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Old Ausable Channel
Literature Review

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1.0 PREFACE

The Old Ausable Channel (OAC) has been identified as an important ecosystem in the Recovery for Species at Risk Strategy in the Ausable River. The OAC is both unique and significant as it supports a large and diverse biological community including three rare species at risk fish. This historic channel is isolated from the present Ausable River and is characterized by clear, still water and dense aquatic vegetation. The OAC is no longer part of a flowing river system but receives water almost exclusively from groundwater seepage.

This channel appears to be evolving from a riverine system to a more pond-like ecosystem that may eventually become even less aquatic and more terrestrial. This evolution will have significant impacts on the important biological community as well as the suitability for other activities, such as recreation

The development of a management plan for the Old Ausable Channel watershed is required to ensure that the stakeholders have an opportunity to plan for a common vision. The management plan will be developed by a multi-stakeholder team and provide a unified vision for management of this unique system as well as the steps required to fulfill this vision.

The initial step in the development of this management plan is to compile the existing watershed and channel information that has already been produced by the range of stakeholders. This information will provide a base from which to identify critical information which is required to make the appropriate management decisions.

2.0 PURPOSE AND SCOPE

The purpose of this literature review is to collect and summarize the existing information that can be used to facilitate further decision making during the development of the management plan. Therefore, the scope of this literature review was limited to those literature sources that met both of the two following criteria.

- Literature must relate directly to the Old Ausable Channel **or** it's watershed
- Literature must contain useful information, not anecdotal or common knowledge that would directly relate to the management of the channel or the watershed, as it relates to any of the management priorities that may become defined.

For example, literature references which merely mentioned these (or similar) words (Old Ausable Channel) but not containing management-related information were excluded. Similarly, many documents relating to the natural resources and management of the Pinery such as fore-dunes were excluded as they were not an OAC watershed issue.

3.0 SYNTHESIS OF SELECTED LITERATURE

The selected literature was summarized from a range of sources, most of which were "peer reviewed" by someone in a professional or academic setting. These sources were of two main types. The first type was Bachelors and Masters of Science university theses, predominantly from the University of Western Ontario (UWO). An inter-disciplinary team from UWO, representing the fields of plant ecology, hydrogeology, chemistry, biology and earth sciences, has been conducting intensive and comprehensive research on this site since 1993. These theses and scientific papers were prepared as a result of this research and represent a reasonably thorough understanding of the conditions existing at the time of the research.

The second type was government or para-government documents and included authors such as the Ausable Bayfield Conservation Authority (and its predecessors), Pinery Provincial Park (Pinery) and the Royal Ontario Museum.

For convenient reference purposes, several reference terms need to be defined. OAC or the "channel" refers to the river channel as bounded by the riverbed whereas the OAC watershed refers to the area from which drained water eventually ends up in the channel.

The entire **length** of the OAC will be referred to as four geographically distinct regions. These regions are relatively homogeneous internally yet differ from each other by at least one critical determinant and so were sampled accordingly by the various researchers. The <u>OAC mouth region</u> extends 1.0 km from the point of discharge to the Ausable River upstream to the Burley Bridge in the Pinery. The <u>southern region</u> extends 3.0 km from the Burley Bridge upstream to the Pinery dam. The <u>central region</u> extends 6.5 km from the Pinery dam upstream to the Pinery's northern boundary. The <u>northern region</u> extends about 3.5 km from the Pinery's northern boundary to the northernmost extremity of the channel at River Road in Grand Bend. Conversely, the **width** of the channel is described based on its relative position in the cross section of the channel. For example, the middle of the channel refers to the middle of the "width", not the middle of the length. Similarly, the areas of the channel bordering the shorelines are referred to as the near-shore regions.

This review summarized the literature into the fields of hydrology, biology, hydro-ecology, land use planning and implications for management. The first type of source mainly focused on the hydrology, biology and the ecology whereas the second type of sources focused on the land use planning aspect. The final section, IMPLICATIONS FOR MANAGEMENT, outlines the key environmental issues that will need to be managed to address the priorities that will be defined in the management plan.

3.1 HYDROLOGY

3.1.1 WATERSHED CHARACTERIZATION

3.1.1.1 HISTORIC

The historic Ausable River originally drained into Lake Huron at or near Grand Bend. Many years of sediment transport by long short currents blocked the outlet and caused the river to flow southward, forming a hairpin turn in the river's course at Grand Bend. Eventually, the Ausable River cut a path relatively parallel to the Lake Huron shoreline between dune ridges and discharged to Lake Huron near Port Franks (Dixon, 1963).

The final construction of the "Cut" by the Canada Company in 1875 drastically reduced the flow of water through the OAC. The Ausable River's course changed to flow through the "Cut" and drained the Ausable River watershed as well as Lake Burwell and Lake George. The draining of these lakes facilitated muck agriculture in what is now known as the Thedford Marsh. The Parkhill creek continued to flow through the OAC until 1892 when a short canal was constructed at the Grand Bend, allowing the creek to directly discharge into Lake Huron. This canal effectively cut off the remaining source of river water entering the OAC. Over the last 100 years, the accumulation of organic material and sand in the OAC riverbed has created the shallow, slow-flowing river that exists today (Fox, 1958; Dixon, 1963).

3.1.1.2 CURRENT

The OAC is approximately 14 km long and drains a watershed of approximately 2450 hectares (24.5 km^2), most of which is within the Pinery Provincial Park. The watershed width is approximately 2000 metres at the south end but decreases to approximately 800 metres at the north end. The river channel itself is 0.5-4.5 metres deep and varies in width from 20-80 metres (Steinbach, 1999).

Since the OAC runs through and is bordered by a large sand dune system, it continues to receive water from the dunes which act as an open aquifer system (Steinbachs, 1999). This watershed creates a small flow in the spring but tended to almost dry up completely, especially during the summer and at the north end (ARCA, 1953). With the creation of the Pinery Provincial Park, a dam was constructed on the OAC to raise water levels and improve recreational uses of the OAC (OMNR, 1977). The dam drastically increased the annual volume of water retained in the OAC.

