An Assessment of the Feasibility of Aquaculture in the Grand Rapids Area

by

Jacques Lagassé

A practicum submitted in partial fulfilment
of the requirements for the degree of
Master of Natural Resources Management

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THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES
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ABSTRACT

Grand Rapids, Manitoba is an historic region with a diverse community situated along the Saskatchewan River near the outlet to Lake Winnipeg. The local economic base of Grand Rapids is relatively small, while new employment opportunities are scarce. Aquaculture, the rearing of aquatic organisms for subsistence or economic profit, may offer social and economic improvement opportunities to communities with limited alternatives. The purpose of this study was to identify the types of freshwater aquaculture systems that would be technically feasible, financially viable and socially acceptable in the Grand Rapids area. The work includes an extensive literature review of aquaculture; site visits to aquaculture operations, interviews with personnel, and search for relevant technical and economic data in southern Manitoba; site visits to potential aquaculture locations in waterbodies in the vicinity of Grand Rapids; meetings, presentations and discussions with the Grand Rapids Band Council and the Grand Rapids Fishermen's Cooperative Association, and; interviews with aquaculture experts from the Federal and Provincial governments and industry.

The literature and agency experts agreed that an adequate business plan that identifies and comprehends a predefined market of sizeable scale is a key requirement to viability. Aquaculture is a relatively high risk endeavour requiring technical expertise and financial skills for success, where an entrepreneurial spirit is a definite, and perhaps required, asset.

Investigation of regional aquaculture operations indicated that few of these are economically viable. Many regional operations have failed due to technical inadequacies, poor planning and market definition, and insufficient scale. Most operations are small-scale *extensive* (traditional pond/lake stocking and growout) systems lacking in technical aspects, and managers often had inadequate management skills and expertise, perhaps due

to a perception that success in aquaculture is not difficult to achieve. Some larger scale, *intensive* (high density, e.g., tank and raceway) operations have also failed due to a lack or an inadequacy in one or two key requirements. In view of the experience with aquaculture in Southern Manitoba, smaller or mid-sized facilities for growing fish for sale are not viable, except perhaps in the hands of a very capable manager.

Consultations with the community indicated a disinterested or indifferent attitude. Public meetings failed to attract people and generate discussion. A brief questionnaire handed out at a Fisherman's Association Cooperative meeting was completed or partially completed by 12 of 22 fishers in attendance. However, some fishers thought aquaculture could be important for their community.

A local ground search indicated that few viable possibilities for extensive aquaculture exist in the Grand Rapids area. Many ponds and lakes in the area have been investigated by local fishers and test stocked by Manitoba Department of Natural Resources. Most of these water bodies were technically deficient in one or more key requirements for viability. A large scale operation has not been attempted in the area.

A broader survey of the aquaculture industry in Canada suggested that a number of developmental opportunities were worthy of more intensive examination. Three alternatives were identified, discussed and rejected; the Grand Rapids hatchery was viewed by most agency experts as an economic liability due to high operating and maintenance costs, and therefore could not be used as part of a financially viable operation. Aquaculture facilities operated for conservation, education or tourism objectives are possible but would require ongoing subsidies. The greatest impediment to a viable aquaculture operation is one of general disinterest or indifference by the community.

In view of the above, at present aquaculture as an economic endeavour has little or no potential for success in the Grand Rapids area with respect to the criteria set out in this study. It is recommended that until any members show interest and initiative in this endeavour, Manitoba Hydro discontinue efforts in this regard.

ACKNOWLEDGEMENTS

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This study is dedicated to Kathy, who encouraged me to start and achieve all that I have throughout my academic career.

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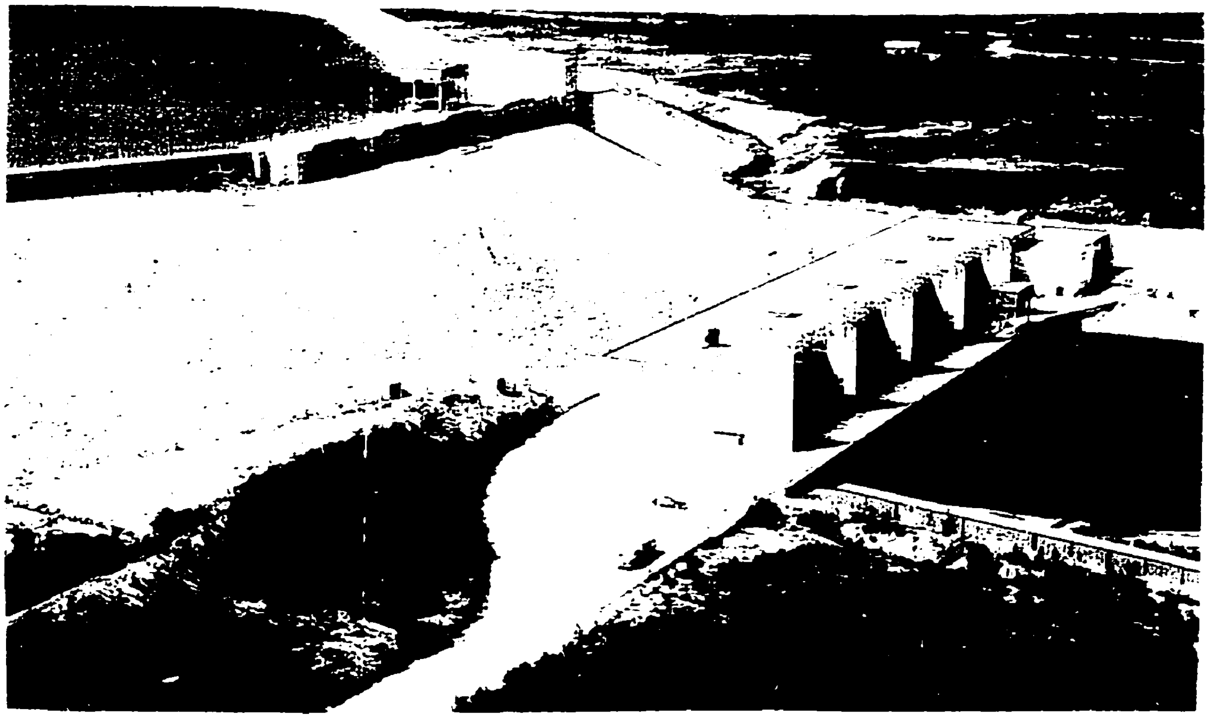

Plate 2 Aerial view of the Grand Rapids Generating Station (Source: Public Affairs, 1996).

'Nothing major is accomplished in the world without passion.'

- Maurice Fontaine, Membre de l'Institute, Université des Sciences et Techniques du Languedoc Sète, France

CHAPTER I - INTRODUCTION

1.1 PREAMBLE

Grand Rapids, Manitoba is a diverse community situated along the Saskatchewan River near the outlet to Lake Winnipeg. The region consists of a community of members from adjacent areas that are the Town of Grand Rapids, Grand Rapids Indian Reserve no. 33 (IR 33) and a subdivision within the Town of Grand Rapids that houses employees of Manitoba Hydro for the operation and maintenance of the Grand Rapids Generating Station (G.R.G.S.). The community and adjoining region are collectively known as the Grand Rapids area.

The local economic base of Grand Rapids is relatively small, while the employment opportunities are scarce. Unemployment is high, manifest in an average family income level below the poverty line. Since the completion of the generating station there have been few new employment opportunities. However, some remote regional economies have benefited by way of an aquaculture operation that is technically feasible, economically viable and socially acceptable. There may be potential for aquaculture to supplement the incomes of some people of the Grand Rapids area. This study will assess the potential for aquaculture to do so and make recommendations in this regard to the communities of the Grand Rapids area and Manitoba Hydro.

1.2 BACKGROUND

Grand Rapids, Manitoba lies approximately 435 kilometres (km) north of Winnipeg via Provincial Trunk Highway 6. The community of Grand Rapids is situated near the mouth of the Saskatchewan River as it flows into the northwest section of Lake Winnipeg (Figure 1). The surrounding area is one of a varied landscape, from grasslands and bogs to boreal forest, and underlain by limestone and dolomitic bedrock with frequent outcropping. Much of the organic and peat soil depth-to-bedrock in the region is 10 to 12 metres, although areas exist that are very shallow. The vegetation cover is mostly black spruce, aspen and willow interspersed by naturally occurring ponds, bogs and small lakes and a few anthropological ponds and borrow pits that result from industrial activities occurring within and around the area.

The community of Grand Rapids is comprised of three spatially distributed components. The small community of the town site proper extends alongside the west shoreline of the last few kilometres of the Saskatchewan River as it empties its waters into Lake Winnipeg. The town community of 740 members (Manitoba Health Population Report, 1998) includes a diversity of ethic origins. Many community members are of native Indian background but there are also significant numbers who are of Scottish, French, German or English ancestry (Damas and Smith Limited, 1976). A bridge on PTH 6 (Plate 1) spans the Saskatchewan River and connects the town community to Grand Rapids IR 33, a Cree community of 376 people. Residents of the town and the reserve share the schools and other facilities situated in the town.

The third component of the community is a small residential subdivision which lays adjacent to the town. The subdivision houses seasonal and permanent employees of the Grand Rapids Generating Station.

Prior to the construction of the Hydro facility and improved highway access to Winnipeg, the community was a relatively isolated settlement subsisting on domestic and commercial fishing and trapping. Following the 1960s economic boom that resulted from employment requirements for the construction of the generating station, the population number fluctuated and then stabilized. However, new economic opportunities have been relatively rare since the completion of the generating station. The town is mainly dependent on operation and maintenance of the generating station facility, commercial fishing, tourism and local service. A provincial fish hatchery built in the early 1970s further contributes to the local economy.

According to a community infrastructure analysis of Grand Rapids (Damas and Smith Limited, 1976) the three components of the community are not only spatially distributed but also vary significantly in their degree of infrastructure and economic development. The building of the Grand Rapids Generating Station generated an economic boon to the 1960s community as the high number of construction positions and economic spin-off increased the local economic base. The result was a relatively high average family income which continued into the early 1970s. However, an influx of workers filled the vast majority of positions requiring greater skills, training and education, and the concomitant higher incomes artificially inflated the community family average income. Although the analysis indicates that the average income for the

