north discharge" alternatives, since the south route has been receiving pit dewatering discharges on the order of several MGD for a number of decades.

TABLE 5.29
SUMMARY OF CHARACTERISTICS OF WETLAND COMMUNITIES LOCATED ON OR NEAR IMPACTED WATER BODIES IN THE WEST TWO RIVERS WATERSHED

Wetland Type	Location	Hydrology	pH	Nutrients	Mineral Content
Shallow marsh	Near reservoir	1	@7	Med - High	High
Shrub swamp	Along river and reservoir	2	@7	Medium	High
Bog	Near reservoir	3	<4.4	Low	Low
Aquatic River Community	Edges of river	6	@7	Varies	Varies
Aquatic Lake Community	Edges of reservoir	6	@7	Varies	Varies

Hydrology Descriptions:
1: Standing water for most of the year.
2: Hydrology is closely tied to the river surface water dynamics. Water table can fluctuate but remains at or near the ground surface for much of the year.
3: Soils usually waterlogged. Separated from groundwater so receive most of water from rainfall.
6: Hydrology is closely tied to the river or lake surface water dynamics.

Multiple Watersheds

Dividing discharge among multiple watersheds can relieve some of the impacts that may occur if only one watershed receives the entire discharge. Again, seasonal variations in river flow should be observed and mimicked if minimal impacts are desired.

HCR System

As discussed previously, under the HCR scenario, the rate of total discharge would be varied and the split between the watersheds would be varied. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River watershed during periods of temperature extremes to protect the trout habit. Similarly, flow could be directed from the Sandy River, or routed down Laurentian Creek during periods critical for wild rice production. According to the *Surface Water Hydrology and Water Quality Technical Memorandum*, these types of discharge scenarios could result in less adverse impacts when compared to the proposed alternative. However, the process to design and implement this type of discharge strategy is complex and requires an extensive monitoring network, and still may not allow Minntac to meet the objectives of discharging an average of 11.1 cfs without adverse impact.

Impacts to wetlands would occur if natural periods of water flow and depth are not observed. If flow is directed away from the Dark River and more flow is directed to Sandy River during a normal low-flow period, wetland vegetation may be inundated and be unable to survive. This would lead to a change in species composition and, possibly, a change in wetland type. Thus, in order for this scenario to work, normal periods of high and low water flows would have to be observed and mimicked.

In addition, the HCR approach would have to consider the scour-related impacts to downstream wetlands, especially the more susceptible wetland types, including nutrient-limited bogs. The potential for increased turbidity, sedimentation, TOC-loading, BOD-loading, and nutrient loading and reduced transparency and DO could impact wetland communities.

5.3.2.3 Alternative C: No Build (No Action)

With no change in the tailing basin management, no new impacts would occur. However, over time, chronic impacts to wetland communities may be seen.

5.3.2.4 Alternative D: Alternative Technologies

Tailing Basin Perimeter Dike Raising

According to the *Surface Water Hydrology and Quality Technical Memorandum*, there may be some potential for additional seepage as a result of the increased water level in the basin. As discussed previously, with increased seepage, the area of cattail and other emergent wetland species may increase or, if permanent flooding occurs, succession to rooted submergents and floating species may occur.

Water Level Reduction through Operational Use

If the water level that normally is discharged from the tailings basin is reduced, this reduction could cause a decrease in water supplied to wetlands located at the discharge points. A decrease in water input could lead to a reduction in the degree of soil saturation and, subsequently, to succession to plant communities less tolerant of saturated conditions (Adamus and Brandt, 1990). Thus, changes in plant communities may be expected if a decrease in discharge causes some areas to become drier.

Water Level Reduction through Process Water Adjustment

This action alternative does not directly impact wetlands.

West Tailing Basin Expansion

Aside from physically removing wetland areas during construction, this action would have no direct impact on surface water or wetlands. This alternative would require a separate environmental evaluation.

5.3.2.5 Alternative E: Design Alternatives

Siphon Placement

According to the *Surface Water Hydrology and Quality Technical Memorandum*, the proposed design alternative related to siphon placement in the tailings basin would not result in any changes to hydrology because it does not change the flow rate downstream of the discharge points. The primary impact of the alternative is to impact the temperature and dissolved oxygen content of the discharge water. From May to August water temperature may be cooler than the water in the receiving water body and in the winter water temperature may be warmer. During summer months, when stratification occurs, the dissolved oxygen concentration in the bottom of the tailings basin can drop below 1 mg/L. Impacts of changes in temperature and dissolved oxygen concentrations are discussed below in Section 5.3.3.

Dark Lake Effluent

This alternative is designed to mitigate temperature differences between tailings basin water and receiving water. Impacts of changes in temperature and dissolved oxygen concentrations are discussed below in Section 5.3.3.

5.3.2.6 Alternative F: Modified Scale or Magnitude Alternatives

As discussed previously, discharge of basin water under Alternative A would have varying degrees of impact based on the discharge regime. It should be emphasized that the closer discharge of basin water mimics the natural hydrologic fluctuations (high and low water periods) of receiving water bodies, the lower the impact would be to wetland communities. This statement is qualified by the fact that even if the natural high and low water periods are preserved, if the flow and water level are significantly increased, negative impacts would still occur. If the majority of the discharge occurs when flow is at its highest and when vegetation is dormant, impacts on wetland vegetation would be less. The lower the additional discharge from the tailings basin (from normal, historical discharge), the lower the impacts to wetlands.

5.3.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

The objective of the SPB system operation is related to improvement of water quality prior to discharge and, as such, would have no different impact to the hydrology of the watersheds than that discussed for the proposed Alternative A.

5.3.3 Wetland Impacts Associated with Surface Water Quality Changes

The impacts of an increase in sulfate, chloride, TDS, pH, hardness (calcium and magnesium), fluoride, mercury and manganese on wetland vegetation are evaluated in this impact analysis. A change in temperature is also evaluated. The *Surface Water Hydrology and Quality Technical Memorandum* discussed how discharge from the Minntac tailings basin would impact concentrations of constituents of concern in Dark and Sandy Rivers.

In general, Minnesota Rules 7050.0210 subp. 13a and 7050.0150 subp. 3 and 6 protect wetlands from water quality pollution that will decrease biological diversity and increase growth of undesirable aquatic species and slime growths. These rules also address material alteration of species composition. Because invasive species such as *Typha* and *Phragmites* tend to be less sensitive to increases in constituents that degrade water quality, an increase in industrial pollutant discharge to rivers and streams may violate these rules. Thus, in areas with emergent vegetation, a decrease in number of desirable species may occur, with a subsequent increase in undesirable invasives that reduce habitat quality and other system functions and values.

This section documents the potential impacts associated with surface water quality modifications, both quantitatively and qualitatively, to area wetlands under the Proposed Project, No Build Alternative, and the Action Alternatives described previously in Section 4.0. Further details pertaining to potential wetland impacts are included in the *Wetlands Technical Memorandum*.

5.3.3.1 Alternative A: Proposed Project (Proposed Action)

Tables 5.18 and 5.19 in Section 5.2.2.1 summarize the predicted increases in sulfate, chloride, TDS, hardness, fluoride and manganese concentrations based on the results of the *Surface Water Hydrology and Quality Technical Memorandum*. As seen in those tables, the concentrations of all constituents decrease as distance from the discharge point increases. Thus, vegetation closer to the discharge points will be more severely affected by mineral toxicity than will vegetation further downstream. Individual constituents, and their potential impacts to wetlands are discussed in the following paragraphs.

<u>Sulfate</u>

The concentrations of sulfate in the Dark and Sandy rivers receiving basin discharge are much higher than average concentrations without discharge (Tables 5.18 and 5.19) and, in addition, higher than toxic levels described by Richardson et al. (1983) and Armstrong et al. (1996). However, these values are much lower than tolerance levels for wild rice reported by Lee (Fred, 2001). For sulfate-sensitive species, the higher concentrations due to tailings basin discharge could cause problems such as reduced growth and reproductive success and death. On the other hand, if the species are not sensitive to sulfate, the higher concentrations may not produce negative effects. The increase in sulfate concentrations may cause negative effects to sensitive vegetation along the Dark and Sandy rivers and lakes in this area.

At the same time, iron under such reducing conditions is sequestered, making it largely unavailable to plants. In plants with certain root morphologies, however, iron under reducing conditions may still be taken up. Reduced iron once in the root system may oxidize in the presence of root oxygen, eventually killing the root. The net result under this model interaction is an overabundance of the macronutrient phosphorus, an under-availability of the micronutrient iron, the potential for reduced iron toxicity, and an eventual plant community species shift from rooted aquatic plants to non-rooted species such as algae and duckweed (*Lemna* spp.). This would likely also be accompanied by increased turbidity and decreased transparency. The combination of effects could potentially lead to a cascading plant assemblage failure and plant assemblage shifts to favor more eutrophic condition-tolerant species over extensive surface area.

During the low-flow periods, as indicated by 7Q10 low-flows, concentrations of sulfate may be increased. However, according to the *Surface Water Hydrology and Quality Technical Memorandum*, during 7Q10 low-flow periods on the Sandy River, sulfate does not exceed the 1,000 mg/L criterion for water quality. On the Dark River, sulfate standards may periodically be exceeded at 7Q10 low- flows at stations close to the discharge. However, further downstream the 1,000 mg/L level of concern concentrations are likely not to be exceeded. During low-flow periods, as previously discussed, sensitive vegetation may be harmed while that vegetation that is not affected by higher concentrations of sulfate will not be harmed. Thus, shifts in community composition may occur in impacted communities.

Hydrated calcium sulfate ($CaSO_4$-2(H_2O)), or gypsum, is one of the more common minerals in sedimentary environments. It is a major rock forming mineral that produces massive beds, usually from precipitation out of highly saline waters. Since it forms easily from saline water, gypsum can have many inclusions of other minerals (Mineral Galleries, 1995). The baseline concentrations of sulfate and calcium were input into the geochemical model PHREEQC (Parkhurst and Appelo, 1999). The results of this modeling indicated that sulfate concentrations would need to be significantly higher than 1,000 mg/L given current baseline concentrations of calcium downstream of the tailings basin in order for gypsum to precipitate. Since sulfate is at much lower concentration in the tailings basin discharge, gypsum should not be a problem along the Dark and Sandy River watersheds.

Chloride

The average chloride concentration in surface water receiving discharge (121 and 136 mg/l for the Sandy and Dark rivers, respectively) is much lower than the salinity threshold for wetland species in the area, with the exception of *Abies balsamea* that is intolerant of salinity. At concentrations of 150 mg/L chloride, this species exhibits considerable signs of stress (Richardson et al., 1983). The highest concentration in surface waters with additional discharge is well below this value. Based on current data, it is concluded that the increase in chloride concentrations should have no effect on wetland vegetation in the areas of potential impact.

During 7Q10 low-flow periods, chloride concentrations may be higher than during high-flow periods. On the Sandy River, Class 3B water quality standards for chloride are likely to be exceeded close to the discharge points, but are unlikely to be exceeded further downstream. However, because the values are expected to be well below the concentrations that affect most freshwater vegetation, negative impacts are not predicted, even during low-flow periods. On the Dark River, Class 3B water quality standards are not expected to be exceeded.

Total Dissolved Solids

Because salinity is determined by the total dissolved salts in a sample, salinity tolerance would provide a estimate of TDS tolerance as well. The highest concentrations of TDS with an additional discharge of 11.1 cfs are 543 and 654 mg/L for the Sandy and Dark rivers, respectively. These values are well below the tolerance threshold for most of the wetland species, particularly shrub species (*Salix* and *Alnus*) located in the riparian shrub swamps. The increase in TDS concentrations should have no harmful effects on wetland vegetation in the areas of potential impact.

Hardness (Calcium and Magnesium)

A substantial increase in surface water hardness is predicted with discharge from the tailings basin. Hardness is a measure of calcium and magnesium ions in water. These plant nutrients, particularly calcium, play an important role in the ecology of wetlands in Minnesota. Some vegetation species in boreal peatlands are so sensitive to pH and calcium concentrations that they can be used as indicators for certain ranges in the water chemistry (Glaser, 1987).

Bogs are nutrient-poor areas with very low calcium concentrations and the plant species growing in bogs are adapted to these conditions (Mitsch and Gosselink, 1993). Because they receive their water from precipitation, the increase in hardness in surface waters will most likely not affect the ecology of bogs in St. Louis County unless increased discharge causes a rise in groundwater which affects the normal bog hydrology.

The wetland maps for St. Louis County have general descriptions and the "bog" category may include both bogs and fens because they are similar peatland ecosystems. However, bogs and fens differ in their source of water (nutrient-poor precipitation versus nutrient-rich groundwater and surface water) and vegetation. Bogs are acidic and usually have a calcium concentration less than 2 mg/L while fens have a higher pH and calcium concentration. If pH and calcium concentrations increase, fens succeed from poor fen to intermediate rich fen to extremely rich fen (Glaser, 1987). An increase in pH and calcium concentrations is interrelated because many calcium species (such as calcium carbonate) cause an increase in pH. Therefore, it can be expected that a significant increase in calcium will cause successional changes within fens that receive impacted water.

Shrub and forested swamps are minerotrophic and the increase in hardness will most likely have no impact on these ecosystems.

<u>Fluoride</u>

Data indicate that the U.S. Federal Secondary Drinking Water Standard of 2 mg/L is not currently being exceeded downstream in the Sandy and Dark Rivers and, therefore, this constituent is not seen as a cause for concern. According to Kabata-Pendias and Pendias (1992), in general fluoride is not toxic to plants up to 30 or 50 ppm in soils. The concentrations seen with an increased discharge of 11.1 cfs on the Dark and Sandy rivers are well below that level and, thus, the higher fluoride concentrations should have no negative impact on vegetation.

<u>Manganese</u>

Based on the review of manganese chemistry, negative consequences from increases in manganese are not expected in the organic-rich, neutral pH soils of shrub and forest swamps. Increased manganese concentrations in organic-rich, acidic peat of bogs and fens may present more of a problem. The bogs, however, receive their water from precipitation and thus will not be impacted by changes in surface water and groundwater chemistry unless a significant rise in water levels occurs. The substrate in fens is acidic to neutral with a high organic matter content and thus this fen vegetation may or may not be impacted, depending on the successional stage

<u>Mercury</u>

According to the *Surface Water Hydrology and Quality Technical Memorandum*, the measured concentrations of the different mercury species in the tailings basin water are less than the concentrations measured in the Dark and Sandy Rivers. As such, the proposed tailings basin discharge would not negatively impact the concentrations in either the Dark and Sandy Rivers.

Synergistic effects, however, associated with changes in concentrations of other constituents, such as sulfate, could increase concentrations of methylmercury. Some wetland vegetation can tolerate elevated levels of mercury and other contaminants, and may uptake them through their roots. These contaminants can accumulate in tissues or seeds that may then be eaten by waterfowl and other wildlife. Bioaccumulation of mercury can cause problems in the food chain, particularly if the animal is harvested for human consumption. Methylmercury is much more toxic than mercury by itself.

<u>Temperature</u>

While thermal alterations can cause changes in primary productivity and shifts in species composition, these changes are normally seen with a significant increase in temperature. Changes are due to physiological factors and decreases in ice cover and increases in growing season length with higher temperatures (Adamus and Brandt, 1990).

According to the *Surface Water Hydrology and Quality Technical Memorandum*, the potential thermal impact from the proposed tailings basin discharge would be seasonal. It appears that in the spring the discharge could retard the warming of the Sandy River for some distance downstream. The depth at which the siphon draws in water could also have an effect on the temperature impact during the summer months. A shallow placement could result in a slight warming, whereas a deep placement could result in a slight cooling. In the fall, a slight impact, if any, may be observed from direct temperature effects. In the winter months a slight cooling downstream may occur. Downstream impacts that may occur as the result of differing temperatures of the tailings basin water may be mitigated by Sandy and Little Sandy Lakes.

The temperature of the stations below Dark Lake would not directly be affected by the temperature of the proposed tailings basin discharge due to the buffering effect of Dark Lake. However, the reach between the discharge point and Dark Lake may experience a cooling in the spring and a warming in the fall.

The potential impacts of temperature would be reduced by splitting the proposed discharge between the Sandy and Dark rivers. Even so impacts to vegetation are not expected based on the changes in temperature discussed in the *Surface Water Hydrology and Quality Technical Memorandum*.

pH

Ambient pH is one of the most important factors that will affect emergent and aquatic wetland species (Adamus and Brandt, 1990). Especially in low alkalinity systems, pH can be more important than nutrient status or water transparency. Background pH of several tributaries to the Dark and Sandy Rivers, presented in Appendix C of the *Surface Water Hydrology and Quality Technical Memorandum,* indicate that background pH ranged from 5.44 to 7.61 in 2003. While this is lower than the pH of the discharge water, one must consider that dilution will lessen impacts in the lower portions of the rivers.

The MPCA Class 2D pH water quality standard for wetlands requires "maintain background" which, in the case of downstream acidic wetlands (such as bogs) that have a low background pH indicates that this standard could be violated. An additional discharge with a higher pH than normal could raise pH in the wetlands. The extent of the impact depends upon hydrology of the impacted wetlands, especially where most of the influent water for each wetland type comes from. Other factors to consider include how much the flow of the river interacts with the wetland and the mixing ratios of river water containing discharge and water flowing into wetlands.

If an increase in river water pH causes an increase in pH in the wetlands, some wetland types would be adversely affected. Poor fens, some swamp types, and bogs maintain acidic conditions due to the buildup of organic matter. If pH increases in these systems, vegetation species less tolerant of acidic conditions would invade and eventually may cause a shift in wetland type. However, because bogs receive their influent water from precipitation and rarely from surface water, this wetland type may not be affected. Wet meadows, marshes and shrub swamps should not be affected by an increase in pH because these wetlands typically have neutral to basic pH and typically receive mineral-rich water.

In addition, beyond direct changes to pH, with an increase in other constituents of concern, changes in pH may occur. As discussed previously, changes in calcium may cause changes in pH as well. If calcium concentrations, and thus pH, increase, a fen may succeed from a poor fen to an intermediate rich fen or extremely rich fen (Glaser, 1987). Bogs may not be impacted because they receive water only from precipitation.

Dissolved Oxygen

Chemical transformations in wetland soils are mediated by availability of oxygen. Hydric soils can quickly become anoxic when waterlogged and anaerobic bacteria can transform constituents such as sulfate into toxic end products in the absence of oxygen. A decrease in dissolved oxygen can impact nutrient cycling and growth of plants.

Impacts of Changes in Water Quality on Threatened and Endangered Species

As discussed, increased discharge will cause changes in sulfate/hydrogen sulfide, water hardness, manganese, methylmercury, and dissolved oxygen that may negatively impact wetland vegetation. Threatened and endangered species may experience the same impacts, with species native to bogs being more sensitive to water chemistry changes than other species. Forbs (herbaceous dicots such as *C. natans, A. schoenoprasum, P. vaginatus, P. vaseyi*, and *X. montana*) are particularly uncommon in polluted wetlands, while sedges tend to predominated contaminated areas (Adamus and Brandt, 1990). Thus, contamination may not only cause an impact to threatened and endangered species, but result in loss of biodiversity as well.

5.3.3.2 Alternative B: Alternative Sites

Laurentian Creek

Discharge of tailing basin water into Laurentian Creek would cause the same water quality problems that discharge of 11.1 cfs to either Sandy or Dark rivers would cause to wetland vegetation on this creek.

Lake Superior Watershed

The *Surface Water Hydrology and Quality Technical Memorandum* considered three mixtures of tailings basin water and existing permitted discharge water when evaluating the impacts of this action alternative on water quality. Under this alternative, impacts to vegetation would be similar to those discussed under Alternative A, with the severity of the impact dependent upon the degree to which the tailings basin water quality differs from the mine pit water quality.

5.3.3.3 Alternative C: No Build (No Action)

According to the *Surface Water Hydrology and Quality Technical Memorandum*, the No Build Alternative would result in additional impacts to the surface water system. Data have shown that with continued use of the tailings basin, the water quality would continue to degrade as the result of evapo-concentration. This could result in increasing concentrations of solutes in the seepage in the tailings basin. As discussed above, the potential impacts to wetlands would be dependent upon the water quality of the seepage.

5.3.3.4 Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising

According to the *Surface Water Hydrology and Quality Technical Memorandum*, raising the tailings basin perimeter dike would continue to adversely impact water quality in the Sandy and Dark Rivers due to evapo-concentration raising concentrations of regulated constituents and increased seepage rates due to higher hydraulic heads. Because many marsh species, such as cattails and reeds, are tolerant of metals and other pollutants, an increase in constituents should not cause problems beyond those discussed above. Species that are more sensitive to pollutants may decrease in numbers and diversity and invasive emergents may increase and form monocultures of undesirable species.

Water Level Reduction

A reduction in the water level of the tailings basin could reduce seepage rates and improve water quality in the Sandy and Dark Rivers, provided that constituents don't increase in concentration due to evapo-concentration. According to the *Surface Water Hydrology and Quality Technical Memorandum,* it is probable that the reduced water level would be accompanied by a further degradation in water quality of the basin and, thus, no net improvement would be seen in receiving water bodies. The impacts to wetland vegetation would be similar to those discussed for the tailings basin perimeter dike raising.

5.3.3.5 Alternative E: Design Alternatives

These design alternatives focus primarily on mitigating impacts of temperature differences in the Sandy and Dark Rivers. A small change in temperature such as that discussed in the *Surface Water Hydrology and Quality Technical Memorandum* should have no negative impacts on vegetation.

5.3.3.6 Alternative F: Modified Scale or Magnitude Alternatives

Although reducing the volume of the discharge would reduce impacts to water quality, it may still be assumed that constituents of concern such as sulfate and calcium may still cause problems to wetlands downstream. According to the *Surface Water Hydrology and Quality Technical Memorandum*, it is not likely that an adequate discharge can occur to the Dark River and Sandy River that would not result in exceedance of water quality standards for some constituents. This alternative would be more effective if the discharge was piped to a relatively unimpacted watershed.

5.3.3.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

As discussed previously in Section 5.2.2.7, implementation of the SPB system would result in a number of water quality modifications.

Although the demonstration system indicated that sulfate could be reduced by 50 percent, reductions in TDS, specific conductivity and hardness were none to slight. Thus, reduction of sulfate will be the primary contribution of the SPB system to effluent water quality. However, methylmercury, alkalinity, manganese, ammonia, sulfide and oxygen demand may increase due to use of the SPB system. While harmful constituents may be lower in discharge flowing into receiving water bodies, equally harmful substances will increase. Thus, the benefits of using this SPB system may not outweigh the negative impacts. Particularly, an increase in methylmercury would have detrimental impacts on wetland vegetation, as would an increase in manganese and oxygen demand. If the demand for dissolved oxygen increases five or ten times over the normal amount, negative impacts to nutrient cycling, vegetation health, and an increase in toxic end products of anaerobic metabolism may result (Adamus and Brandt, 1990). In addition, discharge of water high in oxygen demand may violate Minnesota Rule 7050.0210 subp. 13a relating to general standards for discharges to waters of the State if it causes a reduction in biological diversity, wildlife habitat, and recreational opportunities. An increase in oxygen demand in wetlands has also been shown to cause an increase in non-indigenous species (Adamus and Brandt, 1990). This option should be evaluated in more detail, principally with respect to the necessary tertiary treatment steps, before implementation is considered.

Impacts due to discharge from the SPB system should be different depending upon where the SPB effluent is discharged. If the effluent is discharged into receiving water bodies, impacts may be greater than if effluent is discharged back into the tailings basin. If effluent is discharged back into the tailings basin, dilution would take place (and possibly other reactions that could decrease harmful constituents) and would reduce concentrations of harmful constituents of the effluent. This alternative should be considered and further investigated if an SPB system is going to be implemented.

5.4 WILD RICE

This section describes wild rice baseline conditions (Section 5.4.1) and potential impacts (Section 5.4.2) within the Sandy River watershed associated with implementation of the proposed project or project alternatives. Wild rice beds are known in the Sandy and Pike Rivers, but not in the Dark River. Therefore, only the Sandy River watershed is discussed within this section.

General wild rice characteristics were described previously in Section 2.5.4 and general locations of wild rice areas are shown in Figure 2-9. Detailed wild rice discussions, evaluations, and data sets are contained within the *Wild Rice Technical Memorandum.*

5.4.1 Wild Rice Baseline Conditions

5.4.1.1 General

Wetland characteristics of the Sandy and Pike River watershed make the Sandy and Pike Rivers suitable for production of wild rice. Water currents are mitigated by extensive stream sinuosity and surrounding wetland and bog habitat. These factors buffer the stream against flashiness that could flood and/or uproot immature wild rice plants, or mature plants with weak root systems. Slowed water flow also permits rice seed to settle in specific areas (typically in near-shore areas and other friction points of water flow in the stream course such as river bends and oxbow areas) and establish root systems. Both the Sandy and Pike Rivers are typical northern Minnesota dark-water streams with extensive humic wetland vegetation borders. Annual humic vegetation and plant straw deposition and build-up acts as an insulator, protecting the mineral substrate from freeze-out in winter. This allows under-ice water and substrate temperatures suitable to maintain rice seed in dormancy, while also preserving it against desiccation through freezing.

5.4.1.2 Baseline Wild Rice Data

Comparative values of base biophysical parameters for wild rice are provided in the criteria Table 5.30, *Baseline Criteria for Assessing Impacts to Wild Rice* and in Table 5.31, *2003 Comparative Average Chemical Parameters Measured in Wild Rice-Bearing Lakes and Rivers Adjacent to the Proposed Project Area.* Predominant biophysical parameters of importance include pH, water temperature, water flow rate, water level, alkalinity, TDS, TSS and turbidity, sulfate residual level, and dissolved oxygen level. Chemical factors including heavy metal constituents and macronutrient (nitrogen and phosphorus) levels are also considered.

Alkalinity, the presence of carbonate-bicarbonate-hydroxyl ion buffering components of water, is an important chemical parameter for wild rice productivity. Alkalinity can be suppressed in natural waters as a result of natural humic acid releases from bog materials.

Acidic inputs such as those derived through acid rain will suppress alkalinity. Surface discharges as may occur during spring snowmelt may also temporarily suppress alkalinity. Normal, functional alkalinity levels for wild rice lakes typically range between 40-150 mg/L. Wild rice will tolerate temporarily suppressed levels of alkalinity.

Optimum pH range for wild rice germination and growth is well-defined. Wild rice grows within pH ranging between 6.0 and 8.5 (S.U.). Temperature is critical to successful germination. Water and sediment temperature must approach a sustained level of between 45-50ºF to allow germination and growth of wild rice seed. Critical dissolved oxygen levels are required by the seed in spring to break dormancy and commence with germination. During the germination phase of wild rice growth, dissolved oxygen levels must be at least 8-10 mg/L. Dissolved oxygen typically declines to low levels (2-5 mg/L) in summer months, due to high water temperature and micro-climate zones created by stands of wild rice. Such declines timed at this point in the rice growth cycle are not detrimental to wild rice production.

