



Pinawa Diversion Dam Remediation Program

Development Environmental Assessment (EA) Report

PINAWA DIVERSION DAM REMEDIATION PROGRAM
DEVELOPMENT ENVIRONMENTAL ASSESSMENT REPORT

A Report Prepared
for
Manitoba Hydro

by



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EXECUTIVE SUMMARY

The Pinawa Generating Station (GS) was retired from service on October 25, 1951 just prior to completion of expansion of the Seven Sisters GS in 1952. Concurrent with decommissioning of the GS, the Pinawa Channel Control Dam was modified to create the Pinawa Diversion Dam to direct more flow through the Seven Sisters GS. Over the years, the Diversion Dam has undergone considerable repair work; however, current structural problems have made it necessary to conduct more permanent remediation by adding approximately 30 m of rock infill to the downstream side.

Remediation practices proposed for the Diversion Dam will alter a minor portion of fish habitat immediately downstream of the Dam and as a result, may be viewed as a “harmful alteration, disruption or destruction” of fish habitat (HADD) by the Department of Fisheries and Oceans Canada (DFO) and Manitoba Conservation. Consequently, Manitoba Hydro has prepared an environmental assessment (EA) report which includes both existing environment and impact assessment sections for the Pinawa Channel and associated water bodies.

No significant impacts to the environment are expected as a result of the Project. Though infilling will result in a small loss of channel volume immediately downstream of the Diversion Dam, it will not significantly alter current conditions of the terrestrial or aquatic environments. Because this area is considered low quality fish habitat, losses to the fish community within the channel will be minimal. A small amount of sediment or fines will be released into the channel during construction, but releases will be minimized by the use of clean rockfill and impacts are expected to be minor, localized, and temporary. Consequently, sediment release is not considered to be a significant negative impact to fish or fish habitat, including VEC species. No significant changes to the current flow regime are expected and, as a result, no negative impacts to aquatic vegetation or fauna are anticipated. Mitigation, in the form of littoral zone development and creation of reef habitat, has been suggested for the area upstream of the Diversion Dam rather than downstream as upstream habitat is of more value to fish and supports early life history stages of some species.

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SCIENTIFIC PERMITS

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1.0 INTRODUCTION

The Pinawa Generating Station (GS), or Old Pinawa Dam as it is now known, was retired from service on October 25, 1951 just prior to completion of expansion of the Seven Sisters GS in 1952. Concurrent with decommissioning of the GS, the Pinawa Channel Control Dam was converted into a diversion dam to direct more flow through the Seven Sisters GS (Figure 1). The Diversion Dam has required considerable maintenance and repair work in the last 30 years and structural repairs are required. Manitoba Hydro is proposing to stabilize the existing Diversion Dam rather than demolish the existing structure and rebuild.

Though repairs to the existing Dam are likely to impact fish and fish habitat less significantly than would construction of a new dam (and destruction of the old structure), it is possible that remediation practices may be viewed as a “harmful alteration, disruption or destruction” of fish habitat (HADD) by DFO and Manitoba Conservation. Consequently, Manitoba Hydro is approaching the Project by assuming that DFO will determine that a small-scale HADD will result from the placement of additional material in the Pinawa Channel downstream of the existing Dam. The project is a Class 2 development under the *Manitoba Environment Act* and as such, Manitoba Hydro has prepared this environmental assessment (EA) report which includes both existing environment and impact assessment sections for the Pinawa Channel and associated water bodies.

The following report outlines the Pinawa Diversion Dam remediation project (the Project) and includes descriptions of the existing environment, construction, operation and maintenance plans, environmental effects of the Project, and a discussion on mitigation options and future monitoring of the Project Area and associated water bodies. The environment is described in terms of terrestrial and aquatic habitats, fish communities, and socio-economic considerations within the Project Study Area. This report was prepared using the guidelines set forth by Manitoba Conservation, located in the Environment Act Proposal Report Guidelines Information Bulletin (Manitoba Conservation 2009), based on the Licensing Procedures Regulation (Manitoba Regulation 163/88).

2.0 PROJECT DESCRIPTION

2.1 GENERAL

The Pinawa Diversion Dam is located at the end of Public Road 14 between the north and south banks of the Pinawa Channel at its confluence with the Seven Sisters forebay (Figure 1). The Dam is situated on Crown land, and has been designated as part of the Winnipeg River Power Reserve.

The Pinawa Channel/Lee River connects the Winnipeg River upstream of the Seven Sisters GS to the eastern arm of Lac du Bonnet (Figure 2). Locally, the river upstream of the PTH 313 crossing is known as the Pinawa Channel, while downstream it is known as the Lee River. Before construction of the Pinawa GS in the early 1900's, the Pinawa Channel/Lee River was an overflow channel of the Winnipeg River, conveying flow primarily during spring runoff and following heavy rainfall events. As part of the Pinawa GS Project, the existing channel was deepened and flow was diverted from the Winnipeg River through a control structure built at the mouth of the channel. After the Pinawa GS was decommissioned in 1951, flow into the channel was blocked at the Winnipeg River by filling in the Pinawa Control Structure (now called the Pinawa Diversion Dam). Today, discharge in the Pinawa Channel consists of seepage from the Pinawa Diversion Dam and local drainage.

Increased maintenance requirements with the Diversion Dam and the need to meet current dam safety standards have made it necessary to rehabilitate the structure. Manitoba Hydro has determined that remediating the existing structure is preferable to demolition of the existing dam and construction of a new diversion structure.

2.2 CONSTRUCTION

Remediation will consist of adding large sized rockfill to the downstream side of the Diversion Dam. The base of the rockfill will be approximately 30 m long and will span the width of the channel. This will result in the covering of approximately 1500 to 1800 m² of aquatic substrate immediately downstream of the Diversion Dam. The rockfill will allow current discharge through the Diversion Dam to be maintained. The rock infill will be sourced from the existing Seven Sisters stockpile and will be delivered in tandem or semi dump trucks along Provincial route 211 which leads directly to

the Diversion Dam. Infill work will be conducted from land or above the water, working off of placed rockfill. Use of clean rockfill is expected to minimize potential increases in total suspended solids (TSS) downstream. Consequently, a silt/turbidity curtain will not be required as potential increases in TSS levels are not expected to exceed provincial guidelines. Manitoba Hydro will conduct TSS sampling downstream of the Diversion Dam prior to and during placement of rockfill in the water. Proposed remediation plans for the control structure are illustrated in Figure 3.

Work on the downstream side of the dam will begin immediately following Project approval and licensing. The construction is currently scheduled to take place in the fall of 2010 and is estimated to take approximately ten weeks. Assuming work commences in early October 2010, completion is scheduled for early December. Anticipated construction activities for the rehabilitation are summarized as follows:

- 1) Mobilization (October 4-10, 2010);
- 2) Site foundation preparation (October 6-15, 2010);
- 3) Placement of the first lift of rockfill downstream of the existing dam (in the wet) and TSS monitoring program (October 12-31, 2010);
- 4) Placement of the remaining rockfill, transition fill and road topping (October 20 to November 30, 2010); and
- 5) Site clean-up and demobilization (December 1-3, 2010).

2.3 OPERATION AND MAINTENANCE

Manitoba Hydro will continue to operate the Pinawa Diversion Dam as it is operated today, with regular monitoring and maintenance. Currently, the Pinawa Diversion Dam is inspected twice annually and channel flow directly downstream of the Dam is measured at minimum once per year. After rehabilitation of the Dam is complete, the structure will be inspected several times per year for the first two to three years in order to ensure proper function. Additionally, the post-Project flow regime will maintain current water levels within the channel. Sensors will be placed both upstream and downstream of the structure to measure water levels closely and channel flow downstream of the Dam will be monitored at minimum once per year. Flow rate with respect to the maintenance of current channel water levels is discussed in detail in section 4.3.2.

3.0 STUDY AREA

3.1 GENERAL

The aquatic environment studies focused on waterbodies that have the potential to be directly affected by any changes in water levels and flows as a result of the Project. The Pinawa Diversion Dam Remediation Project Study Area (the Study Area) begins at the Seven Sisters Generating Station (GS), continues past Natalie Lake and the Winnipeg River through the Pinawa Diversion Dam and into the Pinawa Channel. From there, it continues along the Pinawa Channel, past the Pinawa Dam Provincial Park and Old Pinawa Dam into the Lee River, Pinawa Bay and Sunset Bay. The terrestrial and socio-economic assessments focused on the area in the immediate vicinity of the project. A map of the Study Area is illustrated in Figure 2.

3.2 CURRENT CONDITIONS

The area upstream of the Diversion Dam is part of the main channel of the Winnipeg River. This portion of the river is characterized by a relatively wide (80-90 m), deep (4-8 m) channel. The area immediately upstream of the Diversion Dam drops quickly to in excess of 4 m and has very little littoral zone. Water velocity is low and the water is slightly turbid. Shorelines are characterized by a combination of rip rap, natural rock formations, and natural and fallen vegetation. During a one-day spring fisheries survey (Appendix 1), no evidence of spawning or adult foraging by large-bodied fish was found upstream of the Diversion Dam; however, it is expected that there is some limited use of the sparse littoral areas for foraging during summer. The area may support fish that prefer rocky ledges such as smallmouth bass. Some juvenile northern pike and shorthead redhorse were captured along the north shoreline during spring, though fish were not abundant. This area may be used to some extent as rearing habitat; however, shallow water areas along shorelines further upstream within the Winnipeg River are likely more important as rearing habitat. No littoral zone is present along the south bank. This area has been anthropogenically altered for many years, with rip rap supporting the shoreline along most of its length.

The Pinawa Channel originates on the downstream side of the Pinawa Diversion Dam and flows in a northerly direction to the PTH 313 bridge. The Channel can be divided into two sections: upstream

of the Old Pinawa Dam it is a shallow, meandering channel, while downstream of the Dam, within the influence of Lac du Bonnet, the channel becomes much wider and deeper (Schneider-Vieira 1996a). In both areas the water is relatively clear.

The Pinawa Channel is relatively narrow and shallow from its origin at the Pinawa Diversion Dam to upstream of the Old Pinawa Dam (Figure 2). Substrates at the upstream end immediately below the Diversion Dam consist of a combination of sand/silt, cobble, gravel and boulder. Flows are generally between 0.17 and 0.7 m/s. Low quality spawning substrates, relatively strong currents, shallow water (less than 0.7 m), and little or no vegetation or cover limits use of the area for foraging, spawning or rearing for most fish species. The reach experiences a net emigration of fish each year as there is no in-migration from upstream and fish cannot move upstream into the reach past the Old Pinawa Dam. The downstream side of the Diversion Dam is illustrated in Figure 4. Though no fish were captured downstream of the Diversion Dam, the area likely supports a seasonal community of aquatic invertebrates such as insect larvae and various crustaceans. Consequently, for the fish population isolated within the reach, the area likely provides some foraging habitat during the late spring and summer.

Downstream of the rapids and Old Pinawa Dam, the channel is much wider and deeper, and has sloping shorelines with marsh vegetation alternate with areas of bedrock. Much of the shoreline in this part of the river is used for agriculture. Approximately 8 km downstream of the Old Pinawa Dam, at the PTH 313 bridge, flooding from Lac du Bonnet has transformed the river into a broad, lake-like channel. Emergent vegetation is uncommon and most of the shoreline is cut bank or bedrock. Beginning just upstream of the PTH 313 bridge, residential developments occur along much of the shoreline. Several large- and small- bodied fish species have been found in waters below the Old Pinawa Dam (Appendix 1). Habitats below the Old Pinawa Dam support a more complex community of fish, providing higher quality substrates, greater depths and more optimal flows for spawning and rearing. This area is also deep enough to support overwintering habitat for fish species.

Flows within the Pinawa Channel/Lee River are dependent on seepage through the Diversion Dam and local discharge. The amount of seepage is dependent on water levels in the Winnipeg River,

which is controlled by input from upstream sources, and discharge at the Seven Sisters GS. Discharge in the Pinawa Channel ranges from a minimum of 5.7 m³/s (200 cfs) to a maximum of 28.3 m³/s (1000 cfs), with an average of 8.5 m³/s (300 cfs) during June, July, and August (Schneider-Vieira 1996a,b). Downstream of the Old Pinawa Dam, water levels in the Pinawa Channel are affected by levels in Lac du Bonnet. In the lower flooded portion of the Lee River, water levels are directly dependent on levels in Lac du Bonnet

At the lower end of the Pinawa Channel/Lee River widespread use of the water is made by people for recreational purposes. Water-oriented recreational activities such as sport fishing, boating, swimming, canoeing, and kayaking are the primary uses for the system, particularly within the Lee River. As a result, recreational settlements have been developed throughout the region (Lee River Pinawa Channel Study Committee 1981). These developments are comprised of private ownership, leasehold from the Province of Manitoba, and informal user arrangements with private owners. By 1981, approximately 36 per cent of the recreation units were located on privately owned lands, while approximately 14 per cent were located on Director of Survey subdivisions and held through lease arrangements with the Province. The remaining 50 per cent were located on privately owned land by means of informal agreements between the land owner and the user (Lee River Pinawa Channel Study Committee 1981). The use of these lands for unregistered recreational development resulted in stresses on shoreline accessibility, substandard buildings, inadequate sanitation and unchecked demands on local resources. As a result, the Lee River Pinawa Channel Study Committee (1981) recommended a mitigation program promoting the relocation of some recreation units to lower use areas of the waterway.

At the upstream end of the Pinawa Channel the community of Pinawa supports approximately 1500 permanent and seasonal residents, as well as hundreds of recreational users during the summer and fall months. Pinawa offers a number of recreational activities including: golfing, vacationing, hunting, skiing, fishing and other water sports. Land in the immediate vicinity of the Diversion Dam includes some man-made ski and other recreational trails along with forest habitat to the north, the Pinawa Club Golf Course to the south, and the town of Pinawa to the southwest.

A more detailed discussion of the existing environment surrounding the Pinawa Diversion Dam, including investigations of the terrestrial and aquatic environments and fish communities, is available in Appendix 1.

4.0 HABITAT ASSESSMENT - IMPACTS AND MITIGATION

4.1 ASSESSMENT APPROACH

Certain valued ecosystem components (VECs) were selected as the focus of this environmental impact assessment: northern pike, walleye, lake sturgeon, and carmine shiner. The VECs were selected because they met one or more of the following criteria: i) of particular importance (economic, recreational, traditional use) for humans; ii) representative of a group of species; iii) good indicators of effects on producers and consumers within their food web; iv) rare or endangered; or v) of special ecological significance. In this case, species-level VECs were identified in the Pinawa Channel/Lee River based on their importance to local communities in terms of recreational fishing, their value as environmental indicators, and/or their ecological status. The main attributes of the four species-level VECs are:

- Northern Pike: top level predator, harvested in recreational fisheries that is present in the Pinawa Channel;
- Walleye: top level predator, harvested in recreational fisheries that is not documented as present in the Pinawa Channel;
- Lake Sturgeon: mid-level predator, COSEWIC recommended 'endangered' species where it is present (i.e. in the Winnipeg River proper); and
- Carmine Shiner: lower to mid-level omnivore that is present downstream of the Old Pinawa Dam on the Pinawa Channel / Lee River, Species at Risk Act (Canada) listed 'threatened' species in Manitoba, significant biological and scientific interest.