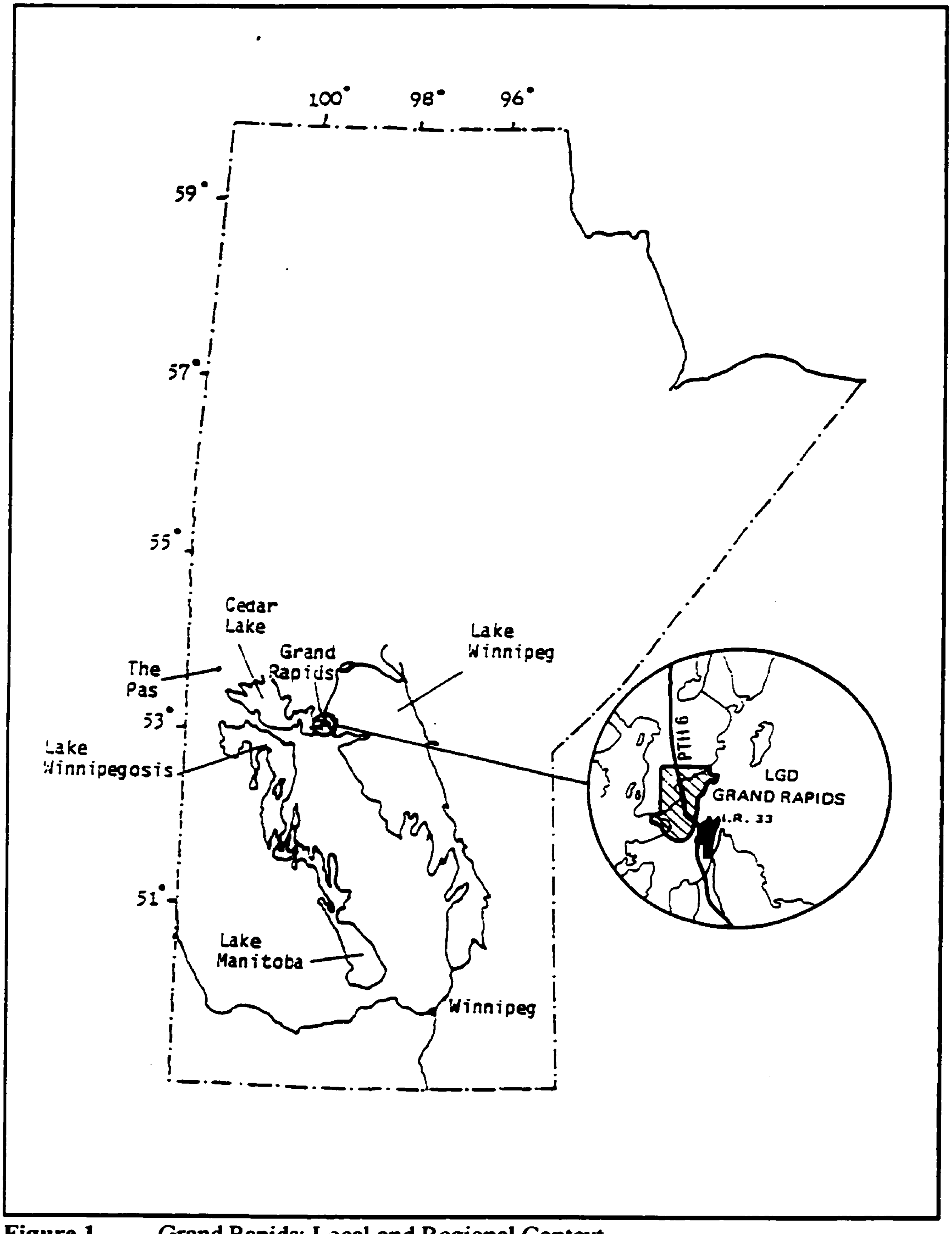

Figure 1 Grand Rapids: Local and Regional Context

community in the early 1970s was slightly higher than the provincial average, the report points out that the range of incomes is wide. The incomes of long-term inhabitants tend to be significantly lower than those of semi-permanent or relatively recent residing status. Discounting the incomes of semi-permanent residents, the average income is greatly depressed to poverty levels and unemployment is well above the provincial average. The disparity is manifest in a significantly inequitable distribution among the income classes.

A number of initiatives have been undertaken by community members in the past, including small-scale, extensive, i.e., pond and lake forms of aquaculture. Aquaculture can be simply defined as the raising of aquatic organisms for economic, social, conservation or personal benefit. In a less formal sense, the term is used in reference to the culture of a specific type of organism, that of finfish. However, this definition precludes many other types of aquaculture organisms such as prawns and crayfish.

A few operations in the area remain in existence; however, many were initiated mainly for personal recreation or test-stocking of lakes, and not for profit. Previous attempts at "put-and-take", i.e., fee-for-fishing business operations involving lake stocking have generally failed due to competition from existing natural sites. However, there appears to have been some marginal economic successes, including some attempts to develop the tourism industry such as in the sportfishing sector.

Aquaculture has been used in lake stocking for the enhancement of natural populations of fish, to support sport and commercial fisheries, and to start a fee-for-fishing operation or a simple hobby farm. Aquaculture has been successfully integrated within restocking programs of small- and medium-sized lakes for recreational purposes, mainly under the direction of government agencies. Alternatively, opportunities may lie in a commercial growout operation that caters to domestic and commercial uses. For example, rainbow trout is a species for which its industry is well developed. The culture industries of high-value species such as walleye and arctic charr continue to develop.

Another potential benefit of aquaculture is education and public awareness of endangered heritage or culturally important species. A system currently in the developmental stage is lake sturgeon culture for the purpose of conservation. Lake sturgeon is an ancient Canadian species that has cultural significance for the region of Grand Rapids. Overfishing and habitat loss continue to stress dwindling stocks and as of 1997 all species of sturgeon have been placed on the "facing extinction" list by CITES (Convention on International Trade in Endangered Species).

Aquaculture is internationally recognized as a source of employment. In Canada it is viewed as an industry with potential for further development (Department of Fisheries and Oceans, 1988; Minister of Supply and Services, 1995). Aquaculture development has occurred to a large extent in rural areas, where it may offer social and economic improvement opportunities to communities with limited economic alternatives. Interest continues to increase as the industry develops and expands. Some native communities in Canada have expressed this interest (Department of Fisheries and Oceans, 1986), including that in the Grand Rapids area (band councillors G. McKay and R. Ballantyne, pers. comm.). New opportunities are required in these areas to alleviate unemployment and increase the incomes of some community members. Some of these remote regional economies have benefited by way of a feasible, viable and acceptable aquaculture operation; there may be potential for the Grand Rapids area to benefit in the same way.

1.3 ISSUE STATEMENT

There are a substantial number of community members in the Grand Rapids area that are unemployed or casually employed. Community employment opportunities and the economic base of a community and its level of economic and institutional development are interdependent. Economic opportunities in the area are limited. Aquaculture may be one way to help alleviate this situation. An assessment of the potential for aquaculture to provide an alternative employment option or a means to supplement the incomes of members of the community is required. In addition, the main source of employment for the town community of Grand Rapids and the Grand Rapids IR 33 is the commercial fishing industry. There is ongoing concern, including that by the people of the First Nations of Canada, regarding the sustainability of commercially and culturally significant fish stocks. Aquaculture may be one component of a fisheries management plan that will help ensure the sustainability of these stocks.

1.4 PURPOSE AND OBJECTIVES

The purpose of this study is to identify the types of freshwater aquaculture systems that are most appropriate and that may be technically feasible, financially viable and socially acceptable, with respect to the Grand Rapids area. The specific objectives of the study are:

1) to prepare an overview of freshwater aquaculture systems in Canada, and their viability;

2) to identify the natural and human resources criteria for the development of viable aquaculture operations in the Grand Rapids area;

3) to perform a technical, social and financial assessment of the aquaculture operations that are identified as potentially feasible, viable, and acceptable;

4) to recommend strategies that are acceptable to the local community.

1.5 SCOPE AND DELIMITATIONS

The scope of the study is delimited to a preliminary evaluation of financial, technical and socio-cultural aspects with respect to aquaculture in the Grand Rapids area.

Technical barriers and research needs are identified and recommendations are made. However, the delimitations of this preliminary assessment are set by (i) the review of scientific and technical literature, (ii) discussions and interviews with experts in the field, (iii) previously documented data, and (iv) a general field search of existing natural and man-made structures. No new experimental data are acquired. In cases where specific data are required in order to further assess a potentially feasible operation, and those data are not readily available, the appropriate research is recommended.

Although technical and financial aspects of the study are obviously highly interrelated, so too are those of a socio-cultural nature. Community aspects expressed during the course of the study will influence the findings. Social factors such as community input, interest, acceptance, job demand, human resources, and risk tolerance levels are interrelated determinants of the economic viability and technical feasibility of a community venture; for example, with regard to the appropriate type of aquaculture system, whereas a system may be technically feasible, it may not be socially acceptable to the community.

Throughout the study, all three disciplines are assessed on an integrated basis; however, the socio-cultural component of the study is delimited to preliminary discussions with interested members of the community. Due to time and monetary limitations and the preliminary nature of the study, a questionnaire is used that attempts to derive some idea of the available resources and the general interest level, concerns, and perspectives of community representatives. It will be recommended that any further assessments regarding aquaculture in the Grand Rapids area include ongoing community input through consultation, workshop and other community development initiatives.

1.6 ORGANIZATION OF THE PRACTICUM

The practicum contains six chapters. Chapter one begins with a brief overview of the socio-economic and biophysical setting of the study. General concepts of aquaculture are introduced. Justification for the study and the issue statement, purpose and objectives are given, followed by the scope and delimitations.

Chapter two presents the research methodology used for each aspect of the study, and explains any delimitations.

Chapter three provides a more detailed description of the regional, historical and infrastructural contexts of the study area. Knowledge of the socio-economic and environmental parameters provides the background information required to identify and use the biophysical and socio-economic criteria to assess the feasibility of a potential operation. Sources of information include the related literature, managers and operators, field experts, members of the community and personal observation.

Chapter four presents a detailed overview of aquaculture in Canada, and includes current global, national and regional trends. The chapter reviews the types of aquaculture operations relevant to the study, the species involved and the manner in which they are used. The technical criteria for site analysis are stated and the stage is set for separate and integrated technical, economic and social feasibility assessments.

Chapter five presents the results and discussion of the assessments, including the technical aspects of site analysis, expert opinion, analysis of economic factors and the social perspectives of the study.

Chapter six summarizes the findings and offers concluding remarks and recommendations.

The appendices include: a list of the scientific names of fish species relevant to the study; the covering letters sent to community representatives; the community perspective questionnaire; the expert opinion interview questionnaire and raw data; pamphlets and advertisements from regional operations; and technical checklists.

CHAPTER II - METHODS

Chapter II will detail the methods involved in the study, from the pre-field study phase to the discussion and analysis of the results.

2.1 PRE-FIELD STUDY PERIOD: COMMUNITY INVOLVEMENT

The study includes a social component that allows for the exchange of information, ideas and concerns between stakeholders to occur on an ongoing basis, so that a more integrated assessment could be made. This component facilitates study and research processes and assists in formulating strategies and recommendations that are socially acceptable to the Grand Rapids community.

Arrangements were made to allow interested members of the community to discuss their perspectives on the development and implementation of a local aquaculture operation. Thus any community input, perspectives and concerns in this regard could be noted and included in the study. Separate meetings with both town site community members and members of IR 33 were arranged. Members were to be informed of developments in meetings with others through ongoing liaison with Councillors and the town Mayor.

An initial reciprocal familiarization period occurred throughout the summer season. Before the field season, a letter of request to meet with the Chief of the Reserve was sent. Requests to meet with the Town Mayor and the superintendent of Manitoba Hydro were also sent. The letters state the intentions and reasons for the study, and request involvement of the Chief, the Mayor, a representative from Manitoba Hydro and community members in the study. Specifically, a request was made to arrange a meeting with the Chief and interested community members. To this end, the Chief delegated all responsibilities to the Band Council. A meeting with the Council was arranged. A separate meeting was also arranged to meet with the Mayor, who was also an employee of Manitoba Hydro. Thus, for the initial part of the study, the Mayor was a representative of the town community (to June 1996) and Manitoba Hydro.

The initial meetings with the Band Council and the Mayor allowed for informal discussion to take place regarding the need for and intent of the study. Before discussing the study, a token of appreciation was offered to the Council for allowing for the opportunity to visit the area and discuss the study. The Council accepted the token and presentation and discussion followed.

A study outline detailing specific intentions was presented and concluded with a request for the Council to participate in the study. The Council verbally agreed to this request. Written assurances were provided that gave the Council and Mayor access to all information amassed by the study that may be of interest to community members, and telephone access to the Ethics Review Board in Winnipeg, should any questions or concerns arise regarding ethical aspects of the study.

The desire for an integrated, community effort was stressed; a request to involve interested community members in the study was made. It was felt that interaction with community members would aid in assessing areas in which documented data does not exist (e.g., depth of and species in a particular pond, previous attempts to grow fish, etc.) by way of access to traditional ecological knowledge.

In August 1995, announcements of the study and forthcoming meetings were made in the local newsletter with the help of community members, and were posted on various community bulletin boards (see Appendix D).

In keeping with the multi-stakeholder aspect of the study, a summary of the study written in Cree is included.

2.2 ASSESSMENT OF HUMAN RESOURCES

The availability of human resources required for a hypothetical aquaculture operation in the Grand Rapids area was assessed, albeit in a limited manner, through a review of the related literature and discussion with aquaculture agencies, managers and operators, and members of the community. Industry and research experts, including the manager of the hatchery were formally interviewed. An employee from the community was informally interviewed.