TABLE 5.30
BASELINE CRITERIA FOR ASSESSING IMPACTS TO WILD RICE

Criteria	Representative Literature Sources	Comments
Sustained water level changes not to exceed six (6) inches or more around baseline conditions during germination, floating leaf, and panicle/kernel production stages in wild rice plant development; flashy changes in water level to be mitigated during months of June-July.	Oelke et al. (1982); Aiken, S. G. et al. (1988); Persell, J. S. (1992); Pillsbury, R. W. et al. (1998); Pip, E., and J. Stepaniuk (1988)	Wild rice-producing lakes of specific importance in the impact area of influence have average depths of approximately two feet. Relatively small water level decreases in these shallow lakes could cause significant long-term impacts on wild rice production and harvest potential.
Flow rate not to exceed 8-10 cubic feet per second (cfs) above site-specific baseline flow rate during germination, boot stage, and floating-leaf stage of the wild rice plant cycle.	Meeker, J. E. (1993); Meeker, J. E. (1996); Dore, W. G. (1969)	
Heavy metal concentrations in plant tissue or kernels above levels not to exceed levels considered acceptable in grains for human consumption, in lakes, streams, and creeks	Pip, E. (1993); Lee, P. F. (1996); Pip, E. (1984)	
pH not to be less than 6.0 units or greater than 8.5 units during full cycle of wild rice plants.	Oelke, E. A. (1993); Sparling, D. W., and T. P. Lowe (1998); Lee, P. F. (1985); Dore, W. G. (1969)	

TABLE 5.31
2003 COMPARATIVE AVERAGE CHEMICAL PARAMETERS MEASURED IN WILD RICE-BEARING LAKES AND RIVERS ADJACENT TO THE PROPOSED PROJECT AREA

Lake or River Name	pH	DO (mg/L)	TDS (mg/L)	Temp (°F)
Big Rice Lake	6.9	5.2	24.3	63.1
Little Rice Lake	6.9	6.6	20.4	62.0
Breda Lake	7.0	5.9	39.4	62.9
Cabin Lake	7.5	6.7	34.5	65.8
Campers Lake	7.2	6.6	45.8	66.2
Cramer Lake	7.7	7.7	47.9	66.0
Kettle Lake	7.4	5.5	35.5	66.3
Round Island Lake	7.2	5.8	37.4	61.9
Stone Lake	7.5	6.1	59.2	63.8
Vermilion River	6.9	6.8	48.5	70.0
Sandy River (n = 4 sites)	7.2	5.4	625.8	69.8

TSS in water refracts incoming sunlight, and can substantially alter the amount of light in specific wavelengths necessary for plant photosynthesis. This may occur as a result of direct substance loading to the water body, or possibly through internal eutrophication processes as described by Smoulders et al. (1995, 1996, 2003). Once wild rice reaches the emergent stages of growth, this problem is largely alleviated. However, if soil erosion and enhanced turbidity occurs within the early germination and submersed growth ("boot stage"), rice plant development may be hindered or ceased. As such, it is critical to assess and mitigate land impacts leading to erosion and sedimentation during the critical months of April through June. Enhanced deposition of suspended solids, in combination with reductions in circulation rates within a basin, can effectively aid in filling the basin and smothering wild rice seed, thus reducing germination and yield. There are no clear, uniform scientific criteria that can be judged acceptable for wild rice for all systems. Upstream land use and deposition load, flow rates to and from the basin, and timing of the sediment load are all critical factors that must be assessed on an individual system basis. As such, Minntac baseline data values and erosion potentials expected through construction and operation are valid to be used in this analysis.

Table 5.32, *2003 Comparative Wild Rice Stem Densities in Lakes and Rivers in Watersheds Surrounding the Project Watershed,* defines comparative values of wild rice stems density in lakes and rivers adjacent to the Sandy River impact area.

TABLE 5.32
2003 COMPARATIVE WILD RICE STEM DENSITIES IN LAKES AND RIVERS IN WATERSHEDS SURROUNDING THE PROJECT WATERSHED

Lake/River Name	Average Number Stems per ½ square meter
Big Rice Lake	29
Little Rice Lake	18
Breda Lake	48
Cabin Lake	43
Campers Lake	21
Cramer Lake	43
Kettle Lake	19
Round Island Lake	79
Stone Lake	39
Vermilion River	37
Sandy River	13

Table 5.33, *2003 Comparative Average Water Depths Measured in Wild Rice-Bearing Lakes and Rivers Adjacent to the Project Area,* shows comparative values of average water depths observed in wild rice lakes and streams adjacent to the Sandy River in 2003.

TABLE 5.33
2003 COMPARATIVE AVERAGE WATER DEPTHS MEASURED IN WILD RICE-BEARING LAKES AND RIVERS ADJACENT TO THE PROJECT AREA

Lake/River Name	Average 2003 Season Water Depth (Inches)
Big Rice Lake	44
Little Rice Lake	16
Breda Lake	22
Cabin Lake	25
Campers Lake	21
Cramer Lake	29
Kettle Lake	29
Round Island Lake	26
Stone Lake	33
Vermilion River	17
Sandy River	18

5.4.1.3 Historical and Current Wild Rice Distribution, Sandy and Pike Rivers

Historical references cite that, in 1982, there existed 121 acres of wild rice in Sandy Lake, and 89 acres of wild rice in Little Sandy Lake. This reference also indicates that survey of these lakes by MDNR ceased in 1992. The historical reference in 1987 cites the presence of up to 200 acres of wild rice within Twin Lakes (including Sandy and Little Sandy, amounts per lake not differentiated), in 1984, 1985, and 1987. In 2000 and 2001, wild rice was found in only trace quantities within Sandy and Little Sandy lakes by Bois Forte DNR surveyors (Bois Forte DNR, 2001). The same survey also found approximately one-half acre of wild rice within the Sandy River, approximately six miles from the river origin at Twin Lakes. A historical accounting provided by the MDNR (McHugh, 1987) references this Sandy River rice bed as a large, 40-50 acre rice bed area.

In summer 2002, approximately three river miles of wild rice beds were reported to the MPCA by the 1854 Authority. MPCA subsequently notified the EIS contractor and the Minnesota State DNR (J. Strudell, Memorandum, 2002). Beds were reported to exist within the upper reach of the Pike River (between its confluence with the Sandy River and the Pike River Flowage). Actual surface area coverage and biomass production of the wild rice beds within the Pike River were not evaluated, although GPS data points locating specific wild rice beds were collected (D. Vogt, 1854 Authority, Personal Communication and Memorandum, 2004). No historical or anecdotal references to these rice beds are presently available.

5.4.2 Wild Rice Impacts

This section documents the potential impacts, both quantitatively and qualitatively, to wild rice areas under the proposed Alternative A, No Build Alternative, and the Action Alternatives described previously in Section 4.0. Further details pertaining to potential wetland impacts are included in the *Wild Rice Technical Memorandum.*

5.4.2.1 Alternative A: Proposed Project (Proposed Action)

This impact analysis is primarily focused upon identification of potential effects of the proposed project to baseline levels of wild rice in the Sandy and Pike Rivers. Proposed discharge effects assessed herein include the following:

- Relative percent flow increases
- Potential increased water level, overland flow, and flooding
- Potential increased channel scour, erosion, and sedimentation
- Potential changes to groundwater within the Sandy River
- Potential changes to water chemistry of the Sandy River
- Potential economic impacts occurring with loss of Sandy River wild rice

<u>Impacts Occurring to Wild Rice with Relative Percent Flow Increases</u>

Table 5.34, *Reported 7Q10 Low -Flows for Sites Along the Sandy River and Pike River,* and Table 5.35*, Average Instantaneous Flow and 100 Year Peak Flow, Sandy and Pike Rivers,* provide summary data originally compiled in the *Surface Water Hydrology and Quality Technical Memorandum*. These data are appropriate references for the following discussion of projected flow rate impacts on wild rice.

Instantaneous flow averages for each site as defined in Table 5.35 are based upon n = 13 available data values. Broken out by year, data consist of eight values collected in 1999, one value collected in 2000, and four values collected in 2003. No data were reported for 2001. Most values were collected during spring and summer months of April-August. Only two (values were collected during fall (September-October), and two values were collected during low-flow winter months (December-January). As such, average instantaneous flow between September and January is likely to be more statistically variable than spring and summer flow averages.

TABLE 5.34 REPORTED 7Q10 LOW-FLOWS FOR SITES ALONG THE SANDY RIVER AND PIKE RIVER	
Station	**7Q10 Low-Flow (cfs)**
701	0.27
S-1	0.83
S-2	1.5
S-3	2.5

TABLE 5.35 INSTANTANEOUS FLOW AVERAGES FOR SITES ALONG THE SANDY RIVER AND PIKE RIVER		
Station	**Average Flow (cfs)**	**2-Year Peak (cfs)**
030	0.45	No data
701	21	180
S-1	100	457
S-2	321	724
S-3	No data	1010

In 1999, average instantaneous flow at sites immediately bracketing rice beds (S-1 and S-2; no data available for S-3) were 142.2 cfs and 353.6 cfs, respectively (n=8). This includes instantaneous flow values collected during winter months; as such, this value more reasonably approximates total annual flow rate. In 2000, average instantaneous flow at S-1 and S-2 was 37.9 cfs and 60.9 cfs, respectively, but neither of the site values have any degrees of freedom (n=1). In 2001, flow at S-1 and S-2 was not estimated. In 2003, only flow data at S-1 were collected (April through August; no winter low-flow values). Average flow at S-1 in 2003 was 32.3 cfs (n=4).

The *Surface Water Hydrology and Quality Technical Memorandum* compared monthly annual baseline flows in the Sandy River (Station S-1) to flows adjusted for 5.6 and 11.1 cfs tailings basin discharge scenarios. Addition of 5.6 cfs tailings basin discharge to baseline stream flows caused an increase in monthly flow by 5 to 6 cfs. This increase is within the stated flow criteria maximum of 8-10 cfs (Table 5.30). When the 11.1 cfs discharge was included, monthly average flows increased by 11 to 14 cfs. This general increase is outside the acceptable criteria range of flow for wild rice.

The importance of 7Q10 low-flow rates, the relation of these to instantaneous flow rates, and the effect of 7Q10 low-flows on wild rice germination and growth should be defined. The 7Q10 values represent the 7-day average low-flow value based on a 10-year recurrence interval. According to collected instantaneous flow rate data and seasonal hydrology characteristics of the region, peak surface flows are anticipated to occur during the months of April, May, and June, and are concurrent with spring precipitation and snowmelt runoff. An elevated peak in precipitation runoff is also anticipated in fall, between September and November. This is concurrent with the lowest predicted relative percent flow increases. Highest percent flow increases occur during 7Q10 low-flow months (January-March). As such, an impact from drainage basin discharge is potentially anticipated at 7Q10 low-flow months when tailings basin discharge makes up the major portion of the total flow. Wild rice at this time will likely be in a dormant, over-wintering condition. Thus, potential effect to germinating and growing plants will likely be minimal.

Wild rice seed beds are contained in straw under ice, however, could potentially be affected through contact with increased concentrations of sulfate during this time period, in a manner defined by Armstrong et al. (1996) and described below under *Impacts to Wild Rice with Changes in Chemical Quality*.

Conversely, during peak spring runoff, natural flows combined with additional tailings basin discharge flows of 5.6 or 11.1 cfs would result in relative flow increases of 2-9 percent. Flow increases of 9 percent, associated with 11.1 cfs discharge rates, would likely produce flow rates outside the wild rice flow criteria and should be considered to be a potential impact to wild rice in mid-reaches of the Sandy River, either through scouring loss of seed-beds, or uprooting of germinating rice plants.

Flow increase projections must also be considered conservative in terms of other wild rice beds. Projected estimates are derived from data collected at Station S-2, where stream channel width can, to a larger extent, mitigate additional flow impacts. This is adjacent to the Sandy River wild rice beds. Hence, minimal impact to these rice beds is projected to occur with the predicted flow increase.

Chronic impacts to these rice beds may occur if flow is stabilized with tailings basin discharge and the incidence of disturbance within the river channel is reduced. Under these conditions, wild rice, which prefers periodic disturbance regimes, could be impacted (Dukerschein, 1999). Historic and current flow and seepage data are limited, so a comprehensive picture of long-term baseline changes to the hydrological regime of the Pike River is not available. However, projected annual monthly flow increases expected in the Pike River with the 11.1 cfs discharge are largely stabilized across the entire year, ranging between 11 and 14 percent, even during winter low-flow months. Projected monthly flows under the 5.6 cfs discharge regimen are less stable, ranging between 7-14 percent above baseline during peak flow months and 30-80 percent above baseline during winter low-flow months. Flow stability projected with the 11.1 cfs discharge regimen suggests some potential for a more hydrologically-stable system that, over time, could additionally influence and impact wild rice production.

Wild rice beds located further upstream within the Sandy River would not be as buffered from relative flow impacts as beds located further north in the Pike River, since in headwater areas of the river proposed flows have the potential to well exceed the baseline wild rice flow criteria.

Impacts to Wild Rice with Water Level Change, Flooding, and Overland Flow

Water levels in 2001 on Sandy River (Table 5.33) indicate a level similar to the Vermilion River, the nearest comparable rice producing river system. Other reported 2003 water levels are higher than the reported river levels, up to nearly four feet in Big Rice Lake. This is indicative of the difference between lake and river wild rice habitat, and also highlights an example of the normal range variability associated with wild rice growth.

Average 7Q10 low-flow values shown on Table 5.34 were calculated throughout the watershed. Adding additional flow in the amount of either 5.6 or 11.1 cfs (the difference between these discharge rates amounts to approximately five percent more flow during the January-March low-flow period) might result in upstream locations near headwaters of the Sandy River exhibiting a very substantial winter flow increase, if water volume does not exceed the existing river channel capacity and run off in to adjacent wetland areas.

However, rating curves for the Pike River (Station S-2) show potentially small stage height increases. Height increases of 0.18 and 0.30 ft are anticipated with the addition of 5.6 and 11.1 cfs tailings basin discharge, respectively, during an average February low-flow of 7.0 cfs. Similarly, average April flow (267 cfs) would produce a stage height increase of 0.04-0.09 ft above baseline levels. These relatively small, projected changes in water levels are within the wild rice water level criteria range, and would have minimal impact on wild rice in the Pike River, especially if tailings basin discharge flows are attenuated during germination, boot stage, and floating-leaf stages of rice growth in the spring.

Impacts to Wild Rice with Channel Scouring, Erosion, and Sedimentation

Erosion and channel scouring would likely occur during periods of high channel flow. Erosion and channel scouring would transport particulate sediment particles downstream. If sediment deposition occurs over existing rice beds, viable rice seed could be covered and germination might be retarded as a result of poor oxygenation or inappropriate germination temperature. Considering that wild rice requires 120 days to reach maturity, any such setback in germination or growth during the short northern Minnesota growing season may cause rice crop failure. Successive year crop failures would, over three to six years, likely result in permanent rice plant community failure, since no viable seed would remain to re-establish plants. When the 11.1 cfs basin discharge was considered, two-year peak flows were projected to increase by one percent downstream (S-3, Pike Bay), and six percent upstream (701, headwaters seepage area). When the 5.6 cfs option was considered, flow increases downstream at S-3 and upstream at 701 were projected to be 0.6 and 3.1 percent, respectively. These increases would likely cause minimal erosion at those locations. As explained in the *Surface Water Hydrology and Quality Technical Memorandum*, greater erosion due to channel scouring from a new tailings basin discharge is likely to occur in the upper reaches of the Sandy River. Transported sediment from such scouring may be transported downstream, cover rice seed, and impact its ability to germinate. While periodic impact from natural flood conditions would likely occur and is anticipated, transported sediment likely would have less impact on the wild ricebeds further downstream in the Pike River.

<u>Impacts to Wild Rice with Changes in Groundwater Quality/Quantity</u>

Groundwater data are limited, making analysis of potential effects to wild rice difficult. MDNR modeling of groundwater within the proposed project area does suggest that discharge base-flow additions of basin discharge water may proportionally over-ride groundwater temperature influence, possibly leading to a seasonal thermal impact. In spring, tailings basin discharge may retard warming of Sandy River flow for some distance downstream. If water temperatures are kept below a 50º F germination temperature, wild rice growth would be delayed. If growth is delayed for an extended time, plants would not meet the degree-day requirement to mature and produce seed.

<u>Impacts to Wild Rice with Changes in Chemical Quality</u>

Table 5.36, *Chemical Components of Concern in Minntac Tailings Discharge Water,* shows major chemical constituents of concern with respect to wild rice in the Minntac tailings basin discharge:

TABLE 5.36
CHEMICAL COMPONENTS OF CONCERN
IN MINNTAC TAILINGS DISCHARGE WATER

Chemical	Average Concentration (mg/L)
Alkalinity	183
Hardness	928
Chloride	122
Conductivity (umhos/cm)	1886
pH	8.31
Sulfate	711 (MWH, 1/04); 811 (Minntac, 2/04)
TDS	1380
Manganese	277

Table 5.37, *Baseline Water Quality Parameters at Sandy River Monitoring Stations,* shows existing baseline water chemistry of Sandy River water for major parameters of concern:

TABLE 5.37
BASELINE WATER QUALITY PARAMETERS
AT SANDY RIVER MONITORING STATIONS

Parameter	Station Average Value			
	030 (seepage)	701 (midstream)	S-1 (Pike River)	S-2 (Pike Bay)
Chloride (mg/L)	158	48	27	NM
Hardness (mg/L)	1119	304	148	NM
Manganese (μg/L)	2006	164	41	NM
pH (S.U.)	7.36	7.19	6.93	6.88
Sulfate (mg/L)	757	223	108	64
Temperature °F	52.3	53.2	54.1	NM
TDS (mg/L)	1500	467	317	219

Notes:
1. Based on data from Table 5.16
NM = not measured

Chloride Impacts: There is no established standard for chloride in relation to wild rice. Average chloride concentrations were measured at 48 mg/L at midstream Station 701and 27 mg/L at downstream Station S-1.

Hardness Impacts: A wild rice standard for hardness is not available. The average hardness concentration of tailings basin water is 928 mg/L. Average hardness values of 676 mg/L at Station 701, and 392 mg/L at Station S-1, are predicted. No toxic effect of hardness has been reported for wild rice

Fluoride Impacts: No regulatory standard for fluoride exists in relation to wild rice. Literature review has not yielded information about effects of fluoride on wild rice. Likewise, the Minnesota Class 1 water quality standard for fluoride (2.0 mg/L) is not directly applicable to wild rice, so it cannot be used in an analysis of impacts to wild rice.

Manganese Impacts: No defined standard for manganese exists in relation to wild rice. Scientific literature suggests that prolonged saturated conditions may promote manganese deficiencies in plants, and acidic bog conditions may further exacerbate toxicity. Data relating manganese toxicity in land-based plants is provided in the *Wetlands Technical Memorandum*, and suggests a range of permissible manganese levels ranging between 40 and 300 mg/L. One aquatic-based species, *Typha latifolia*, has a reported tolerance level of 550 mg/L. As soils within the Sandy River watershed are considered primarily minerotrophic, it seems unlikely that consistent acidic conditions would exist that lead to manganese toxicity in wild rice. The *Surface Water Hydrology and Quality Technical Memorandum* reports that levels of manganese in areas of the Sandy River closest to the currently-existing rice beds (S-2) would be at or near 114 mg/L. While elevated from current manganese level (36 mg/L), this value does not exceed the value known tolerated by *Typha latifolia*. Further, although no data was calculated for manganese levels upstream of Pike Bay, it is anticipated that manganese would be substantially lower in Pike Bay from levels seen at S-2. Upon this review of available data, it seems reasonable to assume that the projected elevation of manganese would not be toxic to wild rice in the mid- and lower-reaches of Sandy and Pike Rivers.

Sulfate Impacts: The most significant change to the Sandy River system under the proposed project would be increased sulfate concentrations. The *Surface Water Hydrology and Quality Technical Memorandum* reported that average sulfate concentration in tailings basin discharge water is presently 711 mg/L. Minntac, in a focused feasibility study dated February 2004, stated that this average annual concentration is actually 811 mg/L. Current Minnesota State Water Quality Class 4 standards set an agricultural maximum concentration for sulfate of 10 mg/L during periods when the rice may be susceptible to damage by high sulfate levels.

Sulfate levels seen at all stations listed in Table 5.37 exceeded this Class 4 standard 97 percent of the time. Baseline sulfate levels in Sandy River water presently range between 757 and 64 mg/L, with highest values occurring at the seepage area (Station 030). Analysis of sulfate residuals in water in a seven-mile stretch of the Sandy River (Bois Forte DNR, 2000) is consistent with the *Surface Water Hydrology and Quality Technical Memorandum*, showing a range of 432 to 55 mg/L, with values decreasing incrementally downstream. Analysis also showed an average 118 mg/L sulfate in water within rice beds, and 275 mg/L sulfate in sediment within rice beds. Water sulfate outside the same rice bed areas was lower in concentration than within the beds (197 mg/L), while sediment sulfate outside the same rice bed areas was elevated, but not statistically higher than sediment sulfate within the rice beds (351 mg/L).

The sulfate level necessary for wild rice has been debated for many years. Toxicity levels of sulfate are likewise not well defined. Wild rice has been reported in water with sulfate levels of 2-1300 mg/L. Studies carried out in the 1950s indicate that sulfate in proximity to wild rice fluctuated around 10 mg/L, with a maximum tolerance level of 50 mg/L. Recent research indicates that higher sulfate residuals (equal to or greater than 250 mg/L) may be tolerated by wild rice.

There is speculation that sulfate drainage through Sandy and Little Sandy Lakes may have led to the decline of wild rice in these basins. Wild rice once covered over 200 acres within the basins (MDNR, 1987; 1999). Presently, it exists only in trace amounts. While there is no direct evidence that sulfate alone caused the wild rice decline, indirect evidence for such is compelling. For example, it can be noted that, prior to tailings basin discharge, wild rice was reported in abundance within Sandy and Little Sandy Lakes. Concurrent sulfate levels recorded at that time showed an average sulfate level of 7.6 mg/L, nearly 100 times less than current sulfate discharge levels (URS, 2001). It should be noted, however, that other factors, as, for instance, aquatic animal (muskrat, beaver) habitat expansion or increased motorboat use, may have concurrently attributed to the loss of rice, which appears to have occurred largely during the mid-to late 1980s.

Armstrong et al. (1996) suggested a reason for decline in an aquatic plant species (*Phragmites*) that may also be applicable to wild rice. Armstrong et al. suggest that straw (dead plant stems) build-up after annual growth die-back may create permanent anoxia within the plant stand if such occurs in stagnant or slow-moving water. Anoxia subsequently leads to hydrogen sulfide (H_2S) accumulation, which injures roots of growing plants, causing decline in the stand. This effect seems exacerbated by pre-existing, high sulfate levels in brackish water.

Wild rice is known to produce ample quantities of straw at the end of its growth season (Archibold, O. W., 1991). Degradation of plant material is characteristically slowed in brackish, anoxic conditions (Sain, 1984; Holm, 1991). Sulfide is a known plant phytotoxin that restricts root growth and nutrient absorption (Vamos, 1959; Goodman and Williams, 1961; Takijima, 1965; Wang, Cheng, and Tung, 1967; Lynch 1978, 1982; Sanderson and Armstrong, 1980; Koch, Mendelssohn, and McKee, 1990). It is also an inhibitor of aerobic respiration and nutrient uptake, as well as a photosynthesis inhibitor (Allam and Hollis, 1972; Mendelssohn and McKee, 1988; Pezeshki et al., 1988). Joshi and Holling (1977) demonstrated these effects in rice under stagnant paddy growing conditions. These reports likely closely describe conditions presently existing in Sandy and Little Sandy Lakes, making this is a very relevant possibility for rice decline that should be studied further.

Another possible mechanism contributing to wild rice decline may be extrapolated from ecosystem modeling work performed by Roelofs (1991) and Smoulders et al. (1995, 1996, and 2003). According to these authors, a feed-back system of "internal eutrophication" may occur in an aquatic system exposed to excess sulfate. As sulfate levels increase under reducing sediment conditions, H_2S is produced. As H_2S levels in sediment increase, phosphorus, once bound, is liberated from the sediment, resulting in increased water column phosphorus levels and movement of the system toward a state of increased eutrophication.

At the same time, iron under such reducing conditions is sequestered, making it largely unavailable to plants. In plants with certain root morphologies, however, iron under reducing conditions may still be taken up. Reduced iron once in the root system may oxidize in the presence of root oxygen, eventually killing the root.

The net result under this model interaction is an overabundance of the macronutrient phosphorus, an under-availability of the micronutrient iron, the potential for reduced iron toxicity, and an eventual plant community species shift from rooted aquatic plants to non-rooted species such as algae and duckweed (*Lemna* spp.). This would likely also be accompanied by increased turbidity and decreased transparency. The combination of effects could potentially lead to a cascading plant assemblage failure and plant assemblage shifts to favor more eutrophic condition-tolerant species over extensive surface area.

It should be noted, however, that these effects were all observed in a plant (*Stratiotes aloides* L.) possessing root physiology quite different from that of wild rice. A potential to hinder wild rice germination through increased water turbidity and reduced water column transparency is apparent. However, the model's impact through iron bio-availability and root system toxicity has not been thoroughly evaluated for wild rice, and may not be applicable in its regard.

Lee (2000) addressed iron bio-availability issues in wild rice, and suggested that iron, rather than sulfate, may cause stress to wild rice. According to Lee, iron is present in less than optimum amounts for wild rice in Minntac tailings water. In his 2000 bioassay study using Minntac water, Lee observed that iron concentrations in the Minntac tailings water (0.26 mg/L in bioassay sample water, 0.1 mg/L reported in the tailings basin) were approximately 10 times lower than iron in standard nutrient solutions used in the bioassay.

Concurrently, sulfate in Minntac water was very high (greater than 500 mg/L, vs. 38-40 mg/L in standard nutrient media). Seedlings grown in the iron-deficient, high-sulfate Minntac water exhibited reddish color and larger root growth than standard-media grown seedlings. Since iron is a required nutrient for wild rice in the development stage and is in higher concentration than any other nutrient during the submerged stage of growth (Lee and Stewart 1983), it is suggested that seeds exposed to the Minntac water experienced nutrient deficiency in the bioassay.