Although a broad range of environmental components are considered in this report, the determination of whether or not impacts are 'significant' focuses on the degree of change from existing conditions and value of the individual component or VEC. The significance of potential impacts to VECs was evaluated on the basis of the following criteria:

- Societal value of affected environmental component;
- Ecological value or sensitivity of affected environmental components (rarity and uniqueness, fragility, importance within ecosystem, importance to scientific studies);
- Duration of the effect;
- Frequency of the phenomenon or event causing the effect;

- Spatial boundaries or geographical extent of the effect (single point, localized, regional);
- Reversibility of the effect/time to recover after the source of the effect ceases; and
- Magnitude of the effect compared to existing conditions.

The central question is whether a Project effect is likely to cause any significant adverse environmental impact, after mitigation measures are implemented. Such residual environmental effects that are both ‘likely’ and ‘adverse’ are considered in the determination of significance.

In order to determine whether an environmental effect is ‘adverse’, the quality of the existing environment is compared to the predicted quality of the environment once the Project is in place, for example using some or all of the following criteria:

- adverse effects on the health of biota, including plants, animals and fish;
- threat to rare or endangered species;
- reductions in species diversity or disruption of food webs;
- loss or damage to habitats, including habitat fragmentation;
- discharges or release of persistent and/or toxic chemicals, microbiological agents, nutrients, radiation, or thermal energy;
- populations declines, particularly in top predator, large or long-lived species;
- removal of resource materials from the environment;
- transformation of natural landscapes;
- obstruction of migration or passage of wildlife; and
- adverse effects on the quality and/or quantity of the biophysical environment.

4.2 LINKAGES

An ecosystem-based approach has been employed to assess the potential impacts of the Project on the terrestrial and aquatic environments as well as fish communities. Since the work involves placing material in the water, effects will likely only occur in the aquatic environment. Impacts to the terrestrial environment will be minimal and primarily related to riparian vegetation. Because impacts to aquatic habitat during construction are related to infill of the Pinawa Channel downstream of the Diversion Dam there is a small possibility of water level and flow changes, and possible impacts on aquatic vegetation growth were investigated. Impacts to fish communities during construction are

related to indirect effects arising from transient changes to water quality and aquatic habitat. Potential direct linkages to fish communities may include the following:

- Inputs of sediments, fines, and other potential contaminants from work areas, material stockpiles and other sites via runoff and construction activities;
- Infilling of nearshore habitats;
- Reduction of water flow into Lee River; and
- Noise disturbance from construction activities.

4.3 POTENTIAL PROJECT EFFECTS

4.3.1 Terrestrial Habitat

The terrestrial environment surrounding the Pinawa Diversion Dam is largely composed of anthropogenically altered habitat. To the south, the Pinawa Club Golf Course, the Town of Pinawa, and other facilities have eliminated some of the natural vegetation that once existed in that area. To the north, an abundance of ski and recreational trails are interspersed through the existing habitat, though forested areas remain. Any undisturbed natural forest habitat remaining in the area is far enough from the Dam site that no significant physical impacts are expected. While some disturbance is expected in terms of noise, such disturbance is considered local, temporary, and not significant.

It is possible that during remediation, the small corridor of vegetation separating the Pinawa Club Golf Course and the Diversion Dam may be physically impacted; however, this area is minor and not significant to terrestrial wildlife in the area. Currently, this corridor experiences foot traffic on a regular basis by residents and recreational users crossing over the Dam to reach the north bank and its various trails.

4.3.2 Aquatic Habitat

No significant water level variations are expected at any point on the Pinawa Channel during or after the Project. Although the project has been designed to maintain existing flows in the channel, hydraulic analyses were conducted to assess potential water level effects in the Pinawa Channel resulting from inadvertent flow reductions caused by the project. The approximate 25%, 50%, and 75% historical flows (since 1990) through the existing flow-through rockfill dam were considered,

and possible flow reductions of 10%, 20%, and 30% were tested for each of the three existing flow conditions. Modeling was done using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Centers River Analysis System (HEC-RAS) software package. The HEC-RAS backwater model of the Pinawa Channel used for this study was originally developed by Manitoba Hydro and was later modified by KGS Group (2006).

The HEC-RAS backwater model was used to perform one-dimensional steady flow conditions. The normal operating reservoir level (254.81 m) for the McArthur G.S. was used as the downstream boundary conditions for the backwater model. A water level duration curve at Sylvia Lake was developed and used as a basis for estimating seepage through the Pinawa Dam. The seepage through the Pinawa Dam corresponding to the 25th, 50th, and 75th percentile water levels were estimated using a rating curve developed by Manitoba Hydro.

Examination of the water surface profiles indicated no significant drop in water levels due to 10%, 20%, and 30% flow reductions (tables 1 and 2; Figure 5). In particular, water levels downstream of the Old Pinawa Dam and upstream of the bridge showed virtually no distinction amongst the various flow regimes. Water levels at the remaining cross-sections decreased such that average water depths were reduced by 0.4% to 14.5%. The maximum reduction was noted upstream of the Old Pinawa Dam, where the average water depth decreased from 0.62 m to 0.53 m. Average velocities downstream of the Old Pinawa Dam and upstream of the PR 313 bridge were extremely low (0.01 to 0.04 m/s) and decreased by at most 0.01 m/s from the flow reductions investigated. Similarly, average velocities at the cross-section downstream of the Pinawa Diversion Dam were only 0.07 m/s to 0.12 m/s, and dropped by at most 0.03 m/s for any of the flow scenarios. Consequently, any reductions in flow as a result of the Project are not considered significant and not expected to negatively impact the Project area or surrounding water bodies. The water surface profile produced using the HEC-RAS at representative cross-sections for the approximate 50th percentile is illustrated in Figure 6.

Light attenuation as a result of suspended solids has been negatively correlated with algal photosynthesis (Blanch et al. 1998), macrophyte photosynthesis (Harding et al. 1986), plant growth and floral diversity (Gardiner 1991), elsewhere. As a result of this, summer CO₂ uptake and O₂

production can also decline (Long 2007). The short-term release of fines during the Project will be small, localized, and temporary, and is not expected to significantly impact light availability in the Pinawa Channel/Lee River. Similarly, no significant variations in water levels are expected as a result of the Project and anticipated impacts to depth and light availability are not considered significant.

No significant impacts to phytoplankton or rooted vascular macrophyte growth are expected as a result of the Project. Though prolonged release of sediments and fines has been known to increase turbidity and decrease light availability for growth, such a prolonged release is not expected during remediation. Short-term release of fines is expected during rock infill; however, these impacts will be small, localized, temporary and will occur during the late fall/winter. No losses of aquatic vegetation are therefore expected as a result of the Project as little vegetation exists in the area immediately downstream of the Diversion Dam.

4.3.3 Fish

With respect to VEC's only one species is known to occur in the Pinawa Channel between the Project site (i.e. Diversion Dam) and the Old Pinawa site. Northern pike are known locally to be present but are likely restricted to slower marshy areas further downstream. The laminar flow and lack of cover in the blasted portion of the Pinawa Channel immediately downstream of the Diversion Dam is not optimal northern pike habitat. Consequently, the affected area immediately downstream of the Diversion Dam is considered to be relatively low quality fish habitat, particularly for the VEC species (see Appendix 1 – Fish Habitat Utilization).

Effects of suspended solids on fish can occur at several levels, including 1) physiological damage to fish and their eggs as a result of degraded water quality; 2) impacts to prey; 3) indirect impacts on aquatic vegetation; and 4) physical changes to the abiotic habitat (Long 2007). However, such impacts are most often the result of the long-term presence of introduced fines or continuous release of large quantities of fines, as seen with large construction projects. For example, Kirk (1992) found that prey species such as *Daphnia ambigua* had reduced maximum body length, age-specific survivorship, and fecundity in the long-term presence of suspended clay. In addition, sediments can settle, smother eggs and destroy spawning beds by filling interstitial spaces (Ward 1992).

Though small amounts of sediment are likely to be released during remediation, no long-term suspension of fines, long distance transportation of fines, significant habitat alteration, nor water quality impacts are expected. As previously discussed, clean rockfill material will be added to the downstream side of the Dam using an existing stockpile of rock infill, which will minimize the amount of potential sediment release into the channel. Additionally, by adding clean rockfill to one side of the dam, habitat loss will be significantly reduced. The new rockfill will result in a minor alteration to aquatic habitat.

Remediation activities will not be performed during critical spawning periods for fish within the channel. While historical development of hydroelectric facilities on the Winnipeg River proper may have “decreased spawning habitat for the carmine shiner by altering depth, flow and turbidity” (COSEWIC 2007), the carmine shiner is not found in the Pinawa Channel and this project does not impact on the habitat of this species downstream of Old Pinawa Dam. Likewise, lake sturgeon are not present in the Pinawa Channel and are not impacted by the Project. As discussed in section 4.3.2, no significant drop in water levels or flow will result from the remediation Project. Should the project result in an inadvertent decrease in flow, average velocities would not be expected to decrease by more than 0.01 to 0.03 m/s and no negative effects would be anticipated for fish communities or other biota within the channel.

4.4 SUMMARY OF RESIDUAL EFFECTS

Remediation of the Pinawa Diversion Dam consists of adding materials to the existing structure and will not require extensive construction activities. As such, potential impacts from the Project will not significantly affect habitat variables such as water level, depth, light availability, or phytoplankton and macrophyte growth. Though water quality can affect vegetation growth in aquatic habitats, negative effects are often related to prolonged and heavy exposure to fines at critical times of the year. Short-term, small amounts of sediment or fines may be released in the immediate vicinity of the dam site; however, the effects will be minimized by reducing the time required for remediation (i.e., ensuring that infilling is conducted in a timely manner) and by using clean rock infill. Potential slight reductions in flow through the existing structure after construction are not expected to significantly affect water levels or velocities.

Terrestrial habitat within the vicinity of the Diversion Dam will not be impacted significantly. During remediation, a small amount of habitat along the shoreline on either side of the Dam will be impacted; however, those impacts will be localized, temporary, and not significant. Noise disturbance within the immediate vicinity of the Diversion Dam during remediation is expected to be localized, temporary, and not significant.

Remediation activities will not affect fish species or their habitat to any significant extent. Small amounts of sediment or fines may be released in the immediate vicinity of the dam site; however, these effects will be small, localized, temporary, and not significant. Loss of fish habitat as a result of the Project will be minor as existing downstream habitat is considered of relatively low value to fish (including VECs). No evidence of spawning, rearing, or foraging was found during habitat utilization investigations and the area is too shallow for overwintering. Consequently, any potential impacts to fish populations as a result of the Project would be unmeasurable. A fish habitat compensation plan will be submitted to DFO in order to offset the potential negative effects to fish habitat.

5.0 SOCIO-ECONOMIC CONSIDERATIONS

5.1 ASSESSMENT APPROACH

The determination of whether or not socio-economic impacts are ‘significant’ focuses on the degree of change from existing conditions and value of the individual component. The central question is whether a Project effect is likely to cause any significant adverse socio-economic impact, after mitigation measures are implemented. Such residual effects that are both ‘likely’ and ‘adverse’ are considered in the determination of significance.

In order to determine whether a socio-economic effect is ‘adverse’, the quality of the current conditions is compared to the predicted quality of the conditions once the Project is in place, for example using some or all of the following criteria:

- adverse effects on the health of the local community;
- adverse effects to current functioning of the community, recreationally or otherwise;
- loss or damage to private or public property;
- removal of resource materials from the environment; and
- transformation of natural landscapes;

5.2 LINKAGES

Socio-economic impacts were assessed in terms of potential disruption of residential or recreational activities and proximity of the Project to the Pinawa Club Golf Course, recreational trails, and the Town of Pinawa. Results indicated that impacts resulting from the Project will be related to access (of the north bank recreational trails) and noise disturbance.

5.3 POTENTIAL PROJECT EFFECTS

The majority of Project impacts to the local community and recreational users during construction are related to noise disturbance and access to recreational trails on the north side of the Diversion Dam. The ski trails to the north of the Dam are part of the Trans Canada trails and are heavily used year round. The Project may also have direct effects on recreational activities to the south as the Pinawa Club Golf Course exists almost immediately beside the Dam. The town of Pinawa is located

just over one kilometer from the Diversion Dam and it is possible that noise disturbance will impact local residents during remediation. The construction area is not utilized by local residents or recreational users.

5.4 SUMMARY OF RESIDUAL EFFECTS

No changes with respect to socio-economic conditions are expected as a result of the Project. While remediation activities may decrease access to ski and other recreational trails on the north side of the Diversion Dam, reduced access should only occur during the relatively low use time from late October to early December. To the extent that it is possible, Manitoba Hydro will undertake to provide access to local residents and recreational users during remediation. Though noise disturbances are unavoidable in the immediate vicinity of the dam site, remediation activities have been scheduled so as to impact the local community and recreational users as little as possible. For example, the Pinawa Club Golf Course is situated close enough to the Dam site that the low level noise expected during remediation may have been a cause for concern. However, no such disturbance is expected as the golf course will likely be closed for the season before remediation activities begin. Any disturbances made during construction will be localized, temporary, and not significant.

6.0 MITIGATION OPTIONS AND MONITORING

6.1 MONITORING

No long-term negative impacts to the environment are expected as a result of the Project. Once construction is complete, the Pinawa Diversion Dam will be operated as it is today, with regular monitoring and maintenance. After rehabilitation of the Dam is complete, the structure will be inspected several times per year for the first two to three years in order to ensure proper function, and maintenance activities will be performed as needed. The new flow regime will be managed in such a way as to maintain current water levels within the channel. Sensors will be placed both upstream and downstream of the structure to measure water levels closely and channel flow downstream of the Dam will be monitored at minimum once per year. The aquatic habitat upstream and downstream of the Diversion Dam is expected to remain relatively unchanged, with minor impacts to the environment in the immediate vicinity of the Dam. Consequently, environmental monitoring is not planned following the completion of remediation activities.

6.2 MITIGATION

Remediation of the Pinawa Diversion Dam is expected to have minor and localized impacts to terrestrial or aquatic habitat and fish communities within the Study Area. During remediation, a small amount of terrestrial habitat along the shoreline on either side of the Dam will be impacted as a result of vehicle traffic and equipment; however, this habitat has been anthropogenically altered and does not represent important or unique habitat for terrestrial plants or animals. As such, shoreline stabilization along impacted areas is expected to be sufficient once remediation is complete and no further mitigation is anticipated.