2.3 TECHNICAL ASSESSMENT

The first part of the study is an assessment of the available types of aquaculture that may be applicable to the Grand Rapids area. The assessment includes an overview of freshwater aquaculture in Canada and a literature review of the types of aquaculture operations and their associated requirements. Topics include the types of fish-rearing systems and the methods involved (e.g., fingerling or grow-out production; extensive/traditional pond or intensive/cage or tank/raceway facilities), fish species and market end-uses and the associated product definition (e.g., rainbow trout for restaurant/white-cloth table use; grocer/supermarket - whole/pan-size, dressed, filleted; lake sturgeon stocking for mitigative or conservation; lake stocking for recreational purposes). The assessment consists of:

- a review of scientific literature and technical publications;
- discussions with experts in-the-field, including those from fisheries and aquaculture agencies, and manager/operators of current and defunct aquaculture operations; and
- a review of successful and failed aquaculture operations, specifically those that may be applicable to the Grand Rapids area.

Fisheries and aquaculture agencies and regional aquaculture operators were identified, contacted and consulted on an ongoing basis to discuss components of successful and failed operations that may be applicable to the Grand Rapids area. The field ground search aspect includes a preliminary assessment of the availability and suitability of local resources. Field trips occurred over the 1995 summer period, roughly on a monthly basis, to assess the study area and regional operations. The length of time for each trip typically involved 3 days. A preliminary ground survey assessment of local water resources (e.g., ponds and small lakes; the regional coast of Lake Winnipeg; the forebay and tailrace of the Grand Rapids Generating Station and the downstream section of the Saskatchewan River) and an assessment of the human resources requirement and availability in the Grand Rapids area were conducted. Thus, regional bodies of water that are available for use in appropriate types of aquaculture may be located, and the skills and experience required for those operations may be determined. Through these assessments, feasible types of aquaculture operations that may be applicable to the Grand Rapids area may be identified.

Prior to the field trips, preliminary research was conducted in consultation with the Manitoba Department of Natural Resources (DNR) and Manitoba Environment to identify feasible sites for intensive or extensive systems of aquaculture (involving tanks, raceways or cages, or involving naturally existing ponds and small lakes or anthropologically generated borrow pits and dug-outs, respectively). This research included an assessment of existing data with respect to local water resources (ponds, lakes, the Saskatchewan River) and regional climatic factors. References to aerial photography maps were made, and consultations with identified experts were held.

Following these preliminary research steps, field trips were made to conduct a ground survey of potential sites in order to assess their suitability for aquaculture and to identify obvious technical barriers. The assessment of the area was made in conjunction with ongoing consultations with experts in aquaculture research, operation and management. Thus, a comparison could be made between identified physical site characteristics and system requirements, as described in the literature and identified through consultations with experts.

Based on these assessments, potentially feasible aquaculture alternatives for the Grand Rapids area were identified. An assessment of those alternatives was then conducted in order to determine the extent of their viability. The technical assessment identifies any technical barriers or research needs that may exist. The social aspects of the study are integrated with the findings, and the Appendices (see Chapter 5.1; Appendix E).

2.3 FINANCIAL ASSESSMENT

The financial assessment of a potentially feasible aquaculture operation in the Grand Rapids area was interpolated from a general economic assessment of the viability of aquaculture in Central Canada, using empirical evidence and information obtained through discussion and interviews with experts. Discussion of successful and failed operations qualitatively indicates the viability of a similar hypothetical operation in the Grand Rapids area. Several examples are included in the study.

Once the most potentially feasible, appropriate, and acceptable types of systems and operations were identified, and a ground survey of local sites was conducted, an assessment of alternatives based on these findings follows. The final report summarizes the findings of the study and includes recommendations for Manitoba Hydro.

CHAPTER III - THE GRAND RAPIDS AREA - REGIONAL, HISTORICAL AND INFRASTRUCTURAL CONTEXTS

Chapter III provides the reader with a more thorough understanding of the study area and surrounding region through a review in the following contexts. The regional section depicts the geological environment, with a focus on the Saskatchewan River and the water bodies in the region. The historical section includes discussion of the first peoples of the area, exploration era and the present day status (for more discussion of the area's history see Ch. 4.8.3.2 Cultural Significance to the Grand Rapids area). The infrastructural context discusses the layout of the communities and facilities in place that are important to the local base economy.

3.1 REGIONAL CONTEXT

Provincial Trunk Highway 6 provides Grand Rapids and more northern communities access to the largest nearby urban setting, Winnipeg, and vice versa (see Figures 1 and 8).

The Saskatchewan River is 1,940 km long, the fourth longest river in Canada. The catchment area of the watershed is roughly 340,000 km^2 of the 1.07 million km^2 drained by the Nelson River Watershed (Figure 2). The source of the river is in the eastern range

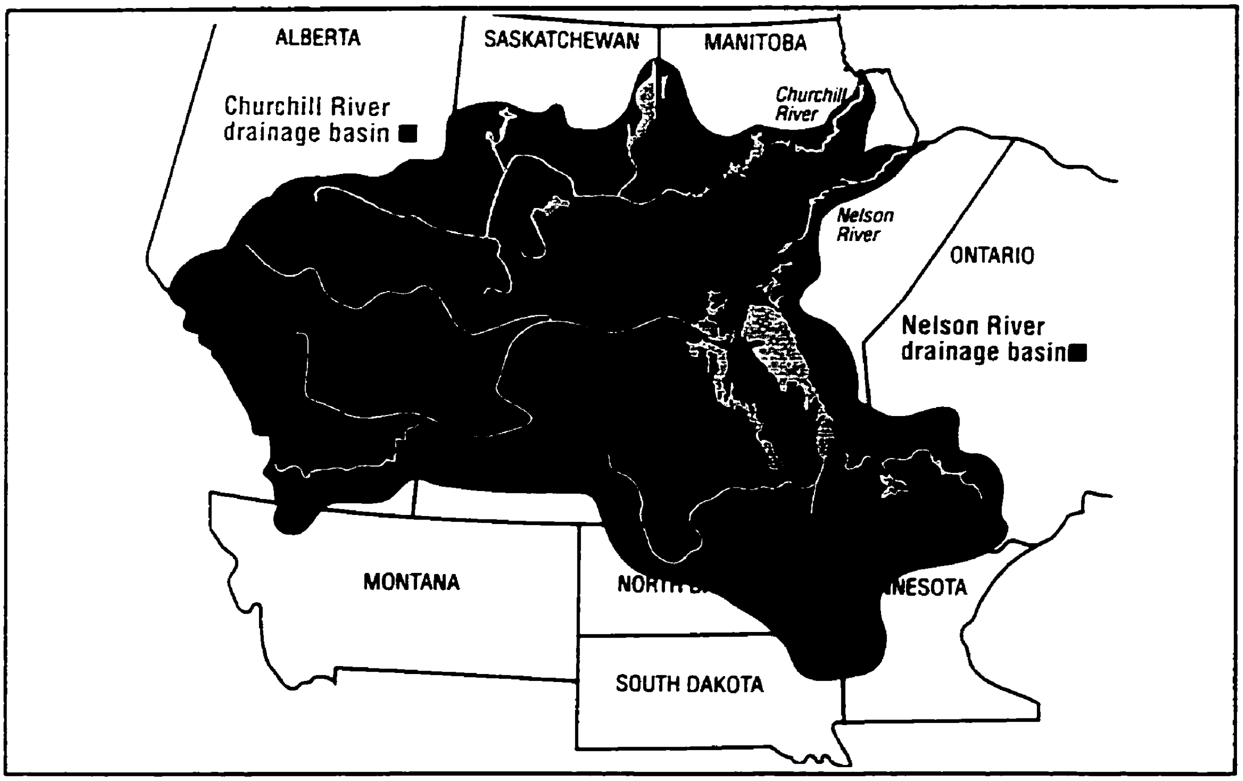

Figure 2 The catchment areas of the Nelson and Churchill Rivers (Source: Public Affairs, 1991).

of the Rocky Mountains in Alberta, where waters collect in the North and South Saskatchewan Rivers and begin their long route across the province of Saskatchewan. The two rivers join near Prince Albert in Central Saskatchewan, and the waters enter Manitoba to be collected by Lake Winnipeg. From Lake Winnipeg, collected waters continue their journey to the sea via the Nelson River and into Hudson Bay.

The river flows from Saskatchewan into Manitoba at The Pas and into Cedar Lake, 36 km upstream from Grand Rapids. A year-round commercial fishing industry on Cedar Lake constitutes the major part of the economic base for the Indian/Metis community of Easterville (Chemawawin IR 2), named after Donald Easter, Chief of the Chemawawin Band. The town is located on the south side of the lake, about 40 km west of Grand of Grand Rapids (100 km by highway). The lake area is approximately 1100 mi^2 (2850 km^2) (Moshenko and McGregor, 1978). Cross Bay, the southeastern merger of Cedar Lake, forms the forebay, i.e., the water storage area, of the generating station. Within the 36 km between Cedar Lake and Lake Winnipeg, a natural water fall of 36 metres (m) occurs. Much of this drop, 23 m, occurs in the turbulent 5-km stretch for which Grand Rapids was named. It is from these topographical features that a 36.6 m head develops and is available to the generating station.

3.2 HISTORICAL CONTEXT

The long and often turbulent Saskatchewan River is aptly named for the Cree word Kisiskatchewan, meaning "swift current" (McCarthy, 1988). Aboriginal inhabitants of the area harvested abundant sturgeon and whitefish from the Rapids for centuries. The fish was smoked for immediate use or dried for winter use, and the oil was used for cooking. In addition, these species have important cultural significance to native peoples of the region (see the subsection under Lake sturgeon, 4.8.3.2 Cultural Significance to the Grand Rapids area).

In 1960, prior to excavation for construction of the tailrace and powerhouse for the Grand Rapids generating station, a reconnaissance of the area was made. As a result of the study, the provincial Department of Mines and Natural Resources and Dr. William Mayer-Oakes, founding head of the Department of Anthropology at the University of Manitoba arranged a major archaeological dig. Findings of the tailrace bay site, an historically fertile and representative site for the entire area, consisted mainly of sturgeon remains and tools derived from the fish, and fragments of pottery (Mayer-Oakes, 1970). European manufactured artifacts, calculated as existing from the year 745 A.D. (sic) to the present, are indicative of the early trade period. More than 23,000 items were collected during 1961 and 1962. The oldest of these indicate the site had been used for subsistence fishing since about 2500 B.C., and the items reflect the many progressive changes in the lives of the early inhabitants of the Grand Rapids area.

In 1741, Le Chevalier de la Verendrye, a son of renowned explorer Pierre de la Verendrye, built Fort Bourbon downstream of the final six km stretch of rapids of the Saskatchewan River. It was the first of many trading posts that would eventually be called the Grand Rapids settlement. The river became known as the gateway to the northwest to explorers, traders, missionaries and settlers.

In 1877 the Hudson's Bay Company built the first railway of Canada's western interior: a tramway of a narrow gauge and powered by mules and horses. For nearly 20 years, the 5.6 km rail system replaced the difficult portage that was required to bypass the rapids and move cargo. However, as the turn of the century approached, railroad development in western Canada brought the Saskatchewan River's importance as a transportation route to an end. In the 1940s the tramway ran as a tourist attraction before succumbing to years of disuse. A section of the original tramway and a replica of a tramcar are kept in Tramway Park and in the reception building area at Grand Rapids Generating Station (Plates 3, 4 and 5).