Other research has shown, however, that iron concentrations such as those seen in Minntac tailings water and bioassay water are, in fact, not uncommon in wild rice-bearing waters. Persell (1992) reported average iron concentrations in Nett Lake, northern Minnesota's premier wild rice lake, of 0.27 mg/L. Painchaud and Archibold (1990) likewise reported a range of iron in sediments of native wild rice lakes in Canada as 0-0.62 mg/0.2 m^2. Similarly, critical macro-nutrients nitrogen and phosphorus within both the tailings basin discharge (nitrogen 0.2 mg/L; phosphorus 20 μg/L) and in baseline flow of the Sandy River/Pike River (nitrogen 0.17 mg/L; phosphorus 60 μg/L), are closely aligned with values of other wild rice systems in the project area, such as Nett Lake (nitrogen 0.10 mg/L; phosphorus 56 μg/L)(Persell 1992). Therefore, confounding effects of macro-nutrient nitrogen and phosphorus or micro-nutrient iron are considered minimal in this analysis.

Heavy Metal and pH Impacts: Acidification of wetlands due to acid drainage can impact pH and elevate and mobilize concentrations of certain metals in solution from varied sources, increase bioavailability of these metals to aquatic plants and fauna (Albers and Camardese, 1993), and cause injury or death to the receiving organisms. Lee (2000), for example, reported reduced leaf, shoot, and root growth in wild rice seedlings with intermediate levels of Al, Cu, and Pb; plants subsequently died under higher concentrations of these metals. Artificial decreases in pH in test wetlands to pH 4.8-5.3 (Sparling and Lowe, 1997) showed that acidification had a stronger effect on water than on soil chemistry. Sulfate and manganese increased as pH, alkalinity, and nitrogen decreased. Metals, especially Mn, B, Sr, Ba and Zn, were taken up by plants more substantially under acidified conditions, but were higher in submersed plant species than emergent ones.

The criteria range of pH suitable for wild rice is 6.0-8.5. Comparative pH values seen in lakes and rivers adjacent to the proposed development area are between 6.9 and 7.5, also within acceptable wild rice criteria range. Average pH within the Sandy River (7.2) is currently within this criteria range. Average reported pH of the tailings basin is 8.3, within the upper limit of acceptable pH for wild rice. No industry process changes are anticipated that might alter pH within the tailings basin. If pH 8.3 discharge occurs consistently at either 5.6 or 11.1 cfs, some pH value increases may occur to water within the Sandy River. However, it is expected that significant pH changes above the upper criteria level would not consistently occur. Thus, further impacts to wild rice, either through direct physiological alteration or through lowered-pH metal mobilization and toxicity, would not be expected.

Baseline values for metals in wild rice as reported are typically higher than water quality standard values (by an order of magnitude, since rice values are provided in ppm, while water quality standards for metals are largely reported as μg/L). These reported tissue metal levels were apparently not detrimental to wild rice tested in this evaluation. No metals concentration data for Sandy or Pike River wild rice are available for comparison.

Metals in Minntac tailings discharge water, with the exception of manganese, are below drinking water quality standard limits. Metals detected in the discharge include aluminum (25 μg/L); arsenic (1.2 μg/L); cobalt (0.8 μg/L); copper (1.5 μg/L); and iron (0.1 mg/L). Manganese is present in the discharge at levels of 277 μg/L. The potential impact of iron was discussed above. Discharge also contains low-level mercury, at concentrations substantially lower than the Class 2B standard for aquatic life and recreation (6.9 ppt). Potential impacts of mercury are defined in the *Mercury and Methylmercury Technical Memorandum.*

A regulatory standard for manganese in relation to wild rice has not been developed. Manganese concentrations decrease downstream in the Sandy River to an average 63 μg/L at midstream Station 701, and 36 μg/L at Station S-1 near the Pike River rice beds. Discharge additions are projected to increase downstream manganese concentrations to 114 μg/L. These values are outside the acceptable drinking water standard, but no specific inference can be made to the potential impact to wild rice.

Dissolved Oxygen Impacts: Wild rice requires high dissolved oxygen concentrations (8.0-12.0 ppm) in spring as a seed dormancy-breaking requirement (Oelke et al., 1982). Average dissolved oxygen values in adjacent area streams (Rice River, 7.7 mg/L; Littlefork River, 9.3 mg/L) indicate the aeration potential necessary for rice germination.

Values for dissolved oxygen in the Sandy River (average 5.43 mg/L) are slightly depressed, probably due to the time of year (August) during which the data were collected (Bois Forte DNR, 2001). No data reflective of Sandy River dissolved oxygen during spring germination time are available for review. BOD data for the tailings basin suggest low BOD within tailings basin discharge water (typically less than 2 mg/L). A reported periodic COD of 18-22 mg/L has the potential to cause temporary stress impact to downstream biota. However, the majority of COD recordings show low (<1.0-7.5 mg/L) demand. Overall impact to wild rice is expected to be minimal, unless high COD water is released at critical germination times in spring.

Alkalinity Impacts: Tailings basin discharge reportedly contains bicarbonate alkalinity of 183 mg/L. This value is greater than the minimum accepted criteria value for wild rice (40 mg/L). No data are available to show alkalinity concentrations through the mid- to lower reaches of the Sandy River, so an assessment of its potential impact to wild rice cannot be made.

TDS Impacts: Baseline TDS levels of 1,380 mg/L exist within tailings discharge water. Predicted impact of TDS follows that of sulfate, because sulfate anion comprises a large portion of the total TDS. As with sulfate, effect of TDS on wild rice is not clear. Because sulfate is a primary ion in TDS, it would be prudent to consider high TDS as a potential physiological impact to wild rice until further research on its effect is accomplished.

Temperature Impacts: Average temperature data provided (Table 5.31) do not define temperature highs and lows as typically seen in shallow water bodies in fall and summer, respectively. Wild rice matures in Minnesota in approximately 110 days, and requires about 2,600 growing degree days (40 °F base). Temperatures of 50 °F are essential to break seed dormancy and commence the plant life cycle. Seed will not germinate for at least three months after reaching maturity, even if environmental conditions are suitable for growth. This after-ripening period must occur in water at near-freezing temperatures (34–35 °F) in order to degrade the seed pericarp and meet the chemical dormancy requirements within the seed necessary for successful germination. In spring, ambient water and sediment temperatures of 45-50 °F must be reached before germination begins. Water temperatures in the Sandy River may be affected by tailings basin discharge. In spring, tailings basin water has been found to be 3-6 °F cooler than Sandy River water. In summer, deeper tailings ponds remain cooler than the river. If discharge from these cooler ponds occurs in the spring of the year, this may slow water temperature increases downstream. Such temperature manipulations may retard wild rice germination. If germination is slowed extensively, the plants would not receive the necessary growing-days required to reach maturity and produce seed.

Economic Impacts of Altered Sandy River Wild Rice Production

The marketing system for native (non-paddy) wild rice consists of five major groups. These include: harvesters, buyers, processors, wholesalers, and retailers. Native raw ("green") wild rice seed is often purchased by buyers at the location where it is harvested. Some buyers are merely brokers, while some also perform rice processing. Most buyers of native wild rice in Minnesota fill small niche and personal markets, developed individually through years of personal marketing. Cultivated ("paddy") wild rice exhibits a more consistent annual yield, and as such is more commonly purchased by larger buyers who may be wholesalers or food companies. Two examples of these are Busch Agricultural Resources, Inc., or Uncle Ben's, Inc. The commercial wild rice market has further expanded in recent years by over 50 percent, due to the marketing of wild rice "blends." Although such blends typically contain only 15 percent wild rice, they make up over two-thirds of the total commercial wild rice sales.

Wild rice was an expensive gourmet food when it was only available from natural wild rice stands. Growth of wild rice under paddy conditions coincided with market expansion, which resulted in lowered prices and a consistent supply. Native wild rice and its small-scale harvesters were subsequently priced out of the expanding wild rice market. Since 1968, wholesale price for processed paddy wild rice has ranged between $2.10-$5.00 per pound of rice. Paddy producers typically receive between $1.75-$2.00 per pound for their green rice product. Native wild rice harvester/processors, alternatively, charge between $5.00-$8.00 per pound of processed native wild rice product, claiming that the native product is superior in taste, texture, and cooking time to commercially-grown rice. In recent years, native rice has also been marketed as a "natural" product, claimed to grow with minimum input of inorganic fertilizers, herbicides, or pesticides. Harvesters of raw ("green") native rice typically receive between $0.50-1.50 per pound from buyers. Price paid is dictated primarily by the variable native crop production in a given year. Higher production will cause a reduction in price paid for green rice, as product exceeds demand.

Quantitatively, "high" production of native wild rice is typically considered to be at or above 300 pounds of rice kernels per acre of surface area utilized by rice plants, although rice grown under enriched paddy conditions can exceed 1,000 pounds per acre (Oelke et al. 1982). High yield in native wild rice is typically accompanied by rice stem densities totaling at or greater than 60 kernel bearing stems (including tillers) per ½ square meter (or 15 or greater stems per square foot) (Archibold and Weichel, 1985).

In 2003, the Vermilion River, the nearest and most comparable water body to Sandy River in terms of river-type wild rice growing conditions, produced wild rice beds that yielded moderate stem density (37 stems/1/2 square meter). Comparatively, year 2000 measures of Sandy River stem densities were, on average, 13 stems per 1/2 square meter, or 65 percent less than the moderate production seen in the Vermilion River. Surveys of area coverage have indicated that only approximately one-half acre of wild rice exists on the Sandy River. This translates to approximately 53 pounds of wild rice within the one existing wild rice existing stand.

Calculated acreage of the Pike River rice bed area, based upon an assumption of an average bed width of six feet, is 2.17 acres. Assuming similar stem densities within the Pike River beds as in the Sandy River, an additional 228 pounds of wild rice might potentially be obtained from wild rice beds located within the Pike River. The total weight of rice (281 pounds), sold to a buyer at an average price of

$1.00 per pound, would provide $281 of income to one harvesting team, or $140.50 per harvest team member. In the present condition, these limited rice beds will not support more than one harvesting team per year.

Rice production in Sandy Lake, Little Sandy Lake, and the Sandy River is presently low to non-existent. It remains possible that, due to the cyclic nature of wild rice production, low density of rice in the Sandy River were a natural occurrence in 2000; however, no additional data have been collected prior to or after the 2000 assessment to validate this possibility. Extremely limited rice bed distribution, coupled with low yield potentials within existing beds, indicate that baseline wild rice production within the Sandy River watershed is very low.

At its present production level, the economic value of wild rice from this system is insignificant. Rice in the Sandy River may have sustenance value to the few harvesters who collect from the limited beds, but these rice beds in their current condition do not presently produce saleable product in enough quantity to be marketable.

5.4.2.2 Alternative B: Alternative Sites

Laurentian Creek

Laurentian Creek is considered to be a viable alternative discharge site to receive tailings basin water. Laurentian Creek would continuously receive untreated tailings basin water at a rate of 5,000 gpm (2.6 billion gallons per year). Tailings basin water would bypass Little Sandy and Sandy Lakes and to reach a confluence with the Sandy River upstream of monitoring Station 701. Possible impacts to wild rice downstream of Station 701 would be the same or greater than with discharge through Sandy and Little Sandy Lakes. Possible greater long-term impact may occur as water baring high levels of sulfate would be directed completely via channel flow to rice beds in the Sandy River, without the option of flow reduction and possible sulfate retention within Sandy and Little Sandy Lakes. Laurentian Creek would be impacted, as tailings discharge would occur near the creek headwater, flow volume is large and continuous, and the creek has a relatively small watershed. The Class 4 agricultural standard for wild rice would continue to be exceeded. If the goal of flow reduction around Sandy and Little Sandy Lakes is to provide wild rice beds relief from high sulfate flows, then this option is appropriate. However, it is not clear that flow diversion would allow rice beds within Sandy and Little Sandy Lakes to recover, and diversion through Laurentian Creek would clearly degrade that system and possibly further impact wild rice in the Sandy River.

Larson (1999) carried out a field evaluation of sulfate in water at twelve sampling points between the tailings seepage area (site 030) and the outfall of the Sandy River at Sandy Lake. The initial sulfate residual level of 697 mg/L measured at the outfall dropped 48 percent, to 360 mg/L at the Admiral Lake Flowage, approximately 1.5 miles from seepage site 030. From the Admiral Lake flowage to the confluence of Little Sandy Lake (approximately 1.5 miles), sulfate level decreased 7 percent, to 336 mg/L. Thus, sulfate from tailings seepage point to confluence with Little Sandy Lake was reduced 55 percent. Sulfate in flow through Little Sandy Lake dropped from 336 mg/L to 250 mg/L at the confluence with Sandy Lake, a 26 percent decrease. Sulfate levels at the outfall of Sandy Lake into the Sandy River were 222 mg/l, representing an additional 11 percent decrease. The total decline in sulfate levels from tailings basin seepage to Sandy Lake outfall was 68 percent. Of this total percentage, Sandy and Little Sandy Lakes together conserved 34 percent of the original sulfate residual released. The total distance over which this retention of sulfate took place is approximately 4.5 river miles.

The total flow distance within Laurentian Creek before its confluence with the Sandy River is approximately three miles. None of these river miles contains obvious impoundment areas or backwater areas where flow may be reduced. It appears less likely in this instance that sulfate residuals would be retained within this system as effectively as are such in the Twin Lakes, or in the alternative

West Two Rivers Reservoir. This could lead to even greater discharge of sulfate well exceeding the wild rice standard within the Sandy River. If the objective of rerouting flow away from Twin Lakes is to conserve wild rice, then this action would be too late to be of any real assistance, because wild rice is now only present in trace amounts within these basins. It remains possible that wild rice may reestablish in these lakes if sulfate residuals are rerouted, assuming that enough rice plants presently remain to produce future seed. This is unlikely, however, because wild rice seed and plants are heavily used as feed and damaged for shelter by waterfowl and other marsh animals such as muskrat and beaver; trace numbers of rice plants would not likely produce enough seed that would escape predation and grow into mature plants.

West Two Rivers Discharge

Discharge to the Lake Superior watershed includes consideration of piped discharge from the Minntac tailings basin to the West Two Rivers in Mt. Iron, (permitted SD001 outfall). Discharge would then flow south to West Two Rivers Reservoir. After some residence time in West Two Rivers, flow would continue south to the St. Louis River. Flow then would continue some 80 miles south to the confluence with the Cloquet River, and ultimately Lake Superior.

Wild rice resources within West Two Rivers and West Two Rivers Reservoir are reportedly minimal to absent (personal communication, MDNR, May 2004). In the mid- to late 1980s an attempt was made by the MDNR to artificially seed wild rice in the West Two Rivers Reservoir, apparently without success. No known surveys of wild rice production in this basin have been made since that time. Further investigations of relevant wild rice databases show no contemporary or historical accounts of wild rice in these waters. Other concerns related to fishery development both in the West Two Rivers Reservoir and the St. Louis River (receiving waters of the West Two Rivers) are addressed in the *Aquatic Resources Technical Memorandum*.

Multiple Watersheds

One obvious option in regard to multiple watersheds is to divide the discharge between the Sandy/Pike River and Dark River watersheds. Earlier sections of this report relate potential impact to wild rice through discharge of either 11.1 cfs or 5.6 cfs ("split flow") to the Sandy River. However, this option should also include variable flow discharge between the systems, with attention given to timing of discharge to accommodate seasonal growth processes of wild rice. This "biologically-controlled release" (or hydraulically-controlled release) of tailings discharge would accommodate spring germination of rice growth by limiting or severely reducing flow discharge between the months of April-June. By limiting flow discharge over already increased runoff flows, rice plants would less likely be dislodged and lost. Similarly, discharge might be curtailed in low-flow months (January-March). This would cause rice seed less exposure to more concentrated sulfate residual, present as a result of low natural stream flow during this time of the year. Discharge would be optimally released during summer and fall months (July-November), when wild rice is in its mature form, and less likely to be impacted by temporary high flow and sulfate residuals.

5.4.2.3 Alternative C: No Build (No Action)

Under this alternative, no further project actions would take place. Seepage would continue to occur from the tailings basin into the Sandy River watershed. Tailings basin flow would continue to be directed through Admiral Lake, Little Sandy Lake, and Sandy Lake, into the Sandy River. Sulfate residual deposition to the Sandy River would likely increase, as tailings basin cells accumulate additional fine and coarse tailings and sulfate becomes more concentrated in the basin. Sulfate residuals downstream in the Sandy and Pike Rivers would likely increase and stay consistently high, creating a potentially chronic toxic condition for wild rice.

5.4.2.4 Alternative D: Alternative Technologies

This alternative addresses whether the life of the tailings basin can be extended through modification to the existing tailings basin operation and management. Possible modifications include:

- **Tailings Basin Perimeter Dike Raising**: This alternative would increase the effective water holding capacity of the existing tailings basin through increase of basin side-wall height. Increased water levels in the tailings basin could increase seepage discharge rates due to higher hydraulic head. This in turn could result in increased pollutant loading downstream. Sulfate residuals downstream would likely increase creating a potentially toxic condition for wild rice.

- **Water Level Reduction**: Water level reduction within the basin is considered possible through removal of water for routine mine operations and processes. Since this alternative is focused on water recycling and does not have a direct bearing on surface water quality or wild rice production, it is not discussed further.

- **Water Level Reduction through Process Water Adjustment:** This alternative suggests the reduction of tailings basin water levels through use of additional make-up water and process water recycling. This alternative has no impact on surface water or wild rice, and it therefore not addressed further.

- **West Tailings Basin Expansion:** This option suggests expansion of the existing basin structure to the west of the current basin. Since this alternative has no direct bearing on wild rice in the Sandy River, it is not considered further in the analysis.

5.4.2.5 Alternative E: Design Alternative

One additional design alternative is siphon placement, which may have a direct bearing on water temperatures within the receiving basins.

<u>**Siphon Placement**</u>

Basin water is to be discharged to the respective watershed(s) via a pipe siphon system that lifts water over the dike wall. Water from within the basin may be of varied temperature, depending on the time of year siphoned, and the depth from which the water is collected. If discharge water with a temperature different from the receiving water is released, thermal impacts to biota in the receiving system may occur.

5.4.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Baseline water quality data is elevated, due to continued seepage of tailings basin effluent into the Sandy River. Because of this, almost any additional discharge from the tailings basin would likely exceed water quality standards, as well as increased concentrations of tailings basin constituents such as sulfate, that will place additional potential stress on remaining rice plant communities. Therefore, long-term discharges would likely have substantial long-term impacts on the surrounding environment, including wild rice. Reduction of flow rates may reduce the immediate impact, but would likely create a prolonged, chronic impact condition. The end result would likely be adverse affects on the surrounding environment.

5.4.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Minntac is reviewing potential use of an SPB system to reduce sulfate and associated tailings basin constituents prior to discharge and has recently reported bench studies and reduced-scale field studies of the SPB system. The SPB effectively reduces process water sulfate 50-60%, depending on nutrient types added to the bioreactor. However, it has been found that, in the absence of associated mitigation measures such as direct discharge, the SPB does not concurrently reduce both sulfate along with TDS, chloride, and conductivity.

Further, metals concentrations in tailings water are generally low and are generally reduced to near detection limits by the SPB, but arsenic, barium, boron, and manganese increased. Both arsenic and manganese increased by an order of magnitude (0.003-0.125 and 0.175-2 mg/L, respectively). Since manganese is considered a plant micro-nutrient and no known negative consequences to wild rice from excess manganese is documented, effects of this increase on wild rice cannot be projected. Arsenic, however, is a metal with bioaccumulation potential and serious human health effects; increased arsenic discharge as a result of SPB concentration in tailings water is a concern. The SPB-dilution option is considered an "intermediate" between direct discharge of untreated effluent and direct discharge of SPB-treated effluent; whereby the SPB-treated effluent is pumped back in to the treatment pond. However, it may dilute some metals while concurrently concentrating other metals as well as macronutrients nitrogen and phosphorus in the tailings basin. If pre-SPB treated effluent is divided among several waterways, however, dilution of the concentrated effluent could occur. No data are presently available to model the potential impact to wild rice or other aquatic biota under this HCR scenario. Further evaluations should be directed at its reduction in tailings discharge, and toward examinations to determine if other metals such as methylmercury could also increase with SPB treatment, due to increased methylation associated with sulfate reduction. Potential mercury impacts associated with this technology are more definitively described in the *Mercury and Methylmercury Technical Memorandum.*

One VOC, methyl-isobutyl ketone (MIBK), was also determined to be present in SPB-treated discharge, but that VOC was found to be an additive to the ethanol used as a carbon source in the reactor during SPB testing in 2002. Specifically denatured ethanol containing methanol has been used in all subsequent field testing.

A potential for increased discharge of nitrogen and phosphorus has been suggested, resulting from nutrient addition to the SPB reactor. Depending on the total mass of unconsumed nitrogen and phosphorus , the potential for concentration of these macronutrients within the tailings basin increases. Additional research on nutrient types and quantities added to the reactor was defined in Appendix B of the *Focused Feasibility Study*. However, the context of this additional research was for determining nutrient effects on sulfate reduction and carbon utilization in the reactor. Properly designed and implemented tertiary treatment steps should also address the potential for and mitigation against receiving water eutrophication through excess macronutrient nitrogen and phosphorous release as constituents of the tailings discharge.

The proposed net effects of this tailings basin sulfate reduction for the Sandy River (under a direct SPB-treated discharge scenario) are summarized as follows:

- Sulfate levels in the tailings basin are expected to increase from 811 mg/L in 2004, to 868 mg/L in 2006, at the time of SPB implementation.
- Tailings basin water discharge (5,000 gpm) treated only with the SPB system would reduce tailings water sulfate to 675 mg/L.
- Discharge of chloride, hardness, TDS, specific conductance, and some metals, including arsenic, would increase.
- Nitrogen and phosphorus discharge could increase.
- Metals of human health concern, such as arsenic and mercury, could increase.

The SPB system, while a potentially useful tool to reduce sulfate would not, by itself, reduce sulfate to meet wild rice growth and production criteria within the Sandy River. As a "dilution" pre-treatment for effluent being discharged in to the tailings basin, it appears possible that the SPB might further concentrate some factors (metals, nutrients) within the basin. HCR may effectively distribute the discharge (treated or not) between different waterways, and may effectively dilute potential contaminants and reduce the potential for downstream scouring and associated water quality impacts. However, no quantitative data are presently available to determine the effectiveness of HCR in this regard. Multivariate evaluations relating the effect of HCR under natural conditions and under the SPB-treated or non-treatment scenarios should be concluded before a commitment to apply SPB and HCR are made.

5.5 AQUATIC RESOURCES

This section describes baseline conditions associated with the aquatic resources (Section 5.5.1) and potential impacts (Sections 5.5.2) within the Dark River and Sandy River watersheds associated with implementation of the proposed project or project alternatives. General aquatic resource characteristics were described previously in Section 2.5.5 and the location of the designated trout water is shown in Figure 2-10, *Location of Dark River Trout Water*. Detailed aquatic resources discussions, evaluations, and data sets are contained within the *Aquatic Resources Technical Memorandum.*

5.5.1 Aquatic Resources Baseline Conditions

Baseline conditions within the Dark River watershed are discussed in Section 5.5.1.1 and those within the Sandy River watershed are described in Section 5.5.1.2.

5.5.1.1 Dark River Watershed

Dark River

The Dark River flows approximately 21 miles, originating from black spruce swamps at the base of the Laurentian Divide. The upper portion of Dark River, upstream of Dark Lake, is predominantly low bog with some flat to gently rolling topography. In this segment, the Dark River is a warmwater stream. Downstream of Dark Lake the topography changes from flat terrain to a steep rolling forested area. Stream temperatures begin to decrease below Dark Lake, and continue downstream. Near County Road 65, the river receives coldwater inputs from several tributaries and springs, lowering the water temperature in this segment. In the downstream portion, the gradient increases and the substrate changes to rock, cobble, and sand. In the lower portion, the stream slows and the substrate is composed mainly of sand.

The Dark River is unique to this part of Minnesota, with groundwater inputs in the lower portions sustaining a coldwater trout fishery, in comparison to the warmwater streams typical of the area. There is evidence that the groundwater inflows are more substantial farther downstream of Dark Lake, with increasing numbers of intolerant fish and macroinvertebrate species that are sensitive to changes in water quality. Approximately one mile downstream of Dark Lake, the Dark River is listed as a Designated Trout Stream under Minnesota Rule 6264.0050 subpart 4. This reach is considered to be one of the best trout streams in the Grand Rapids Fisheries Management Area, and is a high management priority, with self-sustaining populations of brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta)*.

Brown trout and brook trout had been stocked historically. However, a MDNR 1990 survey noted evidence of natural reproduction of brown and brook trout. Stocking was discontinued in 1991 when populations appeared to be self-supporting.

Beaver impoundments and siltation are factors identified in past surveys that are degrading the Dark River. To improve trout habitat, extensive stream improvement projects including streambank stabilization, instream debris removal, installation of brush mats to increase velocities, removal of beaver, and removal of vegetation favorable to beaver, have been conducted on the Dark River.

Dark Lake is located approximately four miles downstream of the tailings basin, with an area of approximately 232 acres and a maximum depth of 31 feet. The majority (70 percent) of the lake is shallower than 15 feet. It is a soft water lake of moderate chemical fertility. The water is dark brown from swamp and bog drainage. The lake is thermally stratified during parts of the year. Beaver dams are common and may impede fish migration into and out of Dark Lake. Homes/cabins are scattered around the lake, with the highest concentration on the lake's west side.

The construction of the tailings basin has reduced the original drainage area of Dark Lake by approximately 19 percent (9.5 square miles). Previous reports have mentioned that lake levels have dropped about 0.4 feet and have become more stable. According to the *Lake Management Plan* (MDNR, 2000), there is no evidence that these changes have impacted the fishery. The lake's water chemistry has changed since the construction of the tailings basin with total alkalinity, total phosphorus, and sulfates all exhibiting increases since first being measured in 1955.