Impacts to the aquatic environment upstream of the Diversion Dam are expected to be minor, localized, and not significant. Although some foot traffic may occur along the shoreline of the Dam, no damage or alteration of existing habitat is anticipated. No impacts are expected along the north or south shorelines upstream of the Diversion Dam. There is no mitigation proposed for this area.

Minor impacts are expected to the aquatic environment downstream of the Diversion Dam. The new structure will continue to provide the same interstitial spaces through which small invertebrates and fish may pass from the Winnipeg River into the Pinawa Channel or colonize for some stage of their life history. Though some loss of channel volume is expected, the area is considered of low value for fish. Consequently, although there is a permanent change to the fish habitat, the changes are small, local, and not significant.

While there will be some infilling of aquatic habitat downstream of the diversion dam, mitigatory measures are not recommended in this area because of the limited fish population and the low value of the habitat. However, preventative measures including the use of clean rockfill and avoidance of key timing windows for fish species, will be taken during remediation. Compensation opportunities exist upstream of the Diversion Dam in the Winnipeg River proper where there is potential to significantly increase the quality of fish habitat that is already being exploited by some species and life history stages. Environmental assessments revealed that just upstream of the Diversion Dam there is a scarcity of shallow, littoral area along the south bank, while along the north bank they are sporadic and less than one meter long. Increasing the amount of littoral habitat that is accessible to fish and invertebrates will increase the habitat available for forage fish and juveniles of larger species (e.g. northern pike). In addition, construction of reef habitat within the channel upstream of the Dam will also provide habitat for many fish and invertebrate species. Such a reef would be placed at depths of two meters or more, pursuant to the guidelines established for navigable waters.

7.0 CONCLUSIONS

Terrestrial habitat within the vicinity of the Diversion Dam will not be impacted significantly. During remediation, a small amount of habitat on either side of the dam will be affected; however, those impacts will be localized, temporary, and not significant.

No significant alteration of aquatic habitat upstream of the Diversion Dam will occur as a result of remediation. Though some foot traffic may occur along the shoreline upstream of the Dam, no negative impacts to the fish or invertebrate habitat are anticipated.

The footprint of the Project will amount to approximately 1500 to 1800 m² of altered aquatic habitat immediately downstream of the Diversion Dam. Although this area may be utilized during the late spring and summer by insect larvae, other crustaceans and some fish, it is considered of low value for fish species overall. Consequently, this alteration of aquatic habitat in the immediate vicinity of the Dam is not considered significant. No VEC or other fish species were observed in this area; the lower water velocities, deeper water, better cover, and more preferable substrate further downstream likely support a wider variety of fauna and more complex communities of fish and invertebrates. Those habitats will not be impacted by the Project. Opportunities exist upstream of the Diversion Dam to compensate for potential harmful alterations to fish habitat on the downstream side. A fish habitat compensation plan will be submitted to DFO under separate cover.

A small amount of sediment or fines will be released into the water during construction, but releases are expected to be minor, localized, and temporary. Consequently, sediment release is not considered to be a significant negative impact to fish or fish habitat, including VEC species. No significant changes to the current flow regime are expected and, as a result, no significant negative impacts to aquatic vegetation or fauna are anticipated.

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TABLES

Table 1. Hydraulic conditions in the Pinawa Channel at selected cross-section. V and D represent flow velocity and flow depth in the channel.

Run Scenario	Flow (m ³ /s)	D/S of Diversion Dam			13 km U/S of 313 Bridge			U/S of Old Pinawa Dam			D/S of Old Pinawa Dam			U/S of 313 Bridge		
		Ave V (m/s)	Ave D (m)	Max D (m)	Ave V (m/s)	Ave D (m)	Max D (m)	Ave V (m/s)	Ave D (m)	Max D (m)	Ave V (m/s)	Ave D (m)	Max D (m)	Ave V (m/s)	Ave D (m)	Max D (m)
25 percentile	6.6	0.1	2.08	2.63	0	2.81	4.39	0.54	0.58	1.16	0.03	0.98	3.23	0.02	2.56	5.02
10% reduction	5.94	0.09	2.06	2.6	0	2.79	4.37	0.53	0.55	1.11	0.03	0.98	3.22	0.02	2.56	5.02
20% reduction	5.28	0.08	2.04	2.57	0	2.78	4.34	0.52	0.53	1.05	0.02	0.98	3.22	0.01	2.56	5.02
30% reduction	4.62	0.07	2.02	2.53	0	2.76	4.32	0.5	0.5	1.01	0.02	0.98	3.22	0.01	2.56	5.02
50 percentile	6.86	0.1	2.09	2.64	0	2.81	4.4	0.55	0.59	1.17	0.03	0.98	3.23	0.02	2.56	5.02
10% reduction	6.17	0.09	2.07	2.61	0	2.8	4.38	0.53	0.56	1.13	0.03	0.98	3.22	0.02	2.56	5.02
20% reduction	5.49	0.09	2.05	2.58	0	2.78	4.35	0.53	0.53	1.07	0.03	0.98	3.22	0.01	2.56	5.02
30% reduction	4.8	0.08	2.03	2.54	0	2.76	4.33	0.51	0.51	1.02	0.02	0.98	3.22	0.01	2.56	5.02
75 percentile	7.82	0.12	2.12	2.68	0.01	2.83	4.43	0.57	0.62	1.23	0.04	0.99	3.23	0.02	2.57	5.03
10% reduction	7.04	0.11	2.1	2.65	0	2.82	4.41	0.55	0.59	1.19	0.03	0.98	3.23	0.02	2.56	5.02
20% reduction	6.26	0.1	2.07	2.61	0	2.8	4.38	0.54	0.57	1.13	0.03	0.98	3.22	0.02	2.56	5.02
30% reduction	5.47	0.09	2.05	2.58	0	2.78	4.35	0.53	0.53	1.07	0.03	0.98	3.22	0.01	2.56	5.02

Table 2. Relative percent increases or decreases in hydraulic conditions in the Pinawa Channel. The hydraulic conditions of the approximate 25, 50, and 75 percentile historical flows are compared with the corresponding possible flow reductions of 10%, 20%, and 30%.

Run Scenario	Flow (m ³ /s)	D/S of Diversion Dam			13 km U/S of 313 Bridge			U/S of Old Pinawa Dam			D/S of Old Pinawa Dam			U/S of 313 Bridge		
		Avg V (%)	Avg D (%)	Max D (%)	Avg V (%)	Avg D (%)	Max D (%)	Avg V (%)	Avg D (%)	Max D (%)	Avg V (%)	Avg D (%)	Max D (%)	Avg V (%)	Avg D (%)	Max D (%)
25 percentile	6.6															
10% reduction	5.94	10	1	1.1	0	0.7	0.5	1.9	5.2	4.3	0	0	0.3	0	0	0
20% reduction	5.28	20	1.9	2.3	0	1.1	1.1	3.7	8.6	9.5	33.3	0	0.3	50	0	0
30% reduction	4.62	30	2.9	3.8	0	1.8	1.6	7.4	13.8	12.9	33.3	0	0.3	50	0	0
50 percentile	6.86															
10% reduction	6.17	10	1	1.1	0	0.4	0.5	3.6	5.1	3.4	0	0	0.3	0	0	0
20% reduction	5.49	10	1.9	2.3	0	1.1	1.1	3.6	10.2	8.5	0	0	0.3	50	0	0
30% reduction	4.8	20	2.9	3.8	0	1.8	1.6	7.3	13.6	12.8	33.3	0	0.3	50	0	0
75 percentile	7.82															
10% reduction	7.04	8.3	0.9	1.1	100	0.4	0.5	3.5	4.8	3.3	25	1	0	0	0.4	0.2
20% reduction	6.26	16.7	2.4	2.6	100	1.1	1.1	5.3	8.1	8.1	25	1	0.3	0	0.4	0.2
30% reduction	5.47	25	3.3	3.7	100	1.8	1.8	7	14.5	13	25	1	0.3	50	0.4	0.2

FIGURES

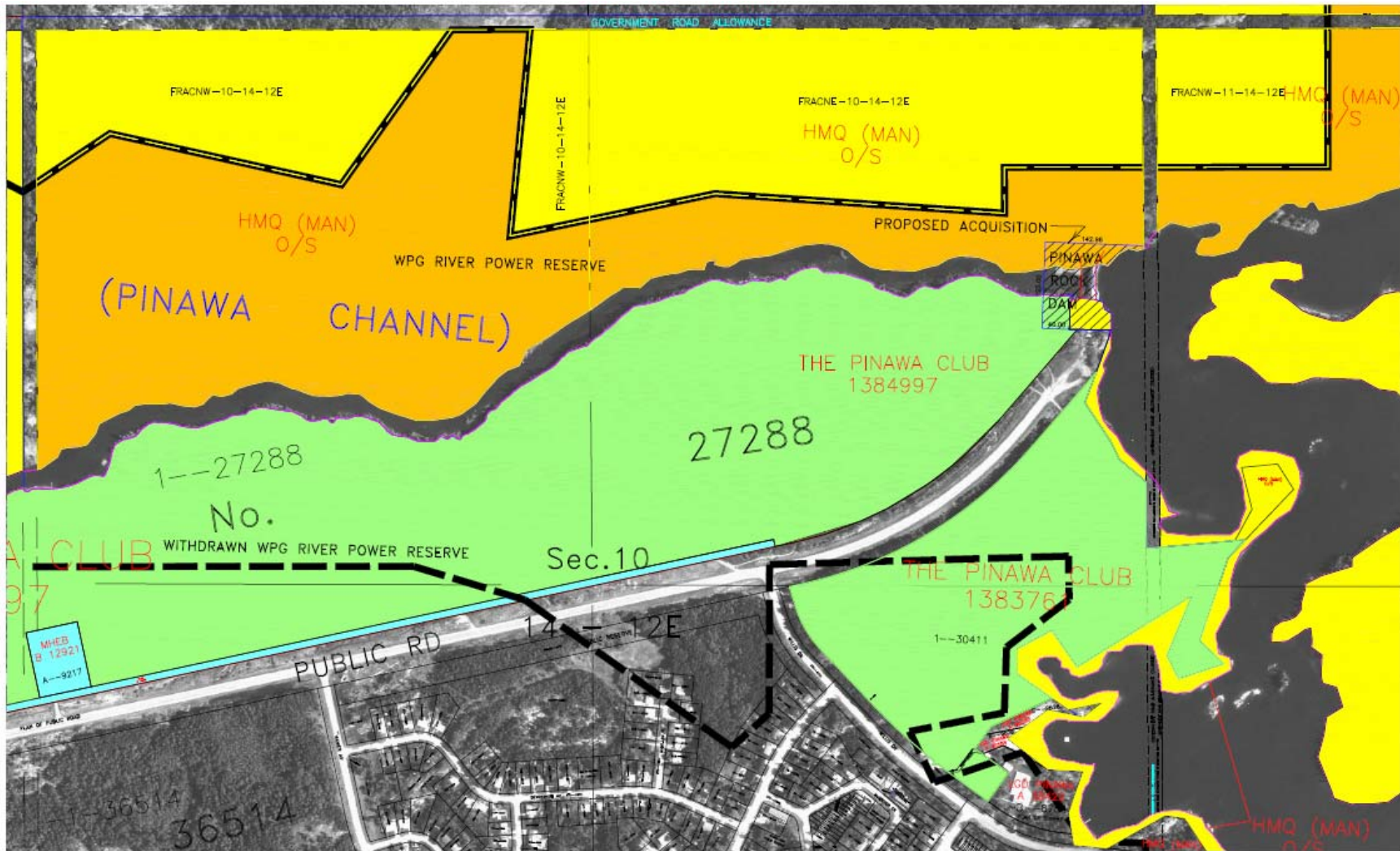


Figure 1. The Pinawa Dam Remediation Project Study Area illustrating land use designation and property ownership.

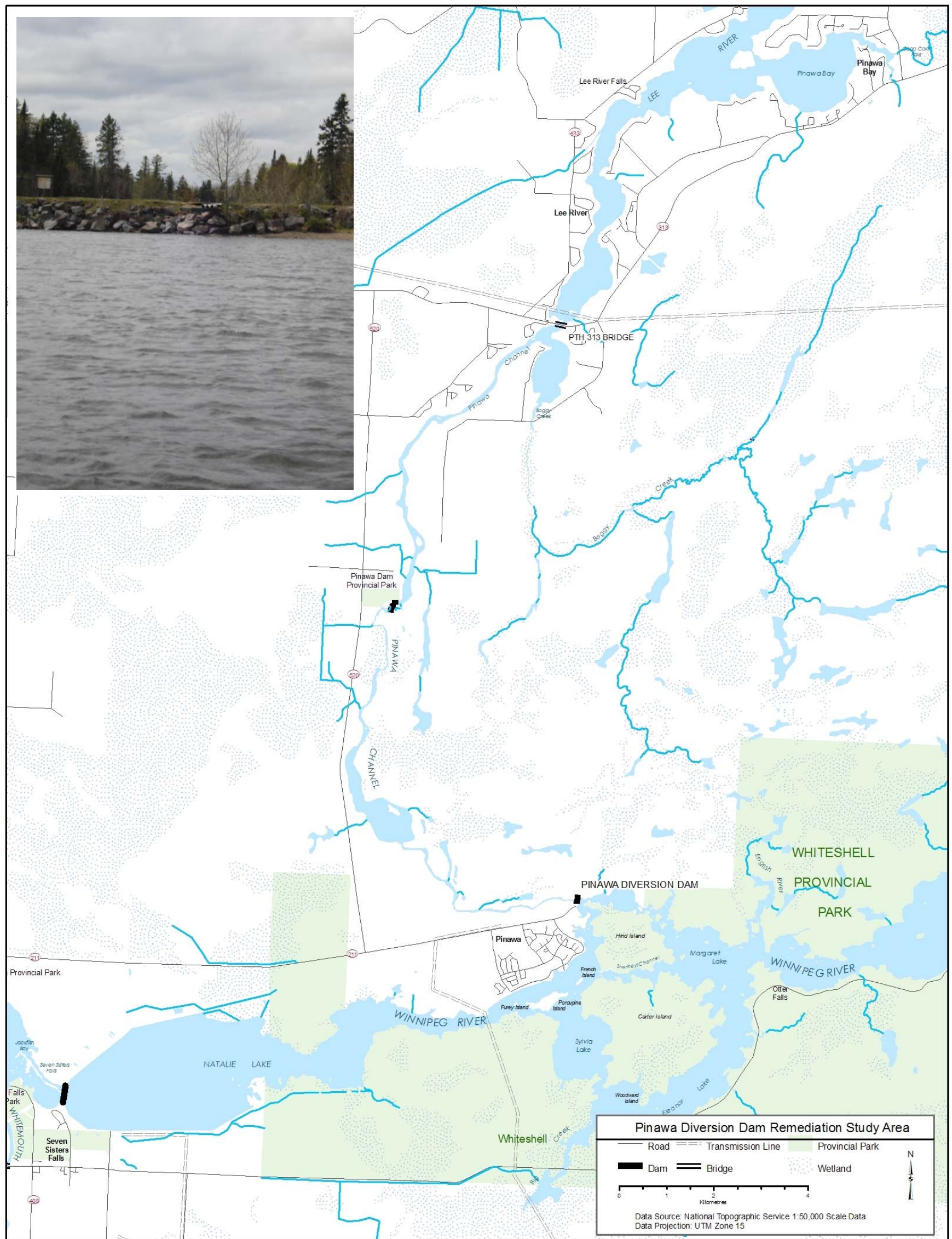


Figure 2. Pinawa Diversion Dam Remediation Project Study Area.