Four distinct continuous hydrostratigraphic units have been identified within the overburden of the study area. A **clay rich till**, with a low hydraulic conductivity, acts as an aquitard, forming the lower boundary of the aquifer (Steinbachs, 1999). An undulating **lacustrine sand** unit overlies the basal till layer. This unit grades upward from a well sorted fine grained silty sand to a fairly well sorted fine grained sand containing up to 5% gravel and is characteristic of a beach barrier bar within a proglacial lake (McNeil, 1999). The third unit has poorly sorted sediments, ranging in size from fine sand to gravel and is characteristic of **nearshore or beach deposits**. The uppermost unit is a fairly clean, well sorted, **aeolian dune sand** deposit (Steinbachs, 1999).

The OAC penetrates the overburden to at least the depth of the near shore deposits. However, the uppermost aeolian dune sand unit forms the majority of the substrate along the shoreline of the OAC. Furthermore, both the lacustrine sand unit and the nearshore deposits pinch out moving northeast as the clay rich till approaches the surface near Grand Bend (McNeil, 1999). Conversely, these units generally become thicker toward the south end of the OAC.

3.1.2 WATER BUDGET COMPONENTS

3.1.2.1 PRECIPITATION AND INFILTRATION

A detailed hydrological study of the OAC was performed by Simpson (2001). The OAC is recharged entirely from ground water. Ground water is recharged from precipitation; a significant portion of which is derived from the spring snowmelt. The OAC receives approximately 700 mm of precipitation per year. This area receives most of it's precipitation in April and September, coinciding with early spring and early fall (McNeil, 1999).

Attenuation, and hence mixing, of water from precipitation events occurs dominantly in the unsaturated zone above the water table. There was little mixing occurring within the saturated zone below the water table. The average time required for major precipitation events to reach the water table varies from two to four months, depending on the volume and intensity of the recharge event (Simpson, 2001).

3.1.2.2 RECHARGE FROM GROUNDWATER

The ground water table slopes from the highest elevation in the sand dunes delineating the watershed boundary down to the banks of the channel. This slope provides the hydraulic head necessary to move the groundwater into the river channel (Tebbens, 1999; Czetner, 1999). The ground water within the OAC watershed is recharged exclusively from precipitation and is not significantly recharged by either surface water bodies (e.g., Lake Huron, Parkhill Creek or the Ausable River) or deep ground water (Steinbachs, 1999).

Groundwater is discharged from the groundwater table into the OAC along the entire length of the channel but there is considerable spatial and temporal variability to this discharge.

Spatial variability is observed as a result of preferential flow characteristics as well as aquifer substrate differences. Sand lenses are created by preferential flow through sediments of high hydraulic conductivity. These lenses exist throughout the channel but are found dominantly in the central region (McNeil, 1999). These sand lenses are particularly noticeable following a large and sustained rainfall event where upwelling of cool groundwater can be observed.

A steadier baseflow from groundwater to the channel has been observed along the length of the channel. This baseflow increases considerably moving from the north to the south as the catchment area increases and the aquifer sediments become both wider and deeper (Steinbachs, 1999). The travel time for groundwater to reach the channel varies from several weeks to years. This travel time varies considerably with the distance from the aquifer to the channel as well as the hydraulic head gradient.

3.1.2.3 STREAMFLOW AND EVAPORATION

Water discharged from the OAC peaks in July but decreases to less than half by September. The peak input (snowmelt in April) is offset from the peak discharge (in July) by approximately three months (Simpson, 2001).

The OAC experiences significant evaporation, especially during the summer and fall months. Evaporation rates averaged on the order of 13% of the total inflow of water into the channel. Evaporation rates, as a percentage of the inflow rates, ranged from nearly zero in March to a high of 43% in November (Simpson, 2001).

As a result of evaporation and decreased recharge in the summer and fall months, water volumes in the OAC were significantly lower in the fall and winter months. Reductions in water volumes in excess of 5 percent were noted. Water volumes returned to their highest levels in the late spring and summer following the snowmelt and spring rains.

The OAC is only moderately well mixed from one end to the other. This is mainly due to the long residence time (average of three months) of water within the OAC (Simpson, 2001).

3.1.3 WATER QUALITY

Water from precipitation filters through the aquifer's substrates and picks up products of the reduction/oxidation reactions. The limestone based substrates dissolve in the acidic rainfall to dominantly calcium and carbonate ions which are carried by the water into the groundwater and eventually the channel. The time spent in the aquifer exposed to these ions determines the concentrations in the groundwater discharged to the channel.

Water quality in the OAC and its watershed has been evaluated (Steinbachs, 1999; Wiklund, 2001; Schincariol, 2004). Water quality has been evaluated for ph, electrical conductivity, temperature, dissolved oxygen, turbidity and alkalinity (Wiklund, 2001). Steinbachs (1999) measured temperature, pH, electrical conductivity, oxidation/reduction potential and alkalinity as well as the major cations (lithium, potassium, ammonium, sodium, magnesium, calcium) and anions (nitrite, phosphate, fluoride, nitrate, chloride, sulphate) for both the channel water and ground water.

The chemical analyses confirmed that all groundwater samples have a strong calcium bicarbonate nature. These ions had the most effect on the other associated parameters, such as pH, electrical conductivity and alkalinity. Steinbachs (1999) observed that, generally, the concentration of various ions increased from south to north with a resulting increase in electrical conductivity and decrease in oxidation/reduction potential. Calcium, magnesium and bicarbonate ions were the dominant ions responsible for this change. The lower ion concentrations in the south and central regions were due to dilution from the greater volumes of ground water discharged into the channel in these regions.

There was some evidence of anthropogenic influences in the OAC mouth region and in the northern region. Nitrate samples were highest in the OAC mouth region. The source was possibly from “backflushed” Ausable River water which likely had higher levels of nitrate leached from agricultural areas in the watershed. There was also a large increase of sodium and chloride ions at a site in the northern region near a paved municipal road which was inferred to be from de-icing salt. However, these ions became sufficiently diluted downstream from this site. Similarly, there was some evidence of slightly elevated ammonium and phosphate ion concentrations in the northern region that may have originated in septic effluents and fertilizers associated with residential activities. However, since the ions were sufficiently diluted by the time they reached the river channel, greatly elevated concentrations were not observed.