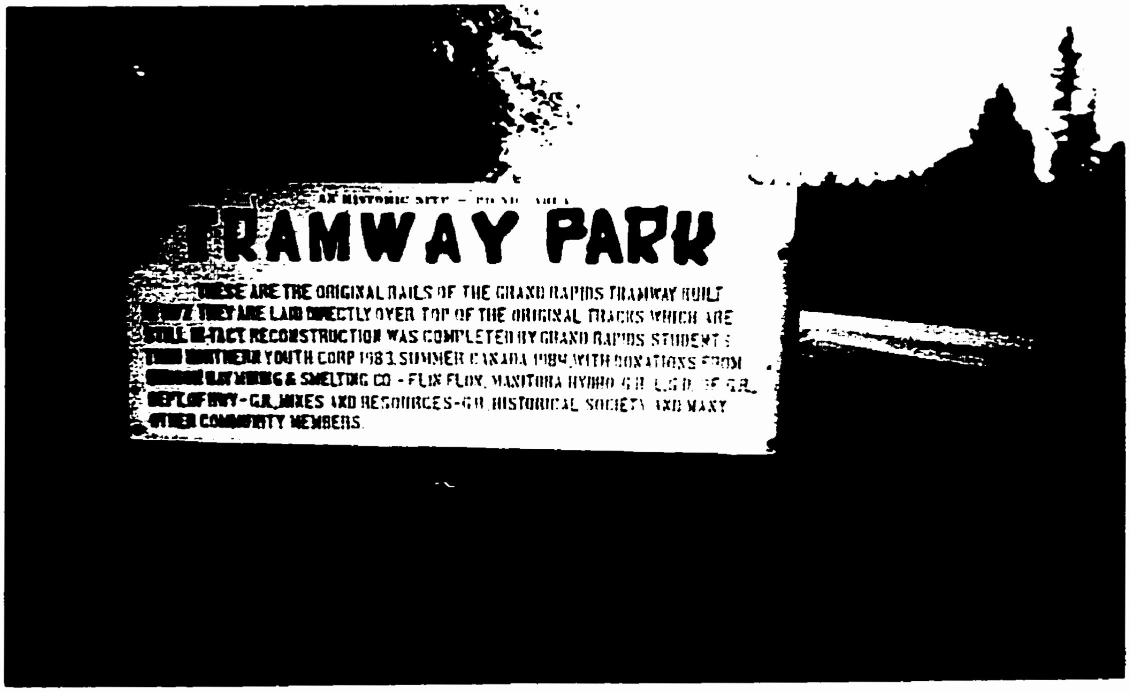

Plate 3 Tramway Park sign - abandoned historic site and tourist area.

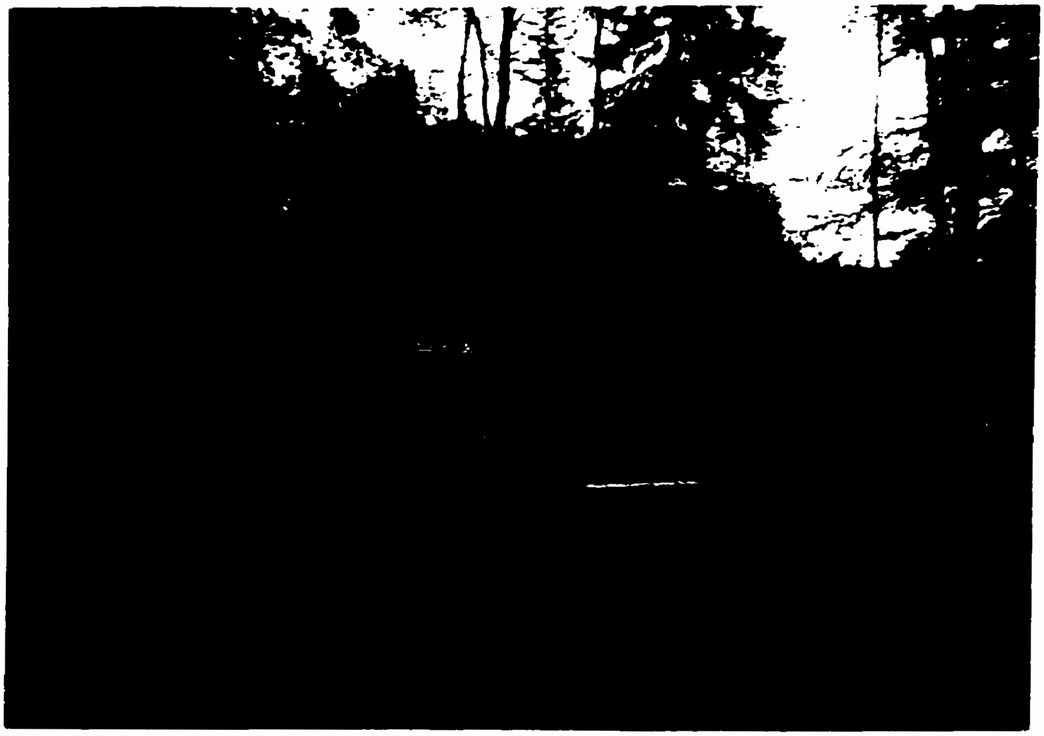

Plate 4 Original tramcar and section of rail in Tramway Park.

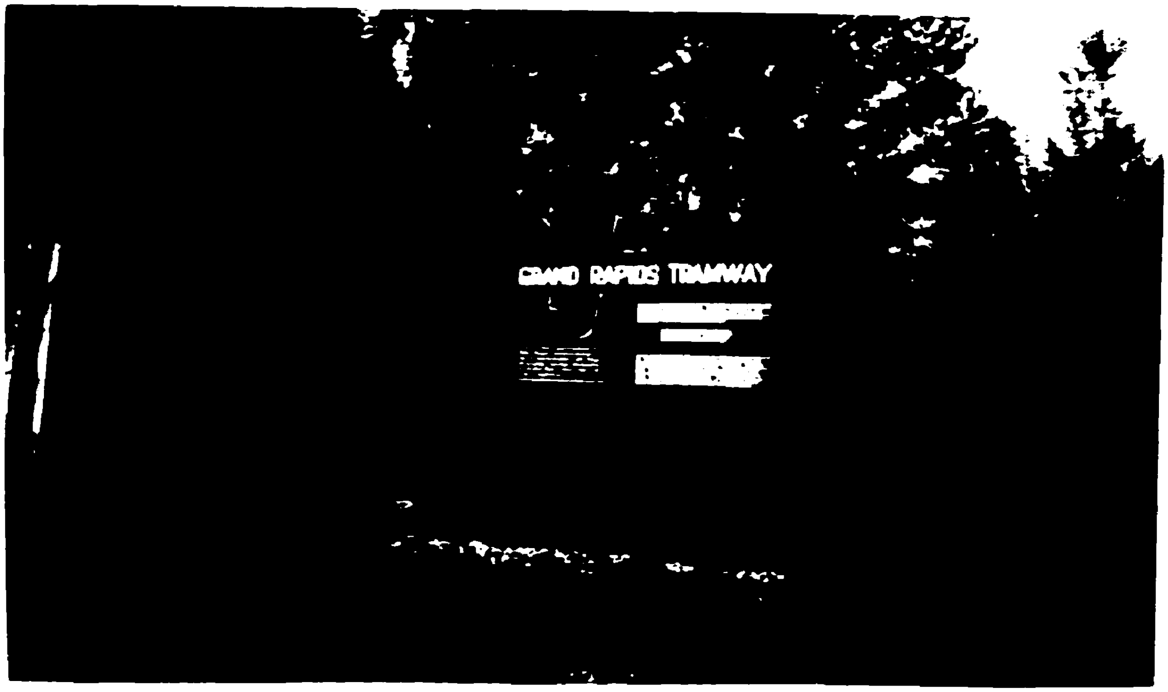

Plate 5 Tramcar, sign and rail renewed by school children and funded by Manitoba Hydro

In the late 1880's Grand Rapids became a centre for Lake Winnipeg commercial fishing. Currently, fishing and trapping are the main economic activities of regional communities. However, there are concerns within the community that walleye, a high-valued species, is becoming depleted while the culturally significant lake sturgeon, a slow-growing and long-lived species, is becoming endangered in all waters in which it is naturally found.

3.3 INFRASTRUCTURAL CONTEXT

The resurfacing of PTH 6 in the 1960's improved the economic and infrastructural position of northern communities by serving to decrease their isolation from urban communities. However, these communities were largely self-sufficient entities prior to this

this development, and while the Grand Rapids area continues to be a relatively isolated community with a stable population, the improved infrastructural position did little to increase the local economic base and considered to be barely adequate (Damas and Smith Limited, Engineers, Planners and Project Managers, 1976). Many community members are unemployed or underemployed, relying on seasonal employment provided by commercial fishing, tourism, forestry and Manitoba Hydro.

3.3.1 Town of Grand Rapids

The town extends linearly along Grand Rapids Drive. Municipal administration is responsible for the town site and the Manitoba Hydro subdivision. A Resident Administrator appointed by the Provincial Government heads an elected local committee.

As previously discussed, the town experienced a boom from the construction of the Manitoba Hydro generating station during the 1960s. However, long term employment opportunities for the community were limited as community members lacked the necessary skills.

3.3.2 Grand Rapids Indian Reserve No. 33

The Reserve area covers 1.852 hectares adjacent to the town (Indian and Northern Affairs Canada. 1989). Fifty-five hectares are classified as community. 828 hectares as forest and 969 hectares as other. Some of the potential for the limited forestry development expansion in this and surrounding areas has been realized.

3.3.3 The Residential Subdivision

The degree of infrastructure development of the residential subdivision is high relative to that of the town and Reserve. A certain degree of socio-economic fragmentation exists among the three community components and as a result, social tension has arisen in the past (Damas and Smith Limited, Engineers, Planners and Project Managers, 1976).

3.3.4 Grand Rapids Generating Station

The generating station is located on the Saskatchewan River three km upstream and west of the town site community. Construction of the station began in 1960 and was completed in 1968. The station has a capacity of 472 megawatts (Public Affairs, Manitoba Hydro, 1994). Cross Bay forms the forebay, which is enclosed by a "grout curtain", an underground seal which prevents seepage into the numerous crevices within the limestone.

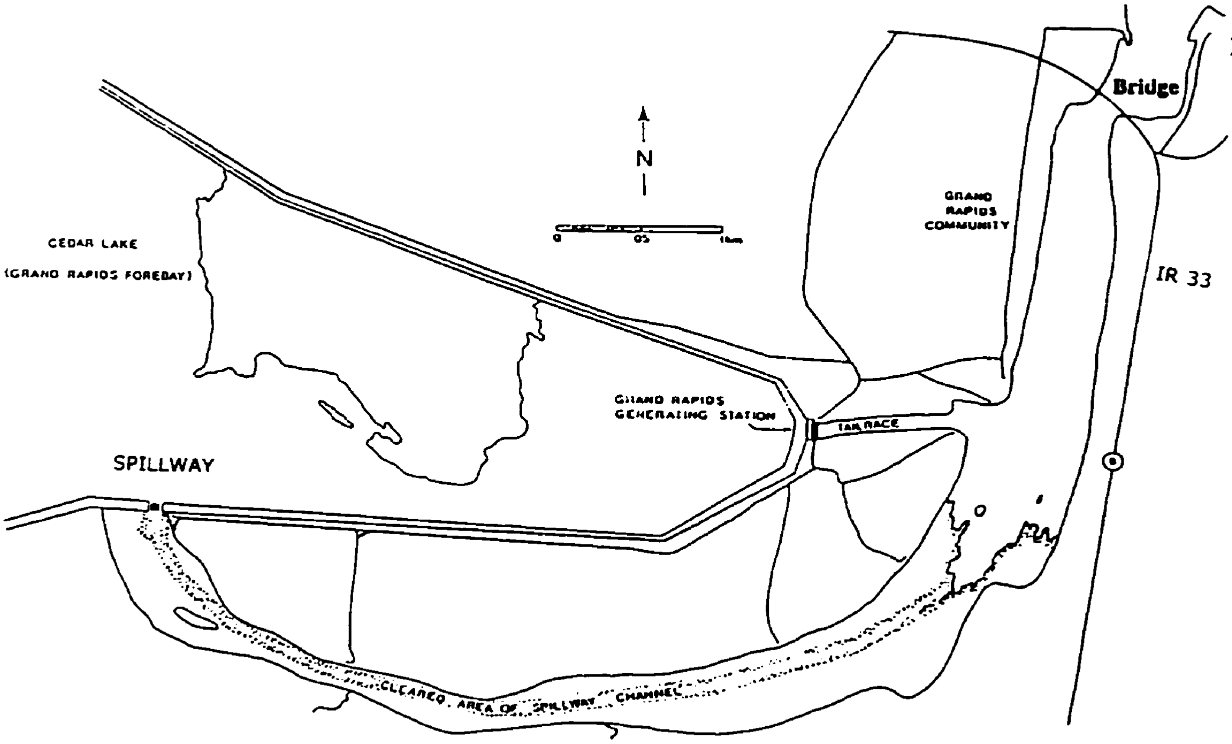

Plate 6 Grand Rapids Community, IR 33 and The Grand Rapids Generating Station - Local context. (Modified from North/South Consultants Inc., 1995).