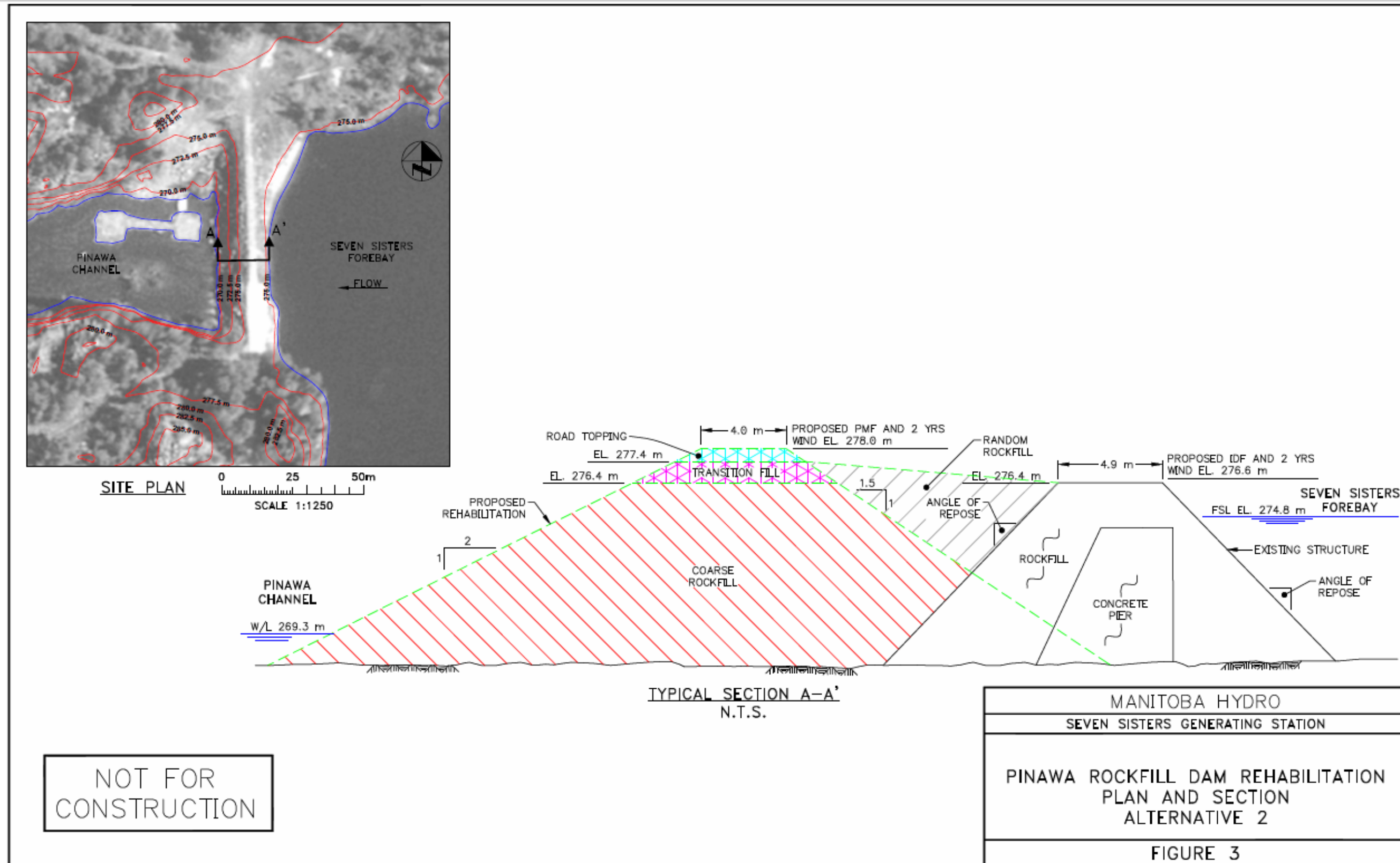


Figure 3. Pinawa Control Structure Remediation Plans and Section illustrations.



Figure 4. Photograph of the upstream face of the Pinawa Diversion Dam, showing the existing fish study structure slated to be removed before remediation of the Dam begins.

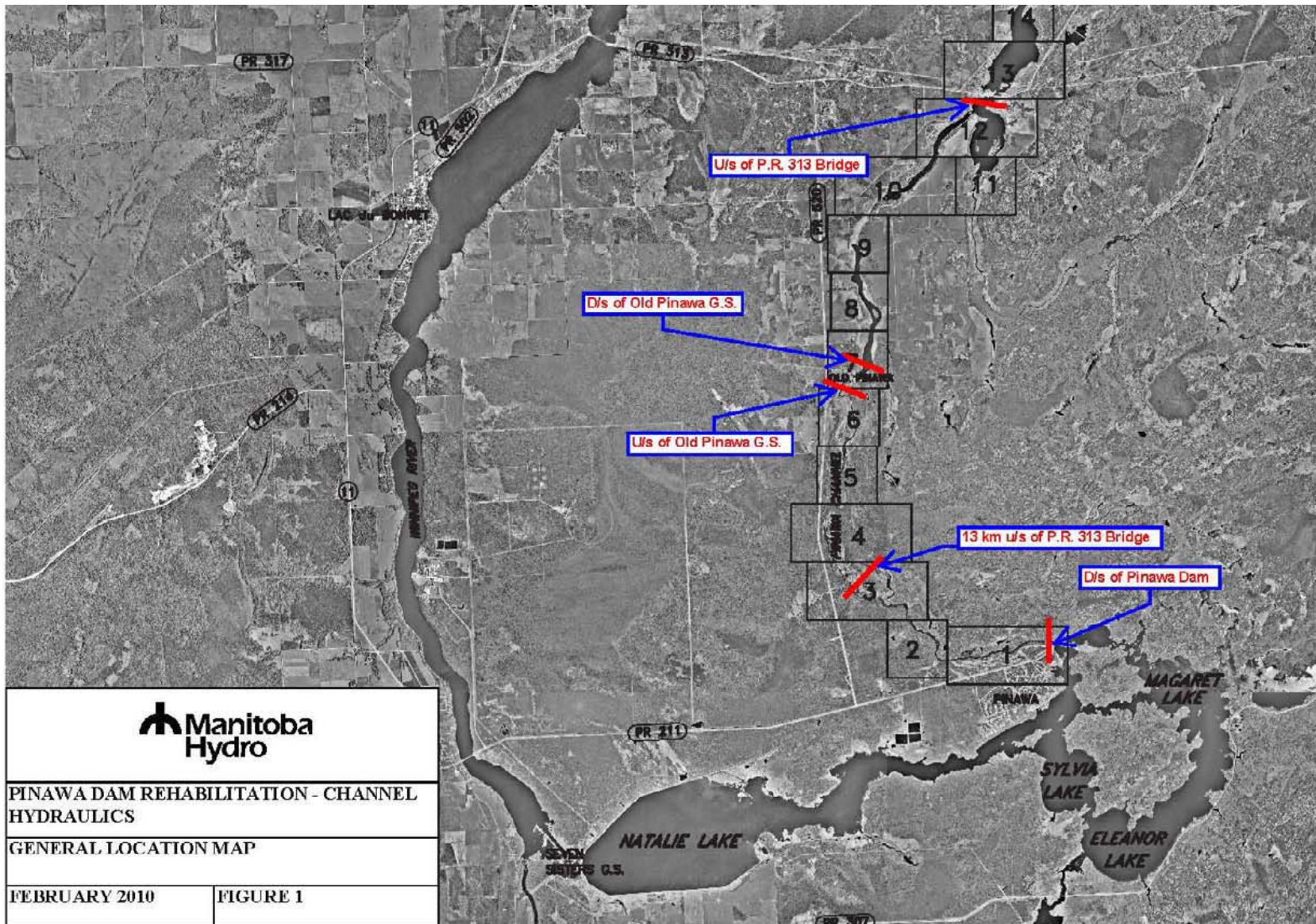


Figure 5. General location map showing representative cross-sections in the Pinawa Channel.

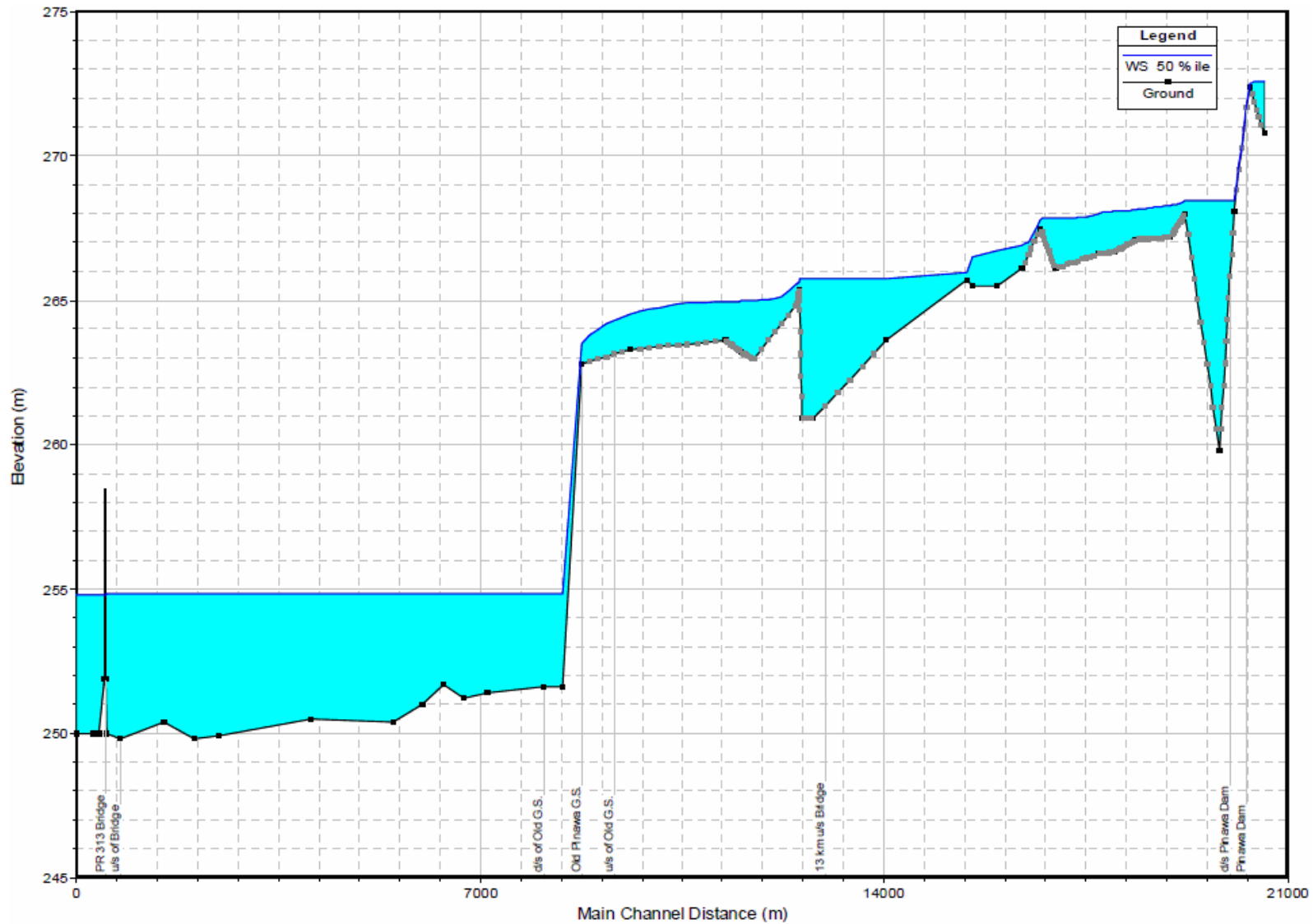


Figure 6. Computed water surface profile using HEC-RAS at representative cross-sections for the approximate 50th percentile flow.

APPENDIX 1.

**EXISTING ENVIRONMENT
TERRESTRIAL HABITAT, AQUATIC HABITAT, AND FISH**

1.0 EXISTING ENVIRONMENT

The following provides a description of terrestrial habitat located in the immediate vicinity of the Pinawa Diversion Dam and aquatic habitat and fish within the Pinawa Channel/Lee River. Phytoplankton and rooted vascular macrophytes are included as components of the aquatic habitat.

1.1 METHODS

The following section was based on data collected in the spring of 2010, in addition to reports published by the Lee River Pinawa Channel Study Committee (1981) and Schneider-Vieira (1996a,b). Included are descriptions of the methods used to determine the characteristics of terrestrial and aquatic habitat in and near the Pinawa Diversion Dam.

1.1.1 Terrestrial Habitat

The terrestrial habitat upstream and downstream of the Pinawa Diversion Dam was assessed on May 4, 2010. Vegetation on the north and south banks along either side of the Diversion Dam were characterized to a distance of approximately 300 m and representative sites were photographed.

1.1.2 Aquatic Habitat

The aquatic habitat upstream and downstream of the Diversion Dam was assessed on May 4, 2010, including the north and south banks. Shoreline habitat was characterized to a distance of approximately 300 m and representative sites were photographed.

Upstream of the Diversion Dam, temperature was measured along the shoreline and again approximately 30 m from shore, while secchi depth was measured at one site 30 m from shore. Downstream of the Diversion Dam, temperature was measured at two sites; the north pool and approximately 30 m from the Dam. Secchi depth was not measured as bottom substrate was clearly visible from the water surface. Channel width, water velocity, and discharge were measured at one site approximately 20 m downstream of the Dam. Channel width was measured using a tape measure. Channel width was measured at a location that reflected an average width for the channel within 300 m of the dam. A Swoffer model 2100 velocity meter was used to

collect channel velocity data. The 30 m wide wetted channel was divided into ten equidistant sections and a velocity reading (m/s) was taken at 60 per cent of channel depth at the center of each section. Figure A1 illustrates the cross section of the channel at which sectional discharges were measured. Sectional discharges (q) and total discharge (Q) were calculated using the following formulas:

$$q = v \times A$$

Where,

q = sectional discharge (m³/s)

v = sectional velocity (m/s)

A = cross-sectional area (section width x mean sectional depth)

And,

$$Q = \sum q_{1-10}$$

Where,

Q = total channel discharge (m³/s)

1.1.3 Fish

Potential fish habitat upstream and downstream of the Diversion Dam was assessed on May 4, 2010. The assessment included both north and south banks as well as inside the channel. Shoreline habitat was recorded and photographed to a distance of approximately 300 m.