In general, the increased ion concentration in the north end were likely due to the low discharge rates of groundwater combined with the very high evaporation rates in summer. Anthropogenic impacts, such as septic systems, fertilizers and road salt may be minor sources of these ions.

The pH tended to remain fairly stable at around 8.2 for the bottom 5km of the OAC but gradually decreased to about 7.6 at the northern end of the channel. Similarly, electrical conductivity and alkalinity remained stable for the lower 5 km but gradually increased towards the north end. In contrast to the consistent electrical conductivity measurements, the alkalinity results exhibited much greater variability. No significant differences in water temperature or dissolved oxygen levels were noted along the course of the channel. Turbidity consistently remained very low above the dam. Turbidity readings below the dam increased significantly with very high variability exhibited (Wiklund, 2001).

There were significant differences from year to year in pH, electrical conductivity, alkalinity and water temperature but not for dissolved oxygen. It is likely that these differences were the result of differences in meteorological and hydrological conditions amongst the years (Wiklund, 2001).

3.2 BIOLOGY

3.2.1 FISH

3.2.1.1 DIVERSITY AND ABUNDANCE

The OAC is home to a large, diverse and stable population of fish. In a recent survey, the species composition was very similar upstream and downstream of the park dam. 22 species have been detected downstream while 20 species have been detected upstream. Although there were 18 species in common on both sides of the dam, the relative abundance of species differed. Of the fishes detected downstream, approximately 60% were centrarchids, predominantly pumpkinseed and longear sunfish, while the next most abundant group were cyprinids at 25%. In contrast, of the fishes detected upstream of the dam, almost 70% consisted of four cyprinid species: blackchin shiner, golden shiner, blacknose shiner, and pugnose shiner with just 7% consisting of centrarchid species. Percids (predominately yellow perch) were the second most abundant group upstream and the third most abundant downstream (Edwards et al, 2005).

From 1982 to 1997, there appeared to be a trend toward a predominance of sunfishes with a corresponding decrease in minnows. This trend is expected to continue and the fish community structure of the OAC will shift away from one with high numbers of cyprinids towards one dominated by centrarchids. Compared to 1982, there were fewer fish sampled overall and fewer longear sunfish in 1997, but there was an increase in diversity of the centrarchid community (Holm and Boehm, 1998).

The diversity and relative abundance of species have remained relatively stable between 2002 and 2004. Common carp is the only invasive species detected in the OAC, and only three specimens were detected in 2002. Common carp and largemouth bass were not detected in 2004; however, they were never very abundant in 2002, and it is possible they escaped detection in 2004 (Edwards et al, 2005).

3.2.1.2 SPECIES AT RISK

Three fish species at risk recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are found in the OAC. These Species At Risk (SAR) fish include the lake chubsucker (**threatened**), pugnose shiner (**endangered**) and grass pickerel (**special concern**) (COSEWIC, 2006). Canadian populations of lake chubsucker are found only in southwestern Ontario where they inhabit quiet, clear, heavily vegetated waters and are intolerant of turbidity and siltation (Mandrak and Crossman, 1993). In Canada, the pugnose shiner is found only in Ontario and only in the OAC, Lake St. Clair, sections of Lake Erie, and one area of the St. Lawrence River. Pugnose shiner is found in quiet areas of lakes, large rivers, and stagnant channels and is commonly associated with heavy aquatic vegetation, especially *Chara,* such as seen in the OAC (Holm and Mandrak, 2002).

The population of the grass pickerel in the OAC remains relatively stable as the existing water conditions (neutral to slightly basic pH, clear with little flow, shallower than 2 metre depth with abundant to dense submerged, floating and emergent aquatic vegetation) create ideal habitat (Crossman and Holm, 2005). The grass pickerel is found in limited numbers in Ontario and Quebec (COSEWIC, 2005) and it was captured by DFO in 2002, 2004 and 2005 OAC studies.

The central region upstream of the dam had the highest levels of the pugnose shiner and lake chubsucker, and relatively low levels of centrarchids (predators) compared to downstream (Edwards et al, 2005). Both pugnose shiner and lake chubsucker were detected in the southern region below the dam, although not in any great numbers. Below the dam, almost all of the pugnose shiners collected were caught at one site, which was the only site in this region that had 100% submergent aquatic vegetation, providing ideal habitat for these species which prefer heavily weeded areas.

There are some challenges in identifying recent (2002-2004) population trends from the data presented in Edwards et al (2005) as there have been four different sampling techniques used, each with their own advantages and disadvantages. Furthermore, the sample times were in different seasons which likely affected mobility of different species. For example, lake chubsucker was not detected upstream of the dam in 1982 whereas one was seen in 1997 and 12 in 2004. This relatively large increase may have been due to the difference in the sampling technique used, not differences in populations.

The continued health of the pugnose shiner and lake chubsucker populations likely depends on centrarchid populations remaining low (Edwards et al, 2005). To this end, they suggested that it might be necessary to remove from the channel, any centrarchids caught upstream of the dam.

3.2.2 AQUATIC MACROPHYTES

Several major vegetation types were recognized during a research study by Wiklund (2001). Each type is associated with a particular set of environmental conditions in different regions of the channel. These major vegetation types are commonly found growing in various associations which make up four major community types. These four major plan community types can be described as being dominated by *Chara vulgaris* (*Chara*), *Myriophyllum spicatum*, *Elodea canadenses* and *Vallisneria americana*.

Chara is, by far, the most dominant aquatic macrophyte in the OAC. It is most dominant from the dam up to the Beach O' Pines road. This species grows as a submerged anchored macrophyte and is dominant because of two main factors found in this region: low turbidity and low phosphate content of water. *Myriophyllum verticillatum* is an important secondary species within the *Chara* dominated region, particularly in the shallow to moderate depths. *Chara* also grows in association with the lily pads, *Nymphea odorata* (white) and *Nuphar variegatum* (yellow) in shallow depths of near-shore regions.