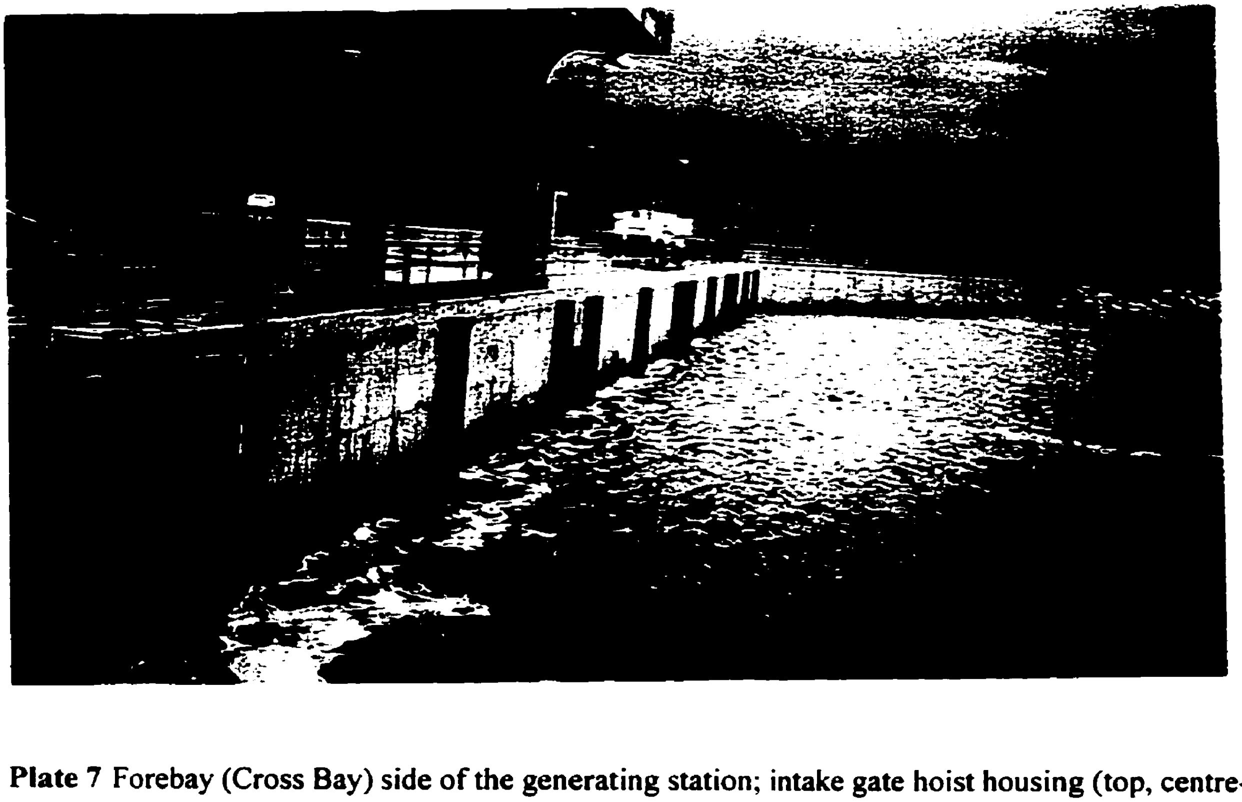

Plate 7 Forebay (Cross Bay) side of the generating station; intake gate hoist housing (top, centre-left) control trash racks that collect logs and other debris (bottom left).

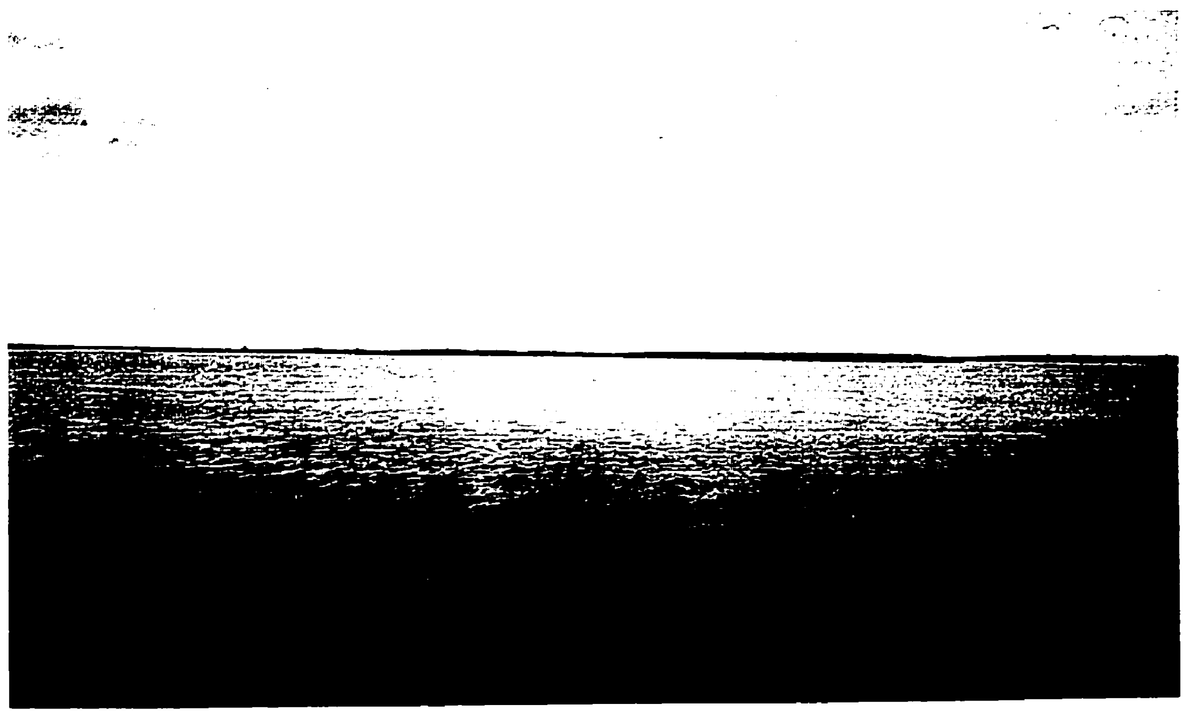

Plate 8 Expansive section of Cross Bay as seen from top of generating station.

3.3.5 Grand Rapids Hatchery

The Department of Mines, Resources and Environmental Management built the Grand Rapids fish hatchery. The hatchery is the production source and departure point for stocking lakes in the region. The hatchery incubates fish eggs to produce fingerlings for stocking commercial and sport fishing areas in the province. An assessment of the potential to incorporate the resources and services of the hatchery into the development of an aquaculture operation was made. A partnership between interested parties and the entities involved, i.e., potential operation managers, DNR Fisheries Branch and Manitoba Hydro may be possible. A working arrangement, including financial support, exists.

Species reared by the hatchery include various indigenous or introduced species of trout, which are relatively slow growing, do not have access to adequate spawning requirements or do not compete well with natural predators such as northern pike. In addition, the hatchery began sturgeon culture in 1994.

Trout species grown in the hatchery operation include rainbow, brook and lake trouts, and splake (a hybrid between brook trout and lake trout). Of these, rainbow trout is the species of choice for many prairie culturists due to its hardiness and adaptability to culture and its marketing power. Other species grown and stocked include whitefish, walleye, and sturgeon.

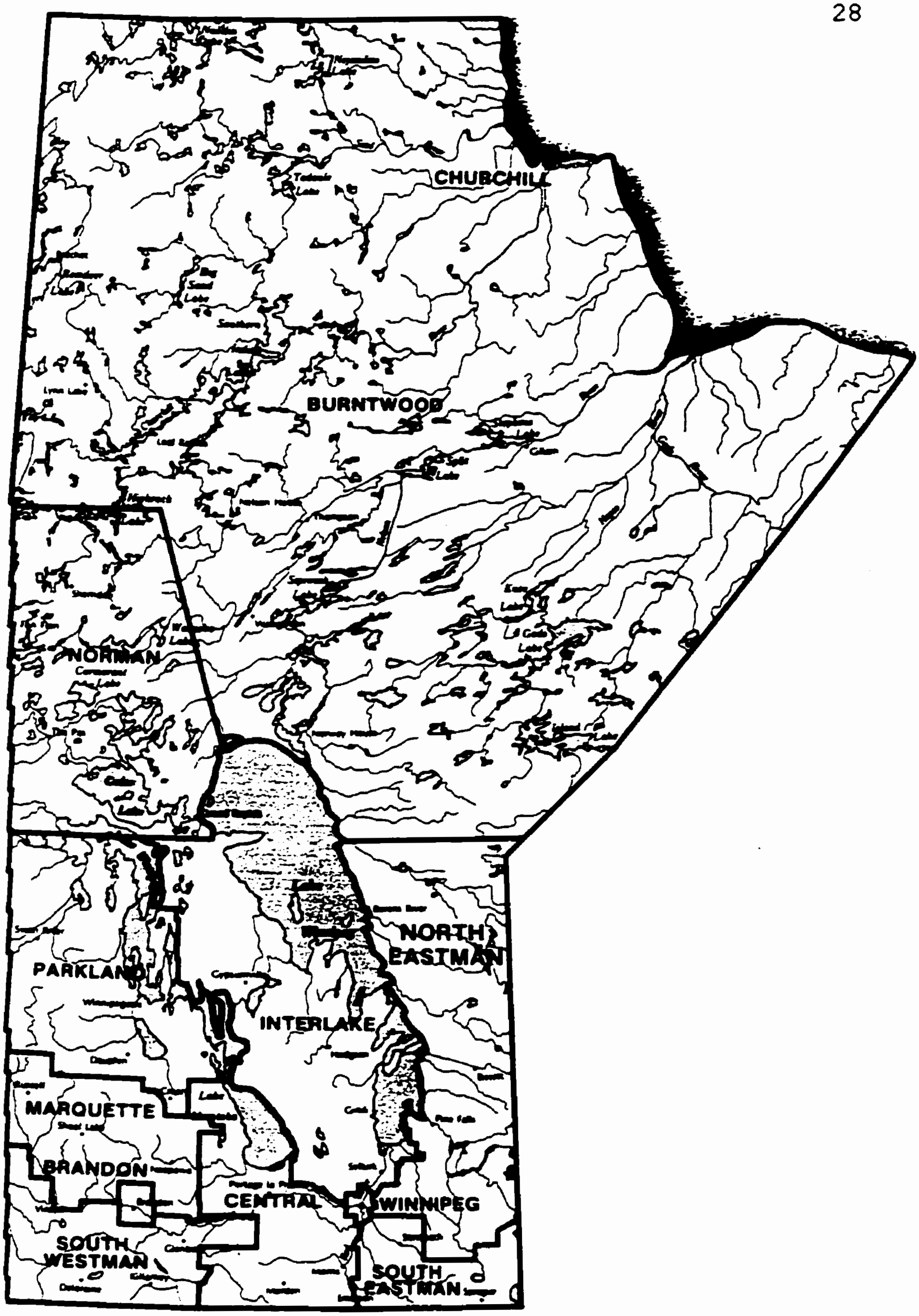

Figure 3 Manitoba Health Regional Boundaries (Source: Health Information Systems Branch, Manitoba Health).