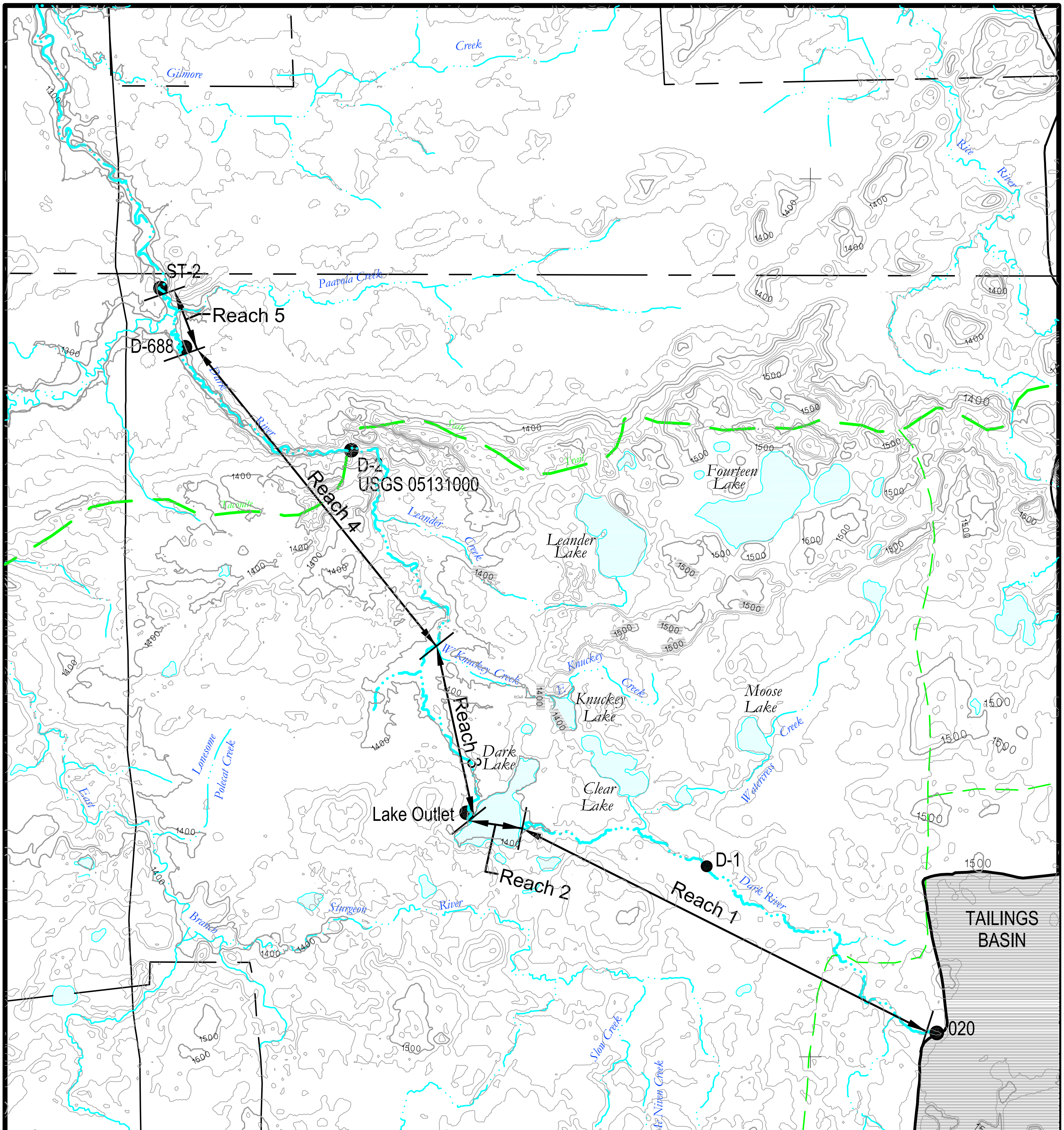
In order to assess the magnitude of impacts to the aquatic biological resources within the Dark River (including Dark Lake), the river was divided into the following five reaches as shown on Table 5.38, *Stream Reaches on the Dark River*.

Reaches were determined based on the habitat differences within each reach, the different biological communities expected to be found within each reach, the historical and current range of brook and brown trout, and physical features such as roads. Figure 5-14, *Reaches of the Dark River,* shows the locations of each reach and the segment of the Dark River that has been designated as trout waters. Reaches 1, 2 and 3 are upstream of groundwater inputs; Reaches 1, 2, and the upstream half of Reach 3 are not considered part of the designated trout water. Trout spawning habitat is likely limited to the spring area in Reach 4, approximately ¼ mile downstream of County Road 481.

TABLE 5.38 STREAM REACHES ON THE DARK RIVER			
Reach	**Description**	**Designated Trout Water?**	**Location**
1	Lotic – Headwaters; upstream of groundwater inputs	No	Minntac Tailings Basin to Dark Lake
2	Lentic – Upstream of groundwater inputs	No	Dark Lake
3	Lotic – Upstream of groundwater inputs	Yes[1]	Dark Lake to County Road 65
4	Lotic – Receives groundwater inputs; rock/cobble substrate; trout spawning habitat	Yes	County Road 65 to County Road 688
5	Lotic – Receives groundwater inputs; sand substrate, slower moving	Yes	County Road 688 to Sturgeon River confluence
Note: 1. The downstream half of Reach 3 is considered Designated Trout Stream.			

Dark River Fish Species: The Dark River fish species collected in each of the reaches are listed with relative abundance in Table 5.39, *Fish Species Collected from Dark River and Dark Lake*.

TABLE 5.39 FISH SPECIES COLLECTED FROM DARK RIVER AND DARK LAKE [1,2]						
Common Name	**Scientific Name**	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Black bullhead	*Ameriurus melas*	-	R	R	R	R
Black crappie	*Pomoxis nigromaculatus*	-	C	R	R	R
Blacknose dace	*Rhinichthys atratulus*	-	-	C	C	R
Blacknose shiner	*Notropis heterolepis*	-	-	R	R	R
Blackside darter	*Permian maculate*	(1 fish)	-	R	C	A
Bluegill	*Lopes macrochirus*	-	C	R	R	R
Brook stickleback	*Culaea inconstans*	-	-	R	R	R
Brook trout	*Salvelinus fontinalis*	-	-	R	A	-
Brown bullhead	*Ameiurus nebulosus*	-	R	-	R	-
Brown trout	*Salmo trutta*	-	R	R	C	-
Central mudminnow	*Umbra limi*	-	-	C	C	R
Chestnut lamprey	*Ichthyomyzon castaneus*	-	-	R	R	R
Common shiner	*Luxilus chrysocephalus*	-	-	R	C	A
Creek chub	*Semotilus atromaculatus*	-	R	A	A	C
Fathead minnow	*Pimephales promelas*	-	-	-	R	R
Golden shiner	*Notemigonus crysoleucas*	-	R	R	-	R
Iowa darter	*Etheostoma exile*	-	-	R	-	-
Johnny darter	*Etheostoma nigrum*	-	-	R	C	C
Lamprey sp.	*Ichthyomyzon sp.*	-	-	R	R	C
Largemouth bass	*Micropterus salmoides*	-	R	R	R	R
Log perch	*Percina caprodes*	-	-	R	R	R
Longnose dace	*Rhinichthys cataractae*	-	-	R	C	R
Mimic shiner	*Notropis volucellus*	-	-	-	-	R
Mottled sculpin	*Cottus bairdi*	-	R	R	C	C
Northern brook lamprey	*Ichthyomyzon fossor*	-	-	-	2 specimens positively identified from collections	
Northern pike	*Esox lucius*	-	C	R	R	R
Northern redbelly dace	*Phoxinus eos*	-	-	-	R	-
Pearl dace	*Margariscus margarita*	-	-	R	R	R
Pumpkinseed sunfish	*Lepomis gibbosus*	-	C	R	R	-
Rock bass	*Ambloplites rupestris*	-	R	R	R	R
Shorthead redhorse	*Moxostoma macrolepidotum*	-	R	-	R	-
Silver redhorse	*Moxostoma anisurum*	-	R	-	-	-
Spottail shiner	*Notropis hudsonius*	-	R	-	-	-
Tadpole madtom	*Noturus gyrinus*	-	-	R	-	-
Walleye	*Stizostedion vitreum*	-	C	-	-	-
White sucker	*Catostomus commersoni*	-	C	A	A	A
Yellow perch	*Perca flavescens*	-	A	C	R	R
Notes: 1. Reaches defined in Table 5.38. 2. R = rare, C = common, A = abundant, -= data not available						



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CONTOUR INTERVAL 20 FT.

REV. No.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Review	05/04	T.Leeson	K.Conrath	T.Leeson

MWH

PROJECT No.: 1003659.011816

AutoCAD FILE: Aquatic Ecology.dwg

SCALE: As Shown

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REACHES OF THE DARK RIVER

The data are based on the results of multiple surveys of the Dark River by the MDNR, and span two decades (1983, 1987, 1990, 1992, 1996, and 2000). During each assessment, fish were collected using a backpack shocker. In addition to assessments performed by the MDNR, a separate sampling effort was performed in 1999 for the MPCA at a series of transects downstream of County Road 688 (Reach 5) (MPCA, 1999). Dominant species from the previous assessments were blacksided darter, common shiner, creek chub, longnose dace, mottled sculpin, and white sucker. Brook trout were common in Reach 4 during previous assessments. Brown trout were also common in Reach 4, although not as common as brook trout. During the 2000 MDNR survey, brook trout were more abundant and both trout species were more widely distributed than in past assessments. The dominant fish species collected in each reach of the Dark River are given below.

Reach 1 Fish Species: A single blacksided darter was captured in this reach during previous sampling. No other fish were collected.

Reach 2 (Dark Lake) Fish Species: Dominant fish species in Dark Lake were black crappie, bluegill, northern pike, walleye, white sucker, and yellow perch. Brook trout were not collected, although a single brown trout was collected from the lake. There were no lamprey collected in this reach during past sampling events. Dark Lake (Reach 2) fish data were compiled from multiple surveys completed by the MDNR dating back to 1955 and spanning several decades.

Fish were collected using gillnets and trapnets; some seining was also performed. Yellow perch was typically the most abundant fish species collected in past surveys. White sucker, walleye, and pumpkinseed sunfish were also common species. According to the *Lake Management Plan for Dark Lake* (MDNR, 2000), walleye and northern pike are identified as the primary species of management for Dark Lake, with bluegill and black crappie as secondary management species. Dark Lake has not attained an abundant walleye population, although walleye have been stocked fairly regularly for the past twenty years. In 1992, ages were determined for several species. Northern pike, age 2, were the most frequent in net catches, whereas bluegill catches consisted of fish aged 3, 4, and 5 years. Fifty percent of black crappies were age 3; the remaining 50 percent were age 1 and 2.

Reach 3 Fish Species: Dominant fish species in this reach were white sucker, yellow perch, creek chub, central mudminnow, and blacknose dace. Brown trout were not observed within this reach, however a single brook trout and four chestnut lampreys were collected during past sampling events.

Reach 4 Fish Species: Brook trout was one of the dominant species collected within Reach 4, comprising nearly 13 percent of all fish captured. Other common species included creek chub, longnose dace, mottled sculpin, blacknose dace, blackside darter, central mudminnow, common shiner, and white sucker. Brown trout and chestnut lamprey were also collected from this reach during past sampling events.

Reach 5 Fish Species: Dominant fish species collected from Reach 5 were blackside darter, common shiner, mottled sculpin, and white sucker. Creek chub and Johnny darter were also common in the samples. Five brown trout were collected; brook trout were not collected. Chestnut lamprey and unidentified lamprey species were relatively common in the samples. Northern brook lamprey (two specimens) were collected and positively identified from the lower portions of the Dark River, although the precise location is unknown.

The biological or habitat information obtained for the headwaters upstream of Dark Lake (Reach 1) is very sparse. The only fish survey data available for this reach were collected during one sampling event in October 1983. During the survey, a 15-minute sampling effort using a backpack electrofishing unit yielded one blackside darter. This single sampling event in October provides insufficient information to adequately characterize the fish community in the headwaters of the Dark River because fish diversity and abundance in the upper portions of a stream or river is typically low during the fall months. Specific in-stream and near-stream habitat characteristics of the Dark River upstream of Dark Lake (Reach 1) have not been recorded in recent studies. During the 1983 MDNR survey, the substrate of the sampling site in Reach 1 was predominately muck and sand with smaller amounts of silt, gravel and rubble. The average width at the sampling site was approximately 25 feet, average depth approximately 1.7 feet (maximum depth 3.3 feet). Stream shading was moderate. In more recent studies, Montz et al. (2001) describes the general habitat of the upstream stretch (Reaches 1 and 3) as primarily sand with very little rock or cobble.

Chestnut lamprey (a parasitic lamprey) were collected during the 1990, 1992, and 1996 surveys from the Dark River Reaches 3, 4 and 5. Northern brook lamprey, a non-parasitic lamprey and a species of special concern in Minnesota and a USDA Forest Service Regional Forester's Sensitive Species, were collected in 2000 from the downstream portions of the Dark River.

Trout have not been collected in the headwaters of Reach 3 (downstream of Dark Lake), and were collected only once in the downstream segment of Reach 3. High water temperatures are likely above the optimum range, and often above the upper end of their required temperature range, especially in the upper portions of Reach 3 above the groundwater inputs. Trout may also be limited by the sand and silt substrate in Reaches 3 and 5, which likely limits invertebrate production from lack of habitat. Habitat appears to be a limiting factor in Reach 5 near the mouth, because the substrate in this reach is predominantly sand and silt. The 1999 transect study completed for the Minnesota PCA, characterized the substrate and habitat within Reach 5 at a series of 14 transects extending approximately 228 meters downstream of County Road 688. According to the survey, the substrate in this downstream stretch of the Dark River is largely sand, with smaller amounts of silt and detritus. This segment was characterized by a run, pool, or glide morphology; there were no riffle areas present.

The majority of trout spawning habitat appears to be concentrated in the downstream part of Reach 4 where more appropriate habitat is present (Figure 2-4). In this reach, the water temperature is lowered by groundwater input from several springs and tributaries, and the gradient increases. Gravel, cobble, and consolidated substrates increase and riffles and rapids become more common in this reach.

Dark River Macroinvertebrates: The macroinvertebrate community within the Dark River was sampled by the MDNR for two years (1999-2000) at six sites including one site upstream of Dark Lake, and five sites downstream of Dark Lake (Montz et al., 2001). The study found that the macroinvertebrate community in the Dark River is very diverse, with many taxa that are specific to coldwater streams that are intolerant of water quality degradation. The results of the study indicated that two different macroinvertebrate communities exist in the Dark River. Within Reaches 1 and 3, the macroinvertebates present suggest that the water quality is fair to good, with a macroinvertebrate community that is fairly diverse. Sites farther downstream of Dark Lake (Reaches 4 and 5) support greater numbers and diversity of intolerant taxa, which indicate that the water quality is good to very good. Pollution sensitive stoneflies, while present in low numbers throughout, are more abundant downstream, in Reaches 4 and 5. However, sensitive taxa, such as mayflies and caddisflies, are species-rich, and dominate the macroinvertebrate communities upstream and downstream of Dark Lake, comprising half of the invertebrate sample within each reach. Pollution tolerant midge larvae are also abundant throughout the Dark River. Appendix B of the *Aquatic Resources Technical Memorandum* provides a species list, showing the diversity of the macroinvertebrate community within each stream reach. Table 5.40, *Macroinvertebrates Surveyed in the Dark River and Dark Lake,* shows the densities of macroinvertebrates within each stream reach.

In a separate mussel survey, the creek heelsplitter (*Lasmigona compressa*), a species of special concern, was found live at one site on the Dark River (MDNR, 2002). The approximate location of the siting is not known.

The macroinvertebrate community in Dark Lake was sampled in 1999 as part of MDNR's two-year study of the Dark River. No results were reported for this sampling event. It was hypothesized from the assessment, that since Dark Lake provides the headwaters for the Dark River, and the macroinvertebrate community in the Dark River is diverse and healthy, that the macroinvertebrate community in Dark Lake is also healthy (MDNR Lake Management Plan, 2000).

TABLE 5.40
MACROINVERTEBRATES SURVEYED IN THE DARK RIVER AND DARK LAKE [1,2]

Common Name	Scientific Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Mayflies	*Ephemeroptera*	A	-	C	A	A
Caddisflies	*Tricoptera*	A	-	A	A	A
Stoneflies	*Plecoptera*	R	-	R	R	R
Dragonflies/damselflies	*Odonata*	R	-	R	R	R
Alderflies, dobsonflies	*Megaloptera*	R	-	R	R	-
Beetles	*Coleoptera*	R	-	C	R	R
True bugs	*Hemiptera*	R	-	R	R	R
True flies: midges	*Diptera: Chironomidae*	A	-	A	A	A
True flies	*Other Diptera*	C	-	C	C	C
Snails, bivalves, oligochaetes	*Non-insect taxa*	A	-	C	C	C

Notes:
1. Reaches defined in Table 5.38.
2. R = rare, C = common, A = abundant, -= data not available

Dark River Macrophytes: Macrophytes on the Dark River were surveyed during the 1983 MDNR fisheries survey. Table 5.41, *Aquatic Macrophytes Surveyed in the Dark River and Dark Lake,* shows the species and abundance of macrophytes along the Dark River. During the survey, most of the aquatic vegetation was located downstream of Dark Lake. Floating bur-reed, arrowhead, wild celery, sedges, and lesser duckweed were common aquatic species.

TABLE 5.41
AQUATIC MACROPHYTES SURVEYED IN THE DARK RIVER AND DARK LAKE[1,2]

Common Name	Scientific Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Arrowhead	*Sagittaria sp.*	-	P	C	R	C
Berchtold's pondweed	*Potamogeton berchtoldi*	-	C	-	-	-
Bladderwort	*Utricularia vulgaris*	-	O	-	-	-
Bluntleaf pondweed	*Potamogeton obtusifolius*	-	C	-	-	-
Bushy pondweed	*Potamogeton foliosus*	-	C	R	-	-
Canada waterweed	*Elodea Canadensis*	-	O	R	-	-
Claspingleaf pondweed	*Potamogeton perfoliatus*	-	-	R	R	-
Common bur-reed	*Sparganium eurycarpum*	-	-	R	R	R
Common cattail	*Typha latifolia*	-	O	R	-	-
Common reed	*Phragmites australis*	-	O	-	-	-
Flatstem pondweed	*Potamogeton zosteriformis*	-	C	-	-	-
Floatingleaf bur-reed	*Sparganium fluctuans*	R	O	C	C	R
Floatingleaf pondweed	*Potamogeton natans*	-	C	R	-	-
Greenfruited bur-reed	*Sparganium chlorocarpum*	-	R	-	-	-
Hardstem bulrush	*Scirpus acutus*	-	A	-	-	-
Largeleaf pondweed	*Potamogeton amplifolius*	-	C	R	-	-
Large yellow waterlily	*Nuphar varietatum*	-	C	R	-	-
Leatherleaf	*Chamaedaphne calyculata*	-	O	-	-	-
Lessor duckweed	*Lemna aequinoctialis*	-	-	C	R	-
Little white waterlily	*Nymphaea odorata*	-	C	R	-	-
Little yellow waterlily	*Nuphar microphyllum*		A	-	-	-

TABLE 5.41 AQUATIC MACROPHYTES SURVEYED IN THE DARK RIVER AND DARK LAKE[1,2]						
Common Name	**Scientific Name**	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Needlerush	*Eleocharis acicularis*	-	O	-	-	-
Northern water milfoil	*Myriophyllum exalbescens*	-	A	-	-	-
Nuttall's pondweed	*Potamogeton epihydrus*	-	O	-	-	-
Purple loosestrife	*Lythrum salicaria*	-	R	-	-	-
River pondweed	*Potamogeton sp.*	-	-	-	-	-
Sedge sp.	*Carex sp.*	-	O	C	-	R
Smartweed	*Polygonun sp.*	-	C	R	-	-
Spikerush	*Eleocharis sp.*	-	C	-	-	-
Star duckweed	*Lemna trisulca*	-	-	-	-	R
Stiff wapato	*Sagittaria rigida*	-	-	R	-	-
Swamp fivefinger	*Potentilla palustris*	-	O	-	-	-
Swamp horsetail	*Equisetum fluviatile*	-	C	-	-	-
Three-way sedge	*Dulichium arundinaceum*	-	R	-	-	-
Variable pondweed	*Potamogeton gramineus*	-	C	-	-	-
Water shield	*Brasenia schreberi*	-	O	-	-	-
Watercress	*Rorippa nasturtium-aquaticum*	-	-	-	R	-
White waterlily	*Nymphaea tubersa*	-	C	-	-	-
Whitestem pondweed	*Potamogeton praelongus*	-	O	-	-	-
Wild celery	*Valisneria Americana*	-	C	C	-	-
Wool grass	*Scirpus cyperinus*	-	-	-	R	-
Notes: 1. Reaches defined in Table 5.38. 2. R = rare, C = common, A = abundant, O = occasional, -= data not available						

Information on the macrophyte community of Dark Lake was obtained during fish surveys performed in 1955 and 1992. According to survey results, the macrophyte community in Dark Lake is fairly diverse, with 33 emergent, submergent, and floating species recorded. In 1955 (prior to construction of the tailings basin), common macrophyte species included spikerush, white and yellow water lily, wild celery, pondweed sp., and horsetail. At the time of the 1992 survey, approximately 20 percent of the lake surface was covered by emergent vegetation that consisted primarily of hardstem bulrush, spikerush, and swamp horsetail stands around the shoreline. Northern water milfoil and little yellow waterlily were abundant submergent species.

Sturgeon River

The Sturgeon River originates from three lakes (Sturgeon, South, and Side Lakes) in the Nashwauk Uplands 13 miles northwest of Chisholm, Minnesota. From the headwaters, the river flows easterly through a marshy floodplain eventually moving northward through mixed deciduous/coniferous forest and pastureland before flowing into the Little Fork River. The watershed within the impact area of influence flows through the Little Fox-Vermilion Uplands, a transitional landscape from the bedrock-controlled landscape in the east to the extensive peat lands in the west. The prevailing land use is forest management, although scattered small farms and cabins are present. Aspen dominates the landscape and is the primary tree species harvested. The Dark River, at 33,421 acres, is the fourth largest sub watershed draining to the Sturgeon River. The Sturgeon River is classified as a warmwater fishery, although an occasional trout is caught in the waters, likely to have migrated from the Dark River. Moderate to severe bank erosion has been noted in the past along the lower portions of the Sturgeon River.

Fisheries investigations have been performed periodically on the Sturgeon River dating back to the 1950s. Most recently, a biological sampling program was initiated in 2001 by MDNR in order to assess the river's fish and macroinvertebrate populations and to increase information about lake sturgeon, a species of special concern in Minnesota (Anderson, 2002). The general fish population was sampled by boat and barge electrofishing; lake sturgeons were surveyed using specialized gill nets and baited trot lines. Baseline data on the general fish and macroinvertebrate populations of the Sturgeon River, and the lake sturgeon population, were taken from the 2001 sampling effort. Detailed discussions pertaining to fish, macroinvertebrate, and macrophyte species within the Sturgeon River are contained within the *Aquatic Resources Technical Memorandum.*

Little Fork River

The Little Fork River originates southwest of Lake Vermilion in Lost Lake Swamp and traverses St. Louis, Itasca, and Koochiching Counties before its confluence with the Rainy River at the U.S./Canada border. At the headwaters, the drainage area is primarily alder, willow, and sedge swamp with a few small farms adjacent to the river. Further downstream, the farms disappear, soils change and a large uninhabited deciduous forest replaces the headwater swamp. Near the town of Little Fork, human occupation once again emerges. The Little Fork River is joined by 142 tributaries, the largest being the Sturgeon River that is 51 miles long and 100 feet wide at its confluence with the Little Fork River. The Little Fork River is a designated State Canoe Route. Detailed discussions pertaining to fish, macroinvertebrate, and macrophyte species within the Little Fork River are contained within the *Aquatic Resources Technical Memorandum.*

5.5.1.2 Sandy River Watershed

Sandy River

The Sandy River is a warmwater stream with an unconsolidated silty substrate, and is more typical of streams in this part of Minnesota. It flows from the headwaters of Sandy and Little Sandy Lakes moving east approximately seven miles where it drains into the Pike River. The Sandy River flows through many local wetlands and low-land boggy areas; wetland shrubs and overhanging vegetation often dominate the riparian area. During heavy rains, the transport of organic sediments to the stream from area wetlands occasionally results in problems with DO concentrations. The stream carries a high sediment load and is very discolored.

Upstream of Highway 53, the land is undeveloped with no residential development on or near the river; downstream of Highway 53, the existing land use is predominately residential, although the riparian areas remain intact and undeveloped. With the exception of the Minntac facility, there is no industrial development along the river.

In order to assess the magnitude of impacts to the aquatic biological resources within the Sandy River (and including Little Sandy and Sandy Lakes), the river was divided into the following five reaches:

- Reach 1 – Tailings basin to Little Sandy Lake
- Reach 2 – Little Sandy and Sandy Lakes
- Reach 3 – Sandy Lake to the Sandy River/Pike River Confluence
- Reach 4 – Sandy River/Pike River confluence to Lake Vermilion
- Reach 5 – Lake Vermilion

Figure 5-15, *Reaches of the Sandy and Pike River*s, shows the location of each reach.

Sandy River Fish Species: The 1854 Authority, in conjunction with the Fond du Lac Band have been gathering biological and habitat data on the Sandy and Pike Rivers. In 2002, the fish fauna in the Sandy River was sampled at two sites upstream of County Road 805 by the Fond du Lac Reservation (Field data sheets for the 2002 sampling season provided by the Fond du Lac Reservation).

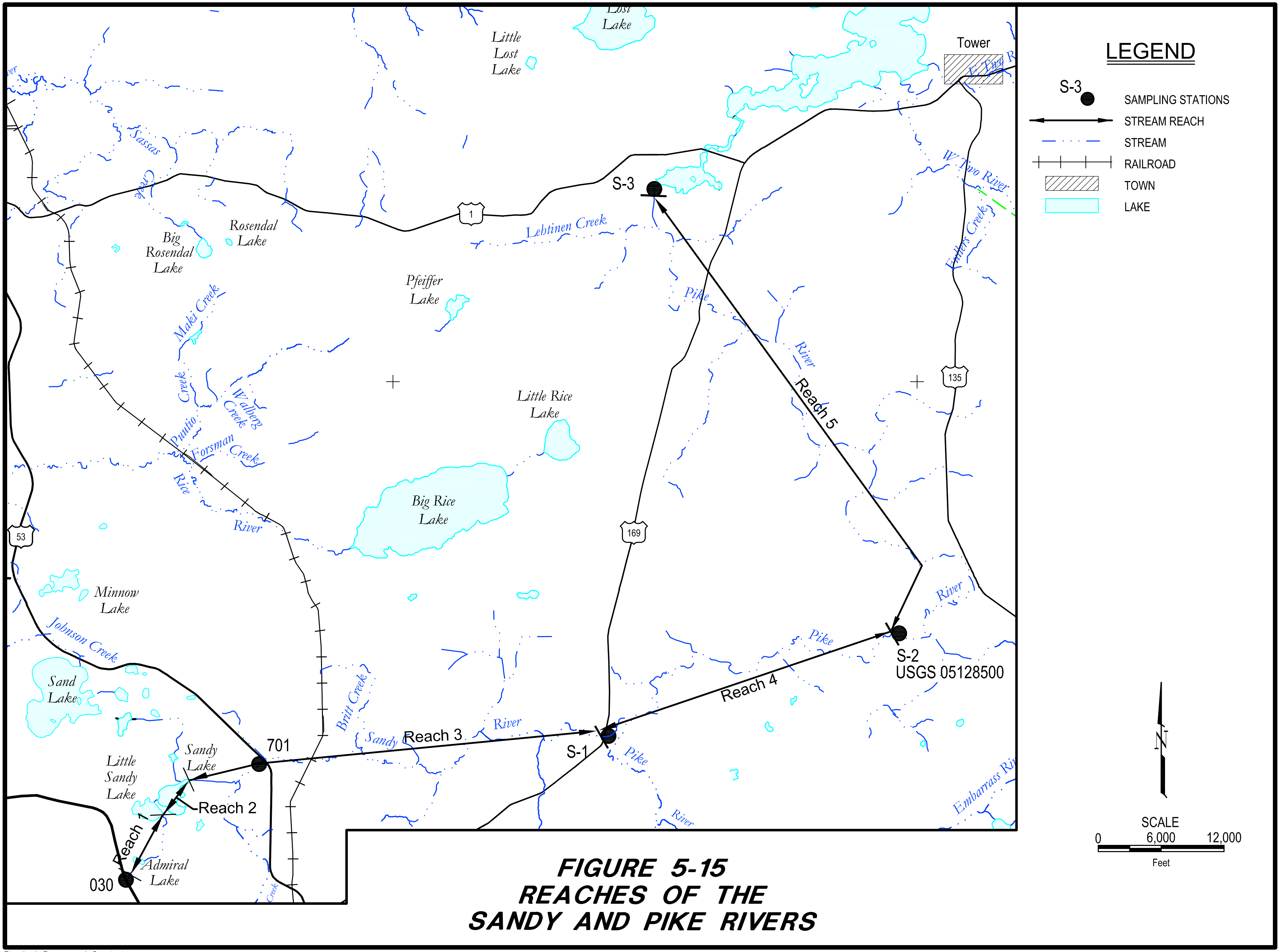


FIGURE 5-15
REACHES OF THE
SANDY AND PIKE RIVERS

Fig 5-15 Reaces of Sandy.dwg

Fish species collected on the Sandy River during the 2002 sampling event are listed in Table 5.42, *Fish Species Collected from the Sandy River*. Available data from the 2002 sampling season is somewhat limited since, at the time of the survey, northern Minnesota had received several severe storm events and the Sandy River was running at or near bank-full stage, and likely represented atypical conditions. The site on the Pike River was not sampled. Macroinvertebrate sampling did not occur at any sites, and minimal aquatic vegetation sampling was performed. Habitat descriptions at the sample sites were not recorded during this survey. Fish densities were low for all species collected. Only twelve specimens were captured during sampling; Johnny darter was the most abundant species.