Wolffia and *Lemna* minor community is found in the same zone as *Chara* between the dam and the Beach O' Pines road. These floating hydrophytes are of insignificant incidence for most of the channel but carpet this area by late summer. The submerged anchored *Chara* communities are dominant from spring to mid summer after which the floating species, *Wolffia* and *Lemna* minor communities become dominant.

In contrast, *Chara* was almost completely absent south of the dam due to higher turbidity and nutrient levels from periodic "back-flushing" of Ausable River water. In the southern region, *Myriophyllum spicatum* and *Elodea canadensis* are the dominant macrophytes where excess nutrients and turbidity eliminate the highly competitive *Chara*. *Myriophyllum spicatum* tends to dominate the first 1.5 km region south of the dam, likely due to better competitiveness at the shallower depths of water. Conversely, *Elodea canadensis* dominated the next 1.5 km stretch to the Burley bridge. This is likely due to greater competitiveness in the deeper water found in this stretch.

South of the Burley Bridge, a completely different set of conditions exist. A flow of water is visible as the channel significantly narrows and backwash from the Ausable River occurs following heavy rains. *Vallisneria Americana* becomes the dominant macrophyte in this region due to the considerable rooting strength and tolerance to higher nutrient and turbidity conditions. Similarly, *Potamogeton pulcher* is also suited to the fluctuating flow and low light conditions south of the Burley Bridge.

3.2.3 BENTHIC MICROBES

An investigation of the status of the benthic microbes in the OAC was completed by AK Dewdney in Maun (publishing in progress). A relatively rich assemblage of cyanobacteria, protists and microfauna were observed to inhabit the OAC. The richness measurements indicated that 232 species were observed which was similar to recent observations in a small, rural and mildly eutrophic field stream.

The investigation was completed several times during the warm months from May to October. As expected, the number of benthic microbes increased as the season got warmer. However, within each sampling period, there was no evidence to suggest that distinct benthic community types, in terms of species composition, were observed.

Richness measurements, an indicator of channel health, varied along the length of the channel. These counts indicated good health at the north end and exhibited good consistency with little variability. Samples taken towards the south end indicated, on average, fair health but exhibited much greater variability with some results indicating less than fair health. There was speculation that the possible causes of reduced health were caused by sediment disturbance related to increased canoeing/paddleboating pressure as well as the backflushing of Ausable river water.

Overall, the health status of the benthic microbes is fair to good in the OAC with no zones of poor health observed.

3.3 ECOLOGY

There are several important interactions between the geology and hydrology of the OAC and the resulting flora and fauna distributions.

3.3.1 GEOLOGY-HYDROLOGY interaction

The surficial geology of the OAC watershed is a major controlling factor in the function of the entire OAC ecosystem. The coarse size and calcium carbonate nature of the sediments as well as the sedimentation patterns control the major flows in the hydrologic cycle. The infiltration rate of water to the groundwater table and subsequently to the actual river channel is mainly controlled by the geology. The residence time of the water in each of the aquifer substrates has a significant effect on the chemistry of the water discharged into the channel.

3.3.2 HYDROLOGY-PHYTOLOGY interaction

The hydrology of the OAC and its watershed is a major controlling factor of the aquatic phytology in the channel. Turbidity, and lack thereof, is a major determinant of the types of aquatic macrophytes present in the different regions of the OAC. The dominant macrophyte *Chara* dominates most of the still quiet areas lacking turbidity, yet is almost completely absent from those regions below the dam which have higher turbidity. Conversely, Vallisneria Americana is found only in the high turbid conditions in the OAC mouth region. In the same fashion, the depth of channel water in the channel is a strong determinant of the minor aquatic species of each community types.

The hydrology also plays a major role affecting the various ion concentrations. The speed at which the water moves to the groundwater and absorbs the various ions of reduction/oxidation reactions directly controls the water ion concentration entering the channel. Also, the dilution of the calcium and carbonate ions (and their associated parameters, electrical conductivity, alkalinity, pH) and the impact of anthropogenic nutrient sources, such as ammonium, nitrate and phosphate, are both controlled by the hydrologic processes. The retention time of the water in the channel determines the degree to which the nutrients are available to encourage plant growth. The concentration of these ions affects the type of community that proliferates in the various regions of the OAC.

3.3.3 GEOLOGY/HYDROLOGY/PHYTOLOGY-ZOOLOGY interaction

The preferred habitat of the SAR fishes (pugnose shiner, lake chubsucker and grass pickerel) is sandy bottoms, moderate water depths, low turbidity waters and weedy conditions. In the OAC case, the geology conditions (sandy substrates) combined with the hydrologic conditions (moderate depth and still water above the dam) provide the ideal habitat for these species. The presence of large numbers of aquatic macrophytes completes their preferred habitat. These conditions are mostly found in the central area where the majority of these fishes have been found. In contrast, the moderate turbidity in the southern region restricts their proliferation in this region and the high turbidity in the OAC mouth region completely prohibits their proliferation in this area. Similarly, these species are not found in the northern region due to the lack of adequate water depth in the channel and a lack of sandy bottom where the clay aquitard breaches the thinning sand deposits.

3.3.4 SUCCESSION

Primary succession has been observed in the OAC. The construction of the two channels which eliminated the upstream source of nutrient flushing water drastically accelerated the natural evolution of the OAC. The construction of the dam, likely further accelerated this trend from a riverine sere through a pond sere and eventually to a terrestrial sere.

The proliferation of aquatic plants throughout the OAC increases the amount of organic matter deposited in the channel, leading to infilling of the channel. Similarly, the eutrophication in the shallower northern region, combined with the general transition from Chara to rootless morphs demonstrates that primary succession is occurring most rapidly in this section of the channel. The northernmost 160 m stretch of the channel between River Road and Lake Road in Grand Bend known as the “mud hole” is very shallow and can dry up completely during the summer months (Simpson, 2001). In contrast, the OAC mouth region most resembles a riverine sere and therefore, has experienced the least rapid rate of succession.

3.4 LAND USE PLANNING

Land use in the OAC is primarily residential and recreational, including conservation (Steinbachs 1999).