Fish utilization and habitat within the vicinity of the Diversion Dam were assessed on May 4, 2010. Assessments included upstream and downstream sides of the Pinawa Diversion Dam, along the north and south banks, and within the channel itself. Potential cover available for fish was also assessed. Habitat type was recorded and photographed to a distance of approximately 300 m.

1.1.3.1 Backpack Electrofishing

Electrofishing surveys were conducted on May 4, 2010 using a Smith-Root Model LR-24 backpack electrofisher. Voltage was set at 500-700 V, frequency at 50 Hz, pulse width at 31 with resulting amperages of 0.18 A. Fished sections of shoreline measured approximately 10-50 m and are illustrated in Figure A2. Date, time of day, fishing duration (in seconds) and UTM coordinates at the start and end of each electrofishing transect were recorded. Water temperature (using a handheld thermometer), substrate descriptions and photographs were collected at each site. Lack of shoreline and increased water depths along the south rock face and south bank upstream of the Diversion Dam prevented electrofishing. Strong currents prevented effective electrofishing downstream of the Diversion Dam and, consequently, sampling in this area was limited to seining.

Captured fish were retained in a 10 gallon bucket until completion of each survey. All captured fish were identified to species and enumerated. All captured fish were released at the completion of sampling into the section of shoreline from which they were captured. Representative photographs of most species were taken with an Olympus Stylus Tough 8000 waterproof digital camera.

1.1.3.2 Seining

Seining surveys both upstream and downstream of the Diversion Dam were conducted on May 4, 2010 using a pursed beach seine with 2.0 m high by 7 m long wings and a 1.5 m by 2.5 m purse. Seined transects were 10 – 21 m long at a distance of 1-7 m distance from shore depending on existing depths. One seined transect was conducted at mid-channel downstream from the Diversion Dam. Seining transects are illustrated in Figure A3. The maximum water depth fished at each site ranged from 0.5-1 m. Date, time of day, fishing duration (in seconds) and UTM coordinates at the start and end of each seining transect were recorded. Sites selected for seining consisted primarily of finer substrate (i.e. sand, silt, gravel). Substrates dominated by cobble and/or boulder could not be efficiently sampled with a seine and were limited to electrofisher sampling.

Captured fish were transferred from the purse of the seine to a 10 gallon bucket for processing. All captured fish were identified to species, enumerated, and released at the completion of

sampling back into the section of shoreline from which they were captured. Representative photographs of most species were taken with an Olympus Stylus Tough 8000 waterproof digital camera.

1.2 RESULTS AND DISCUSSION

1.2.1 Terrestrial Habitat

The terrestrial environment on both sides of the Pinawa Diversion Dam represents a combination of natural forested and recreational areas. To the north, forested areas containing birch, spruce, trembling aspen, willow, shrubs, and grasses continue from the Dam site, upstream and downstream along the channel (Figure A4). The forested area in the immediate vicinity of the Diversion Dam is interspersed with man-made trails that are used for skiing, hiking and other recreational activities. Deer, beaver, and garter snakes were observed in the area, along with evidence of other small mammals. Habitat to the south includes the Pinawa Club Golf Course, which begins almost immediately following the north edge of the dam, beyond a small corridor of trees and shrubs (Figure A5). The golf course is designed around patches of natural forest vegetation such as birch, spruce, and trembling aspen (Figure A6). Beyond the golf course to the southwest is the Town of Pinawa.

As a result of blasting during channel excavation, habitat downstream of the Diversion Dam to the south represents a steep wall of rock with some shrubs, trees, and mosses between boulders or on uneven surfaces (Figure A7). Limited shoreline exists along the south bank downstream of the Diversion Dam; the rock wall continues into the water in most areas. Habitat to the north of the channel is comprised of gentle slopes in the first 40 to 50 m downstream of the Diversion Dam, and is similar to habitat upstream of the dam (Figure A8). Beyond that, a steep incline of rocks, interspersed with birch, spruce, willow, and shrubs continues downstream in a similar manner as observed on the south bank (Figure A9).

1.2.2 Aquatic Habitat

The Pinawa Channel/Lee River lies between the Winnipeg River upstream of the Seven Sisters GS and the eastern arm of Lac du Bonnet. Locally, the river upstream of the PTH 313 crossing is known as the Pinawa Channel, while downstream it is known as the Lee River. The Pinawa Channel is relatively narrow (30-50 m) and shallow (less than 3 m) from its origin at the Pinawa Diversion Dam to upstream of the Old Pinawa Dam. Downstream of the Old Pinawa Dam, the channel is more than twice the width and depths can exceed 10 m in some areas (Schneider-Vieira 1996a).

Ice cover on the Pinawa Channel/Lee River begins to thaw in late April/early May when temperatures approach 0°C (Schneider-Vieira 1996a). By the late May/early June, water temperatures increase to between 8 and 10°C and by late June, water temperature increases to approximately 20°C.

Wind-generated surface currents (in conjunction with the deeper return currents that they create) provide mixing in open areas of the Lee River, including the widest portions of the river where channel width reaches 1 km (Schneider-Vieira 1996b). Mixing from partially isolated side bays may be limited to times when wind direction is perpendicular to the opening of the bay.

1.2.2.1 Water Level Variation

The Pinawa Channel is divided into two sections: upstream of the Old Pinawa Dam, the channel is shallow with slow moving water, while downstream (within the influence of Lac du Bonnet), the channel becomes much wider and deeper (Schneider-Vieira 1996a).

Average water level in the Pinawa Channel/Lee River often varies over the long and short terms. For example, from July to early September of 1995, lake level increased and decreased approximately 0.03 m on a weekly basis (Schneider-Vieira 1996b). Average lake levels in 1995 were slightly lower than in 1994, and the rate of fluctuation was slightly greater (Schneider-Vieira 1996b).

1.2.2.2 Depth and Light Availability

The Pinawa Diversion Dam separates Margaret Lake on the Winnipeg River from the Pinawa Channel. Depths along the Winnipeg River and most of Margaret Lake exceed 6 m, although

maximum depths in some areas may be 4 m or less. To the north, the shoreline extends less than one meter into the channel before dropping sharply. There is virtually no littoral zone (10 cm or less) on the south side of the Dam, as depths of 4 m or more occur immediately offshore.. Upstream of the Diversion Dam, secchi transparency was approximately 1.5 m and offshore depths ranged from 4.2 to 6.8 m. Points at which depth and secchi transparencies were measured are illustrated in Figure A10.

Downstream of the Diversion Dam, the Pinawa Channel/Lee River contains relatively clear water throughout. The channel is narrow and shallow (usually under 3 m) from its origin at the Pinawa Diversion Dam to upstream of the Old Pinawa Dam (approximately 11 km). Downstream of the Old Pinawa Dam, the channel is much wider and deeper, with depths greater than 11 m in some locations.

For the first 500 m downstream of the Dam depths are less than 1 m and water is transparent enough to see the bottom. Schneider-Vieira (1996a) found a secchi transparency of approximately 1.9 m in deeper waters in the Pinawa channel in 1994. Such water clarity allows sufficient light to promote vegetation and phytoplankton growth throughout the spring and summer. However, substrate conditions and velocities immediately downstream of the Diversion Dam likely prevent substantial growths of vegetation. Further downstream, growths of blue-green algal mats prevent sufficient light penetration to support the growth of rooted vegetation in some years (Schneider-Vieira 1996a).

Turbidity, a measure of light reflection in water, can range from 1.0 to 3.2 NTU (Nephelometric Turbidity Units) at upstream locations and 3.1 to 6.2 NTU at downstream locations. Schneider-Vieira (1996a) found that the difference in turbidity was related to increases in phytoplankton growth.

1.2.2.3 Water Movements

Flow in the Winnipeg River upstream of the Diversion Dam is separated between Margaret and Eleanor lakes. Water velocities in Margaret Lake immediately upstream of the Diversion Dam are relatively slow and are generally less than 0.1 m/s.

Discharge within the Pinawa Channel/Lee River depends on leakage through the Diversion Dam and local discharge. Although the amount of leakage can vary depending on water levels in the

Winnipeg River, it remains relatively consistent throughout the open-water period. Pinawa Channel discharge, measure on May 4, 2010, within 100 m of the Dam was 7.15 m³/s. In 1995, Schneider-Vieira (1996b) measured discharges of 9.3 m³/s from March to June and 7.1 m³/s from July to early September. Discharge during late August and early September in 1994 and 1995 was 7.7 and 7.3 m³/s, respectively. Schneider-Vieira (1996b) also estimated discharge in Boggy (near the PTH 313 bridge) and Rice (near Pinawa Bay in the Lee River) creeks and found that flow in both creeks peaked in June. During the rest of the summer, flow was relatively constant, averaging 0.28 and 0.19 m³/s, respectively. Discharge in the ditch entering at Lee River Falls and Kulikowski Channel maintained an estimated summer average of 0.06 m³/s, while Kulikowski Channel itself maintained an estimated flow of 0.03 m³/s. Together, these streams accounted for less than 10% of the flow in the Pinawa Channel during summer.

The lower portion of the Lee River is a hydrologically complex system. Discharge is dependent on flow entering from the Pinawa Channel and several tributaries, as well as the rate of water level change in Lac du Bonnet (Schneider-Vieira 1996a,b). The distribution of flow within the channel is affected by channel morphology; the old river channel may carry much of the flow, while shallow areas flooded by construction of the McArthur GS may have little or no flow. Water residence time is calculated from discharge and volume within a given river reach. However, where flow is confined to a portion of the channel, as in much of the lower Lee River, water residence time can vary considerably across the river. Water residence time in zero-flow areas is dependent on the rate of mixing with the main flow area (e.g. by wind or thermal induced currents), while residence time in main flow areas is primarily dependent on discharge.

Water residence time increases in the lower sections of the Pinawa Channel/Lee River as the channel becomes wider and deeper (Schneider-Vieira 1996a). Water requires 51 to 56 days to move from the beginning of the Pinawa Channel to the mouth of the Lee River, varying with season and year (Schneider-Vieira 1996a,b). Flow in the Pinawa Channel, upstream of the PTH 313 bridge, is relatively rapid, requiring approximately 4 days to move 19.3 km. Flow is considerably slower in the Lee River; 9 days to travel 5 km to Lee River Falls and an additional 43 days for the final 10 km to the mouth (Schneider-Vieira 1996a). Water residence time in the Lee River, the bay at the end of Boggy Creek, and Pinawa Bay are affected by fluctuation in the level of Lac du Bonnet which, under certain conditions, can be the principle source of flow in

Pinawa Bay. Short water residence time in the Pinawa Channel upstream of the Pinawa Dam precludes accumulation of phytoplankton biomass while the longer water residence time in the lower Lee River permits algae to accumulate. However, Schneider-Vieira (1996b) indicated that differences in water residence time between 1994 and 1995 did not appear to be the cause of differences in algal growth because, 1) no bloom developed in Pinawa Bay in 1995 even though water residence time was much greater than in the Lee River; and 2) under suitable growing conditions, algae can form dense populations in a much shorter period of time.

1.2.2.4 Phytoplankton and Rooted Vascular Macrophytes

The growth of both algae and rooted plants tends to be greater in waters of lower flow, either in lakes or in sheltered areas along rivers, particularly under low flow conditions. Certain types of attached algae can grow on stones in areas of rapid water flow, but the accumulation of biomass is limited. Growth is also promoted by warm temperatures, sunlight, and inorganic nutrients, particularly nitrogen and phosphorus-containing compounds (constituents of domestic and agricultural waste water).

The Pinawa Channel contains emergent and submergent vegetation along most of its length, and a well-developed coating of epiphytic algae is abundant (Schneider-Vieira 1996a). Microscopic algae cover most boulders, except in areas of higher flow, where dense mats of the filamentous green alga, *Cladophora*, develop. Dense mats of *Cladophora* frequently develop in rapids of rivers where sufficient sunlight reaches the bottom and waters are rich in nutrients (Schneider-Vieira 1996a). Emergent vegetation becomes increasingly less abundant further downstream in Lee River, and submerged vegetation also appears less abundant further downstream.

1.2.2.4.1 Phytoplankton

Algae are a natural part of the ecosystem in any lake or river. They generally exist in one of three conditions: as microscopic particles suspended in the water (phytoplankton); as floating mats on open water or in sheltered areas along the shore; or attached to rocks or other hard objects, either as a uniform surface scum or as long filaments.

Phytoplankton is composed of several major groups of algae, the most common of which are the blue-green algae, green algae, diatoms, cryptophytes and chrysophytes. In many waters, the

phytoplankton is dominated by one or a few of these groups, since each differs in its requirements for growth. In many eutrophic lakes (i.e., lakes rich in nutrients), a bloom of diatoms occurs in spring, followed by an increase in blue-green algae in late summer, when waters are warmest (Wetzel 1983). In fall, populations of blue-green algae decline and a second bloom of diatoms may occur. Flowing waters generally have less phytoplankton because the turbulent water produces poor conditions for growth and shore residence times do not allow populations to increase. The phytoplankton of flowing water is often dominated by algae such as diatoms that have been washed off the rocks upon which they usually grow.

In most fresh waters where human activity has resulted in eutrophication, excessive proliferation of algae has been linked to inputs of phosphorus (Schindler 1981). Although other substances, most notably nitrogen, can limit phytoplankton growth, phosphorus is most often the key nutrient for eutrophication. The concentration of nitrogen and phosphorus in the water column follows a predictable cycle, though there is considerable variation based on the trophic status (i.e., concentration of nutrients) of the lake (Wetzel 1983). The amount of phosphorus and nitrogen dissolved in the water peaks in late winter or early spring, before the start of the growing season. At this time, inputs by regeneration from the sediments, decaying plant matter, and inflowing water have accumulated for the entire winter. Increasing light levels and water temperature, in conjunction with high nutrient concentrations, initiate a spring bloom of algae, which generally lasts until nutrients or other conditions become limiting.

Typically, in eutrophic lakes, the initial spring bloom is dominated by diatoms, which are seldom a major nuisance because they do not accumulate at the water surface (Schneider-Vieira 1996a). However, in nutrient-rich areas, the supply of nitrogen is often depleted more rapidly than that of phosphorus, creating conditions favourable for the proliferation of certain types of blue-green algae. Many of these algae are able to fix nitrogen, and, in the absence of competition for phosphorus from other algal groups, can form massive blooms when other growing conditions (e.g., warm water temperature, adequate sunlight, stable water column) are favourable. Blue-green phytoplankton contain gas vacuoles which cause them to float to the surface, forming the unsightly 'pea-soup' waters frequently observed on sheltered, nutrient-rich waters in late summer. These blooms last until the supply of phosphorus is exhausted or other conditions (e.g., temperature, sunlight, or water column stability) become adverse (Schneider-Vieira 1996a).