TABLE 5.42
FISH SPECIES COLLECTED FROM THE SANDY RIVER

Common Name	Scientific Name	Density[1]
Blacknose dace	*Notropis heterolepis*	R
Burbot	*Lota lota*	R
Central mudminnow	*Umbra limi*	R
Johnny darter	*Phoxinus neogaeus*	R
White sucker	*Catostomus commersoni*	R

Notes:
1. R = rare, C = common, A = abundant

Sandy River Macroinvertebrates: Macroinvertebrates were collected by MDNR over two years (1999 to 2000) from two sites on the Sandy River; Site 1, downstream of Sandy Lake, and Site 2, upstream of the confluence of the Sandy and Pike Rivers. Macroinvertebrates were not collected by the Fond du Lac Band during their 2002 sampling event on the Sandy River. The MDNR study results indicate that the macroinvertebrate community in the Sandy River is more typical of warmwater streams, with less diversity, fewer intolerant taxa, and fewer numbers of insects in comparison to the Dark River. Site 1, downstream of Sandy Lake, had slow current and a soft unconsolidated substrate. In addition, while the river substrate was generally soft sediment, the substrate at Site 2 had more sand with some rock and cobble, and a swifter current. Midges were the dominant macroinvertebrate collected from Site 1 during the macroinvertebrate study, comprising over 40 percent of the organisms collected. Mayflies and non-insect taxa, such as snails, bivalves, oligochaetes, and leeches were the next most abundant groups; together comprising over 40 percent of the sample.

At Site 2, upstream of the Sandy and Pike River confluence, midges, non-insect taxa, and mayflies also made up the vast majority of the macroinvertebrate community. However, at this site nearly half of the macroinvertebrate community was composed of mayflies; non-insect taxa and midges were abundant, but were present in lower numbers. Appendix B of the *Aquatic Resources Technical Memorandum* provides a species listing of the macroinvertebrate community downstream of Sandy Lake (Site 1) and upstream of the Sandy River and Pike River confluence (Site 2). Table 5.43, *Macroinvertebrates Collected from the Sandy River 1999 to 2000,* provides the densities of the different macroinvertebrate taxa collected from the Sandy River.

Sandy River Macrophytes: Macrophyte data for the Sandy River were not available.

<u>**Pike River**</u>

The Sandy River drains into the Pike River approximately 10 miles downstream of the Minntac tailings basin. Downstream of the Sandy River tributary, the Pike River flows northerly approximately 16 miles eventually flowing into Lake Vermilion. Land adjacent to the Pike River is characterized by low-land bogs and a treeless riparian zone intermixed with upland forested areas. Land use along the Pike River is predominately rural residential; with many areas throughout the reach used for agriculture, primarily haying and pasture fields (Barr Engineering, 2001). Near Lake Vermilion, residential and some commercial development become common.

TABLE 5.43 MACROINVERTEBRATES COLLECTED FROM THE SANDY RIVER 1999-2000			
Taxa	**Common name**	**Site 1[1,3]**	**Site 2[1,3]**
Ephemeroptera	Mayflies	A	A
Tricoptera	Caddisflies	R	R
Plecoptera	Stoneflies	R	R
Odonata	Dragonflies/damselflies	C	R
Megaloptera	Alderflies, dobsonflies	-	-
Coleoptera	Beetles	R	R
Hemiptera	True bugs	R	R
Diptera: Chironomidae	True flies: Midges	A	A
Other Diptera	True flies	R	R
Non-insect taxa	Snails, bivalves, oligochaetes	A	A

Notes:
1. Site 1 – Downstream of Sandy Lake
2. Site 2 – Upstream of Sandy River and Pike River confluence.
3. R = rare, C = common, A = abundant

There is a walleye hatchery managed by MDNR at the mouth of the Pike River/Pike Bay where it flows into Lake Vermilion. In addition to the hatchery, this site is one of the two largest walleye egg taking operations in the state.

Fish were sampled in 1982 and 2002 on the Pike River. The fish species collected in these surveys are listed in Table 5.44, *Fish Species Collected from Pike River*. The 1982 survey, which used a series of 22 trapnets set on the Pike River between County Road 367 and Highway 169, was conducted specifically to sample the following species: walleye, white sucker, northern pike, rock bass, and yellow perch. Other fish species were not recorded. Sucker species were the dominant fish species encountered during the survey. During the 2002 survey performed by the Fond du Lac Band, a more comprehensive approach was taken, with electroshocking techniques used to characterize the fish fauna at five sites along the Pike River at a section extending downstream of Highway 169 to Lake Vermilion (field data sheets for the 2002 sampling season provided by the Fond du Lac Reservation). Like the Sandy River, the Pike River was sampled under high flows and the results may not be representative of normal conditions. Fish densities were low, although greater numbers were collected from the Pike River than from the Sandy River. Burbot was the most abundant species collected, with Johnny darter, central mudminnow, longnose dace, and yellow perch also common in samples.

TABLE 5.44 FISH SPECIES COLLECTED FROM PIKE RIVER		
Common Name	**Scientific Name**	**Density[1]**
Burbot	*Lota lota*	C
Blacknose dace	*Notropis heterolepis*	R
Central mudminnow	*Umbra limi*	C
Finescale dace	*Phoxinus neogaeus*	R
Johnny darter	*Etheostoma nigrum*	C
Longnose dace	*Rhinichthys cataractae*	C
Northern pike	*Esox lucius*	R
Rock bass	*Ambloplites rupestris*	R
Spottail shiner	*Notropis hudsonius*	R
Walleye	*Stizostedion vitreum*	R
White sucker	*Catostomus commersoni*	C
Yellow perch	*Perca flavescens*	C

Notes:
1. R = rare, C = common, A = abundant

Macroinvertebrates were collected by MDNR in 2000, from one site on the Pike River (Montz et al., 2001). Macroinvertebrates were not collected by the Fond du Lac during 2002 sampling. According to MDNR's data, taxa richness was significantly lower in the Pike River in comparison to the Dark River. Pike River results, however, were based on a single sampling event at one site, which provides a weak comparison to the intensive two year sampling program on the Dark River. Pike River macroinvertebrate samples were dominated by mayflies, which comprised over half of the sample. Midges were the second most abundant macroinvertebrate collected. During the fish survey on the Pike River in 2002, mussels were documented in the area, although they were not identified. The habitat at the sampling location was sand, rock, and cobble, with some instream vegetation. Appendix B of the *Aquatic Resources Technical Memorandum* provides a species listing of the macroinvertebrate community collected from the Pike River. Table 5.45, *Macroinvertebrates Collected from the Pike River 2000,* shows the abundance of different macroinvertebrate taxa collected.

TABLE 5.45
MACROINVERTEBRATES COLLECTED FROM THE PIKE RIVER 2000

Taxa	Common name	Density[1]
Ephemeroptera	Mayflies	A
Tricoptera	Caddisflies	R
Plecoptera	Stoneflies	R
Odonata	Dragonflies/damselflies	R
Megaloptera	Alderflies, dobsonflies	-
Coleoptera	Beetles	R
Hemiptera	True bugs	R
Diptera: Chironomidae	True flies: Midges	A
Other Diptera	True flies	R
Non-insect taxa	Snails, bivalves, oligochaetes	C

Notes:
1. R = rare, C = common, A = abundant, -= data not available

Some macrophytes were recorded from the Pike River during the 2002 fish sampling event, the majority of which were documented from a sampling site just upstream of Lake Vermilion. The aquatic macrophytes were found to be mostly emergent species with some submersed and floating species. Aquatic macrophytes include: reed canary grass (*Phalarus arundinacea*), wool grass (*Scirpus cyperinus*), whorl-leaf watermilfoil (*Myriophyllum verticillatum*), sedges (*Carex sp.*), rushes (*Juncus sp.*), coontail (*Cerataphyllum demersum*), eel grass (*Vallisneria sp.*), American mannagrass (*Glyceria grandis*), and yellow pond lily (*Nuphar lutea*). Macrophyte abundance is unknown.

Sandy Lake

Sandy Lake is located approximately 1.5 miles from the tailings basin and is the headwaters for the Sandy River. It is connected to Little Sandy Lake by a deep canal. Historically it appears that both lakes were one lake before a road was built separating the lakes. Sandy Lake is approximately 114 acres with a maximum depth of three feet. Soft organic muck comprises the bottom of the main body of the lake. Periodic checks on winter oxygen levels indicate that fish winterkill occurs occasionally.

Sandy Lake is predicted to be a fairly mesotrophic lake due to it's shallowness and relatively short flushing rate. Both predicted concentrations of chlorophyll and total phosphorus (14 and 40 μg/L, respectively) are high as compared to reference lakes (4-10 and 14-27 μg/L, respectively). However, the reference lake data set likely did not include lakes as shallow as Sandy Lake. Based on the geomorphology of Sandy Lake, it is likely that nutrient concentrations are naturally higher than the ecoregion reference lakes.

In 1966, prior to mine construction, a Game Lake Survey was performed to characterize Sandy Lake and to visually document the biological resources of the lake. During this survey, minnows and northern pike were the only fish sighted. In 1987, a Fisheries Lake Survey was performed using one gillnet and two trapnets at each sampling location. Northern pike was the most abundant species collected in 1987, observed in above average numbers. White sucker and yellow perch were present in below average numbers. Table 5.46, *Fish Species Collected from Sandy Lake*, shows the fish species observed during these previous surveys.

TABLE 5.46 FISH SPECIES COLLECTED FROM SANDY LAKE		
Common Name	**Scientific Name**	**Density[1]**
Minnows	*Cyprinidae*	C
Northern pike	*Esox lucius*	C
White sucker	*Catostomus commersoni*	R
Yellow perch	*Perca flavescens*	R
Notes: 1. R = rare, C = common, A = abundant		

Macroinvertebrate data were not available for Sandy Lake.

There are no recent surveys that document the aquatic vegetation in Sandy Lake. During the 1966 Game Lake Survey performed prior to mine construction, approximately 80 percent of the lake area was covered by standing emergent vegetation. A list of aquatic macrophytes found in Sandy Lake is presented in Table 5.47, *Aquatic Macrophytes Surveyed in Sandy Lake*. Wild rice was the most common plant species encountered, covering a large percentage of the lake surface. Yellow waterlily and little yellow waterlily were common submergent plants. Submerged vegetation was scarce due to the dark bog-stained water preventing sunlight penetration.

TABLE 5.47 AQUATIC MACROPHYTES SURVEYED IN SANDY LAKE	
Common Name	**Scientific Name**
Floating bur-reed	*Sparganium fluctuans*
Greenfruited bur-reed	*Sparganium chlorocarpum*
Little yellow waterlily	*Nuphar microphyllum*
Needlerush	*Eleocharis acicularis*
Pickeralweed	*Pontederia cordata*
Stiff wapato	*Sagittaria rigida*
White waterlily	*Nymphaea tuberosa*
Wild rice	*Zizania aquatica*
Yellow waterlily	*Nuphar variegatum*

Little Sandy Lake

Little Sandy Lake drains into Sandy Lake through a deep canal that connects the two water bodies. It is smaller than Sandy Lake with an area of 83 acres and a maximum depth of three feet. It has similar physical and chemical characteristics to Sandy Lake: an organic muck bottom, low DO levels that cause occasional winterkill, and dark brown water from bog staining.

A Game Lake Survey was also completed for Little Sandy Lake in 1966 prior to mine construction, and a Fisheries Lake Survey was performed in 1987. Similar to Sandy Lake, minnows and northern pike were common species in Little Sandy Lake during the 1966 survey. White sucker was the most abundant species collected in 1987 although northern pike, white sucker, and yellow perch were all present in above average numbers. Black bullheads were observed during 1987 sampling, but were not collected. Table 5.48, *Fish Species Collected from Little Sandy Lake,* shows the fish species observed during previous surveys.

TABLE 5.48 FISH SPECIES COLLECTED FROM LITTLE SANDY LAKE		
Common Name	**Scientific Name**	**Density[1]**
Black bullhead	*Ameriurus melas*	Data unavailable
Minnows	*Cyprinidae*	C
Northern pike	*Esox lucius*	C
White sucker	*Catostomus commersoni*	C
Yellow perch	*Perca flavescens*	C
Notes : 1. R = rare, C = common, A = abundant		

Macroinvertebrate data were not available for Little Sandy Lake.

Similar to Sandy Lake, there are no recent surveys that document the aquatic vegetation in Little Sandy Lake. During the 1966 Game Lake Survey performed prior to mine construction, approximately 50 percent of the lake area was covered by standing emergent vegetation. Wild rice stands were of moderate density throughout the lake. Beds of spikerush were common along the shoreline margin. Floating bur-reed and little yellow waterlily were common submergent species. According to the survey report, the dark bog staining common in Sandy Lake and Little Sandy Lake prevents sufficient sunlight penetration to allow adequate growth of submerged aquatic vegetation. Table 5.49, *Aquatic Macrophytes Surveyed in Little Sandy Lake,* shows the plant species documented from the 1966 survey.

TABLE 5.49 AQUATIC MACROPHYTES SURVEYED IN LITTLE SANDY LAKE	
Common Name	**Scientific Name**
Floating bur-reed	*Sparganium fluctuans*
Floatingleaf pondweed	*Potamogeton natans*
Little yellow waterlily	*Nuphar microphyllum*
Needlerush	*Eleocharis acicularis*
Pickeralweed	*Pontederia cordata*
Spikerush	*Eleocharis palustris*
Stiff wapato	*Sagittaria rigida*
Swamp horsetail	*Equisetum fluviatile*
Variableleaf pondweed	*Potamogeton gramineus*
White waterlily	*Nymphaea tuberosa*
Wild rice	*Zizania aquatica*
Yellow waterlily	*Nuphar variegatum*

Lake Vermilion

Lake Vermilion (Figure 2-7) is included in the statewide Large Lake Program, which provides for intensive fisheries management of the ten largest lakes in Minnesota. The lake is located in the Northern Lakes and Forests ecoregion and the Rainy River basin. It has an area of 40,557 acres with a maximum depth of 76 feet. The lake is point source impacted, and is only partially supporting its designated uses. As previously noted, MDNR manages a walleye hatchery at the mouth of the Pike River where it flows into Lake Vermilion.

Effective May 10, 2003, new regulations established slot limits for northern pike in several of Minnesota's popular fishing lakes, including Lake Vermilion. Under the new regulations, northern pike between 24 and 36 inches must be returned immediately to the water. This is part of a statewide initiative by MDNR to increase the size of northern pike so that more reach trophy-size dimensions. Approximately one-third of the northern pike caught on Lake Vermilion in 2002 would have fallen within the new protected category.

Population assessments for fish are performed annually on Lake Vermilion by MDNR. In 2001 (most recent data posted on the MDNR website), dominant species were bluegill, yellow perch, walleye, and tullibee *(Coregonus artedii)* (*MDNR web address: http://www.onthelake.net/fishing/vermilionreport.htm*). During the last five years, walleye and northern pike were stocked annually; muskellunge were stocked every other year. Table 5.50, *Fish Species Collected from Lake Vermilion,* shows the species collected during the 2001 annual survey.

According to MDNR, macroinvertebrate and aquatic macrophyte surveys have not been performed for Lake Vermilion, although it is a future goal for the agency (personal communication with Joe Geis and Duane Williams, MDNR, July 9, 2004).

TABLE 5.50
FISH SPECIES COLLECTED FROM LAKE VERMILION

Common Name	Scientific Name	Density
Black crappie	*Pomoxis nigromaculatus*	R
Bluegill	*Lepomis macrochirus*	A
Brown bullhead	*Ameiurus nebulosus*	C
Burbot	*Lota lota*	R
Golden shiner	*Notemigonus crysoleucas*	R
Largemouth bass	*Micropterus salmoides*	R
Muskellunge	*Esox masquinongy*	R
Northern pike	*Esox lucius*	R
Pumpkinseed sunfish	*Lepomis gibbosus*	C
Rock bass	*Ambloplites rupestris*	C
Smallmouth bass	*Micropterus dolomieu*	R
Tullibee (Cisco)	*Coregonus artedii*	C
Walleye	*Stizostedion vitreum*	A
White Sucker	*Catostomus commersoni*	R
Yellow Perch	*Perca flavescens*	A

Notes:
1. R = rare, C = common, A = abundant

5.5.2 Aquatic Resources Impacts

This section documents the potential impacts, both quantitatively and qualitatively, to aquatic resources associated with implementation of the proposed Alternative A, the No Build Alternative, or the Action Alternatives described previously in Section 4.0. Further details pertaining to potential aquatic resources impacts are included in the *Aquatic Resources Technical Memorandum.*

5.5.2.1 Alternative A: Proposed Project (Proposed Action)

Dark River/ Sturgeon River Watershed

The hydrological and water quality impacts of the proposed project on the aquatic biota in the Dark River/Sturgeon River watershed from the point of the Minntac tailings basin discharge into the Dark River to the confluence with the Sturgeon River were evaluated. Adverse impacts resulting from the proposed project are expected to be more severe in the reach of the Dark River from the point of discharge to Dark Lake than in any other part of the watershed. Unfortunately, the data on the aquatic biota and aquatic habitat in that reach are quite limited. Essentially no information on the aquatic habitat or biota is available for the segment of the Dark River from the point of the proposed discharge to the State Route 25 river crossing, located about 0.7 miles upstream of Dark Lake. Available information on the aquatic habitat and aquatic fauna in the segment of the river between State Route 25 and Dark Lake is based on a single sampling event in 1983.

The hydrological and water quality impacts resulting from the proposed project on the fish and macroinvertebrate communities in the segment of the Dark River between State Route 25 and Dark Lake are expected generally to be minor. Increased flows resulting from the proposed project would be beneficial to the fish and macroinvertebrate communities that may be present in the segment during normally low-flow periods, but may result in shifts of habitat usage by fish during other periods of the year.

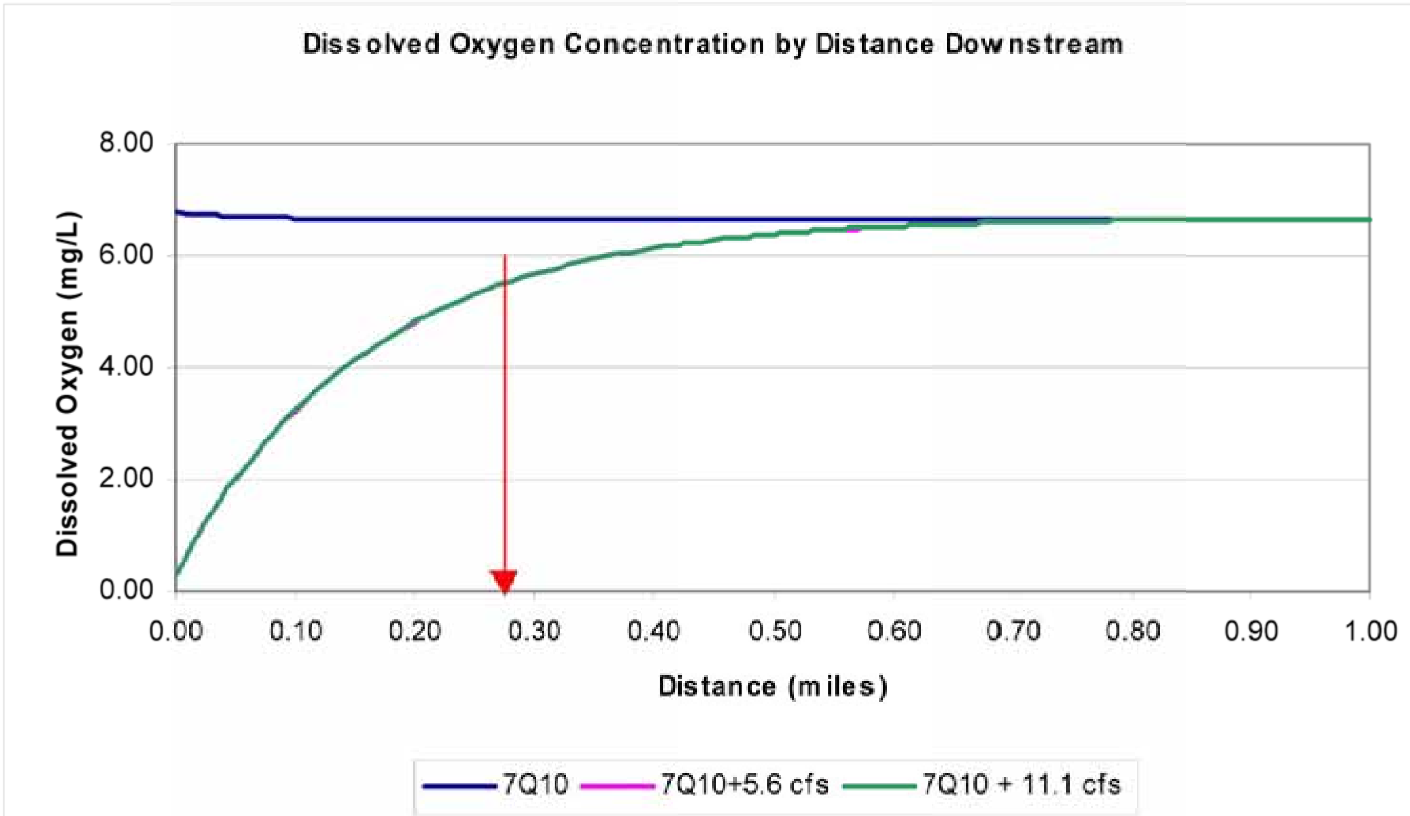
Substrate characteristics in the reach would likely change in response to the increased flows, especially during the initial period of increase. Increased velocities and reduced residence time may increase scouring and nutrient replenishment that can result in a shift of the community structure of the stream.

Under 7Q10 low-flow conditions, most concentrations would be higher for the parameters of concern and impacts would extend farther downstream. However, the magnitude of the impacts would not change under the low flow conditions. Nitrogen and phosphorus concentrations would be more similar to the chemistry of the tailings basin, which is low in phosphorus and high in nitrogen (compared to local surface waters). Consequently, the impacts would be similar to those under average flow conditions with slightly higher nitrogen concentrations and slightly lower phosphorus concentrations. The magnitude of these differences would not change the potential impacts to the aquatic ecology of the stream. Dissolved oxygen impacts were analyzed for low-flow conditions and the impacts would be similar under 7Q10 streamflow.

Adverse impacts to the fish and macroinvertebrate communities that may be present in the segment resulting from changes in temperature or DO produced by the proposed project are not expected. Reaeration of the water discharged from the tailings basin would occur rather quickly, as indicated in Figure 5-16, *Reaeration of Tailings Basin Water Discharged to the Dark River as a Function of Travel Distance Downstream*. However, the effects of other chemical constituents of the proposed discharge on the biota that may be present are uncertain, and may be adverse. The uncertainty derives from the absence of available information on the effects of these constituents at the levels that could occur in the segment. The hydrological and water quality impacts upstream of State Route 25 cannot be determined because of the absence of available information on the aquatic habitats and fauna in that segment of the Dark River.

The hydrological and water quality impacts resulting from the proposed project on the fish and macroinvertebrate communities in Dark Lake are expected to be generally beneficial. Increased flows resulting from the proposed project would increase the available fish and macroinvertebrate habitat during normally low-flow periods. Temperature and DO impacts resulting from the proposed project are not expected to be adverse to the aquatic biota in Dark Lake. However, the impacts of the chemical constituents of the proposed discharge on the Dark Lake biota cannot be determined because of insufficient data on the concentrations of those constituents in Dark Lake. High total inorganic nitrogen (TIN) concentrations as a result of discharge may have some adverse impacts on the community structure, however it is unclear as to the extent or magnitude of the impacts. It is likely that the impacts would be minimal.

Downstream of Dark Lake, the proposed project would have adverse impacts on the trout populations of the Dark River.



NOTE: THE ARROW REPRESENTS THE 5.5 mg/L DO STANDARDS FOR WARM WATER FISHERIES PLUS A 0.5 mg/L ADDITION TO ACCOUNT FOR DO SAG FROM DIURNAL FLUCTUATIONS. CONVERGENCE OF THE LINES REPRESENTS THE DISTANCE WHERE EQUILIBRIUM IS ACHIEVED. BOTH THE 5.6 AND 11.1 cfs SCENARIOS HAD THE SAME REAERATION CURVE.

FIGURE 5-16
REAERATION OF TAILINGS BASIN WATER DISCHARGED TO THE DARK RIVER AS A FUNCTION OF TRAVEL DISTANCE DOWNSTREAM

FILENAME: Fig 5-16 TB Wtr Dark Rvr.dwg

Although the increased flows resulting from the proposed project would have little adverse impacts on the fish and macroinvertebrate communities, and may even be beneficial under low-flow conditions, the changes in stream temperature produced by those flows would make the habitat unsuitable for trout. The proposed discharge would dilute or suppress groundwater inputs to the Dark River, thereby increasing the river temperatures during the warm summer months. Based on the thermal modeling of the trout water portion of the Dark River, the increases would exceed the upper avoidance temperatures of the trout species in that portion and would reduce or eliminate the thermal refugia utilized by those species under existing conditions.