3.4.1 RESIDENTIAL

Approximately 3.5 km (250 ha) of the most northerly section of the OAC (and upstream watershed) is used for residential purposes. This area is used for permanent residences as well as seasonal and four-season cottages. The dominant method for treating domestic wastewater is through the use of septic systems. The dominant source of domestic water is municipal water systems.

A range of landscaping practices exists within the residential portion of the OAC. Yards range from fully naturalized (undisturbed) through partially naturalized (wild vegetation trimmed) to intensively managed lawns (lawn grass species, fertilized and manicured) extending to the water's edge. Decks, firepits and lounging chairs/areas are common on most developed properties.

A major road (Highway 21) runs nearly parallel to the OAC near the eastern boundary of the OAC watershed. Three roads (2 culverts, 1 dam) cross the OAC within the Pinery whereas six roads (5 culverts, 1 dam) cross the channel in the residential portion.

3.4.2 RECREATION

The Pinery Provincial Park occupies the remaining 10.5 km (2200 ha) of the OAC watershed. The Pinery has been a recreational destination for many decades (ARCA, 1953; Nicholson, 1947). This trend continues today (OMNR, 1986). Recreational pursuits include canoeing and fishing in the channel as well as hiking, camping and naturalist activities within the OAC watershed. The Pinery hosts 11 walking and biking trails of various lengths which highlight the natural features of the park (Pinery website, 2006). These activities tend to be very low impact and are not believed to create an adverse affect on the watershed or the channel itself.

3.4.3 CONSERVATION/PRESERVATION

The OAC watershed within the Pinery is renowned for is wide array of interesting and unique ecosystems and the organisms that live within them. The Pinery is also home to large and diverse populations of flora and fauna. Many unique species of reptiles and amphibians, mammals, birds, fish, plants, trees, butterflies and insects are found in the Pinery.

The Pinery hosts 50% of the remaining oak savanna in the world. This globally rare habitat is a transition zone between prairie grasslands and oak forests that is kept stable by periodic forest fires. Through the use of prescribed burns and removal of pine plantations, the Pinery has restored its Oak savanna ecosystems (Pinery website, May 2006).

The Pinery also features unique freshwater coastal dunes. Sand is eroded from shores and bluffs north of Grand Bend and transported by long shore drift to the Grand bend area where it is blown into dunes. Over thousands of years, the dunes become colonized by vegetation and stabilized from further movement. These dune systems are relatively fragile so access is limited to these areas and conservation measures including dune grass planting are implemented to stabilize and repair earlier damage (Pinery website, May 2006).

Park staff actively manage the natural resources to improve the ecosystem for the unique and rare species. Management techniques include prescribed burns, removal of non-native or over-populated species, as well as planting/re-introducing native species. These techniques assist in recreating the natural eco-systems and improve habitat for a range of rare and unique species, including the re-introduction of the extirpated Karner Blue butterfly (Pinery website, May 2006).

3.5 IMPLICATIONS FOR MANAGEMENT

3.5.1 LIMITATIONS OF LITERATURE

Most of the research cited in this literature review was conducted from 1995 until 2000. This information would have been accurate as of that time frame. There has been a constant, but not drastic, evolution of the channel since then which has created some conditions that exist today that are not exactly the same as the previous ones cited (Cairns, personal communication). Furthermore, there was no long term monitoring of these research studies. Each research study, essentially, collected point source (in time and space) data. The suitability of the short-term point source data for making long term implications is unknown.

Despite these potential short-comings, the literature is quite comprehensive, encompassing the geology, hydrology, phytology and zoology of the OAC watershed. The basic underlying bio-physical processes are basically understood, even if the actual physical parameters, such as precipitation and temperature, change from year to year.

3.5.2 STATUS QUO

Current watershed activities do not appear to be greatly adversely affecting the channel during the 1995-2000 timeframe. Although there are no consistent long-term studies available, some pieces of the literature tend to suggest that the channel health is not degrading. Current anthropogenic practices, with the possible minor exception of roadsalt and septage effluents, do not appear to be greatly adversely affecting the eco-system of the channel.

However, as the northern region continues to experience residential development, there exists a possibility that increased construction activities could lead to an adverse affect due to the proximity and vulnerability of the channel.

3.5.3 POTENTIAL ISSUES REQUIRING MANAGEMENT SOLUTIONS

Although the literature suggests that the channel was not adversely affected in a major way by anthropogenic activities, there are some pro-active steps that could be taken to improve the current situation or, at the very least, to ensure that the ecosystem does not degrade in the future.

There are several important parameters identified in the literature which could be managed appropriately to facilitate the priorities that are identified. The desirable parameters include:

- **low turbidity waters –** still, clear waters are the preferred habitat for several SAR fish as well as preferred conditions for some macrophytes. In addition, it is the preferred conditions for the channel's most popular recreation activity – canoeing – both inside and outside the Pinery. Residential property values are also improved with direct access to low turbidity waters.

- **nutrient poor waters –** nutrient rich waters accelerate the eutrophication of the channel, causing excessive plant growth which causes rapid infilling, deteriorated canoeing conditions and lower property values.

- **increased streamflow** – an increase in streamflow would assist to lower the nutrient content of channel water via dilution. Increased streamflow would also decrease the conditions for insect breeding, especially mosquitoes. Furthermore, a larger streamflow extended over a longer period during the spring and summer would assist to minimize the hydrological conditions in which *Chara* proliferates. For example, the groundwater flow entering the channel through the sand lenses is sufficiently strong to dislodge *Chara* from the riverbed. A management challenge would be to manage the hydrology to gain the benefits of increased streamflow without adversely increasing the turbidity.

- **increased water depth** - an increase in water depth, especially to greater than 2 metres, would decrease the amount of plant growth in the channel, as well as provide more canoe-navigable waters throughout the season. A greater volume of water could also provide increased habitat for fish in the channel.

4.0 LITERATURE SOURCES

HYDROLOGY

Czetner, Zolton. 1999. **Delineation of the water table at the north end of the Pinery Provincial Park using ground penetrating radar.** University of Western Ontario, Faculty of Earth Sciences. London, ON. 106 pp.