During the death and decomposition of these massive blooms, anoxia and resultant summerkill of fish populations can occur. In small prairie pothole lakes, a repetitive sequence of blue-green algal blooms and crashes can occur during the summer months (Barica 1974).

In the Pinawa Channel, dense blooms of the blue-green alga *Aphanizomenon* usually form in August, a few kilometers downstream of the PTH 313 bridge (Schneider-Vieira 1996a). The density of the bloom increases until, at the lower end of the Lee River and nearby Lac du Bonnet, water in the centre channel becomes an opaque green and cells accumulate along the shoreline to form a thick, green sludge. Such dense blooms of blue-green algae occur in waters with high phosphorus concentrations, especially in situations where low nitrogen:phosphorus ratio favours the growth of blue-green algae, rather than other phytoplankton groups (Schneider-Vieira 1996a). These dense blooms may not be observed in all years. For example, in 1995, the dense and extensive blooms seen in 1994 did not develop (Schneider-Vieira 1996b). A small bloom of blue-green algae was observed in mid-July but the bloom failed to proliferate, suggesting that high nutrient concentrations and inputs in late winter and spring were not high enough to support an algal bloom, though phosphorous levels appeared to be similar to those in 1994.

In August of 1994, Schneider-Vieira (1996a) determined that the concentration of phosphorus was positively related to that of chlorophyll *a*, a photosynthetic pigment useful for the estimation of the relative amount of phytoplankton. Both chlorophyll and phosphorus were uniformly low in the Pinawa Channel, intermediate at sites in the mid Lee River, and extremely high near the mouth. It was not certain if the association of extremely high concentrations of phytoplankton and phosphorus in the lower Lee River revealed a cause/effect relationship, or whether phosphorus concentration was elevated due to the accumulation of phytoplankton in the surface waters. By late September, the bloom of *Aphanizomenon* had declined considerably. Phosphorus concentrations at stations where phytoplankton biomass had been highest had also declined, suggesting that phosphorus had been concentrated in surface waters by the algal cells. However, phosphorus levels had increased at the upstream stations, suggesting that it was being released by dying plants and attached algae. Schneider-Vieira 1996 (a,b) found that in winter, the amount of phosphorus throughout the Pinawa Channel/Lee River was uniformly high entering from Lake Winnipeg, suggesting that local inputs were not occurring.

Schneider-Vieira (1996a) summarized the state of Pinawa Channel/Lee River phytoplankton community and nutrient concentrations in the following way:

The baseline phosphorus concentration is relatively high and uniform from the upstream end at the Pinawa Control Dam to the mouth of the Lee River. This indicates that during the winter months, the amount of phosphorus is dependent on levels in the Winnipeg River and significant local inputs are not occurring.

In August, during the growing season, phosphorus levels in the Pinawa Channel and upper Lee River are reduced below levels reported during the winter months, suggesting that uptake by plants and attached algae is removing phosphorus from the water column. The concentration of phosphorus in the water at these sites is below the level at which nuisance blooms of phytoplankton are expected to occur.

The extremely dense bloom of algae in the lower Lee River was associated with extremely high levels of phosphorus. The concentration of phosphorus at the furthest downstream station was greater than observed during the winter months and levels of chlorophyll exceeded those predicted based on phosphorus levels during winter. This difference between expected and observed phosphorus concentrations can be attributed to the accumulation of phosphorus in the surface waters in conjunction with the algal cells and/or local inputs of phosphorus.

Experimental studies in other areas have demonstrated that blue-green algal blooms are triggered, not only by high phosphorus levels, but by a nitrogen:phosphorus ratio below a critical value. At this critical point, other groups of algae are not able to compete effectively with bluegreens and the latter predominate. The nitrogen:phosphorus ratio in the March samples was greater than that when bluegreens can proliferate. This suggests that, during the growing season, uptake by plants and other algae or additional phosphorus inputs are reducing the nitrogen:phosphorus ratio.

Short water residence time in the Pinawa Channel upstream of the Pinawa Dam precludes accumulation of phytoplankton biomass while the longer water residence time in the lower Lee River permits algae to accumulate. Greater biomass of algae is also possible because phosphorus levels are higher in this portion of the river.

It appears that the combination of high phosphorus concentrations and longer water residence time in the lower Lee River creates conditions suitable for the proliferation of blue-green algae. Based on measurements made by Schneider-Vieira (1996a), the rate of phosphorus input in the lower, developed section of the Lee River is much higher than in the upper, undeveloped reaches of the Pinawa Channel. However as discussed in section 1.2.2.3, differences in water residence time may not contribute as significantly to bloom proliferation as previously thought.

1.2.2.4.2 Rooted Vascular Macrophytes

Rooted aquatic plants occur in waterbodies where soft sediments permit rooting. A few types of plants with roots (e.g. duckweed) form floating mats on the water surface. Emergent vegetation is more abundant in areas just upstream of the Old Pinawa Dam. Downstream of the rapids and Old Pinawa Dam, the channel widens, and areas of bedrock become more common and pronounced. Emergent vegetation is uncommon and most of the shoreline is cut bank or bedrock. This is also true for the area immediately downstream of the Diversion Dam. The combination of sand/silt, cobble, gravel, and boulder coupled with high water velocities prevent the growth of emergent vegetation.

Once water temperatures reach 18-20°C (late July/early June) within the Lee River, extensive beds of submerged plants become visible, especially in shallow water areas downstream of Lee River Falls (Schneider-Vieira 1996b). Aquatic vegetation continues to increase through August, particularly in tributaries entering the Pinawa Channel/Lee River. These areas eventually become solid mats of vegetation that continue into the fall.

In some years, nutrient and light conditions support an overgrowth of blue-green algae which may form dense mats that do not allow sufficient light for rooted vegetation growth. For example, during a dense blue-green algal bloom in 1994, no rooted plants were observed, suggesting that plants may have succumbed due to shading caused by the thick surface layer of blue-green algae (Schneider-Vieira 1996b).

1.2.3 Fish

While this assessment considers Project-related effects on the fish community as a whole, certain fish species, identified as valued ecosystem components (VECs), have been selected as the focus of the assessment. Key recreational fish species (i.e., walleye and northern pike) were identified

as VECs along with species that have been labeled as ‘Endangered’ (e.g. lake sturgeon) or ‘Threatened’ (e.g. carmine shiner) by COSEWIC. These species, together with a measure of fish diversity, are the focus for assessing the significance of any Project-related effects on the general fish community.

1.2.3.1 VEC Species

It is not possible to investigate and describe all individual aquatic components of the ecosystem in all places at all times or to predict and assess the possible effects of the Project on each component. Therefore, certain valued ecosystem components (VECs) were selected as the focus of this environmental impact assessment. The VECs were selected because they met one or more of the following criteria: i) of particular importance (economic, recreational, traditional use) for humans; ii) representative of a group of species; iii) good indicators of effects on producers and consumers within their food web; iv) rare or endangered; or v) of special ecological significance. In this case, species-level VECs were identified in the Pinawa Channel/Lee River based on their importance to local communities in terms of recreational fishing, their value as environmental indicators, and/or their ecological status. The main attributes of the four species-level VECs are:

- Northern Pike: top level predator, harvested in recreational fisheries;
- Walleye: top level predator, harvested in recreational fisheries;
- Lake Sturgeon: mid-level predator, COSEWIC listed ‘endangered’ species in the Winnipeg River; and
- Carmine Shiner: lower to mid-level omnivore, COSEWIC listed ‘threatened’ species in Manitoba, significant biological and scientific interest.

1.2.3.1.1 Northern Pike

Northern pike inhabit vegetated areas of lakes and slow meandering rivers (McPhail and Lindsey 1970; Scott and Crossman 1998). Juvenile northern pike prefer habitats in quiet bays with adequate vegetation cover for both ambushing prey and seeking shelter from predators, such as larger northern pike (Chapman and Mackay 1990). Holland and Huston (1984) found that young northern pike were ten times more abundant in emergent vegetation and three times more abundant in submergent vegetation than in unvegetated areas. Adult northern pike prefer areas

less than 5 m in depth for most of the year, moving into deeper water to overwinter (Diana et al. 1977; Inskip 1982; Scott and Crossman 1998). As an ambush predator, northern pike require cover (logs, weeds, stumps, boulders) to capture their prey (Inskip 1982), and adults are most commonly found in moderately vegetated areas along the interface between vegetation and open water (Inskip 1982; Randall et al. 1996; Casselman and Lewis 1996). Grimm (1989) suggested that waterbodies must contain more than 25% submergent vegetation for a northern pike dominated fish community to exist. Northern pike are opportunistic feeders and will feed on whatever is readily accessible, including aquatic invertebrates, fish, ducklings, mice, and other small mammals (Lawler 1965).

Northern pike begin to spawn shortly after ice break-up at water temperatures of 4 to 11°C. Spawning occurs during the day in shallow (< 0.5 m deep) water over heavily vegetated floodplains of rivers, marshes, and bays of larger lakes (Diana et al. 1977; Casselman and Lewis 1996). In southern Manitoba populations, sexual maturity is reached at 2-3 years for males and at 3-4 years for females, and at approximately 400 mm to 500 mm in length, respectively (Scott and Crossman 1998). The life expectancy in southern Manitoba populations is generally 10-12 years.

Northern pike eggs hatch within 12-14 days at typical spawning temperatures (i.e., 4 to 11°C) but can hatch in as little as 4-5 days at higher water temperatures (between 17.8 and 20°C) (Scott and Crossman 1998). Once hatched, young northern pike are inactive for 6-10 days and are often found attached to vegetation (by way of adhesive glands) during this period (Scott and Crossman 1998).

Given its preference for vegetated habitat, northern pike is particularly sensitive to any disturbance to aquatic macrophyte beds.

1.2.3.1.2 Walleye

Walleye are tolerant of a wide range of environmental conditions, but generally prefer large, shallow, lakes (Scott and Crossman 1998). The species tends to prefer slow moving water in lakes and rivers, often remaining near the bottom. Individuals seek cover from sunlight under banks, sunken trees, rocky outcrops, weed beds, and by moving into deeper or more turbid waters during the day (Ryder 1977; Scott and Crossman 1998). During summer, walleye move away from shallower spring spawning habitats into deeper water, possibly to avoid warming lake

temperature, or in response to prey movements (Bodaly 1980; Ford et al. 1995; Scott and Crossman 1998). Winter habitat preferences are similar to those in summer (Scott and Crossman 1998). Young walleye are opportunistic feeders, feeding predominantly on various invertebrates and smaller fish species. As they mature, walleye become predominantly piscivorous, although they will still take advantage of various insect hatches and crayfish when available (Scott and Crossman 1998; Jansen and Dawson 2007).

Walleye populations are often vulnerable to overexploitation, as they are highly sought after in domestic, commercial, and recreational fisheries. In addition, walleye spawning areas are often limited to very discrete locations and as such may be vulnerable to human and natural perturbations in some locations.

Walleye spawning occurs in the spring soon after ice break-up when water temperatures are approximately 6 to 9°C (Ford et al. 1995). Egg deposition typically occurs in streams or shallow inshore areas (water depth < 2 m) over gravel, boulder, or rubble substrates where water flow is adequate for oxygenation and removal of waste products (i.e., at the base of rapids, falls, or riffles in streams or wind-swept shorelines in lakes) (McPhail and Lindsey 1970; Scott and Crossman 1998). Less commonly, walleye have been observed spawning over organic substrate and dead vegetation in northern Manitoba (MB Hydro and NCN 2003) and other regions (Priegel 1970). Walleye may forego spawning in some years when water temperature is not favourable (Scott and Crossman 1998). For example, females will often absorb their eggs when temperatures remain low over an extended period of time (i.e., extended winter temperatures) or increase at a rapid rate. Male walleye generally become sexually mature at two to four years of age and at approximately 275 mm in length, and females at three to six years of age and at approximately 350-430 mm (Scott and Crossman 1998). The maximum life expectancy of walleye in southern Manitoba waters is generally 10-12 years (Scott and Crossman 1998).

It has been suggested that most female walleye release the majority of their eggs in just one night of spawning (Ryder 1977; Scott and Crossman 1998). Once released, the eggs settle into gaps between particles of the spawning substrate, and usually hatch within 12-18 days (Scott and Crossman 1998). Young walleye move nearer the surface of open water approximately 10-15 days after hatching (Scott and Crossman 1998).

1.2.3.1.3 Lake Sturgeon

The lake sturgeon (*Acipenser fulvescens*) is a long-lived species that historically was relatively abundant and widespread in Manitoba. The species was abundant in the Red/Assiniboine drainage, the Winnipeg River, Lake Winnipeg, tributaries on the east side of Lake Winnipeg, the Saskatchewan River, the Churchill River, the Nelson River and the Hayes/God river system.

Naturally reproducing populations of sturgeon are now considered extirpated in the Red/Assiniboine drainage upstream of the Lockport Dam on the Red River and occur only incidentally in catches from Lake Winnipeg. Populations in the Saskatchewan River, Nelson River, Churchill River, tributaries on the east side of Lake Winnipeg, and portions of the Winnipeg River are substantially reduced from historical levels. Though Lake sturgeon have been identified within the Winnipeg River in waters upstream of the Pinawa Channel/Lee River, none have been identified in within the Study Area.

Lake sturgeon has not been given any special status under the *Manitoba Species at Risk Act*. Federally, the status of lake sturgeon has been reviewed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) on multiple occasions. Most recently most western Canadian populations have been assessed as “*Endangered*”, including the Winnipeg River-English River populations. In August, 2007 COSEWIC requested that the Federal Minister of Environment list the species under Schedule 1, thus adding it to the *List of Wildlife Species at Risk* under the *Canada Species at Risk Act* (SARA). In November, 2007 the federal Minister of Environment responded that Canada would initiate consultations with the governments of Manitoba and Ontario, Aboriginal peoples, stakeholders, and the public on whether or not populations of lake sturgeon (including those in the Winnipeg River) should be so listed.