The increases in temperature could also have an adverse impact on the coldwater-associated macroinvertebrates and the cool water fish species present in the trout water reach of the river.

In winter, the increased flow would dilute, or suppress the warmer groundwater inflow, allowing the portion of the river receiving such inflows to reach freezing temperatures. Under certain meteorological conditions, frazile and anchor ice could form, restricting the available habitat in that portion of the river. Additionally, anchor ice formation can freeze, smother, and (during thaws) erode benthic aquatic life such as fish eggs and invertebrates. Thus, increased winter discharge may impact the aquatic resources of the lower Dark River due to increased ice formation.

Although no adverse impacts from reduced levels of DO are expected downstream of Dark Lake, the effects of the chemical constituents of the proposed discharge are uncertain because of insufficient information. However, based on available data, the impacts of those constituents are not expected to be adverse for most of the aquatic biota downstream of Dark Lake.

The chronic effects on the aquatic biota from long-term exposure to increased concentrations of the water quality parameters of concern cannot be determined because no chronic toxicity data on the tailings basin discharge are available. The data are necessary to determine the impacts on the fish and macroinvertebrates from long-term exposure to the parameters of concern. However, the tailing basin discharge must be designed so that chronic toxicity does not become an issue.

Sandy River/Pike River Watershed

The hydrological and water quality impacts of the proposed project on the aquatic biota in the Sandy River/Pike River watershed from the point of the Minntac tailings basin discharge into the Sandy River to Lake Vermilion were evaluated.

Adverse impacts are expected to be more severe in the reach of the Sandy River from the point of discharge to Little Sandy Lake than in any other part of the watershed. Unfortunately, no data on the aquatic biota or aquatic habitat in that reach are available. Consequently, the impacts of the proposed project in this reach cannot be determined. However, sufficient data are available to evaluate most of the impacts on the aquatic biota in Little Sandy Lake/Sandy Lake, and in the downstream reaches of the Sandy River/Pike River to Lake Vermilion.

The hydrological impacts to Little Sandy Lake/Sandy Lake are expected to be generally beneficial, especially during periods of low-flow and during the winter. The increased flows would provide more aquatic habitat during low-flow periods and should reduce conditions producing winterkill in Little Sandy Lake/Sandy Lake. Adverse water quality impacts to Little Sandy Lake/Sandy Lake are expected to be minimal. The aquatic biota in these lakes consist of warm water/cool water species that can readily adapt to temperature changes that may occur as a result of the proposed project. In addition, reaeration of the water discharged from the tailings basin would occur rather quickly, as indicated in Figure 5-17, *Reaeration of Tailings Basin Water Discharged to the Sandy River as a Function of Travel Distance Downstream.*

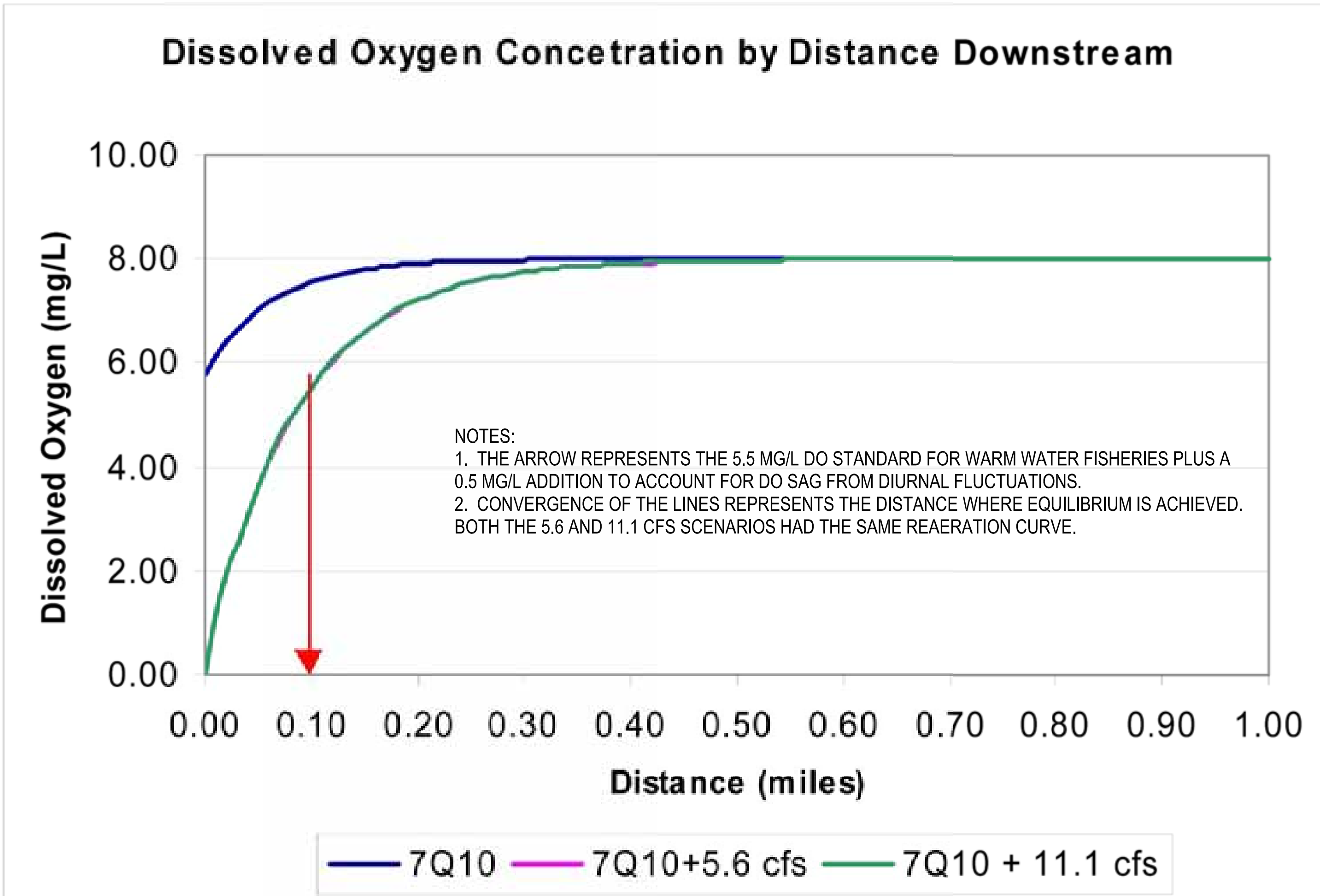


FIGURE 5-17
REAERATION OF TAILINGS BASIN WATER DISCHARGED TO THE SANDY CREEK AS A FUNCTION OF TRAVEL DISTANCE DOWNSTREAM

FILENAME: Fig 5-17 TB Wtr Sandy Ck.dwg

No adverse impacts resulting from reduced levels of DO or increased concentrations of chemical constituents of the proposed discharge are expected. High TIN concentrations as a result of discharge may have some adverse impacts on the community structure, however it is unclear as to the extent or magnitude of the impacts. It is likely that the impacts would be minimal.

Downstream of Little Sandy Lake/Sandy Lake, the impacts of the proposed project are expected to be less than in the lakes. Hydrological and water quality changes in the Sandy River/Pike River would diminish with distance from the lakes. Consequently, no adverse impacts to the aquatic biota resulting from the proposed project are expected in the Sandy River/Pike River from Little Sandy Lake/Sandy Lake to Lake Vermilion. However, the absence of information on the effects of the chemical constituents of the proposed discharge on the aquatic biota of the Sandy River/Pike River result in some uncertainty in the impact analysis.

Potential impacts to wild rice were discussed previously in Section 5.4 of this EIS and further information is presented in the *Wild Rice Technical Memorandum*. As discussed in the Technical Memoranda, a feed-back system of "internal eutrophication" may occur in an aquatic system exposed to excess sulfate. As sulfate levels increase under reducing sediment conditions, hydrogen sulfide (H_2S) is produced. As H_2S levels in sediment increase, phosphorus, once bound, is liberated from the sediment, resulting in increased water column phosphorus levels and movement of the system toward a state of increased eutrophication. This, in turn, could result in minor impacts to the fish and aquatic macroinvertebrates in the Sandy River, which are relatively tolerant of such conditions.

5.5.2.2 Alternative B: Alternative Sites

Laurentian Creek

DO: There are no existing flow data for Laurentian Creek and therefore impacts to DO cannot be evaluated. The potential impacts would be similar to those in Sandy Creek. There may be more oxygenated water in the channel at Laurentian Creek, which may lessen the impacts.

Aquatic Life: Although the aquatic biota are not known for Laurentian Creek, the impacts are expected to be similar to the impacts identified for the Sandy River.

Aquatic Ecology: There are no data available for nutrients in Laurentian Creek. However, it is safe to assume that there would be elevated TIN concentrations as a result of high TIN concentrations in the tailings basin.

Multiple Watersheds

DO: Dividing the 11.1 cfs among multiple watersheds, including seasonal limitations to protect specific water quality parameters, is a complex proposition. However, DO concentrations could be suppressed at each of the discharge points, although the distance downstream where the impact would occur would vary. Under this scenario, appropriate mitigation would be needed to maintain DO levels.

Aquatic Life: According to the Surface Water Hydrology and Quality Technical Memorandum (MWH, 2004), the most viable alternative for discharge to multiple watersheds is discharge to both the Sandy and Dark Rivers and possibly the Lake Superior watershed. Additionally, the rate of total discharge could be varied, and the split between the watersheds varied. This alternative would be a variation of a "Hydrographically Controlled Release" (HCR). As discussed in Alternative G, Minntac evaluated a HCR discharge to the Sandy River. During low-flow periods, total discharge would be limited or stopped. During high-flow periods discharge would be increased and could exceed the proposed 11.1 cfs to make up for periods of low discharge. Flow could be directed away from the Dark River watershed during periods of temperature extremes to protect the trout habit. This discharge scenario could reduce adverse impacts when compared to the proposed alternative. However, the benefits of increased flows during low-flow periods (reduced stress to fish and aquatic macroinvertebrates, and increased aquatic habitat) would not occur, and the increased flows during high-flow periods could have adverse impacts on aquatic habitats (reduced habitat resulting from increased velocities and increased suspended sediments).

Lake Superior Watershed

DO: The potential impacts on DO in the West Two Rivers would be similar to those in Sandy Creek. DO levels would be reduced by the discharge of a low-level siphon at SD001, but would be restored to ambient shortly downstream. There may be more oxygenated water in the channel of West Two Rivers, which may lessen the impacts.

Aquatic Life: Discharge to the south would involve West Two Rivers and West Two Rivers Reservoir. MPCA sampled for fish and macroinvertebrates on the West Two Rivers in July and August 1998, just downstream of Highway 169. (MPCA http://www.pca.state.mn.us/data/eda/). Table 5.51, *Fish Species Collected from the West Two Rivers,* contains the three fish species collected from this stream. At the sample site the substrate is predominantly sand; the stream has an average depth of 1.5 ft, with an average width of 8.2 ft. The banks are characterized by a monoculture of reed canary grass (*Phalarus arundinacae*) which stabilize the streambank and provide low-quality cover for fish and invertebrates.

TABLE 5.51
FISH SPECIES COLLECTED FROM THE WEST TWO RIVERS[1]

Common Name	Scientific Name	Density[2]
Brook Stickleback	*Culaea inconstans*	R
Central Mudminnow	*Umbra limi*	R
Mottled Sculpin	*Cottus bairdi*	C

Notes:
1. Only 35 fish collected during the July and August sampling events.
2. R = rare, C = common, A = abundant

Macroinvertebrate taxa collected include: true flies (midges and other taxa), mayflies, damselflies, caddisflies, beetles, stoneflies, snails, bivalves, and oligochaetes. Abundance values for most of these groups were not available, although according to the data, true flies comprised 40% of the sample (26% midges).

The West Two Rivers Reservoir is managed by MDNR, who sampled the reservoir in 1991 and 2003. The reservoir is approximately 713 surface-acres, with a maximum depth of 27 feet. Fish species collected by the MDNR in 1991 and 2003 are provided in Table 5.52, *Fish Species Collected from the West Two Rivers Reservoir,* (1991 data from Lake Information Report, MDNR website, http://www.dnr.state.mn.us/lakefind/showreport; 2003 data provided by MDNR). According to MDNR's website, the fish populations in 1991 were dominated by very high numbers of small black bullhead and brown bullhead, followed by white sucker and pumpkinseed sunfish. Fish populations in 2003 were also dominated by black bullhead and brown bullhead.

TABLE 5.52
FISH SPECIES COLLECTED FROM THE WEST TWO RIVERS RESERVOIR

Common Name	Scientific Name	Density[1]
Black Bullhead	*Ameriurus melas*	A
Black Crappie	*Pomoxis nigromaculatus*	C
Brown Bullhead	*Ameiurus nebulosus*	A
Golden Shiner	*Notemigonus crysoleucas*	R
Green Sunfish	*Lepomis cyanellus*	R
Northern Pike	*Esox lucius*	R

TABLE 5.52 FISH SPECIES COLLECTED FROM THE WEST TWO RIVERS RESERVOIR		
Common Name	**Scientific Name**	**Density[1]**
Pumpkinseed Sunfish	*Lepomis gibbosus*	C
White Sucker	*Catostomus commersoni*	C
Yellow Perch	*Perca flavescens*	C
Notes : 1. R = rare, C = common, A = abundant		

Macroinvertebrate data for the West Two Rivers Reservoir were unavailable. There are no known threatened, endangered, or sensitive fish or macroinvertebrate species within the section of West Two Rivers upstream of the West Two Rivers Reservoir, or within the reservoir, that would be impacted by this alternative.

In general, water quality impacts to the aquatic biota in the West Two Rivers would be similar to the impacts described for the headwaters of the Dark and Sandy Rivers. The concentrations of the water quality parameters of concern predicted for the West Two Rivers under the different discharge scenarios are similar to the concentrations predicted for the Dark and Sandy Rivers under the proposed project. Inflows from groundwater and several tributaries would reduce concentrations downstream. The buffering capacity of the West Two Rivers Reservoir would further mitigate any water quality changes; no impacts to fish or macroinvertebrates associated with changes in water quality are expected to occur in the reservoir, with the possible exception of mercury.

However, more restrictive Class 2 standards for mercury apply to the Lake Superior watershed. Specifically, a standard of 0.0013 μg/L has been implemented, in comparison to 0.0069 μg/L. Out of seven low-level mercury analyses performed for the mine pit storm water, one exceeded the 0.0013 standard. Although unlikely given dilution, it is possible that the mercury standard could be violated under this alternative. Currently, there is a fish consumption advisory for mercury for the West Two Rivers Reservoir. Violation of the standard could require that mercury levels in fish within the reservoir be closely monitored, although more data on background mercury levels in the receiving waters is required to fully evaluate the potential effects.

The hydrological changes resulting from discharge to the West Two Rivers would be greatest in the West Two Rivers upstream of the reservoir. Outfall SD001 is presently used to discharge mine pit storm water at an average flow rate of 7.5 cfs and a maximum flow of 49.8 cfs, as established by the NPDES permit. The predicted flows under several combined discharge scenarios: average SD001 discharge and split tailings basin discharge; average SD001 discharge with full tailings basin discharge; and maximum SD001 discharge and full tailings basin discharge, would not violate the maximum flows of the permit (MWH, 2004). The hydrological impacts associated with discharge would likely be within the range of most historic flood flows. The discussion below briefly examines the more chronic effects that would be experienced under the daily discharge of 11.1 cfs tailings basin water into the West Two Rivers.

Flow data collected on the West Two Rivers approximately one mile downstream of the discharge site (at Highway 169) indicate that the average flow in July is 6.39 cfs, which would provide good habitat for the fish species present. It is not known, however, if this flow is representative of year-round conditions, although the Minntac mine pit dewatering Outfall SD001 discharge, upstream of Highway 169, averaged 8.2 cfs between December 1999 and December 2002. Increased flows may expand the channel, increasing available habitat for fish and macroinvertebrates in the margins of the channel. However, the proposed discharge of 11.1 cfs could increase stream velocities at the sampling site (assuming channel width and depth do not vary along this segment). Increased velocities may reduce habitat for the central mudminnow, which prefers quiet waters, although it is likely that this species would find refuge close to the banks in the overhanging vegetation and would remain in the area. Brook stickleback habitats could also be affected by higher velocities, and that species would also likely move to the margins of the stream. White sculpin, a bottom dweller, would also be unaffected but may move out of the parts of the channel with the highest velocities.

Substrate characteristics between SD001 and the reservoir would likely change in response to the increased flows, especially during the initial period of increase above the existing pit dewatering baseline flows. However, the degree to which this would occur is difficult to predict from the limited substrate information available on the West Two Rivers. The changes in substrate brought about by the increased flows could reduce water quality through increases in sediment loading, BOD (which would reduce dissolved oxygen) and nutrients.

Hydrological effects on the macroinvertebrates would be similar to those described for Reach 1 on the Dark and Sandy Rivers. The hydrological changes are expected to have little impact on the aquatic resources of the West Two Rivers Reservoir. It is expected that the discharge would have an insignificant effect on the water residence time of the reservoir. The increase in water volume into the lake could improve habitat, in particular, under 7Q10 or other low-flow conditions. The West Two Rivers Reservoir would receive some increase in sediment from the West Two Rivers upstream.

5.5.2.3 Alternative C: No Build (No Action)

Dissolved Oxygen

Under the no-build alternative, discharge would not be allowed and operations would continue as they are now. Although some impacts are expected for water quality due to continued concentration of solutes and increased seep concentration, this would have little impact on DO. Consequently, no impacts are expected under this alternative.

Aquatic Life

The fish and macroinvertebrate fauna in the headwaters of the Dark and Sandy Rivers may experience some impacts under the No Build Alternative. However, the biological information for the headwaters of the two rivers is not available, so specific impacts cannot be determined. The concentrations of the water quality parameters of concern are concentrated at the seep sites, and are well above the concentrations within the tailings basin. If concentrations continue to increase in the basin, seep concentrations would also increase, potentially having an adverse effect on the aquatic biota. However, any water quality impacts on the Sandy River from the seeps would be mitigated to some extent by the buffering capacity of Little Sandy and Sandy Lakes. On the Dark River, several small tributaries enter downstream of the seep, increasing baseline flows, and increasing dilution. Dilution would also occur within Dark Lake, reducing concentrations downstream.

Aquatic Ecology

Some impacts may occur under the No Build Alternative. Elevated TIN concentrations are seen at the Dark River seep site suggesting that TIN may be moving through the groundwater into the stream channel. If TIN concentrations were to continue to increase in the basin, channel TIN would also continue to increase. These high TIN concentrations may lead to higher instream productivity and a reduction in the Index of Biotic Integrity (IBI) scores.

5.5.2.4 Alternative D: Alternative Technologies

Tailings Basin Perimeter Dike Raising

Under this alternative, the tailings basin water would continue to evapo-concentrate and elevate concentrations of the water quality constituents. In addition, increased water levels in the tailings basin could increase seepage rates due to higher hydraulic heads. It is possible that this could have an adverse impact on the biological community present in the headwaters of the Dark and Sandy Rivers. Specific impacts, however, cannot be determined because the fish and macroinvertebrate fauna for the headwaters are not known. In addition, there are no expected impacts on the trophic structure due to raising the perimeter dike. However, some community shifts may occur as a result of impacts to individual species.

Tailings Basin Water Level Reduction

Reducing the water level in the basin through removal of water for other purposes would have no impact on the fish and macroinvertebrate populations within the Dark and Sandy Rivers. In addition, there are no expected impacts on the aquatic trophic structure due to operational changes that reduce the water level in the tailings basin.

5.5.2.5 Alternative E: Design Alternatives

Siphon Placement

Siphon placement could have an impact on the DO concentrations downstream of the selected discharge point. During summer stratification, water below 20 feet in depth in the tailings basin is often below the warm water fisheries standard of 5 mg/L. Drawing water from this depth and discharging into the streams would result in depressed DO concentrations until reaeration brings the concentration back up to equilibrium. Placement of the siphon should consider the DO concentrations. A noted mitigation measure in the *Surface Water Hydrology and Quality Technical Memorandum* was to draw from the bottom to protect water temperatures. However, this may negatively affect DO. If water were drawn from the bottom, the discharge point into the river would require sufficient fall to create enough turbulence to increase water aeration. Further analysis would be required to design the outfall such that DO concentrations are protected.

Siphon placement could have an adverse impact on the fish and macroinvertebrate communities within the Dark and Sandy Rivers. If the new discharge siphon is placed low such that it draws water from the bottom of the basin, there could be major reductions in DO immediately downstream of the tailings basin. This would be a seasonal impact that would be most significant during 7Q10 low-flow periods that occur during warm spring and summer months, when the basin discharge would comprise most, or all, of the stream flow in this reach. Impacts to the fish and macroinvertebrate communities from reduction in DO concentrations are further discussed in the *Aquatic Resources Technical Memorandum*.

Nutrient concentrations (nitrogen and phosphorus) were not significantly different at the surface and bottom of the tailings basin. Consequently, placement of the siphon would have little affect on the impacts resulting from nutrient changes. Although algal production can respond to changes in temperature, it is more likely that algal biomass would respond to shifts in nutrients than in temperature.

Dark Lake Effluent

Water discharged from the tailings basin into the Dark River would reaerate back to equilibrium before reaching Dark Lake. Consequently, there are no impacts on the DO concentrations in Dark Lake. Controlling the discharge out of Dark Lake would have impacts on the downstream DO concentrations if low DO water were withdrawn from the lake, or the downstream flow became proportionally comprised of more groundwater than present conditions. Drawing water from depth in Dark Lake and discharging into Dark River downstream could result in depressed DO concentrations until reaeration would bring the concentration back up to equilibrium. However, based on the previous analysis, reaeration occurs rapidly in the Dark River, making it unlikely that low DO concentrations would continue far downstream. Due to the rapid reaeration, DO impacts are expected to be insignificant.

There would be no adverse impacts to the aquatic fauna associated with control of the Dark Lake outflow. Reduction of flows from Dark Lake during warm periods would allow the cool groundwater into the channel, maintaining the thermal refugia that provide habitat for trout and other temperature sensitive species during periods of high temperatures.

Controlling discharge from the outlet of Dark Lake could result in changes in the residence time and flushing of Dark Lake. It is difficult to assess the impacts to controlling discharge at the Dark Lake outlet without knowing the resultant changes in water level and flushing time. However, an increase in the residence time of the lake could lead to slightly higher phosphorus concentrations and possibly increased sedimentation of algae. This sedimentation could have long-term effects on the nutrient cycling of the lake by increasing the available phosphorus in sediments for internal loading. These factors would have to be addressed in the outlet control design.

5.5.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Dissolved Oxygen and Aquatic Life

The magnitude of discharge to the river has little effect on the reaeration of water moving through the stream channel. The model parameters change with increases in discharge (greater than 50 cfs) and, therefore, reaeration rates would be affected. Reductions in the magnitude of the discharge would not affect the reaeration rate in either of the rivers. The rate of reaeration was the same for both 5.6 and 11.1 cfs discharges. Consequently, the impacts would be the same.

It is unlikely that changes in scale would have a significant impact on the aquatic communities within the Sandy and Dark Rivers. Baseline conditions for the water quality constituents of concern are already elevated in the tailings basin, therefore any discharge would result in increases in concentrations. The predicted concentrations for the different water quality parameters under 5.6 cfs discharge are not as reduced as might be expected, when compared to the predicted concentrations under 11.1 cfs discharge. It is apparent, therefore, that changes in scale for discharge would not result in a similar change in scale for water quality. Similar hydrological impacts are predicted with a discharge of 11.1 cfs and 5.6 cfs tailings basin water. According to the Dark River thermal model, temperature impacts are predicted to occur even with a 5.6 cfs discharge, although the impacts would be somewhat reduced with the reduced discharge.

Dark River and Sandy River Aquatic Ecology

Modification of the scale of the discharge could mitigate some of the effects of the proposed discharge on the trophic status of the water bodies. Phosphorus concentrations in the tailings basin are in-line with ecoregion mean data. Therefore, changes in the magnitude of discharge would likely have little impact on primary production (epiphytic and sestonic algal production). However, increased velocities and reduced residence time may increase scouring and nutrient replenishment that could result in a shift of the community structure of the stream. Increased TIN concentrations would reach further down the stream system as a result of increasing the magnitude of flows and decreasing the dilution effects of downstream segments. TIN concentrations (~3.5 mg/L in the tailings basin are significantly higher than ecoregion means (<0.03 mg/L)). However, recent research suggests that stream systems respond to increases in phosphorus rather than TIN (Nieuwenhuyse and Jones, 1996). Recent research in Minnesota demonstrated that nitrate was a good predictor of IBI scores, with IBI scores decreasing with increases in nitrate. Consequently, higher nitrate concentrations may have deleterious affects on the biotic integrity of the stream. More research is required to further develop this relationship.

Dark Lake and Sandy Lake Aquatic Ecology

Changes in the magnitudes of discharge would affect the lake systems by increasing nutrient loads and decreasing the residence time of the lake. Both Sandy Lakes and Dark Lake have relatively short residence times. Increased flushing of the lake would drive water quality to reflect that of the tailings basin that has a zooplankton community structure typical of lakes in Minnesota. Total phosphorus concentrations would be reduced which would reduce algal biomass in the lake. Additionally, these changes in residence times would result in increased flushing of the lakes, reducing the standing algal biomass. Lakes in Minnesota are often managed for clarity, with recreation standards for Northern Lakes and Forest ecoregion at 30 μg/L and less than 10 μg/L chlorophyll-a. These changes would reduce algal production in the lakes and result in increased clarity. Total phosphorus concentrations would remain well within ecoregion reference means, but the standing algal biomass may be reduced as a result of flushing.

5.5.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Minntac is evaluating an SPB system to reduce sulfate concentrations in the proposed discharge. To date, three options have been evaluated. Option 1: a 5,000 gpm (11.1 cfs) SPB-treated discharge to the Sandy or Dark Rivers; Option 2: an 11,000 gpm (24.5 cfs) SPB system discharge to the tailings facility, with no discharge to the Dark or Sandy Rivers beyond the existing seeps; and Option 3: an HCR discharge from the tailings basin, averaging 5,000 gpm (11.1 cfs) to the Sandy River, plus a 2,400 gpm (5.3 cfs) SPB treated discharge to the tailings facility and water management strategies. Minntac has also proposed to treat the SPB effluent using an aeration and settling basin.