Abstract – This Bachelor of Science thesis investigated the use of ground penetrating radar to map the water table at the north end of Pinery Provincial Park. A total of 13 transects were surveyed and a water table map was produced for this area. Measurements in wells adjacent to the line surveys were taken to verify the accuracy of the ground penetrating radar.

Results indicated that, in areas of dune sand and nearshore deposits, radar data is accurate to within +/- 2 metres of the actual water table depth, as verified by monitoring well measurements. The capillary fringe did not interfere with the water table identification process, as it was relatively small in these coarse sediments. Areas of recharge were found to coincide with areas of topographic high, and discharge areas with topographic lows.

Ground penetrating radar, as a methodology, proved to be best suited for coarse sediments, where many sites with good roadside access facilitate the production of detailed water table maps.

McNeil, John D. 1999. **An examination of the main factors governing the water balance of the Old Ausable River watershed.** Department of Earth Sciences, University of Western Ontario. 61 pp.

Abstract – This Bachelor of Science thesis evaluated the main factors governing the water balance of the Old Ausable River Channel (OARC). A variety of techniques were used to quantify the various parameters of the water balance equation. One hundred and eighty seepage meters were installed at forty-one different locations to determine the spatial and temporal variations of groundwater seepage into the OARC. A streamflow value was obtained through the use of a vertical axis pygmy meter linked to a stream flow computer. Precipitation data was obtained from Environment Canada at Thedford and compared to local precipitation data from the Pinery. Evapotranspiration was determined empirically using two temperature based models. A change in storage was attained by examining the water table fluctuations in wells proximal to the channel.

The complexity of the variables within the basin hydrologic cycle made it difficult to accurately quantify each of the parameters. However, this study showed that an estimate obtained using simplistic methods and calculations can provide a fairly useful alternative.

Simpson, Shawna, L. 2001. **The stable isotope hydrology of the precipitation-ground-water surface water system at the Pinery Provincial Park**. Faculty of Graduate Studies, University of Western Ontario, London, ON. 211 pp.

Abstract – This Master of Science thesis studied the hydrology of the Old Ausable River Channel (OARC) using stable isotope methodologies. Various water components of the hydrologic cycle were quantified. Relative compositions of different isotopes were used to determine various sources of inflow to the OARC. A stable isotope mass balance was used to quantify evaporation.

This study determined that water in the OARC is derived solely from ground water and experiences extreme evaporation in the summer. Evaporative losses during the 'ice-free' portion of the year averaged 13% of the inflow. Assuming that recharge to the OARC remains constant and water levels continue to be artificially maintained, water loss resulting from evaporation is sustainable, and by itself, should not lead to channel degradation.

Steinbachs, Janet N. 1999. **Hydrogeology of the Old Ausable River Channel (OARC) watershed, Grand Bend, Ontario.** Faculty of Graduate Studies, University of Western Ontario, London, ON. 311 pp.

Abstract – This Master of Science thesis was conducted to fully characterize the hydrogeology of the Old Ausable River Channel (OARC), and to assess the potential for contaminant and nutrient transport to the river channel. A field investigation was carried out that included a review of MOE well records in the Grand Bend area, and the installation of water table wells, multilevel bundle samples in addition to seepage meters. Soil, groundwater and surface water samples were collected to fully assess the chemical and physical properties of the watershed.

The surficial aquifer consists of glaciolacustrine and barrier bar sediments overlain by a clay-rich till aquitard. Hydraulic head data revealed that groundwater flow in the watershed is controlled by the sand dune topography, and local flow systems are developed throughout the aquifer.

Groundwater in the Pinery Park appears to be minimally affected by anthropogenic sources of nutrients. Spatial trends in the distribution of various parameters are attributed to natural oxidation-reduction and ion exchange reactions, and changes in the geochemistry of the sediments. The river channel in the Pinery Park is less affected due to higher rates of groundwater discharge, greater dilution of contaminants, and fewer potential anthropogenic sources of nutrients.

In contrast, there is significantly greater potential for ground water and surface water quality impacts from development near Grand Bend. Slow or stagnant flow conditions, in combination with low groundwater discharge rates and possible anthropogenic sources of contaminants serve to significantly accelerate the eutrophication in the northern residential region of the OARC.

Tebbens, Jeffrey T. 1999. **Water table mapping using ground penetrating radar at the Pinery Provincial Park.** University of Western Ontario, Faculty of Earth Sciences. London, ON. 56 pp.

Abstract – This Bachelor of Science thesis investigated the use of fast and accurate ground penetrating radar to map the water table at the south end of the Pinery Provincial Park. A total of 14 transects ranging from 50-500 metres in length were surveyed and a water table map was produced for an area of approximately 4 square kilometers.

Results indicated that, in areas of dune sand and nearshore deposits, radar data is accurate to within 10% of the actual water table depth, as verified by monitoring well measurements. The capillary fringe did not interfere with the water table identification process, as it was relatively small in these coarse sediments. Areas of recharge were found to coincide with areas of topographic high, and discharge areas with topographic lows.

BIOLOGY

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. Species Assessment Available: www.cosewic.gc.ca/eng/sct0/index_e.cfm. Accessed: May, 2006.

Crossman, E.J. and Holm, E. 2005. **COSEWIC status report on the Grass Pickerel, *Esox americanus vermiculatus*, *in* Canada, in COSEWIC assessment and update status report on the Grass Pickerel, *Esox americanus vermiculatus*, in Canada**. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-27 pp.

Abstract – This status report on the Grass Pickerel outlines the rationale supporting the recommended COSEWIC status as Special Concern. This report provides an overview of the species information, distribution, habitat, general biology, population sizes and trends, limiting factors, and protection status in Canada and the US.

The grass pickerel's distribution is interrupted with several larger populations concentrated in tributaries to the upper St. Lawrence river, Upper Niagara and Welland rivers and the upper portion of Lake St. Clair. Smaller populations have been found on the north shore of Lake Erie, in the tributaries to Lake Huron (Old Ausable Channel) and Lake Ontario.

Although the grass pickerel has a small area of occupancy, the total population is not declining in sufficient numbers to warrant a COSEWIC status of Threatened.