The lake sturgeon is considered a cold-water species that is well adapted to feeding on mud, sand, or gravel bottoms. In riverine habitats, lake sturgeon utilize areas of current and often are found on the slower side of current breaks over cobble, gravel, and sand where drifting invertebrates settle. In lacustrine habitats, lake sturgeon are often found in deep water, feeding in depositional and transitional zones. Diet composition of lake sturgeon is linked strongly to the substrates over which they are feeding. The fact that benthic invertebrates comprise a large component of the lake sturgeon diet is supported by the presence of host-specific parasites which

are transmitted by benthic invertebrates (Choudhury et al. 1996; Choudhury and Dick 1998). Although reported diet composition varies by study, molluscs (e.g. Sphaeriidae, Gastropoda), crustaceans (e.g. crayfish) and insects (e.g. Ephemeroptera, Trichoptera, Chironomidae) are important forage items throughout the range of the lake sturgeon (Harkness and Dymond 1961; Houston 1987; Beamish et al. 1998; Choudhury et al. 1996; Chiasson 1997; Werner and Hayes 2005; Lord 2007). Lake sturgeon feed by taking mouthfuls of the substrate and sifting out food items. This type of feeding suggests that smaller lake sturgeon might prefer smaller substrate particle sizes compared to larger lake sturgeon (which would be capable of engulfing larger substrates). However, it has been observed that smaller lake sturgeon, feeding in the same habitats as larger sturgeon, have a less varied diet and appear to be selecting individual food items instead of engulfing portions of substrate (A. Choudhury, pers. comm.). Although lake sturgeon are primarily benthic specialists, they will feed in the water column when the opportunity to feed on concentrated food sources arises (T.A. Dick, pers. comm.).

The species' slow growth, late sexual maturity, and infrequency of spawning have made it particularly vulnerable to over-fishing (Brousseau 1987). These same characteristics, coupled with the preference for large river rapids for spawning, may make lake sturgeon sensitive to habitat alterations related to hydroelectric developments in some locations.

1.2.3.1.4 Carmine Shiner

Carmine shiners are lower to mid-level omnivorous minnows that, in summer, are found at midwater depths of clear, brown, fast flowing creeks and small rivers in Manitoba (DFO 2008). This species prefers clean gravel or rubble substrates, and are usually found in or near riffle habitat (DFO 2008). The biology, distribution, abundance and life history of carmine shiners are relatively unknown, although some information is available. For example, Lowdon et al. (in review, cited in DFO 2008) found that carmine shiners live to at least two years of age and males and females (spawning individuals) attain fork lengths between 55 and 67 mm. Manitoba Hydro (2006) determined that the species spawns between May 15 to July 15. Critical habitat for any life history stage has not been identified for the species. The carmine shiner is not economically important, nor is it a significant forage species; however it continues to be of significant biological and scientific interest (Fisheries and Oceans 2008).

In 2001 COSEWIC designated the Manitoba population of rosyface shiner (*Notropis rubellus*) as ‘Threatened’, based on its disjunct distribution in relation to other populations of the species, its restricted range, and the species’ sensitivity to changes in water temperature and quality (COSEWIC 2001). Subsequently, the Manitoba population was determined to be comprised of carmine shiner (*N. percobromus*), found only in Southern Manitoba in the Whitemouth River and its tributaries, the Bird River and its tributaries and the Pinawa Channel. In 2006, COSEWIC released an updated status report, confirming the status of the carmine shiner as ‘Threatened’ (COSEWIC 2006). In 2003, the Manitoba population of carmine shiner was legally listed as a ‘threatened’ species under the *Species at Risk Act* (SARA). This prohibits the killing, harming, harassing, capture or take of any individuals of the species or the possession, collection or trade in the species. Provisions of the Fisheries Act also apply to the carmine shiner, including the Habitat Provisions (DFO 2008).

DFO (2008) found no evidence that the Manitoba population of carmine shiners has declined over time; however the author goes on to suggest that their apparent limited distribution and abundance may make them vulnerable to anthropogenic disturbances. Habitat loss and/or degradation associated with flow regulation, shoreline development, landscape changes and climate change are considered to be the carmine shiner’s most significant threats, and potential mitigation options vary with the type of disruption and affected waterbody. DFO (2008) designated the threat significance for habitat loss/degradation of the carmine shiner within the Pinawa Channel as unknown; however, the mitigation potential for flow alteration, shoreline/riparian development, and landscape changes was listed as moderate.

Carmine shiners were identified from the Pinawa Channel between 2002 and 2006, immediately below the Old Pinawa Dam, from the Bird River at the first set of rapids upstream from Lac du Bonnet and at the mouth of the Peterson Creek (DFO 2008). None have been observed upstream of the Old Pinawa Dam.

1.2.3.2 Fish Community

No formal fish community studies have been conducted within Margaret Lake, in areas upstream of the Pinawa Diversion Dam, or along the Pinawa Channel/Lee River. However, several fish species are known from or believed to exist in the region. In 2004, Stewart and Watkinson listed

fifty-four fish species with distributional ranges that may include the Study Area. These, along with species that are known to be present in the Pinawa Channel/Lee River are listed in Table 1. It should be noted that the majority of species listed by Stewart and Watkinson (2004) prefer conditions other than those found within the Pinawa Channel, and as a result, are likely absent from the area. Many of these species prefer conditions that are found further downstream, in the Lee River or areas closer to Lac du Bonnet.

Of the four VEC species identified, only one was found within the Project Area. Juvenile northern pike appeared to be the dominant fish along the north shore upstream of the Diversion Dam; however, the species was not considered abundant. Six juvenile northern pike were captured along the north bank of the Diversion Dam during electrofishing, while one each of johnny darter (*Etheostoma nigrum*) and larval shorthead redhorse (*Moxostoma macrolepidotum*) were captured during seining along the northern shoreline of the Dam. Seining and electrofishing downstream of the Dam were unsuccessful.

Sport fish known to inhabit waters upstream of the Dam include walleye (*Sander vitreus*), northern pike, mooneye (*Hiodon tergisus*) and smallmouth bass (*Micropterus dolomieu*). These species have also been observed downstream, though not in waters near the Diversion Dam. Several fish species have been introduced within the Pinawa Channel/Lee River and surrounding areas over the years, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and smallmouth bass (Stewart and Watkinson 2004). For example, approximately 70,000 brown trout fry were stocked in Pinawa Channel in May 2002 by the Province of Manitoba (Manitoba Water Stewardship 2002). To date, no studies have been conducted with respect to community or habitat changes resulting from fish introductions.

1.2.3.3 Habitat Utilization

1.2.3.3.1 Upstream

The Winnipeg River upstream of the Pinawa Diversion Dam contains relatively wide, deep lakes and channels, with depths exceeding 6 m in most places. The area immediately upstream of the Diversion Dam can be characterized as a deep channel with little or no littoral zone. Waters are slow moving and slightly turbid, with substrate that contains primarily soft sand and silt. Such

areas tend to support fish species that prefer deeper, cooler waters during summer months (e.g. bullhead, mooneye).

Shorelines on either side of the Diversion Dam contain a combination of rip rap and natural rock formations, with some fallen terrestrial vegetation in the littoral zone (where it exists). Directly upstream of the Dam, the north bank littoral zone is limited to less than 1 m in most places, and is likely to support small forage fish (e.g. darters) and juveniles of larger species such as northern pike. The south shoreline contains no littoral substrate. This area is characterized by an immediate drop into deep water (4 m or more) and likely supports fish species that prefer rocky ledges (e.g. rock bass, smallmouth bass).

1.2.3.3.2 Downstream

The Pinawa Channel/Lee River contains a combination of habitat types along its length, each likely supporting slightly different fish and invertebrate communities. It is relatively narrow and shallow from its origin at the Pinawa Diversion Dam to the Old Pinawa Dam.

The channel immediately downstream of the Diversion Dam contains a combination of riffle and pool habitat. Man-made structures at the north side of the Dam prevent or significantly decrease water flow, separating roughly one quarter of the channel width into pool habitat. Within the pool, substrate consists of approximately 40% gravel, 30% cobble, 20% sand, and 10% boulder. The remaining channel consists of laminar flow over approximately 40% sand/silt, 30% cobble, 20% gravel, and 10% boulder substrate. The relatively strong current in this area may provide suitable habitat for fish species that prefer fast-flowing water; however little or no cover is available along either shoreline and the existing substrate is sub-optimal for most fish species. No fish were captured downstream of the Diversion Dam.

Waters upstream of the Old Pinawa Dam flow through extensive marshy areas and woodlands. Fish species that prefer cover and/or shallow water (e.g. bluntnose minnow, golden shiner, and weed shiner) are likely to be more abundant along this section. Downstream of the rapids and the Old Pinawa Dam, the channel is much wider and deeper, and sloping shorelines with marsh vegetation alternate with areas of bedrock. These areas contain habitat preferred by fish species such as rock bass, smallmouth bass, and walleye.

The Pinawa Channel downstream of the Diversion Dam was opened up using dynamite, in order to supply the Old Pinawa Dam with a heavy flow of water. The rock bottom further downstream of the Diversion Dam is ideal bass habitat and is known locally as a good place for fishing. Popular sport fish in the channel closer to the Old Pinawa Dam include walleye, northern pike (*Esox lucius*), mooneye (*Hiodon tergisus*) and smallmouth bass (*Micropterus dolomieu*). Most of the fish species known to inhabit the lower Pinawa Channel/Lee River prefer moderate to slow moving, clear water over rocky substrates (Stewart and Watkinson 2004). Fish species known to prefer softer substrates or areas containing aquatic vegetation (e.g. golden shiner [*Notemigonus crysoleucas*], tadpole madtom [*Noturus gyrinus*]) may not be overly abundant in this region as a whole, but may take advantage of the few highly vegetated areas along the length of the channel. Species that may occur in the Pinawa Channel/Lee River are listed in Table 1. Feeding and habitat preferences for species known to inhabit the channel are listed in Table 2.

1.2.3.3 Spawning

Ice cover on the Pinawa Channel/Lee River begins to thaw in late April/early May when temperatures approach 0°C (Schneider-Vieira 1996a). Fish species such as walleye and northern pike begin to spawn shortly thereafter, once ice breakup begins. Walleye spawn in lakes or streams shortly after ice breakup in water temperatures of approximately 4°C and spawning may continue from mid to late April until late May (Stewart and Watkinson 2004). Walleye are broadcast spawners, depositing eggs over rocky substrate (Stewart and Watkinson 2004). Consequently, the rocky substrate and fast-flowing waters in the lower Pinawa Channel are more suited to walleye spawning than the area immediately downstream of the Diversion Dam. No evidence of walleye spawning (eggs, larvae, adults in spawning condition) was found upstream or downstream of the Diversion Dam. Northern pike begin spawning in early April, just after the ice leaves rivers and streams but while most lakes still have ice cover (Stewart and Watkinson 2004). This species moves upstream into shallow, slow moving water containing vegetation. They are broadcast spawners, depositing adhesive eggs over vegetation. The slow moving, vegetated shorelines upstream of the Diversion Dam appear better suited to northern pike spawning than do the fast-flowing waters and vegetation-free areas downstream. Though no evidence of northern pike spawning was found in the immediate vicinity of the Diversion Dam, some juveniles were found upstream along the north shore. This suggests that although northern

pike are likely more abundant further upstream where the littoral zone is longer, some juveniles take advantage of the shallow water areas along the north shore.

Historically, lake sturgeon have not been observed in the Pinawa Channel. None were observed during fish utilization assessments and no eggs or individuals in spawning condition were found in the Study Area. Consequently, the following paragraph represents a general description of spawning habitat for the species. Lake sturgeon move to spawning sites after the ice melts, typically moving from deepwater areas of lakes and large rivers to suitable spawning habitat. Although lake sturgeon have been documented spawning on lake shorelines (Scott and Crossman 1998), this behaviour has not been observed often. In larger rivers, lake sturgeon usually migrate from deeper riverine overwintering habitats to the base of rapids or falls for spawning. Lake sturgeon are known to spawn when water temperatures rise above 10°C (Scott and Crossman 1998) at depths of 0.61-30 m in areas of swift water or rapids over gravel, cobble, and boulder-sized substrates that provide sufficient interstitial spaces for egg incubation and oxygenation (La Haye et al. 2003). On the Winnipeg River, lake sturgeon typically begin spawning when the water temperature approaches 11°C (J. Beyette, retired – Manitoba Fisheries Branch, Eastern Region, pers. comm.). Actual spawning substrates can vary from igneous bedrock (Aadland, pers. comm.) to glacial till-derived gravel, cobble, and boulder, and even areas of coal cinders (Manny and Kennedy 2002). Many of the detailed historic descriptions of lake sturgeon spawning describe the foot of rapids or falls that prevent further upstream migration (Richardson 1836; Stone 1900; Stone 1901). The adhesive eggs are scattered and adhere to rocks and logs and hatch in 5-8 days, depending on water temperature (Kempinger 1988). Female lake sturgeon spawn every 3-5 years while males can spawn every 1-3 years (Harkness and Dymond 1961). Lake sturgeon spawning intervals and growth curves have been linked to growing season by latitude (Noakes et al. 1999).

Spawning behaviour in the carmine shiner has not been observed. However, Manitoba Hydro (2006) determined that this species spawns between May 15 to July 15. Individuals in spawning condition have been found below the Old Pinawa Dam in mid June and late July at water temperatures of 19.3 to 22.5°C, depths of 0.2 to 1.4 m, and velocities of up to 0.53 m/s (Lowdon et al. in review cited in DFO 2008). Though conditions in some areas downstream of the

Diversion Dam may be suitable for carmine shiner spawning, this species has not been observed in areas upstream of the Old Pinawa Dam.

Other species such as rock bass, river darter, sauger, and shiners tend to spawn later in the season when water temperatures reach 16°C or more. Rock bass spawning has not been observed in Manitoba, but in Wisconsin are known to spawn at temperatures between 16° and 21°C (Scott and Crossman 1998). In Manitoba, this species is believed to spawn at temperatures slightly lower than those in more southern climates. Similarly, spawning of golden shiner has not been observed in Manitoba but is believed to take place at temperatures slightly below those seen in Wisconsin (20°C; Becker 1983). No evidence of spawning was observed in the Study Area.

Sauger are thought to spawn in streams or lakes, in shoals or reefs with gravel to rubble substrates (Stewart and Watkinson 2004). This species spawns in late May to early June in fast flowing water, scattering their eggs over rocky substrates. River darters spawn in late May to early June, though spawning habitat is unknown. Tadpole madtoms likely spawn in July, nesting under vegetative cover. Shorthead redhorse begin spawning in early May, at temperatures of 8-10°C. This species prefers to spawn in riffle habitat over substrate that ranges from sand to cobble with scattered boulders. The capture of a single shorthead redhorse larva along the upstream shoreline of the Diversion Dam suggests that this species may utilize the area for rearing purposes. Though some spawning may have occurred near the dam site, the amount of habitat available is small and is not likely an important area for spawning or rearing.

1.2.3.3.4 Rearing

No rearing studies have been conducted upstream or downstream of the Pinawa Diversion Dam. Fish utilization studies indicated that upstream of the Diversion Dam, the north bank may provide rearing habitat for some species. Electrofishing and seining yielded northern pike juveniles and shorthead redhorse larvae in shallow upstream waters. Many species utilize the littoral zone for rearing; however, this type of habitat is significantly more abundant in areas further upstream in the Seven Sisters forebay than in the immediate vicinity of the Diversion Dam. Consequently, this area is not considered important rearing habitat for fish. The combination of rip rap, vegetation, and natural rock formations along the length of the upstream

channel continue into Margaret and Sylvia lakes and Sharkeys Channel, indicating that habitat along the north bank is not rare or unique to the dam site.