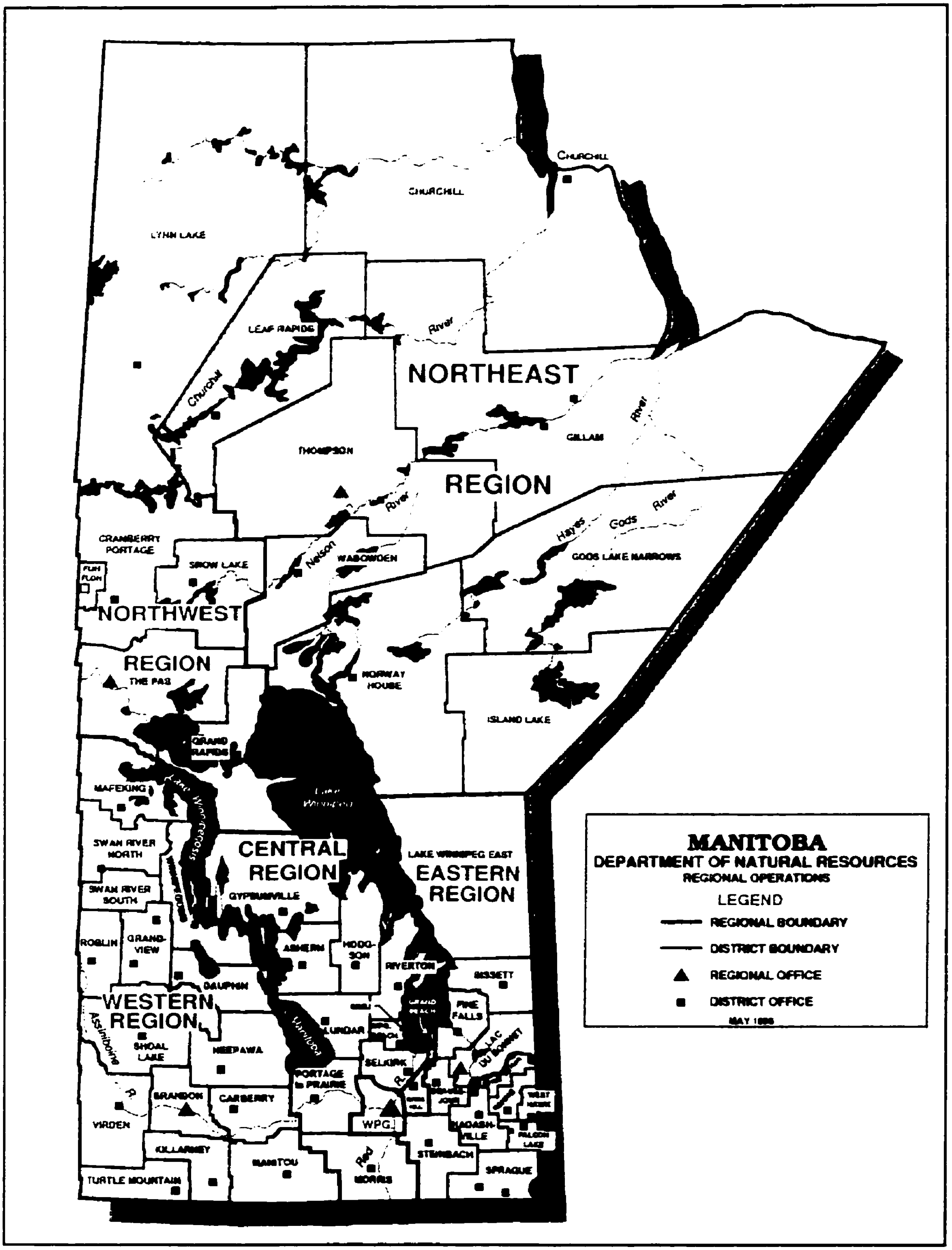

Figure 4 Regional boundaries as defined by DNR.

Plate 9 An employee of the Grand Rapids DNR district office responds to a natural resources-related call.

3.3.6 Manitoba Department of Natural Resources - District Office

Grand Rapids lies on the imaginary border shared by the Norman Region, as defined by Manitoba Health (Figure 3) and the Northwest Region of the province, as defined by DNR (Figure 4). The regional office is found in the Pas. The Grand Rapids district office is situated adjacent to the hatchery facility. The district office enforces regulations of the Fisheries Act for the area and is responsible for licensing and quotas and has other natural resource related responsibilities such as hunting regulations and forest fire management.

CHAPTER IV - OVERVIEW OF AQUACULTURE

Chapter IV provides an understanding of historical, economic, technical and cultural aspects of various types of aquaculture systems. Uses, implications and economic trends in the industry and technical aspects of the culture of exotic and indigenous fish species are reviewed. General requirements for success in the aquaculture industry are discussed. Historical, cultural and commercial uses of species and their potential for use in the Grand Rapids area are reviewed. Finally, criteria for assessing sites in the Grand Rapids area are defined in reference to site suitability for various types of aquaculture systems.

4.1 INTRODUCTION

The term "aquaculture" is defined as the cultivation and harvesting of aquatic organisms, including finfish, shellfish and aquatic plants (Department of Fisheries and Oceans, 1986a; Landau, 1992). This definition may be expanded to include "all activities concerned with the breeding and culture of aquatic organisms" for the purpose of "producing, processing and marketing aquatic plants and animals from fresh, brackish and salt waters" (Barnabé, 1990; p. 25); however, this definition precludes subsistence aquaculture, which has no marketing aspect, but maintains a very important place in the history of aquaculture.

Aquaculture is concerned with four major taxonomic groups: algae and macrophytes (plants); mollusca; crustaceans; and fish. However, and as is the case in this study, aquaculture can also implicitly refer to a specific area of culture (i.e., type of organism), that of finfish.

4.2 USES OF AQUACULTURE AND THEIR IMPLICATIONS

Culture implies "some form of" (human) "intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.", and "...individual or corporate ownership of the stock being cultivated" (Minister of Supply and Services, 1995; p. 3). To explicitly put it, a human interest is involved that has legal (e.g., stakeholder, licensing), ethical (e.g., sustainability, stewardship of the natural environment, which includes the harvested product itself), socio-economic (including those that arise from both privately and publicly funded activities) and political (e.g., ideological; jurisdictional) implications, all of which can be, and usually are interdependent.

The interdependencies and implications of the human intervention aspects of aquaculture can readily be seen. For example, environmental legalities are under the direction of the responsible jurisdiction(s) of the presiding elected political party, as administered through various governmental agencies. These legalities will affect the managerial, and therefore economic aspects of an operation; thus they are determined in part by public awareness of and concern for the environment, and associated perception of and degree of knowledge in relevant environmental issues.

A relatively recent concept within natural resource economics that continues to undergo scrutiny and revision is that of the **Total Economic Value (TEV)** of a particular natural resource. TEV is the total value of the uses and non-uses of a resource. Use values tend do be more tangible and therefore more easily computed, while non-use values are less readily defined or seen and are often (and wrongly) overlooked. Use values include direct (directly consumed), indirect (having a functional benefit) and option (potential for future use) values. Non-use values are less tangible, such as the existence value of a resource, the value to an individual or society gained in the knowledge of the existence of a resource, whether or not that individual intends to ever use it. Thus there is a non-monetary value to individuals and society in the knowledge that habitats and species of plants and animals exist even if the particular individual has no intention of using them in any way; therefore there is a desire to prevent their extinction. From this it can be seen that the business of aquaculture or any industry that has the potential to impact upon environmental aspects is complex and dynamic, and needs to be well managed within an integrated system that addresses and, as need be, reconciles all of these implications.

Aquaculture production has been used with varying degrees of success for the enhancement of natural populations of fish, to support sport and commercial fisheries, or to start a fee-for-fishing operation or a simple hobby farm. Regardless, the main use of aquaculture is to produce food, whether this production is used mainly for subsistence, as it is in many developing countries, or for commercial production for profit-making and job creation, as is generally the case in developed countries. However, the two uses may both play important roles in either setting. In Canada, for instance, subsistence aquaculture continues to be an important activity among some First Nations communities, particularly among coastal communities, and although the majority of national "farm fish" production is generated by coastal operations, a significant number of inland freshwater operations exists.

As developing nations become increasingly prominent in the global economy, the saliency of commercial aquaculture increases, and the gap between subsistence and commercial production narrows. Opportunities may lie in a commercial operation that caters to domestic and commercial uses. For example, rainbow trout is a species for which its industry is well developed. The culture industries of high-value species such as walleye and arctic charr continue to develop. Another potential benefit of aquaculture is public education and awareness of endangered, heritage or culturally important species such as lake sturgeon.

While the demand on natural resources for resource-based commodities and recreation continues to increase in Canada and on a global basis, there is pressure to use aquaculture as a source of supplementing natural stocks. The problem of overfishing stocks is growing in many parts of Canada, in both fresh inland and coastal waters. Fish stocking is often misconstrued as a simple solution to a complex problem. The reality is that stocking on its own is not a solution to overfishing, as it cannot guarantee successful restoration of depleted stocks or subsequent depletion of restored stocks. Fingerling mortality rates are high and stocking densities need to be sufficiently high to ensure that a difference to the overall population will be a significant one. Thus in larger bodies of water, stocking has proven to be a rather fruitless endeavour, as costs are high and there is no way to determine the efficiency or success of such tasks.

There are certain situations in which stocking is useful, such as is the case in which it can be reasonably expected that the number of fingerlings that will survive and reproduce will significantly increase the overall population of the area. In this manner stocking will continue to be an important tool in fisheries management. Currently, perhaps stocking is most valuable for its role in restoring smaller areas that are depleted of high-value commercial species such as walleye, and endangered species such as sturgeon. To this end, aquaculture has been successfully integrated within restocking programs of small- and medium-sized lakes for recreational purposes, mainly under the direction of government agencies

The long-term approach to correcting the overall depletion of valued fish species focuses on spawning bed restoration and enhancement. In general, this approach is viewed as a more practical solution and has been the focus of the Fisheries Branch of DNR in recent years. However, the Fisheries Branch continues to provide stocking services to Northern Manitoba communities wherever it deems the practice to be a worthwhile endeavour.

4.3 WORLD HISTORY AND TRENDS

Aquaculture has been a part of the socio-economic make-up of Asia, having been practised in some highly populated regions for thousands of years. Products from the seas are traditional dietary staples, which helps to explain Asia's dominant position in terms of total production from aquaculture. Currently Asia produces 84% of world production. Europe (9%) and more recently, North America (3%) follow far behind as other main world producers. Although commercial aquaculture is relatively new in Canada, it has made impressive gains in the last few years. The national production value has increased 6 fold over seven years.

The Food and Agricultural Organization (FAO) faction of the United Nations predicts that by the end of the 1990s, aquaculture will account for 35% of all fish production and 40% of international revenues (Boghen, 1995). Currently, the capture fishery produces one hundred million tonnes. Optimistic estimates of future production suggest that this level of production will be maintained, based on what may or may not be realistic assumptions regarding the level of success in dealing with environmental and overfishing abuses. Therefore, there is reason to believe aquaculture will play an increasing role in providing resources for which the capture fishery has traditionally been relied upon.

4.4 AQUACULTURE IN CANADA

Aquaculture began in Canada at least 140 years ago (Boghen, 1995; Emery, 1991; MacCrimmon, 1977). Government hatchery production focused on salmon and trout for public consumption. Documentation written in 1857 in Quebec provide the first detailed records of aquacultural endeavours (Boghen, 1995). These records reveal incubation and hatching studies of the incubation and hatching performance of Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*) (also know as speckled trout and brook charr, respectively) eggs undertaken by Richard Nettle, the first superintendent of fisheries for Lower Canada. Although aquaculture is reported to be first used for restocking purposes of natural lakes (Emery, 1991) and for the commercial propagation of Atlantic salmon and brook trout, aboriginal peoples were the first to attempt the manipulation of salmonid stocks between adjacent streams (Boghen, 1995).