Edwards, A., J. Barnucz, S. Staton, and N.E. Mandrak. 2005. **Survey of the Fish Assemblages in the Old Ausable Channel, Ontario DRAFT.** Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Central and Arctic Region. Burlington, ON. 31 pp.

Abstract – A survey of the fish assemblages was conducted in the Old Ausable Channel in 2004. A variety of different sampling techniques were used, including boat/shore seining, hoop netting and electrofishing. Spatial and temporal trends in the diversity and relative abundance observations were compared above and below the Pinery Dam.

Cyprinids were, by far, the most abundant species upstream of the dam although their relative abundance appears to be decreasing. Percids were the second most abundant species followed by the centrarchids. In contrast, the downstream portion was dominated by centrarchids, followed by cyprinids and lastly, percids. The stretch above the dam had the highest levels of pugnose shiner and lake chubsucker, and relatively low levels of centrarchids compared to downstream. The diversity and relative abundance of species remained relatively the same from 2002 to 2004, with the exception of a few species.

Further standardized sampling throughout the whole channel is necessary to obtain a more complete picture of the changes occurring in the OAC fish assemblages, both upstream and downstream of the dam

Holm, E. and Boehm, D. 1998. **Sampling for Fishes at Risk in Southwestern Ontario, 1997: A report prepared for the Ontario Ministry of Natural Resources (Southcentral and Alymer Region).** Centre for Biodiversity and Conservation Biology - Royal Ontario Museum - Unpublished Report.

Abstract – An intensive fish sampling program was undertaken from June-November 1997 to identify the current status of possible Species at Risk fish in Southwestern Ontario. A variety of sampling methodologies were used including seines, backpack electrofisher, gill nets and a small trawl. 116 collections were made at 77 unique sites with notes made on location, habitat and capture details. Results were presented for three areas (Point Pelee, Old Ausable Channel, Sydenham River) and 22 potential fishes at risk.

The results for the Old Ausable Channel suggest a trend toward a predominance of sunfishes with a corresponding decrease in minnows which will likely continue. Compared to 1982, the 1997 observations indicated an increase in the diversity of the centrarchid community, although there were fewer longer sunfish and less fish overall. The 1982 sampling period occurred in June so the higher numbers may have been due to spawning aggregations.

Holm, E. and N.E. Mandrak. 2002. **Update COSEWIC status report on the Pugnose Shiner, *Notropis anogenus, in* Canada, in COSEWIC assessment and update status report on the Pugnose Shiner, *Notropis anogenus*, in Canada**. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-15 pp.

Abstract – This status report on the Pugnose Shiner outlines the rationale supporting the recommended COSEWIC status as Threatened. This report provides an overview of the species information, distribution, habitat, general biology, population sizes and trends, limiting factors, and protection status in Canada and the US.

The pugnose shiner has a limited and disjunct distribution with reproducing populations in the Old Ausable Channel and limited areas of the Canadian waters of Lake Erie, Lake St. Clair and St. Lawrence River. This species has apparently disappeared from two of the six known areas and the stability, size and range of the remaining four populations are poorly known.

The pugnose shiner's strict habitat requirements (quiet waters, sandy bottoms and heavy plant growth, especially *Chara*) make it a good indicator of environmental quality.

Mandrak, N.E., and E.J. Crossman. 1993. Status of the Lake Chubsucker, *Erimyzon sucetta*, in Canada. Report to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Canadian Wildlife Service. Ottawa. Ontario K1A 0H3.

Abstract – This status report on the Lake Chubsucker outlines the rationale supporting the recommended COSEWIC status as Vulnerable. This report provides an overview of the species information, distribution, habitat, general biology, population sizes and trends, limiting factors, and protection status in Canada and the US.

The lake chubsucker has a disjunct North American distribution and, in Canada, is only found in southwestern Ontario. It is declining in many parts of its range due to drainage or siltation of its critical habitat. In Canada, it is at its northeastern range limit and has only been collected in low numbers at few localities.

ECOLOGY

Maun, M. Anwar (editor) **Biology and Hydrology of the Old Ausable River Channel.** Department of Biology, University of Western Ontario London, ON. (publishing in progress).

Abstract – The report provides a comprehensive overview of the major elements of entire ecosystem of the Old Ausable River Channel (OARC). This detailed summary of the multi-disciplinary investigation, conducted by researchers from the University of Western Ontario, incorporates the studies of plant ecology, hydrology, biology and earth sciences.

This overview identified the significant interaction between the geology, hydrology and the aquatic plant communities located in the channel. A benthic microbe study further suggested that stream health was consistently good at the northern sampling point but tended to exhibited fair results with higher variability towards the south end. Fish populations were not included in this study.

Schincariol Robert A, Maun M Anwar, Steinbachs Janet N, Wiklund Johan A, and Crowe Allan C. March 2004. **Response of an Aquatic Ecosystem to Human Activity: Hydro-ecology of a River Channel in a Dune Watershed.** Journal of Freshwater Ecology, Volume 19, Number 1.

Abstract – This research paper characterized the hydrogeology of a dune watershed and examined the impact of a dam on plant community dynamics. There were four distinct hydrostratigraphic units identified, consisting of a basal unit of grey clay-silt till, overlain in succession by a lacustrine sand, shoreface sediments of sand/gravel and an aeolian dune sand deposit. Deposits vary in depth from 1 metre to about 25 metre in various locations in the watershed.

The dam has essentially separated the channel into two distinct ecological units; north and south. To the north, *Chara vulgaris* was the dominant species because of very low turbidity and elevated calcium and magnesium carbonates and bicarbonates in channel water. To the south of the dam, two other aquatic plant communities dominated primarily because of higher turbidity and backflow of nutrient rich water from the Ausable River.

The OARC is displaying many symptoms of eutrophication and some of the plant species that indicated high nutrient content have already started to invade the northern parts of the channel.

Wiklund, Johan Andre. 2001. **Relationship between the environmental factors and aquatic macrophyte distribution in the Old Ausable River Channel.** Faculty of Graduate Studies, University of Western Ontario, London, ON. 214 pp.