Dissolved Oxygen

If untreated water from the SPB were released directly into the Dark or Sandy rivers (Scenario 1), there is a large potential for impacts on DO. COD, BOD, and ammonia, all of which are oxygen demanding substances, are extremely high in measured outflow from the SPB as shown on Table 5.53, *Chemical Oxygen Demand, 5-Day Biochemical Oxygen Demand, and Ammonia in SPB Influent and Effluent (SPB report)*. Additionally, the levels of phosphorus and TOC in the SPB effluent may increase. Post treatment would have to be implemented to minimize the potential impacts. Based on the *Surface Water Hydrology and Quality Technical Memorandum* , the additional treatment of the SPB effluent using an aeration and settling basin would likely reduce the levels of COD, BOD, ammonia, sulfide, TOC, and phosphorus, but such reductions have yet to be demonstrated.

TABLE 5.53
CHEMICAL OXYGEN DEMAND, 5-DAY BIOCHEMICAL OXYGEN DEMAND, AND AMMONIA IN SPB INFLUENT AND EFFLUENT (SPB REPORT)

Parameter	Influent Average	Effluent Average
COD (process water +carbon) (mg/L)	845	457
BOD_5 (process water+carbon) (mg/L)	410	315
Ammonia (mg/L)	1.33	4.18

If SPB effluent were discharged only to the tailings basin (Options 2 and 3) in conjunction with additional treatment in the aeration and settling basin, the impacts on DO in the Dark and Sandy Rivers would be reduced. Under Scenario 2, there would be no additional impact on DO over baseline conditions because there would be no discharge to the Dark or Sandy Rivers. Under Scenario 3, the levels of the oxygen demanding constituents and levels of nutrients would be reduced.

However, it is unknown to what extent such reductions would eliminate, or greatly reduce, the low level of DO in the hypolimnion of the tailings basin under thermal stratification. If the treatment reduced or eliminated the low DO in the hypolimnion, the DO impacts in the Sandy River would be reduced or eliminated accordingly. If little or no changes occurred to the DO in the hypolimnion, the impacts on the Sandy River would be similar to those of the proposed project.

Aquatic Life

The hydrological (and associated water quality) impacts of directly discharging SPB treated effluent into the Dark and Sandy rivers (Scenario 1) would be identical to those of the proposed project, because there would be no reduction in flow. Temperature and DO changes of the discharge into the Dark or Sandy rivers would be mitigated to some extent by an aeration and settling basin, but the impacts on groundwater inputs in the Dark River trout section would still occur. Under Scenario 2, there would be no impacts over baseline conditions because there would be no discharge to either river. Under Scenario 3, the hydrological (and associated water quality) impacts would increase beyond those of the proposed project, because the proposal is for an HCR release that only averages 11.1 cfs. If no water is released under low-flow conditions, the benefits of the additional flow in the Sandy River (reduced stress to the fish and macroinvertebrates, and increased aquatic habitat) would not occur. Discharges exceeding 11.1 cfs under high-flow conditions would exacerbate the hydrological and associated water quality impacts to aquatic habitats. The extent of the adverse impacts resulting from the high-flow releases are unknown because no minimum or maximum level of discharge was identified, and the channel width, depth and habitat characteristics in Reach 1 of the Sandy River are unknown.

Aquatic Ecology

Nutrient concentrations were all very high in effluent from the SPB as shown on Table 5.54, *Nutrients in SPB Influent and Effluent (SPB Report)*. Although Nitrate+Nitrite was low in SPB effluent, ammonia was very high. If untreated water from the SPB were released directly into the Dark or Sandy Rivers (Scenario 1), rapid nitrification would occur instream, resulting in high TIN concentrations and rapid oxygen consumption. If effluent phosphorus concentrations are above background phosphorus levels for area waters, the quality of those waters would be impacted. Post treatment would have to be implemented to minimize the potential impacts. Based on the *Surface Water Hydrology and Quality Technical Memorandum*, the additional treatment of the SPB effluent using an aeration and settling basin would likely reduce the levels of ammonia and phosphorus, but such reductions have yet to be demonstrated.

TABLE 5.54
NUTRIENTS IN SPB INFLUENT AND EFFLUENT (SPB REPORT)

Parameter	Influent Average	Effluent Average
Nitrite+Nitrate (mg/L)	3.45	<0.1
Total Kjeldahl Nitrogen (mg/L)	8.65	12
Ortho-Phosphorus (mg/L)	0.005	0.255
Total Phosphorus (mg/L)	0.095	0.459

If SPB effluent were discharged only to the tailings basin (Options 2 and 3) in conjunction with additional treatment in the aeration and settling basin, the increases in nutrients in the Dark and Sandy Rivers would be reduced. Under Scenario 2, there would be no additional impact over baseline conditions because there would be no discharge to the Dark or Sandy Rivers. Under Scenario 3, the levels of nutrients would be reduced. However, the extent of the reduction is unknown.

The use of an SPB system would require that the effluent be treated using an aeration and stilling basin to reduce DO and nutrient-loading impacts.

5.6 WILDLIFE

This section describes baseline conditions associated with wildlife (Section 5.6.1) and potential impacts (Sections 5.6.2) associated with implementation of the proposed project or project alternatives. More detailed wildlife discussions and species lists are contained within the *Wildlife Technical Summary*.

5.6.1 Wildlife Baseline Conditions

5.6.1.1 Mammals

Fifty-three species of mammals are known to occur in the northeastern section of Superior National Forest (U.S.F.S., 2003a), nearly all of which may be assumed to be found within the project area. Of these, 13 species are classified by MDNR as "species of concern," 16 as "furbearers," 5 as "small game," and 4 as "big game." Two species, the gray wolf and the lynx, are federally classified as "threatened."

5.6.1.2 Birds

J. C. Green (2003) notes that Superior National Forest, with 155 species of breeding birds, contains more species than any other national forest. She lists 223 species as occurring within Superior National Forest; the USFS (2003a) lists 207 species of birds, including breeding and nonbreeding species. Although these two documents are not limited strictly to the project study area, most of the listed birds are likely to be found there, due to the variety of habitats represented.

Among the 207 species of birds listed by USFS (2003a), two, the peregrine falcon and the common tern, are considered by MDNR to be "threatened" and one, the northern bald eagle is listed as of "special concern" by MDNR and "threatened" by the Federal government.

A blue heron rookery and a bald eagle nest are located on an island in the tailings basin, approximately one mile from the proposed project location. These bird habitats were established after the mine began operation, and to date, normal mine and tailings basin operations and activities have not appeared to affect them (MPCA, 2001).

5.6.1.3 Reptiles

Seven species of reptiles are known to occur in the SFRMP Planning Area of Superior National Forest. These include four turtles and three snakes. One turtle, the snapping turtle, is of "special concern" to MDNR, while two turtles, the wood turtle and the Blandings turtle are designated "threatened" by MDNR. The snapping turtle and Blanding's turtle are largely aquatic, while the wood turtle is associated with high water quality streams and wetlands found in closed woodland.

Water quality and hydrology may also indirectly impact bog and wood turtles by altering habitat and food availability, for example by facilitating the establishment of invasive vegetation, as described in the *Wetlands Technical Memorandum*, or by altering the food chain.

5.6.1.4 Amphibians

Four species of salamanders, one toad, and seven frog species occur in the eastern sector of Superior National Forest. None of these is considered threatened or endangered by State or Federal authorities, or "of concern" to the MDNR.

5.6.1.5 Regional Foresters' Sensitive Species

The Regional Foresters' Sensitive Species (RFSS) list represents species of wildlife and plants that are considered vulnerable to changes in habitat and/or human activity in the context of Superior National Forest. Many of the listed species are also listed as "rare," "vulnerable," or of "special concern" by the State or Federal agencies, but some species listed by those agencies are not included in the RFSS list.

Among the mammals known to occur in Superior National Forest, only the Heather Vole (*Phenacomys intermedius*) is on the RFSS list.

Thirteen bird species are listed as RFSS. Some, such as the Peregrine Falcon, Northern Goshawk, and Wilson's Phalarope, are considered "threatened" by the Federal government. The remaining RFSS species comprise the Great Gray and Boreal Owls, Sharp-tailed Grouse, Yellow Rail, Three-toed Woodpecker, Olive-sided Flycatcher, three woodwarblers, and the LeConte's Sparrow.

One reptile, the Wood Turtle, is on the RFSS list, and State listed as "threatened."

5.6.2 Potential Wildlife Impacts

During the proposed project scoping process, it was determined that impacts associated with the wildlife resources would be primarily of an indirect nature. As such, a technical summary paper was prepared for the wildlife resources rather than a technical memorandum. Potential impacts to the wildlife resources associated with implementation of the alternatives are primarily related to stream flow and water quality changes. These impacts are summarized in the following paragraphs.

5.6.2.1 Stream Flow Changes

The proposed changes in stream flows may affect wildlife in two possible ways: (1) through hydrologically induced changes in habitat (principally) and (2) through changes in water chemistry. Changes in habitat would result primarily from increases in overbank flooding. These events would have to be of sufficient magnitude and duration to alter the long-term water levels in off-stream wetlands and hence the vegetation of these areas. Changes in vegetation would be gradual, requiring years or even decades, to become noticeable. Changes in water levels in these wetlands also might directly affect habitat use by some wildlife species, such as snapping turtles and wood turtles, mink, rails, and various waterbirds. The potential habitat changes and related food chain alterations described in the Wetlands, Wild Rice, Aquatic Resources and Upland Vegetation Technical Memoranda may cause secondary impacts to various wildlife populations, including those listed species that are most associated with wetlands or other water bodies.

Minntac has assisted a bald eagle pair near the tailings basin with the construction of a new nest in a dead tree (Minntac web site) and notes that these birds feed on fish in the tailings basin. Bald eagles are found throughout the drainage basin of Lake Vermilion, their nests generally being within 30 meters of open water.

Concern has been expressed for a blue heron rookery near the tailings basin being affected by activities in connection with the altered flows. Blue herons are sensitive to human activities near their rookeries during the nesting season, but their foraging activities are not likely to be affected, since they commonly forage five to ten miles from their rookeries.

The elusive Yellow Rail, which breeds in grassy wetlands across subarctic Canada, would be locally affected by changes in wetland vegetation in grass-vegetated wetlands. It appears to be uncommon to rare in Superior National Forest, not being listed in the *Virginia EIS* (USFS, 2003b).

5.6.2.2 Water Quality Changes

Chemical changes in lakes may affect the eggs of amphibians placed in those water bodies, reducing populations of those species. Direct effects on adult animals are not likely with the chemical changes expected; aversion and breeding failure is more likely.

Other water-quality issues are as follows:

- Fish-eating wildlife, including listed species such as bald eagles and common terns, are susceptible to health impacts through the consumption of fish with elevated mercury levels. The impacts of the proposed project, and its alternatives, on fish tissue mercury, which is related to the impacts of mercury on fish-eating wildlife, are discussed in the *Mercury and Methylmercury Technical Memorandum*. The extent to which methylmercury in fish tissues will increase as a result of discharges is difficult to quantify. Indications of mercury poisoning in common terns and other species that feed on small or juvenile fishes have not been found, presumably due to the shortness of the food chain leading to their prey.

  The bald eagle, on the other hand, is vulnerable to mercury in fish tissues, because the fish on which it feeds (partially) are generally large and mature individuals, which have had considerable time to accumulate the poison. The *Mercury and Methylmercury Technical Memorandum* notes that in Little Sandy Lake, tissue concentrations in northern pike (a top of chain predator) are expected to exceed the MPCA methylmercury fish tissue water quality criterion of 0.2 mg/Kg. The tolerance level of bald eagles is not known. The tendency of bald eagles to range widely in search of prey, coupled with their preference for food items other than fish (hunter-wounded ducks especially) may help to reduce their risk of mercury poisoning in the Lake Vermilion drainage.

- The elusive Yellow Rail, which breeds in grassy wetlands across subarctic Canada, would be locally affected by changes in wetland vegetation in grass-vegetated wetlands. It appears to be uncommon to rare in Superior National Forest, not being listed in the Virginia EIS (USFS, 2003b).

- The MPCA has identified a criterion associated with the Class 4B water quality standards for livestock and wildlife watering of 1,000 mg/L sulfate. The impacts of the proposed project and its alternatives on downstream sulfate concentrations are discussed further in the *Surface Water Hydrology and Quality Technical Memorandum*.

- Kapustka et al (2003) summarizes research that describes how elevated levels of molybdenum can interfere with the ability of ruminant animals, for example moose, to absorb copper nutrients, leading to molybdenosis that can be potentially fatal to the animals. The impacts of the proposed project and its alternatives on downstream molybdenum concentrations are described in the *Surface Water Hydrology and Quality Technical Memorandum.* It is uncertain whether changes in dissolved molybdenum would be reflected in elevated levels in marsh vegetation and thus affect ruminants feeding on aquatic vegetation, such as moose, or browsers such as deer.

Changes in fish populations, especially overall reduction in numbers, would affect the few fish-eating birds and mammals in the area of influence (double-crested cormorant, mergansers, osprey, bald eagle, some herons, and belted kingfisher, as well as mink and otter). Of these, the only species on the MDNR list of endangered, threatened and special concern species is the bald eagle.

5.7 UPLAND VEGETATION

This section describes baseline conditions associated with upland vegetation (Section 5.7.1) and potential impacts (Section 5.7.2) associated with implementation of the proposed project or project alternatives. More detailed upland vegetation discussions are contained within the *Upland Vegetation Technical Summary.*

5.7.1 Upland Vegetation Baseline Conditions

Upland vegetation in the project area is a mosaic of forest types, including aspen, birch, black spruce, pine, spruce/fir, tamarack, cedar, and northern hardwoods. The project site is located in central St. Louis County in northeastern Minnesota. This area lies within the conifer-hardwood forest zone of Minnesota (Aaseng et. al. 1993) and is comprised of a number of overlapping sub-zones including deciduous forest, northern hardwood-conifer forest, white pine-hardwood forest, upland white cedar forest, jack pine forest, white pine forest, northern hardwood forest and oak forest.

The Dark River watershed has predominantly aspen and pine stands; the Sandy River watershed contains predominantly pine and black spruce stands with small areas of aspen (USFS). Available land cover data for the project area is not complete and not continuous along the primary discharge drainages potentially affected by the project.

The predominant forest type in the area (from MDNR color aerial photography) appears to be aspen forest. Small stands of mixed spruce/fir, birch, and black spruce are scattered throughout the area. Differentiation between aspen forest and aspen-birch forest types (Aaseng et. al. 1993) is not possible from the available images alone. The aspen forest canopy is comprised mainly of quaking aspen (*Populus tremuloides*); the understory is brushy and American hazelnut (*Corylus americana*) is a frequent species (Aaseng et. al. 1993). The aspen-birch forest canopy is a mixture of quaking aspen, bigtooth aspen (*Populus grandidentata*) and paper birch (*Betula papyrifera*). Understory species include beaked hazel (*Corylus cornuta*), mountain maple (*Acer spicatum*), and saplings of later successional species (Aaseng et. al. 1993).

Both aspen and aspen – birch forests are early successional and occur in areas of prior disturbance – fire, logging or wind throw. Aspen forest occurs in wetter localities with poorly drained soils.

The Superior National Forest has proposed management alternatives for the Virginia Forest Management Project Environmental Impact Statement (EIS). Special Management Complexes (SMC) are proposed in the EIS. Proposed SMC 114 includes areas around Sandy and Little Sandy Lakes and the Sandy River; these areas in the Sandy River watershed lie within the potential impact area. Laurentian Creek from the confluence with the Sandy River to approximately one mile upstream lies within SMC 114. There are no SMCs in the Dark River watershed within the potential impact area.

5.7.2 Potential Upland Vegetation Impacts Summary

During the proposed project scoping process, it was determined that impacts associated with upland vegetation resources would be primarily of an indirect nature. As such, a technical summary paper was prepared for the upland vegetation resources rather than a technical memorandum. Potential impacts are summarized in the following paragraphs.

5.7.2.1 Discharge Alternatives

The *Draft Surface Water Hydrology and Quality Technical Memorandum* analyzed potential impacts of increased discharges into the sandy and dark river watersheds using gauge stations with historical flow data. The analysis showed that full or divided incremental flows at the gauge stations would not increase stream stage significantly in either watershed and that stream stage elevation during a 2-year storm flow event would increase by less than 0.1 foot with either full or divided incremental flow into either watershed. The gauged stations on the sandy and dark rivers are well downstream of the proposed discharge points and it was stated that "it is likely that smaller channels further upstream and the headwater areas may be prone to higher degrees of flooding and overland flow; this could not be evaluated based on available data" (*surface water hydrology and quality technical memorandum*). SMC 114 is located within the sandy river watershed in the headwater area, for which impacts could not be evaluated.

The discharge of full incremental flow into Laurentian Creek would produce hydrologic effects similar to those of the Sandy River. Laurentian Creek is not gauged and stage increases with incremental flow could not be estimated. It was noted that the watershed of Laurentian Creek at the presumed discharge location is significantly larger than the headwaters of Sandy River and the resultant hydrologic impacts would be less.

Areas disturbed by construction of outlet structures would be managed according to standard noxious weed control procedures and establishment of poisonous or noxious plants would not be anticipated.

5.7.2.2 West Tailings Basin Expansion Alternative

Diking and discharge of water into the West Tailings Basin Expansion area (Figure 4-4) would eventually remove or flood approximately 3,161 acres of upland vegetation of the aspen forest or aspen-birch forest type. Upland species in the area of flooding would gradually be eliminated as the water table rose or standing water developed in the basin. Neither forest type that would be affected is rare or restricted and the loss of forest area would not be significant relative to the extensive area of the conifer-hardwood zone in Minnesota. A separate environmental analysis and more detailed vegetation evaluation, however, would be required for this alternative.

There are no Superior National Forest SMCs within the West Tailings Basin Expansion area.

Areas disturbed by construction of dike structures would be managed according to standard noxious weed control procedures and establishment of poisonous or noxious plants would not be anticipated.

5.7.2.3 Summary of Impacts

Average stream flows in the Sandy and Dark River watersheds estimated to result from the additional discharge fall well below the estimated 2-year peak storm flow volumes, indicating that on average the additional flow volume would not significantly impact the hydrologic system. Impacts from flooding could occur to upland vegetation communities in the headwater areas of the watersheds immediately downstream of the discharge points, but the precise area of impact can not be determined with existing data. Any area impacted would be small and insignificant compared to the large area of those communities in northern Minnesota. Superior National Forest SMC 114 is located in the upper Sandy River watershed headwater area, for which potential overland flooding could not be evaluated.

Diking and flooding of the West Tailings Basin Expansion would remove approximately 3,161 acres of aspen forest /aspen-birch forest. This would be an insignificant loss compared to the total area of those communities in northern Minnesota. A separate environmental analysis and more detailed vegetation evaluation, however, would be required for this alternative.

5.8 SOCIOECONOMICS

This section describes socioeconomic baseline conditions (Section 5.6.1) and potential impacts to the socioeconomic resources (Sections 5.6.2) associated with implementation of the proposed project or project alternatives. In addition to the discussion below, the proposed project and alternatives would indirectly affect production costs, and potentially job levels, at Minntac.

5.8.1 Socioeconomic Baseline Conditions

The proposed project could potentially impact socioeconomic conditions in portions of St. Louis County located within the Dark River and Sandy River watersheds. The socioeconomic affected environment is defined to include portions of St. Louis County located in these watersheds and along the affected rivers downstream to a point where the wild rice, surface water hydrology, and aquatic resources evaluations terminated. Hydrologic impacts were evaluated to the downstream locations where the impacts were determined to be relatively insignificant. This also defines the extent of direct impacts to property values and land uses along the rivers. Water quality impacts were evaluated to the confluence of the Pike River and Lake Vermilion (Pike/Sandy River Watershed), and the Dark River and Sturgeon River (Dark River Watershed) and in Lake Vermilion. This defines the extent of direct economic impacts based on effects on wild rice and fish populations. Consequently, no impacts to the Little Fork River State Canoe and Boating Route are expected due to its location downstream of the confluence of the Dark and Sturgeon Rivers. In addition, impacts to the Lake Superior watershed at a permitted Minntac discharge point (NPDES Permit #MN0052493 Outfall SD001) were evaluated. This discharge point is located south of the tailings basin and the receiving water is the East Branch of West Two River.

These portions include the cities of Mountain Iron and the townships of Wuori, Sandy, Greenwood, Lake Vermilion, Pike, Embarrass, Kugler, Breitung, Great Scott, Sturgeon, Balkan, Linden, Morcom, and Willow Valley. Secondary impact areas include small portions of Koochiching and Itasca Counties.

The baseline socioeconomic discussion includes consideration of the following:

- Population, employment, and income
- Public services and fiscal impact
- Property values and land uses
- Agriculture and wild rice

5.8.1.1 Population, Employment and Income

Baseline population within the area of influence was assessed based on census information collected during the 2000 census by the U.S. Bureau of the Census. Total population for St. Louis County is 200,568 (USBC, 2001), as indicated in Table 5.55, *2000 Population in the Affected Area.* The area is very sparsely populated. St. Louis County has a population density of 32.2 persons per square mile. Development within the area is characterized by clusters of largely single family dwellings located along rivers and streams, around lakes, and along some thoroughfares. There are many seasonal and year-around vacation homes and recreational cabins located in the area, particularly along the Dark River and along the Pike River toward Pike Bay and Lake Vermilion.

Population in St. Louis County has declined slightly from 2000 – 2002 to 198,799 people or about 0.9%. From 1990 to 2000, county population increased by 1.2%.

Baseline employment within the area of influence was also reviewed based on census information collected during the 2000 census by the U.S. Bureau of the Census. People largely work in the wood products, mining, tourism, and service industries. The vast majority of St. Louis County residents also work in the county, with some workers commuting to neighboring Itasca, Koochiching, Carlton, and Douglas County, Wisconsin. (USBC, 2004) Within the townships identified in Table 5.1, it is assumed that most workers who commute out of the county work in Itasca or Koochiching counties due to practical commuting time constraints. Employment is primarily in mining, forest products, tourism and the service industries.

TABLE 5.55
2000 Population in the Affected Area

Location	Population
St. Louis County	200,568
Wuori Township	563
Sandy Township	382
Greenwood Township	905
Lake Vermilion Township	326
Pike Township	492
Embarrass Township	691
Kugler Township	200
Breitung Township	662
Great Scott Township	622
Sturgeon Township	116
Balkan Township	821
Linden Grove Township	141
Morcom Township	115
Willow Valley Township	139
Total Portions of St. Louis County	**12,868**
Itasca County	**43,992**
Koochiching County	**14,355**
Source: U.S. Bureau of the Census, 2001	

Baseline income within the area of influence was also reviewed based on census information collected during the 2000 census by the U.S. Bureau of the Census and from the Bureau of Economic Analysis. The average unemployment rate in the area is approximately six percent (USBC, 2001). Personal Income in St. Louis County was $5.26 billion in 2000, providing a per capita personal income of $26,246 in that year.

Two sectors are of particular interest for purposes of assessing the impacts from the proposed project and alternatives: agriculture and tourism. Farm earnings in 2000 were $792,000 of total county earnings of $3.87 billion, or less than one percent (USBEA, 2004). Gross receipts from the tourism industry in northeast Minnesota is assumed to be $1.17 billion of the total $9 billion realized by the entire State. The area of influence expected to be directly impacted by the proposed project and alternatives is a fraction of this $1.17 billion, conservatively estimated to be $100 million.

5.8.1.2 Public Services and Fiscal Impacts

The public services expected to be effected in some manner by the proposed project and alternatives include water, wastewater, and roadways. Drinking water is provided to residents and businesses by privately owned wells. There may be some cases where small groups of residents rely on a community-owned well or well system. A substantial portion of the residents of Lake Vermilion rely on lake water for potable uses. There may also be residents living on Dark Lake that rely on direct withdrawal from that lake. Wastewater is managed primarily through individual sewage treatment systems (ISTS). These systems include dry-well systems, mound septic systems, holding tanks for seasonal residents, and other systems. Some of the smaller towns may rely on centralized lagoon systems or small mechanical wastewater treatment facilities.

The area has a minimal network of roadways. The two major roads are U.S. Highways 169 and 53. U.S. 53 extends northward through the area of influence and provides access to that portion of the area that is currently populated. The State of Minnesota also maintains a system of roadways, including State Road 1. St. Louis County also maintains a road system in the area. Finally, cities and townships maintain road systems within their jurisdictions.

5.8.1.3 Property Values and Land Uses

Property values within the area of influence vary greatly. A significant factor in the value of private property is the proximity to water bodies. Over the past five to ten years, St. Louis County and northern Minnesota more generally have seen a dramatic increase in property values with a proximity to recreational amenities. These increases have been fueled primarily by in-migration of retirees from the Minneapolis-St. Paul metropolitan area and growing interest in vacation homes and cabins.

Within the area of influence, market values for rural land varies between $1,000 to $5,000 per acre. Market values for "vacation" properties with lake or river frontage range from $10,000 to $100,000 per acre. Along the Dark River, market values range from $15,000 to $25,000 per acre. Along the Sandy and Pike Rivers, data are only available north of the range of significant hydrologic or water quality impacts. In those areas along the Pike River near Lake Vermilion, market values range from $20,000 to $35,000 per acre. Property values along Pike Bay on Lake Vermilion may exceed $50,000 per acre.

5.8.1.4 Agriculture and Wild Rice

Agricultural activity within the area of influence include commercial fishery and fish hatchery, pulp and paper products, and some crops. Agricultural activity located specifically along the river systems within the area of influence is very limited. Also, according the *Wild Rice Technical Memorandum,* only one acre of wild rice stands were present in the Sandy River. Pike River stands totaled 2.17 acres and production in Sandy Lake and Little Sandy Lake was reported as non-existent. Based on this survey data, it was concluded that a total of $281 per year of income would accrue to wild rice harvesters from this yield.

5.8.2 Potential Socioeconomic Impacts

This section documents the potential impacts, both quantitatively and qualitatively, to socioeconomic resources associated with implementation of the proposed Alternative A, the No Build Alternative, or the Action Alternatives described previously in Section 4.0. Further details pertaining to potential socioeconomic impacts are included in the *Socioeconomics Technical Memorandum.*

5.8.2.1 Alternative A: Proposed Project (Proposed Action)

Impact analysis is primarily focused upon identification of potential effects of the proposed project to baseline. Overall, these impacts are related to the following physical phenomena described in the other technical memoranda:

- Potential increased water level, overland flow, and flooding affecting land uses along the Sandy/Pike and Dark Rivers and trout habitat along the Dark River.
- Potential increased channel scour, erosion, and sedimentation affecting land uses, roadway bridges, and property values along the Sandy/Pike and Dark Rivers.
- Potential water quality changes affecting trout habitat along the Dark River.
- Potential water quality changes affecting private potable lake water supplies.
- Potential methylation of mercury caused by increased sulfates that, in turn, affects safe human consumption of fish from the Sandy/Pike and Dark rivers.