In the 1950s large scale commercial aquaculture began, with a focus on high-value species. Trout farming and oyster cultivation predominated. In the Prairies, aquaculture began in the late 1960s with the extensive (pond/lake) culture of rainbow trout for table use (Dick et al., 1988). In the 1970s the coasts focused on salmon and mussels; however, in Manitoba and throughout the Prairies, the Northwest Territories and Yukon, rainbow trout farming by private aquaculturists predominates into the 1980s and 1990s (Department of Fisheries and Oceans, 1986b; ibid., 1988; Dick et al., 1988; Tabachek and de March, 1991) due to the suitability and hardiness of the species. Fingerlings are bought from hatcheries, stocked in the early spring in ponds, small lakes, potholes and dugouts (i.e., extensive aquaculture - see sections 4.7 and 4.8) and pansize trout are harvested in the fall for table use.

Despite the considerable effort and advances that are characteristic of the industry in Canada, the aquaculture industry remained in a developmental state into the early 1980s, due to individualized and uncoordinated efforts (Minister of Supply and Services, 1995). From 1984 to 1990 the industry experienced a tremendous growth rate, and then levelled off. Currently, aquaculture is in a downturn in the Canadian prairie provinces.

Rearing of charr, a high-value species, has been the focus of research conducted by the Freshwater Institute of the Department of Fisheries and Oceans in Winnipeg for much of the 1990s. In addition, there is continued interest in research involving technically successful intensive (tank) production of walleye fingerlings for lake stocking purposes including a four-year study conducted at the former Rockwood Aquaculture Research Centre (R.A.R.C.) (Loadman et al., 1989) and continued efforts (Moodie et al., 1992; Moodie and Mathias, 1996). Walleye, which are notoriously cannibalistic and difficult to train to artificial feed, were successfully reared from egg stage to maturity, completely within a closed building. However, the economics of such an operation have yet to be worked out.

4.5 ECONOMIC IMPACTS

Currently, aquaculture provides jobs for more than 5,200 Canadians, of which 2,800 are in the production sector and 2,400 are in the supplies and services sector (Minister of Supply and Services, 1995). The Manitoba industry is comprised of about 300 hobbyists and about 30 fish farming operations of which about 20 are commercial operations. Commercially, hatcheries and fingerling production predominate, while the number of growout operations for lake stocking is on the rise. In 1987 a single intensive (tank) growout operation was mainly responsible for the 40 tonnes of commercially raised trout and arctic charr.

Indirect economic impacts include the manufacturing and servicing and processing industries associated with commercial fingerling and growout sites. An operation may include major capital expenditures such as building facilities and raceway, tank, cage and aeration equipment. With regard to extensive (pond, small lake) operations, economic spin-offs tend to be locally contained, consisting mainly of harvesting equipment sales such as gill nets, boats, motors, and safety equipment.

After what is termed a long "developmental" stage, the Canadian industry entered a "first wave" of activity (Minister of Supply and Services, 1995). In 1984 the Canadian industry was valued at $7 million; in three years it increased to $62 million, $109 million by 1988 (Emery, 1992) and $256 million by 1991, averaging an exceptional 67% annual growth rate over the seven year period. Worldwide, the industry provided 19% of the consumed fish and seafood market in 1991. The national expansion was attributed to increased communication and technology transfer, and infrastructure developments including feed manufacturing, applied research and a supplies and services network.

Since 1991 the Canadian industry has entered a "competitive" stage characterized by less dramatic and more stabilized increases. In 1993 the total output was 50,375 tonnes or 6% of Canadian fisheries production, generating $289 million in revenues (Minister of Supply and Services, 1995). The two principal species were and continue to be salmon ($245 million) and trout ($27 million). Oysters, mussels, clams, scallops, and arctic charr follow these. The supply and services sector generates $266 million annually, which includes $53 million in exports. Aquaculture now accounts for 17% of the total landed value of the Canadian fisheries sector.

Despite the intermittent exponential increases, Canadian aquaculture production lags far behind that of many other countries which have recently emerged as major cold water aquaculture producers. These include Norway, the United Kingdom, Chile, Spain and Japan. This lag may partially be attributed to what have predominantly been abundant natural stocks in Canada. However, many of these stocks have been overfished and have significantly declined in recent years.

Globally, fisheries and aquaculture are at a turning point; demand for fish and seafood is expected to reach 120 million tonnes by the 21st century, while the total catch continues to drop after peaking at 100 million tonnes. The results of this trend are job and export losses, particularly in Canada, while the global aquaculture industry continues to develop. The industry and governments continue to develop regional and national strategies in an effort to realize the full potential of the industry. In order that this industry may flourish, sufficient exploitation of existing and newly developed markets is required. For example, lake stocking for recreational use is economically viable in some northern areas, while an offal (fish waste by-products) operation could potentially co-exist and supplement a similar operation. Alternatively, demand for high-value species such as arctic charr and pickerel (i.e., walleye) exists and commands a high price in niche markets in many urban restaurants, particularly those in large Canadian cities east of Winnipeg (Toronto, Montreal). The peak market for aquaculture products occurs when fresh products are in limited supply. Thus the establishment of an operation that could supply a quality product at such a time has the potential to do financially well.

It must be stressed that although opportunities exist in the aquaculture industry, the technical and economic (or rather, financial, including "business-sense") skills and knowledge, and personal character requirements for success are stringent and can be somewhat formidable to the uninitiated (see Chapter 4.6: Requirements for Success). As part of a business plan, product type(s), quantities and qualities, packaged in a form that is suitable for and aesthetically pleasing to a predefined market, must be determined, established and maintained.

An expanding industry means a concurrent increase in employment opportunities. However, operations involving small-scale or hobby farm employment are limited by the harvest season (usually from April to October in Manitoba), and fish are grown almost exclusively for private consumption. Large, commercial-scale pond operations are rare, as, although good business and management skills and sound knowledge of aquacultural aspects may exist in an operation, the outcome can nevertheless be extremely variable due to the lack of control over the numerous environmental and industrial risk factors.

Considering the abundance of natural resources in Canada which are ideally suited to the sector, the internationally recognized technical and management expertise of Canadians in the sector and the development of related state-of-the-art facilities, many government agencies have expressed the belief that Canada is in a position to become a world leader in aquaculture. However, it is felt that in order to do so the industry must realize opportunities for commercial development while striving to remain competitive in a global economy, by addressing factors which will lead to lower production costs and enhanced marketing capabilities while respecting environmental issues. These goals have been extremely difficult to attain, resulting in an industry that continues to lag far behind global industrial leaders.

4.6 REQUIREMENTS FOR SUCCESS IN THE AQUACULTURE INDUSTRY

As has been already alluded to in previous sections, in order to succeed at aquaculture as a business, an operation must be seen foremost as a business, and not as a recreation or part time interest. Many operations have failed due to the predilection of a manager for what has often been referred to as the "romanticism" of the venture. Although a passion for the type of work involved is a definite asset, and perhaps a requirement for success, it is also imperative that managers have a good business plan in place, and a clear understanding of the business industry and have realistic objectives. In addition, although environmental factors pertinent to aquaculture can be readily understood by the non-specialist, and "there is no straightforward formula which can be applied universally, **the skill of the operator is always a major factor in success"** (Divanach and Kentouri, *in* Barnabé, G., ed. 1990; p. 821). The type of operation involved, training, management practices, technological networks (availability of outside expertise), and work ethic are interrelated factors.

Even if good business fundamentals and technical expertise are in place, and as is the case with agriculture, aquaculture is a rather risky business, perhaps even more so due to the living and very mobile nature of the "units of production", the medium in which they exist and the general lack of environmental controls. Just as is the case in an agricultural crop, including animals bred for market, the aquacultural equivalent can be susceptible to poor weather conditions or catastrophic meteorological events, and predators and disease. Inclement seasonal weather conditions can cause a late seeding or harvesting date, and a summer hail storm can devastate a grain crop; vertebrate and invertebrate predators such as birds and insects take their yearly share of plant production from the operator. Likewise, environmental events, various bacterial, fungal and viral diseases and predators can decimate plant and animal crops alike. The aquatic medium introduces additional constraints and concepts foreign to the neophyte culturist, such as the difficulties of tracking the health and welfare of the mobile product.

As is the case in agriculture, in addition to these technical and environmental variables, there are economic forces beyond the control of the producer, which will determine the net price the producer receives per unit of production. These include ongoing input prices (variable operating and maintenance costs) such as fingerlings and feed, and the wholesale price paid for the finished produce. Thus, success is a matter of a proactive management approach, demanding expertise and a solid foundation in business, personal, husbandry skills, etc. In addition, personal traits and characteristics that include dedication, commitment and devotion are required.

During tours and interviews, many experts in the field alluded to a natural or intuitive "knack" a manager may have (perhaps analogous to the "green thumb" of plant growers) in a typical successful aquaculture operation, including such diverse personal skills and characteristics as ingenuity, entrepreneurship, and even nurturing aspects. Catch-phrases and clichés that come to mind include "able to stomach it", "weather the storm" and "sticking it out", all of which are terms directly applicable to the characteristics of successful managers in the agricultural business. Thus it takes a person with a certain degree of entrepreneurship to be able to handle the "ups and downs" of such a business and successfully undertake such an endeavour. If the potential aquaculture manager does not possess these intangible character attributes, then the business cannot thrive and succeed.

4.7 TYPES OF FRESHWATER AQUACULTURE SYSTEMS

4.7.1 Introduction

There are three broad and somewhat overlapping classes or types of aquaculture systems, mainly based on the amount and types of inputs, including the product density, i.e., the number of production units per unit volume of water. The preferred system dictates the site requirements and the type and amounts of capital, labour and skills.

For taxation purposes, aquaculture is treated as a farming activity. The Manitoba Fisheries Branch and the Department of Agriculture handles enquiries and other related matters. Although the provincial capture fishery is regulated and sold through the Freshwater Fish Marketing Corporation (FFMC) in Winnipeg, the federal government exempts aquaculture operators from the requirement to sell their fish to the FFMC..

4.7.2 Intensive Systems

Policy in Manitoba and Saskatchewan allows the development of intensive and semi-intensive aquaculture operations provided they meet the environmental standards of agricultural or food processing operations, as are applicable.

Essentially, intensive systems involve a high capital outlay. They may consist of tanks and raceways, usually made of concrete, plastics and even wood within a hatchery facility. Each type of material has its own particular advantages and disadvantages.

In hatchery systems, eggs are incubated and hatched in trays. When the organs of hatchlings (termed larvae or alevins) are fully formed, the fish are then referred to as juveniles. The process occurs gradually in some fish species, or as a distinct metamorphosis in others.

In the earliest part of the juvenile stage the fish are called fry, and are reared in dense numbers in tanks. In some species, the fry retain the yolksac for some period, while in others it is already absorbed in an earlier stage. The fry are then fed nutrient pellets.

Once accustomed to feeding, the fry are termed "fingerlings". They may then be stocked (released) into natural waters for conservation or sportfishing purposes. Alternatively, the fingerlings may be held in ponds or holding tanks for further growth prior to their release, or in tank systems or raceways for growout purposes, to be marketed as a table or "pan-size" fish.

While it is well documented that prepared feeds in most intensive operations account for about 50% or more of operating costs. in our northern interior climate the energy requirement percentage of total costs increases. decreasing the share of feed costs to about 45% or less (J. Tabachek, pers. comm.).

4.7.3 Semi-intensive Systems

Some authors make a distinction between intensive and semi-intensive systems. The defining characteristics are water volume and product density. In essence, the semi-intensive system is an overlapping subset near the intensive endpoint of the intensive and extensive systems range, and the two approaches are somewhat comparable.