No evidence of spawning or rearing was found in waters immediately downstream of the Diversion Dam. Lack of vegetation, cover or shoreline habitat downstream indicate that this area does not represent important rearing habitat, though marshy and rocky areas closer to the Old Pinawa Dam likely support spawning populations of fish and their offspring.

Though no information is available with respect to rearing within the Pinawa Channel, rearing behaviour and habitat within Manitoba is known for some species that have been observed in the area. For example, species such as northern pike, walleye, lake sturgeon, sauger, and mooneye, do not provide parental care to their young. Northern pike young hatch and grow in highly vegetated areas, and continue to dwell in such areas for most of their lives. Walleye larvae are found throughout the lower channel, feeding on smaller invertebrates, then larger invertebrates and fish. This species tends to prefer rocky substrate throughout its life, descending into deeper water as adults. Lake sturgeon appear to prefer similar habitat types, moving into deeper water as young-of-the-year and remaining in or near river thalwegs. No rearing information is available for carmine shiners, though available reports suggest that spawning and rearing take place at or downstream of the Old Pinawa Dam.

Sauger development is similar to that of walleye, though spawning and hatching occur later in the season (Stewart and Watkinson 2004). Mooneye eggs and young occur at midwater depths over various substrates and likely occur throughout the channel. Juveniles tend to feed on smaller invertebrates, shifting to larger invertebrates, emerging flying insects and small fish as they grow (Stewart and Watkinson 2004).

Species such as brown bullhead, bass, tadpole madtom and some shiners provide parental care to their young. For example, brown bullheads nest in sand/gravel substrates and parents herd their young into tight schools during development. These herds usually occur in July within backwater habitats or tributaries (Stewart and Watkinson 2004). Rock bass rearing in Manitoba has not been observed; however, Scott and Crossman (1998) reported that males of this species excavate a nest in rocky/gravel substrate, guarding and fanning the nest until eggs begin to hatch. This behaviour continues until hatched young disperse from the nest. Young begin to feed on small

invertebrates, then larger invertebrates and small fish as they grow. Tadpole madtom males also excavate and guard nests, ensuring young are protected until dispersal from the nest (Stewart and Watkinson 2004).

1.2.3.3.5 Foraging

Though no foraging studies have been conducted for fish species within the Pinawa Channel/Lee River, several species known from the channel have been studied elsewhere in Manitoba and in southern climates. Some prey species may change due to local abundance and distribution; however, foraging behaviour and prey types in the Study Area are believed to be similar to those in other regions of Manitoba. Foraging behaviour and preferred prey for each fish species found in the Pinawa Channel/Lee River are listed in Table A2.

Waters upstream of the Diversion Dam consist primarily of deep water and are not considered important foraging habitat for most species. However, shallow inshore waters are believed to provide suitable foraging habitat for small forage fish and juveniles of larger species. For example, juvenile northern pike likely feed on small forage fish and invertebrates that utilize the intermittent vegetated areas along the shoreline.

Waters immediately downstream of the Diversion Dam are not likely to support a diverse community of predators and prey. The lack of aquatic vegetation and cover in that area is unsuitable for most prey species, though insect larvae may occur to some extent during late spring and early summer. Consequently, some fish may utilize the area for foraging. Further downstream toward the Old Pinawa Dam, areas containing rocky substrates and marsh habitat likely support more complex food webs and are known to support populations of larger fish species.

1.2.3.3.6 Overwintering

No overwintering information is available for fish species in the Pinawa Channel/Lee River, though most move into deeper waters such as lakes and rivers. Species preferring lake habitats tend to stay for the winter (e.g. walleye), while those preferring shallow waters will migrate into deep water habitats in late fall (e.g. northern pike, shiners, darters, mooneye; Scott and Crossman 1998). Fish inhabiting the Pinawa Channel likely move downstream of the PTH 313 bridge to

overwinter in deep water areas within the Lee River and Lac du Bonnet. Upstream of the Diversion Dam, fish likely move into the deeper waters of Margaret, Sylvia, and Eleanor lakes.

1.2.3.4 Fish Movements

No information on fish movements is available for the Pinawa Channel/Lee River. However, some fish species are known to migrate into certain areas to spawn or to overwinter. For example, northern pike are known to move upstream in early spring to spawn (late April to early May), invading shallow water areas containing vegetation (Stewart and Watkinson 2004). Additionally, walleye have been known to ascend from still-frozen lakes into the warmer waters of tributaries during spawning season (Stewart and Watkinson 2004). No evidence of spawning migrations upstream or downstream of the Diversion Dam has been found.

The Pinawa Diversion Dam does not provide fish passage from the Seven Sisters forebay into the Pinawa Channel. Consequently, it is not possible for this to migrate between the two water bodies.

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Table A1. List of fish species that may occur in the Pinawa Channel/Lee River based on data by Stewart and Watkinson (2004) and local observation.

Common Name	Scientific Name	Known Occurrence
Black bullhead	<i>Ameiurus melas</i>	No
Black crappie	<i>Pomoxis nigromaculatus</i>	No
Blackchin shiner	<i>Notropis heterodon</i>	No
Blacknose shiner	<i>Notropis heterolepis</i>	No
Blackside darter	<i>Percina maculata</i>	No
Bluntnose minnow	<i>Pimephales notatus</i>	Yes
Brook stickleback	<i>Culaea inconstans</i>	No
Brook trout	<i>Salvelinus fontinalis</i>	Yes*
Brown bullhead	<i>Ameiurus nebulosus</i>	Yes
Brown trout	<i>Salmo trutta</i>	Yes*
Burbot	<i>Lota lota</i>	No
Carmine shiner	<i>Notropis percobromus</i>	Yes
Central mudminnow	<i>Umbra limi</i>	No
Channel catfish	<i>Ictalurus punctatus</i>	No
Chestnut lamprey	<i>Ichthyomyzon castaneus</i>	No
Cisco	<i>Coregonus artedi</i>	No
Common shiner	<i>Luxilus cornutus</i>	No
Emerald shiner	<i>Notropis atherinoides</i>	No
Fathead minnow	<i>Pimephales promelas</i>	No
Finescale dace	<i>Phoxinus neogaeus</i>	No
Golden shiner	<i>Notemigonus crysoleucas</i>	Yes
Hornyhead chub	<i>Nocomis biguttatus</i>	No
Iowa darter	<i>Etheostoma exile</i>	No
Johnny darter	<i>Etheostoma nigrum</i>	Yes ¹
Lake chub	<i>Couesius plumbeus</i>	No
Lake sturgeon	<i>Acipenser fulvescens</i>	No
Lake whitefish	<i>Coregonus clupeaformis</i>	No
Logperch	<i>Percina caprodes</i>	No
Longnose dace	<i>Rhinichthys cataractae</i>	No
Longnose sucker	<i>Catostomas catostomas</i>	No
Mimic shiner	<i>Notropis volucellus</i>	No
Mooneye	<i>Hiodon tergisus</i>	Yes
Mottled sculpin	<i>Cottus bairdi</i>	No

*introduced species

¹species captured during this study

Table A1. Continued.

Common Name	Scientific Name	Known Occurrence
Ninespine stickleback	<i>Pungitius pungitius</i>	No
Northern pike	<i>Esox lucius</i>	Yes ¹
Northern redbelly dace	<i>Phoxinus eos</i>	No
Pearl dace	<i>Margariscus margarita</i>	No
Rainbow trout	<i>Oncorhynchus mykiss</i>	Yes*
River darter	<i>Percina shumardi</i>	Yes
Rock bass	<i>Ambloplites rupestris</i>	Yes
Sauger	<i>Sander canadensis</i>	Yes
Shorthead redhorse	<i>Moxostoma macrolepidotum</i>	Yes ¹
Silver lamprey	<i>Ichthyomyzon unicuspis</i>	No
Silver redhorse	<i>Moxostoma anisurum</i>	No
Slimy sculpin	<i>Cottus cognatus</i>	No
Smallmouth bass	<i>Micropterus dolomieu</i>	Yes*
Spoonhead sculpin	<i>Cottus ricei</i>	No
Spottail shiner	<i>Notropis hudsonius</i>	No
Tadpole madtom	<i>Noturus gyrinus</i>	Yes
Trout perch	<i>Percopsis omiscomaycus</i>	No
Walleye	<i>Sander vitreus</i>	Yes
Weed shiner	<i>Notropis texanus</i>	Yes
White sucker	<i>Catostomas commersoni</i>	No
Yellow perch	<i>Perca flavescens</i>	No

*introduced species

¹species captured during this study

Table A2. Feeding and habitat preferences of fish species known to inhabit the Pinawa Channel/Lee River. Introduced species were not included.

Common Name	Scientific Name	Known Occurrence	Feeding	Habitat
Bluntnose minnow	<i>Pimephales notatus</i>	Yes	Omnivorous, feeding on algae, insects (larvae and adults), planktonic Crustacea. Feed at bottom and midwater (Becker 1983; Stewart and Watkinson 2004)	Protected marginal waters of tributary mouths of the Winnipeg River. Occurs over mud substrates with submerged wood as cover and on cobble to boulder substrates. Clear or slightly turbid waters up to 50 cm deep (Stewart and Watkinson 2004)
Brown bullhead	<i>Ameiurus nebulosus</i>	Yes	Benthic predator and scavenger (Stewart and Watkinson 2004)	Benthopelagic, in tributaries and mainstem of rivers, moderate current, tolerant of turbid water, found at depths of less than 50 cm in tributaries and along shorelines to depths of 10 m (Stewart and Watkinson 2004)
Carmine shiner	<i>Notropis percobromus</i>	Yes	Omnivorous, food ranging from detritus to algae, insect larvae, and fish eggs (Reed 1954)	Midwater in riffles and runs, on substrates ranging from gravel to boulders, usually tolerant of turbidity (Becker 1983; Stewart and Watkinson 2004)
Golden shiner	<i>Notemigonus crysoleucas</i>	Yes	Midwater to surface feeders, on planktonic invertebrates and plant material (Scott and Crossman 1979; Stewart and Watkinson 2004)	Prefers quiet, clear waters with aquatic vegetation cover in ponds, oxbow lakes or streams. Usually found over soft substrates in water less than 2 m deep. Tolerant of low oxygen levels and are known to survive in high winterkill lakes (Stewart and Watkinson 2004)
Mooneye	<i>Hiodon tergisus</i>	Yes	Midwater to surface feeders, mainly on aquatic insect larvae and emerging flying insects and some small fish (e.g. emerald shiner) (Stewart and Watkinson 2004)	Less turbid, slower moving water in larger rivers and lakes, water depth and substrate type not important, no preference for faster or slower currents (Stewart and Watkinson 2004)
Northern pike	<i>Esox lucius</i>	Yes	Mainly piscivores, feeding on small fish early in life, but also on insects, small mammals, invertebrates and small aquatic birds (Stewart and Watkinson 2004)	Most common in cool, clear, quiet water with vegetation or other types of cover. More common in lakes but also in flowing water in areas of the lowest flow (Stewart and Watkinson 2004)
River darter	<i>Percina shumardi</i>	Yes	Aquatic insects most common, sometimes zooplankton, small fish and eggs (Hanke 1996)	Prefers pebble-rubble substrates, either in protected or exposed locations. Prefers flowing water or wave action to quiet, protected water. Usually found on rocky substrates with little or no vegetation.(Stewart and Watkinson 2004; Balesic 1971)
Rock bass	<i>Ambloplites rupestris</i>	Yes	Predators on crayfish and other aquatic Crustacea and insects. Minnows and juvenile fish are also taken. (Becker 1983)	Rocky substrates in the littoral zone of lakes and pools and runs in streams and rivers. Prefers areas with submerged wood or aquatic plants as additional cover. Tolerates turbidity (Stewart and Watkinson 2004)
Sauger	<i>Sander canadensis</i>	Yes	Feed on zooplankton and aquatic insects as juveniles, some become piscivorous by the end of their first year. Adults are piscivorous. In addition to fish, crayfish, leeches and aquatic insects are also taken (Stewart and Watkinson 2004)	Prefers shallower, more turbid water than walleye, more common in turbid rivers. Found on substrates ranging from clay or silt to rubble and boulders. More common over rocky substrates (Stewart and Watkinson 2004)
Tadpole madtom	<i>Noturus gyrinus</i>	Yes	Feed mainly on amphipods and chironomids (Case 1970; Stewart and Watkinson 2004)	Quiet, clear weedy protected water. Most common in tributaries to large rivers. Water depth is usually less than 1 m and substrate is usually mud or silt (Stewart and Watkinson 2004)
Walleye	<i>Sander vitreus</i>	Yes	Juveniles begin to feed as planktivores (like sauger), shifting to larger invertebrates and then to fish. Mainly piscivores beyond the first year (Stewart and Watkinson 2004)	Typically found in deeper, in less turbid water than sauger. In turbid rivers, walleye and sauger occur more commonly together (Stewart and Watkinson 2004)
Weed shiner	<i>Notropis texanus</i>	Yes	Mostly plant material and some animals, likely small crustaceans (Becker 1983)	Found along shorelines of lakes and rivers and in streams. Prefers quiet water, in beds of aquatic vegetation. Found in depths up to 1 m, over mud, silt, and sand substrates. Sensitive to habitat alteration. May be tolerant to anoxic conditions like many shiners (Becker 1983; Stewart and Watkinson 2004)



Figure A1. Cross section of the Pinawa Channel downstream of the Pinawa Diversion Dam where sectional discharges were measured in order to calculate total channel discharge.



Figure A2. Electrofishing transects conducted along the north shore upstream of the Pinawa Diversion Dam.



Figure A3. Seining transects conducted upstream and downstream of the Pinawa Diversion Dam.



Figure A4. Terrestrial habitat along the north bank of the Pinawa Diversion Dam.



Figure A5. Vegetation corridor separating the Pinawa Diversion Dam and the Pinawa Club Golf Course (south bank). Right of the corridor is the Pinawa Diversion Dam (circled in yellow), while to the left is the Pinawa Club Golf Course (circled in red).



Figure A6. The Pinawa Club Golf Course along the south bank of the Pinawa Diversion Dam.



Figure A7. Terrestrial habitat downstream of the Pinawa Diversion Dam, south bank.



Figure A8. Terrestrial habitat downstream of the Pinawa Diversion Dam, north bank slope.



a)



b)

Figure A9. Terrestrial habitat downstream of the Pinawa Diversion Dam, 40-50 m downstream of the Dam (a). Photograph b) represents both south (left) and north (right) banks, more than 50 m downstream of the Dam.