Impacts Related to Water Level Change, Flooding, and Overland Flow

Based on conclusions of the *Surface Water Technical Memorandum*, the proposed project would affect water levels, flooding, overland flows, and low-flows in both the Dark River and Sandy River. Increased water levels, flooding, and low-flows may affect property values and land uses immediately adjacent to the Sandy/Pike and Dark Rivers. It is expected that there may be localized impacts that affect land uses (e.g., North Dark River Trail), most likely those related to maintenance of lakeshore and utilization of the lakeshore or streamside for recreational purposes.

Also, it is possible that such changes to surface water flows may affect roadways and, in particular, bridges extending over affected watercourses. Such water flows may result in minor increases in maintenance of bridge abutments and culverts and other stormwater management facilities that provide for roadwater drainage. These impacts are difficult to estimate, but are expected to be largely insignificant.

Changes in surface water flows are not expected to impact roadway bridges, property values, or land uses along the Pike Bay shoreline on Lake Vermilion due to the fact that attenuation of such surface water flows results in negligible changes.

It is concluded that these impacts would be relatively minor, except in perhaps some localized cases. In any event, it is not expected that land uses would change outright as a result of these flow changes.

Impacts Related to Channel Scouring, Erosion, and Sedimentation

Based on conclusions of the *Surface Water Technical Memorandum*, the proposed project may cause some sporadic channel scouring, erosion, and sedimentation in both the Dark and Sandy/Pike Rivers. Increased water levels, flooding, and higher low-flows cause this phenomena. This, in turn, may affect property values and shoreline land. It is expected that there may be localized impacts that affect land uses, most likely those related to maintenance of lakeshore and utilization of the lakeshore for recreational purposes. These impacts are difficult to estimate, but are expected to be largely insignificant.
Also, it is possible that such changes to river energy (and related channel scour, erosion, and sedimentation) may affect roadways and, in particular, bridges extending over affected watercourses. Such water flows may result in minor increases in maintenance of bridge abutments and culverts and other stormwater management facilities that provide for roadwater drainage.

Channel scour, erosion, and sedimentation are not expected to impact roadway bridges, property values, or land uses along the Pike Bay shoreline on Lake Vermilion due to the fact that attenuation of such surface water flows results in negligible changes. It is also not expected to impact the potability of private surface water supplies.

It is concluded that these impacts would be relatively minor, except in perhaps some localized cases. In any event, it is not expected that land uses would change outright as a result of these flow changes. It is also concluded that these minor impacts would not affect tax base or fiscal conditions.

Impacts Related to Changes in Groundwater Quality/Quantity

Groundwater data are limited, making analysis of potential effects to private water wells difficult. MDNR modeling of groundwater within the proposed project area does suggest that discharge base-flow additions of basin discharge water may proportionally over-ride groundwater temperature influence, possibly leading to a seasonal thermal impact.

Changes in groundwater quality or quantity are not expected to impact the potability of private groundwater or surface water supplies along the Pike Bay shoreline on Lake Vermilion.

It is concluded that these impacts would be relatively minor, except in perhaps some localized cases. In any event, it is not expected that large-scale replacement of private water wells would result from these changes. It is also concluded that these minor impacts would not affect property values or fiscal conditions.

Impacts Related to Changes in Water Quality

The *Aquatic Resources Technical Memorandum* concludes that temperature effects in the Dark River would affect the viability of trout habitat throughout the Designated Trout Stream area downstream of Dark Lake (MWH, 2004). This document concludes that the area is already marginal trout habitat and that elevated temperatures and suppressed groundwater inflows would result in deterioration of the habitat. This result would likely not be allowed by the MDNR since the designation is defined by State statute.

According to the MDNR, coldwater angling in northeast Minnesota is strongly associated with the resort market in the area (MDNR, 2002). The economic impacts as a result of the loss of a Designated Trout Stream would include direct, indirect, and induced economic activity related to coldwater angling, in particular and to area tourism more generally.

Based on MDNR survey information, it is estimated that there are 200,000 coldwater angling days in northeastern Minnesota each year. This represents spending of $18 million each year, direct sales of

$12 million, income of $7 million, and 250 jobs in the region. Based on the number of coldwater angling locations in that region, it is estimated that the Dark River might witness 1,500 coldwater angling days each year. So, it may be concluded that the Dark River trout fishery generates spending of $135,000 each year, direct sales of $90,000, income of $52,000, and two jobs. Considering indirect and induced affects (MDNR, 2002), it is estimated that the trout fishery resource generates direct sales of $140,000, income of $80,000 and three jobs.

It is concluded that the overall regional economic impacts of loss of the Dark River Designated Trout Stream would be relatively minor compared with the regional tourism and coldwater angling economy. However, there would likely be indirect impacts including reduced property values and reductions in related recreational activity along the Dark River that may occur as a result of loss of the trout fishery. There is no known trout fishery on the Sandy/Pike River.

The MDNR also reports that its surveys indicate that coldwater angling provides significant social benefits, including social affiliation, personal achievement, nature appreciation, relaxation, escape, and fishing for recreation. Loss of the Dark River trout fishery would result in loss of these types of social benefit.

The *Mercury and Methylmercury Technical Memorandum* concludes that increased concentrations of sulfate in water and sediments can increase the rate at which mercury is converted to methylmercury. Methylmercury is of particular importance because this form accumulates in the food chain at a much higher rate compared to inorganic forms of mercury. In larger fish, all the mercury contained in tissues is in the form of methylmercury.

Several water bodies within the study area have been listed as not meeting standards due to fish consumption advisories related to mercury concentration of sport fish. This impairment is widespread across Minnesota. Of 1,277 water bodies on the 2002 303(d) list, about 80 percent are listed based to impairments due to fish consumption advisories for mercury. (MWH 2004)

The *Mercury and Methylmercury Technical Memorandum* concluded that, although the data set is limited, it is probable that the increased mercury and methylmercury concentrations reported downstream of the tailings basin are related to the high sulfate concentrations in the tailings basin seeps. The discharge under the proposed project would increase the sulfate concentrations in the water column downstream of the tailings basin. It was therefore concluded that the pool of sulfate available to enter the sediments, where mercury methylation occurs, would increase. The current data set is not sufficient to predict either the level of increase in sulfate concentration in the sediments or the incremental increase in mercury methylation in the sediments.

Increasing accumulations of mercury in fish tissue would continue to impact the economic activity related to recreational angling as well as commercial fishery. Both the MDH and the MPCA have established consumption advisories and related thresholds for recommended maximum human consumption of fish. It is reasonable to conclude that such consumption limits may become more severe with increased methylation of mercury in the Sandy/Pike and Dark Rivers and Pike Bay due to the proposed project. This would in turn have direct, indirect, and induced impacts on employment, income, and property values within the area of influence. Presently, the available data are too limited to quantify such impacts, however, increasing pervasiveness of mercury accumulation in fish tissue may reasonably be expected to create economic impacts statewide due to perceived, if not actual, health risks related to the consumption of fish.

Further, decreased recreational angling would have related social impacts including affiliation, personal achievement, nature appreciation, relaxation, escape, and fishing for recreation as described above.

5.8.2.2 Alternative B: Alternate Discharge Sites

Laurentian Creek

Laurentian Creek is considered to be a viable alternative discharge site to receive tailing basin water, in addition to the Sandy/Pike and Dark Rivers and the West Two River Reservoir. It is expected that impacts to the trout fishery and property values along the Dark River would be reduced if this alternative were pursued. Also, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within the watershed receiving the new pipe discharge, while lessening the risk of downstream mercury bioaccumulation in the watersheds that continue to receive only seepage discharge from the tailings basin.

West Two River Discharge

Discharge to the Lake Superior watershed includes consideration of piped discharge from the Minntac mine to the West Two Rivers in Mt. Iron. Discharge would then flow south to West Two Rivers Reservoir. After some residence time in West Two Rivers, flow would continue south to the St. Louis River. Flow then continues some 80 miles south to the confluence with the Cloquet River, and ultimately Lake Superior.

While there is residential and agricultural development along the West Two Rivers south of the reservoir, it is expected that increased flows may result in some minor impacts to land uses and property values along that river reach, particularly through the area known as Cherry. It is expected that impacts to the trout fishery and property values along the Dark River would be reduced if this alternative were pursued. However, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within the watershed receiving the new pipe discharge, while lessening the risk of downstream mercury bioaccumulation in the watersheds that continue to receive only seepage discharge from the tailings basin.

Multiple Watersheds

One obvious option in regard to multiple watersheds is to divide the discharge between the Sandy/Pike River and Dark River watersheds. Earlier sections of this report relate potential impact to wild rice through discharge of either 11.1 cfs or 5.6 cfs ("split flow") to the Sandy River. It is expected that impacts to the trout fishery and property values along the Dark River would be reduced if this alternative were pursued. However, according to the *Aquatic Resources Technical Memorandum,* this split discharge alternative would still result in deterioration of trout habitat in the Designated Trout Stream on the Dark River and these impacts would be similar to those described under Alternative A above. Further, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within the watersheds receiving the new pipe discharges, while lessening the risk of downstream mercury bioaccumulation in the watersheds that continue to receive only seepage discharge from the tailings basin.

5.8.2.3 Alternative C: No Build (No Action)

Under this alternative, no further project actions would take place. Seepage would continue to occur from the tailings basin. Tailings basin flow would continue to be directed through Admiral Lake, Little Sandy Lake, and Sandy Lake, into the Sandy/Pike River. Impacts to the socioeconomic resources would be expected to be minimal under this alternative.

Under this alternative, methylation of mercury is expected to increase due to increasing sulfate concentrations in tailings basin seeps. It is expected that this, in turn, would continue to degrade the fishery resource with related economic and social impacts.

5.8.2.4 Alternative D: Alternative Technologies

This alternative addresses whether the life of the tailing basin can be extended through modification to the existing basin operation and management. Possible modifications are discussed below.

Tailing Basin Perimeter Dike Raising

This alternative would increase the effective water holding capacity of the existing basin through increase of basin side-wall height. Because this alternative seeks to impound greater effluent volume, it would have no direct bearing on surface water quantity. However, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within both the Sandy/Pike and Dark Rivers, as well as Pike Bay and Lake Vermilion more generally.

Water Level Reduction

Water level reduction within the basin is considered possible through removal of water for routine mine operations and processes. Since this alternative is focused on water recycle and does not have direct bearing on surface water quantity or quality, it is not anticipated to impact socioeconomic resources.

Water Level Reduction through Process Water Adjustment

This alternative suggests the reduction of tailings basin water levels through use of additional make-up water and process water recycling. This alternative has no impact on surface water or the socioeconomic resources described.

West Tailing Basin Expansion

This option suggests expansion of the existing basin structure to the west of the current basin. However, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within both the Sandy/Pike and Dark Rivers, as well as Pike Bay and Lake Vermilion more generally. A separate environmental evaluation would be required for this alternative.

5.8.2.5 Alternative E: Design Alternative

Designs to permit increased use of basin water for recycle or make-up water are considered alternatives to reduce water levels within the basin. Since these do not directly impact surface water or water quality, this alternative is not discussed in detail here. One additional design alternative is siphon placement, which may have direct bearing on water temperatures within the receiving basins. This, in turn, would have an impact on trout habitat and tourism.

Siphon Placement

Basin water would be discharged to the respective watershed(s) via a pipe siphon system that lifts water over the dike wall. Water from within the basin may be of varied temperature, depending on the time of year siphoned, and the depth from which the water is collected. If discharge water with a temperature different from the receiving water is released, thermal impacts to biota in the receiving system may occur. This, in turn, would have an impact on trout habitat and potentially on tourism.

5.8.2.6 Alternative F: Modified Scale or Magnitude Alternatives

Almost any additional discharge from the tailing basin would likely exceed water quality standards, as well as result in increased concentrations of tailings basin constituents such as sulfate, that would place additional potential stress on remaining rice plant communities. Therefore, long-term discharges would likely have long-term impacts on the surrounding environment and related socioeconomic impacts similar to those described above for the proposed project. Further, increased methylation of mercury due to increased sulfate levels may be expected to also impact other recreational and commercial fishery activities within the watershed receiving the new pipe discharge, while lessening the risk of downstream mercury bioaccumulation in the watersheds that continue to receive only seepage discharge from the tailings basin.

5.8.2.7 Alternative G: Alternatives Incorporating Reasonable Mitigation Measures

Minntac is reviewing potential use of an SPB system to reduce sulfate and associated tailings basin constituents prior to discharge as set forth in Part 7 of the 2003 SOC between Minntac and the MPCA, dated October 31, 2003. Minntac has recently reported bench studies and reduced-scale field studies of the system. The system has been found to effectively reduce sulfate between 50-60%, depending on nutrient types added to the bioreactor.

It is concluded that the SPB, while a potentially useful tool to reduce sulfate levels, would not, by itself, reduce those levels to meet wild rice growth and production criteria within the Sandy River (MWH, 2004). In addition, the system would result in increases in concentrations of other constituents. This alternative would be likely to result in similar socioeconomic impacts as described under the proposed project.

6.0 MITIGATION MEASURES

During the EIS process, MPCA developed two mitigation scenarios to address impacts associated with the No Build and discharge alternatives identified in Section 4 and evaluated by resource area in Section 5 of this EIS. These mitigation scenarios are briefly described below.

6.1 MITIGATION SCENARIO 1

This mitigation scenario entails the continuous discharge of 8 cfs of SPB treated agglomerator process water to the East Branch of West Two Rivers. Implementation of this scenario would result in reduced total mercury and total sulfate mass loadings over the current pit dewatering discharge to the south. This scenario would likely involve diverting some of the existing pit dewatering flow to Minntac for plant makeup water. In addition, under this scenario, SPB tertiary treatment would likely be required to address water quality issues.

As indicated in Table 6.1, *Comparison of Mitigation Scenarios with the No Build and Discharge Alternatives*, the primary benefits associated with Mitigation Scenario 1 include the following:

- No major impact to baseline hydrology
- Reduction in total mercury and total sulfate mass loading
- Decreased risk of mercury bioaccumulation
- No impacts to downstream wild rice beds
- No major impacts to socioeconomic resources
- Reduction of pollutant loadings to the Dark River and Sandy River watersheds

6.2 MITIGATION SCENARIO 2

This mitigation scenario entails the continuous discharge of 8 cfs of tailings basin wastewater to the East Branch of West Two Rivers, after the tailings basin receives SPB-treated wet scrubber effluent. Under this scenario, SPB tertiary treatment would also likely be required to address water quality issues.

As indicated in Table 6.1, the primary benefits associated with Mitigation Scenario 2 include the following:

- No major impact to baseline hydrology
- No impacts to downstream wild rice beds
- Reduction of pollutant loadings to the Dark River and Sandy River watersheds.

6.3 ALTERNATIVE SELECTION PROCESS

As indicated previously in Section 4.4, MPCA can select one of the alternatives evaluated within the EIS or a combination of alternatives, such as those outlined in Section 4.4. In addition, MPCA can impose special conditions and/or additional mitigation strategies on its selection to insure protection of environmental and socioeconomic resources. Potential mitigation strategies, such as those outlined above, may be considered in the alternative selection process.

Some key information was not available for evaluation within this EIS. Per Minnesota Rules 4410.2500, key missing information that would assist in alternative selection is summarized below:

- Effluent chronic toxicity data (e.g., due to organic compounds from chemical reagents and/or elevated dissolved salts/conductivity).

- Tertiary treatment information for the SPB treatment system; tertiary treatment of the SPB effluent would be required, as appropriate, to prevent downstream water quality violations related to constituents such as ammonia, bicarbonates, Mn, Fe, As, Al, sulfide, BOD, COD, P, Hg, methylmercury; etc.

- Specific information regarding HCR design related to minimizing downstream impacts.

MPCA may require additional site-specific evaluations prior to final design and implementation of the selected action.

TABLE 6.1
COMPARISON OF MITIGATION SCENARIOS WITH THE NO BUILD AND DISCHARGE ALTERNATIVES

Alternative	Drainage	Surface Water		Aquatic resources			Wetlands	Wild rice	Wildlife	Socioeconomics Downstream
		Hydrology	Wastewater Quality[1]	Fish Tissue Mercury	Toxicity	Phosphorus				
Mitigation Scenarios										
Mitigation Scenario 1: 8 cfs continuous discharge of agglomerator process water submerged packed-bed reactor (SPB) effluent treatment system to East Branch of West Two Rivers such that both the total mercury and total sulfate mass loadings are reduced from those currently with the pit dewatering discharges to the south; this alternative probably would involve diverting some of the existing pit dewatering flows to Minntac plant makeup water	**Dark**	No significant issues	Decreasing standard violations of hardness, chloride, conductivity; decreasing potential standards violations of sulfate, total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	No issues	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	Sandy-Pike-Vermilion	No significant issues	Decreasing standard violations of hardness, chloride, conductivity, sulfate; decreasing potential standards violations of total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	Decreasing potential water quality impacts, principally due to decreasing sulfate/dissolved solids	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	West Two Rivers	Relatively little impact to baseline	Standard violations of hardness, chloride, conductivity downstream; SPB tertiary treatment for oxygen demand, ammonia, bicarbonates, manganese, iron, aluminum needed	Downstream bioaccumulation of mercury risk lessened; SPB tertiary treatment for organic carbon, mercury, methylmercury needed	Potential toxicity due to higher dissolved solids, process reagents; SPB tertiary treatment for sulfide needed	SPB tertiary treatment for phosphorus needed	Increased water quality impacts on bogs (lesser than in Sandy drainage and maybe less than in Dark drainage) due to increased hardness, pH; potential sulfur impacts to wetlands upstream of West Two Rivers Reservoir if discharge sulfate concentrations exceed those of current pit dewatering	No issues	Potential impacts due to aquatic toxicity, wetlands changes	No significant issues
Mitigation Scenario 2: 8 cfs continuous discharge of tailings basin wastewater to East Branch of West Two Rivers after the tailings basin receives SPB-treated agglomerator process water effluent	**Dark**	No significant issues	Decreasing standard violations of hardness, chloride, conductivity; decreasing potential standards violations of sulfate, total dissolved solids, bicarbonates downstream; SPB tertiary treatment may be needed	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	No issues	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	Sandy-Pike-Vermilion	No significant issues	Decreasing standard violations of hardness, chloride, conductivity, sulfate; decreasing potential standards violations of total dissolved solids, bicarbonates downstream; SPB tertiary treatment may be needed	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	Decreasing potential water quality impacts, principally due to decreasing sulfate/dissolved solids	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	West Two Rivers	Relatively little impact to baseline	Standard violations of hardness, chloride, conductivity downstream; SPB tertiary treatment may be needed	Increased downstream bioaccumulation of mercury risk due to increased sulfate (and possibly also total mercury) loading	Potential toxicity due to higher dissolved solids, process reagents	SPB tertiary treatment may be needed; potentially increased internal phosphorus loading due to increased sulfate loading	Increased water quality impacts, especially on bogs (lesser than in Sandy drainage and maybe less than in Dark drainage), due to increased sulfate, hardness, pH; leading to potential plant community changes and biodiversity losses	No issues	Potential impacts due to molybdenum, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling
No Build and Discharge Alternatives										
Alternative C: No Build	**Dark**	No significant issues	Increasing standard violations of hardness,	Increasing downstream	Potentially increasing toxicity due to higher	Potentially increasing internal phosphorus	Increasing water quality impacts due to increasing	No issues	Potentially increasing impacts due to	Potential impacts related to

TABLE 6.1
COMPARISON OF MITIGATION SCENARIOS WITH THE NO BUILD AND DISCHARGE ALTERNATIVES

Alternative	Drainage	Surface Water		Aquatic resources			Wetlands	Wild rice	Wildlife	Socioeconomics Downstream
		Hydrology	Wastewater Quality[1]	Fish Tissue Mercury	Toxicity	Phosphorus				
			chloride, conductivity; increasing potential standards violations of sulfate, total dissolved solids, bicarbonates downstream	bioaccumulation of mercury risk due to increased sulfate loading	dissolved solids (including chloride)	loading due to increasing sulfate loading	sulfate and chloride; leading to potential plant community changes and biodiversity losses		sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	diminished angling
	Sandy-Pike-Vermilion	No significant issues	Increasing standard violations of hardness, chloride, conductivity, sulfate increasing potential standards violations of total dissolved solids, bicarbonates downstream	Increasing downstream bioaccumulation of mercury risk due to increased sulfate loading	Potentially increasing toxicity due to higher dissolved solids (including chloride)	Potentially increasing internal phosphorus loading due to increasing sulfate loading	Increasing water quality impacts (greater than in other drainage routes) due to increasing sulfate and chloride; leading to potential plant community changes and biodiversity losses	Potentially increasing water quality impacts, principally due to increasing sulfate/dissolved solids	Potentially increasing impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling
	West Two Rivers	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No issues	No significant issues	No significant issues
Alternative A: Proposed Project (11.1 cfs siphon continuous discharge of tailings basin wastewater to Dark River)	**Dark**	Multiple concerns related to channel scouring in upstream reaches	Increased standard violations of hardness, chloride, conductivity increased potential standards violations of sulfate, total dissolved solids, fluoride downstream	Increased downstream bioaccumulation of mercury risk due to increased sulfate (and possibly also total mercury) loading	Baseline population more diverse and less tolerant to impacts than in other drainage routes; temperature impacts on trout stream; potentially increased toxicity due to higher dissolved solids, process reagents	Potentially increased internal phosphorus loading due to increased sulfate loading	Increased water quality impacts, especially on bogs, due to increased sulfate, hardness, pH; hydrology impacts due to scouring, flooding, interrupted natural hydrologic cycles; leading to potential plant community changes and biodiversity losses	No issues	Potentially increased impacts due to hydrology changes, molybdenum, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling
	Sandy-Pike-Vermilion	No significant issues	Decreasing standard violations of hardness, chloride, conductivity, sulfate; decreasing potential standards violations of total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	Decreasing potential water quality impacts, principally due to decreasing sulfate/dissolved solids	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	West Two Rivers	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No issues	No significant issues	No significant issues
Alternative A: Proposed Project (11.1 cfs siphon continuous discharge of tailings basin wastewater to Sandy River)	**Dark**	No significant issues	Decreasing standard violations of hardness, chloride, conductivity; decreasing potential standards violations of sulfate, total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	No issues	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	Sandy-Pike-Vermilion	Multiple concerns related to channel scouring in upstream reaches	Increased standard violations of hardness, chloride, conductivity, sulfate increased potential standards violations of total dissolved solids, fluoride downstream	Increased downstream bioaccumulation of mercury risk due to increased sulfate (and possibly also total mercury) loading	Potentially increased toxicity due to higher dissolved solids, process reagents	Potentially increased internal phosphorus loading due to increased sulfate loading	Increased water quality impacts, especially on bogs (greater than in other drainage routes), due to increased sulfate, hardness, pH; hydrology impacts due to scouring, flooding, interrupted natural hydrologic cycles; leading to potential plant community changes and biodiversity losses	Increased water quality impacts, principally due to increased sulfate/dissolved solids; hydrology impacts due to scouring, flooding, interrupted natural flow cycles	Potentially increased impacts due to hydrology changes, molybdenum, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling
	West Two Rivers	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No issues	No significant issues	No significant issues
Alternative A: Propose Project with HCR (11.1 cfs siphon hydrographically	**Dark**	No significant issues	Decreasing standard violations of hardness, chloride, conductivity; decreasing potential standards violations of	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	No issues	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels,	Diminished angling less likely

TABLE 6.1
COMPARISON OF MITIGATION SCENARIOS WITH THE NO BUILD AND DISCHARGE ALTERNATIVES

Alternative	Drainage	Surface Water		Aquatic resources			Wetlands	Wild rice	Wildlife	Socioeconomics Downstream
		Hydrology	Wastewater Quality[1]	Fish Tissue Mercury	Toxicity	Phosphorus				
controlled release [HCR] discharge of tailings basin wastewater to Sandy River)			sulfate, total dissolved solids, bicarbonates downstream						wetlands changes	
	Sandy-Pike-Vermilion	Multiple concerns related to channel scouring in upstream reaches (lesser or greater than continuous discharge depending on system design); potential bridge damage (depending on system design)	Increased standard violations of hardness, chloride, conductivity downstream	Increased downstream bioaccumulation of mercury risk due to increased sulfate (and possibly also total mercury) loading	Potentially increased toxicity due to higher dissolved solids, process reagents	Potentially increased internal phosphorus loading due to increased sulfate loading	Increased water quality impacts, especially on bogs (greater than in other drainage routes), due to increased sulfate, hardness, pH; hydrology impacts due to scouring, flooding, interrupted natural hydrologic cycles (lesser or greater than continuous discharge depending on system design); leading to potential plant community changes and biodiversity losses	Potential increased water quality impacts, principally due to increased sulfate/dissolved solids; hydrology impacts due to scouring, flooding, interrupted natural flow cycles (lesser or greater than continuous discharge depending on system design)	Potentially increased impacts (depending in part on system design) due to hydrology changes, molybdenum, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling
	West Two Rivers	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No significant issues	No issues	No significant issues	No significant issues
Alternative B: Alternative Site (11.1 cfs siphon continuous discharge of tailings basin wastewater to East Branch of West Two Rivers)	**Dark**	No significant issues	Decreasing standard violations of hardness, chloride, conductivity; decreasing potential standards violations of sulfate, total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	No issues	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	Sandy-Pike-Vermilion	No significant issues	Decreasing standard violations of hardness, chloride, conductivity, sulfate; decreasing potential standards violations of total dissolved solids, bicarbonates downstream	Downstream bioaccumulation of mercury risk lessened	Decreasing potential toxicity due to lower dissolved solids	Risk lessened of potential internal phosphorus loading due to sulfate loading	Decreasing water quality impacts due to decreasing sulfate and chloride	Decreasing potential water quality impacts, principally due to decreasing sulfate/dissolved solids	Decreasing potential impacts due to sulfate, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Diminished angling less likely
	West Two Rivers	Multiple concerns related to channel scouring in upstream reaches (less than in other drainage routes due to existing 8 cfs average pit dewatering discharge baseline)	Standard violations of hardness, chloride, conductivity downstream	Increased downstream bioaccumulation of mercury risk due to increased sulfate (and possibly also total mercury) loading	Potential toxicity due to higher dissolved solids, process reagents	Potentially increased internal phosphorus loading due to increased sulfate loading	Increased water quality impacts, especially on bogs (lesser than in Sandy drainage and maybe less than in Dark drainage), due to increased sulfate, hardness, pH; hydrology impacts due to scouring, flooding, interrupted natural hydrologic cycles; leading to potential plant community changes and biodiversity losses	No issues	Potential impacts due to hydrology changes, molybdenum, fish mercury, aquatic toxicity, phosphorus levels, wetlands changes	Potential impacts related to diminished angling

Notes:
1. Versus numerical water column standards (excluding molybdenum, wetlands pH and wild rice)

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