Abstract – This Master of Science thesis documented environmental factors and distributions of aquatic plants in the OARC and found definite correlations between these factors and the plant distributions. Seepage of bicarbonate-rich ground water maintains the level of water in the OARC. The dam in the lower OARC was found to have significant impact on the water depth, turbidity and the type of vegetation.

Several major plant community types were recognized; each with their own unique geographical distribution. The major community types north of the dam were dominated by *Chara vulgaris*, in associations with *Myriophyllum verticillatum, Nymphea odorata, Nuphar variegatum,* and *Wolffia* and *Lemna* minor. The major community types south of the dam consisted of *Elodea canadensis, Myriophyllum spicatum, Vallisneria americana, Potamogeton pulcher* and *N. variegatum.*

Canonical Correlation Analysis of the four dominant plant species and four environmental variables (water depth, turbidity, sediment ammonium, fine sand content) showed highly significant correlation.

LAND USE PLANNING

Ausable River Conservation Authority. 1953. **The Pinery: a report to be submitted to the Ausable River Conservation Authority at Parkhill.** Submitted by the Advisory board on parks and recreation and the Advisory board on reforestation, Ausable River Conservation Authority. 22 pp.

Abstract – This report outlines a proposal to expropriate the lands forming the current Pinery Provincial Park from the Canada Company. This proposal suggests that provincial monies be used by the Ausable River Conservation Authority to purchase these lands which be made available for public use.

This proposal outlines a brief history of the area, the current status and the need for conservation. A description of the natural resources (lands and forests, beach, river) is provided as well as proposed uses and development potential for each of these resources. An independent valuation of these properties as well as plans for the acquisition, administration and financing of this project are also included.

Cairns, Melody. 2006. **Pinery Provincial Park Management Technician**, personal communication.

Nicholson, Norman L. 1947. **A Geographic Study of the watershed of the Ausable River, Ontario.** Geography Department, University of Western Ontario. 165 pp.

Abstract – This report provides a geographic study of the Ausable watershed, as it existed in the mid 1940's. A detailed geographical description is provided for the geology/physiography, climate, soils and the flora/fauna. The economic and social uses of the region are explored for the following natural resources: geology, forest and woodlands, cropland and pasture land, settlements and the various land use regions. Finally, a prescription for future rural zoning and the Grand Bend-Port Franks recreational zone is provided.

This thesis report is an unofficial companion document to the Ausable Valley Conservation Report (1949), in that it provides complementary information on the same region for the same time frame.

Ontario Department of Planning and Development. 1949. **Ausable Valley Conservation Report 1949.** Ontario Department of Planning and Development: Conservation Branch, Toronto, Canada. 361 pp.

Abstract – This report provides a detailed and comprehensive overview of the natural resources of the Ausable Valley up to 1949. A general introduction of the area is given followed by an intensively detailed description of the following natural resources: soil/land use, forestry, water, wildlife and recreation facilities. This report focuses mainly on the land use implications on the use of the above natural resources, with some consideration for recreational value and almost no consideration for natural heritage conservation.

Ontario Ministry of Natural Resources. 1977. **Pinery Provincial Park - Revised Master Plan Draft.** Peterborough ON. 71 pp.

Abstract – The Master Plan for the Pinery Provincial Park was first published in 1971. It suggested that the Pinery should be managed as a recreation class park. Growing awareness of the Pinery's natural features and the Pinery's popularity led to this revised Master Plan.

This revised plan called for the Pinery to remain a natural environment park and provides the basis for future management. This plan outlined a description of the park area, a regional market analysis and a description of the biophysical and cultural resources. The Park policy, zoning restrictions and management policy and plan are defined in detail. Finally, the visitor and education services are presented.

Ontario Ministry of Natural Resources. 1986. **Pinery Provincial Park – Management Plan.** Peterborough ON. 9 pp.

Abstract – The Master Plan for the Pinery Provincial Park was first published in 1971 and revised in 1977. This plan represents a refinement of the 1977 plan. The Park's goal is to continue to remain a natural environment park while providing high quality educational and recreational opportunities.

To this end, the park policy is outlined as well as the identification of specific objectives in different areas and the definition of management zones. A description of the management plans for the various resources including water, landforms, vegetation, fauna and archaeological sites. Client services including recreational facilities, visitor services in addition to related issues are presented. A statement of the development principles and an implementation strategy is also provided.

HISTORY

Dixon, Andy. 1963. **What most people don't see at Grand Bend**. A. Talbot, London, Canada. 27 pp.

Abstract – A general overview of the natural features of the larger Grand Bend area. It includes a general description, with maps of the lower Ausable watershed in the Grand Bend vicinity. This includes the ice-age era watershed, the changes during pioneer times era as well as the current status of the watershed. A general description is provided of the geomorphic processes which were responsible for creating the different changes.

Several other unique and interesting geological formations are described. These include a description and geology of the fossil formation found in the conservation area at Rock Glen near Arkona. The flint deposits south of Port Franks is described as well as the social and market economy that developed around this valuable resource. Similarly, there is a description of the shale deposits which gave Kettle Point its name. Finally, there is a mystery outlined, with popular theories, regarding the remnants of a stone building within the Pinery.

Fox, William Sherwood. 1958. **'T Ain't Runnin' No More - Twenty Years After: A story of Grand Bend, the Pinery and the watershed of the Aux Sables River**. Oxford Book Shop Limited, London, Canada. 89 pp.

Abstract – A narrative and poetic history of the Grand Bend area provides details on the early settlement and the natural features of the Grand Bend general area, including the Pinery and the lower watershed of the Ausable River. An early history describes the creation, controversy over flooding and eventual destruction of Brewster's Dam and Saw Mill located on the OAC near Grand Bend. A description of the early settlement includes the establishment of the St. Peter's Church at St. Joseph, the hunting and recreational pursuits in Lake Smith and the Goose marshes. The lakes drained by the "Cut" now support a muck agriculture industry near Thedford. Lastly, a very early history elaborating on the Missionary explorers at Grand Bend is provided.

RECREATION

Pinery Park. 2006. http://www.pinerypark.on.ca/ausable_channel.html.