The semi-intensive approach to aquaculture is the most popular method for the culture of many finfish organisms. In general, water is directed from a conveniently

Figure 5 Naturally protected site at Dark Harbour, Grand Manan, New Brunswick, formerly used by Fundy Aquaculture Ltd. A barrier beach shelters the harbour from prevailing northwesterly winds and seas. Two large herring weirs accompany the cages.

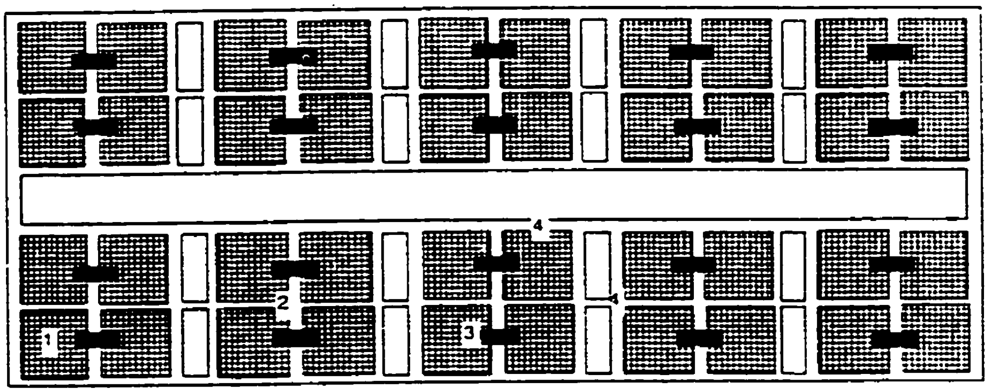

Figure 6 Platform comprising two lines of five units of four cages. 1) On-growing cages. 2) Four-cage units. 3) Automatic feeder. 4) Walkway.

situated natural source such as a lake, reservoir or well to the facility. The water makes a single pass or is partially retained and recirculated. The system may include raceway, throughway pond, or embankment-pond subsystems. Cage culture may also be included in this category as high product densities are involved.

With respect to regulations, cage culture (Dick et al., 1988), and indeed most new operations (B. Scaife, pers. comm.) tend to be treated on a case-by-case basis. Evaluation includes the consideration of such aspects as species type and use, water facility size and depth, potential for pollution and sensitivity of the environs to pollution.

Greater control over the growing and other conditions is offered by intensive and semi-intensive systems. Specifically, advantages include:

- water flow rate and volume is controlled,
- water can be filtered to screen out predators or vectors of disease,

- diseases can be more easily detected and treated through increased ease of handling,
- temperature can be regulated in some systems,
- feeds can be used more precisely and with much less waste,
- discharge is more easily controlled,
- design for increasing aeration is simple, and
- poaching is restricted.

The disadvantages of intensive and semi-intensive systems include:

- they tend to be more expensive to develop and operate (which may be offset by increased production or produce value),
- they require a more complex management plan and greater expertise, and
- the risk of disease is increased through conditions of overcrowding and increased stress.

4.7.4 Extensive Systems

Traditionalists and hobbyists purchase fingerlings and raise fish for their own consumption, in naturally occurring, privately or Crown owned ponds or dugouts. In Manitoba, there is no requirement for a license to grow fish, but a fish farming license is required for commercial operations, or any operations existing on Crown land. A dealer's license is required to sell to retailers, restaurants or export markets. Licenses are reviewed annually and issued by DNR. In 1988, there were about 6,000 enthusiasts of this type of aquaculture across the Prairies (Dick et al., 1988).

In traditional pond or dugout culture, the growing season is usually limited to about 7 months, as most ponds will freeze over. Fingerlings are introduced around mid- to late-April and harvested in mid- to late-October in most of Manitoba with the exception of the most northern areas. However, year-round production can be achieved in ponds with adequate depth and shelter, and mechanical aeration provided through a pump system can keep a section of the pond ice-free.

During the growing season, ponds may be fertilized to increase their productivity. Phytoplankton are the primary beneficiaries, which directly or indirectly benefit zooplankton and benthic organisms (i.e., bottom dwelling organisms in the littoral zone, or shore region), and ultimately the organism of interest. However, care is required to ensure that added nutrients are not simply swept away by a current that is too fast, resulting in waste and perhaps adverse ecological effects downstream. Conversely, excess nutrients or a current that is too slow may result in a proliferation of phytoplankton and ultimately, an algal bloom. This phenomenon is temperature and nutrient dependent, tending to occur in shallow waters in mid to late summer. The greenish mass clouds the water and exceeds its carrying capacity to sustain the algae, resulting in an algal population crash. The subsequent bacterial decay of the algae utilizes dissolved oxygen (DO) in the water and may reduce the DO concentration to below that which the fish and other aquatic organisms require. The result is the death of a large number of those organisms that are most susceptible, i.e., those that require the greatest DO concentration in order to survive. This chain of events is informally referred to as "summerkill".

Eutrophication, the natural process equivalent to pond fertilization, is the term used to describe nutrient input into a natural body of water. Watershed runoff is the main contributor to this nutrient input. However, the input process rate may be artificially increased in areas where agricultural fertilizers are used, thus increasing the likelihood of summerkill in such areas.

Despite the large number of hobbyists involved in extensive culture, commercial operations of this sort have seldom succeeded (Dick et al., 1988). Although production costs are low, environmental factors are difficult to control resulting in increased risks of failure. These risks include summerkill from algal blooms and predation by birds, mammals and poachers. Another problem lies in the "off" (musty or muddy) flavour that may develop in fish grown in ponds with muddy sediment, caused by the ingestion of certain types of blue-green algae (*Oscillatoria spp.*) and bacteria-like micro-organisms, rendering the product unmarketable (for further discussion, see 4.8.1.3 Extensive systems).

Conversely, despite the numerous problems encountered by hobbyists, their continued interest in aquaculture has resulted in the development of improved techniques and a concurrent reduction in such problems for all types of aquaculture.

4.8 FRESHWATER SPECIES AND THEIR USES IN AQUACULTURE

4.8.1 Rainbow Trout

4.8.1.1 Introduction

Until 1988, rainbow trout (*Oncorhynchus mykiss*, previously *Salmo gairdneri*) was classified in the Salmoniidae, a group of fish that includes the Atlantic salmon, the brown trout and several other trout species, as well as arctic charr (*Salvelinus* and *Salmo* *spp.*), inconnu (*Stenodus leucichthys*), arctic grayling (*Thymallus arcticus*), and the many species of whitefish and cisco (genera *Prosopium* and *Coregonus*). However, research with respect to their origin indicated that rainbow trout were more closely related to other trout species (genera *Oncorhynchus*) and the many species of Pacific salmon than to brown trout and Atlantic salmon (Smith and Stearley, 1989). Of all these, rainbow trout is particularly attractive to anglers due to the taste and texture of its flesh, its aesthetic qualities and its fighting prowess. These reasons and the inherent adaptability of rainbow trout to freshwater aquaculture make it the species of choice for many prairie culturists.

4.8.1.2 Bio-life history

As is the case for many trout species and salmonids, the sexes of rainbow trout are easily distinguishable during spawning season. The belly of the female trout becomes extended with roe and the genital papilla enlarges and reddens. Males become more brightly coloured, and the lower jaws of older males develop a hooked beak appearance. For some aquacultural aspects such as breeding and marketing purposes, monosex or sterile cultures of trout are desired, as reproductive males tend to have a lower quality meat and a less attractive appearance, rendering them less desirable and therefore less unmarketable.

Most rainbow trout begin to spawn near the end of their second year of life, from January to May. Timing depends on genetic variation, climate and other environmental factors. Some of these factors are exploited in various types of aquaculture systems. The following biological aspects may be used to control the sex of offspring for future purposes.

When older females are bred with younger males, the offspring are predominantly male, which is usually not a desired outcome. All-female spawns may be produced using a technique known as sex-reversal, in which the androgen (so-called "male-producing" hormone) levels of young females are elevated. Androgen, a group of hormones that include testosterone, produces male attributes, and is naturally offset by the female hormone equivalent, oestrogen. The treated females become sex-inverted males that are genetically female, but are able to reproduce with normal females. The offspring of such a cross would all be female.

Organisms having more than two sets of chromosomes, which is the usual "diploid" case, are termed polyploid. This genetic composition may be produced in trout by "shocking" newly fertilized eggs. Shocking is used to produce tetraploids (four sets of chromosomes) or triploids (three sets). Shocking techniques include temperature (cold or heat) and hydrostatic pressure shocking. The technique selected depends on the species and the desired results. In general, tetraploids are used for brooding purposes while triploids, which are sterile, are used for growout production. Sterile trout may reduce or eliminate many unwanted characteristics that may be associated with reproductive species.

Mating between a tetraploid and a diploid will also produce triploids. This method of producing sterile fish is preferred to the direct shocking method, as the latter may retard growth, while the reproductive method results in relatively increased growth rates of the offspring.

4.8.1.3 Extensive Systems

Seven to ten centimetre-long fingerlings are purchased from hatcheries and stocked into pothole lakes and dugouts in late April to early May and harvested in the late fall, when they weigh 250-500 g. The other main use for rainbow trout fingerlings is lake stocking for sportfishing. Rainbow trout is valued both for its high-quality meat and as an attractive and active fighting fish. However, terrain and marketing problems exist in Manitoba and Saskatchewan.

The ideal trout pond is at least 5 metres deep, although several variables determine the optimum depth (Bjornson, 1994). Conversely, good management strategies may compensate for less than ideal conditions otherwise required for the successful culture of fish. For example, "rotation" is a system that allows shallow ponds to "rebuild" their ecosystem between uses. Alternatively, pond walls may be built up to "create" depth (see 4.7.4 for further information on bio-technical aspects of extensive culture systems).

Regardless of the type of system or species, with the exception of certain exogenous (i.e., foreign) species such as Tilapia, water quality is a must in order to manage a successful operation. Clean, clear water is most desirable, but turbid water may also produce high yields of trout. Ponds open to prevailing winds will be better aerated (specifically, oxygenated), while high tree stands or vegetation near the south shoreline provides fish with shade and cooler water and a desirable feeding area.

The desired species of aquatic vegetation and their densities vary; thick stands of cattail are desirable, while algae or submerged weeds may cause serious water quality problems. For protection against bird predators, deep cut shorelines may deter heron, but offer no protection against cormorants. For diving birds, owl decoys, scarecrows and other deterrents such as propane cannons and pond eyes must be moved daily to retain their effectiveness.

Trout require a diverse and abundant food source to attain a sufficiently high growth rate. Fresh water shrimp (*Grammarus spp.*), leeches, minnows, crayfish and aquatic insects such as backswimmers and mayflies are all excellent sources of protein. In addition, this natural diet gives fish their pinkish pigmentation, which consumers find appealing, and may result in better tasting fish. Commercially available trout food may be used to supplement ponds. Fertilization may also help under certain circumstances, but care must be used to ensure the pond is not over-fertilized, in which algal blooms or excessive nutrient losses from the system may result (see 4.7.4 Extensive Systems).

As previously mentioned, a problem sometimes encountered by culturists is the development of an off-flavour in fish grown in muddy ponds. The cause is reported to be due to a chemical called geosmin, which gives clay soils their "earthy" smell. Geosmin is produced by many blue-green algae of the genus *Oscillatoria* and a group of micro-organisms resembling bacteria called actinomycetes. The micro-organisms thrive on muddy sediment that is high in organic matter. The off-flavour can be removed by holding the fish in clean, preferably flowing water for 7 to 14 days, during which time the chemical is metabolized. The higher the water temperature, the less time required to do so.

Of course, the preferable choice of action is a pro-active rather than a reactive one. In the case of such water quality management issues, the pro-active line of thinking would be to avoid water bodies that are prone to producing significant concentrations of geosmin. Unfortunately, as there are many interrelated contributing factors involved, there is no way of predicting with absolute accuracy whether such is the case for a particular pond. However, there are indicators, including pond depth, morphology and sediment composition.

Despite the interest in rainbow trout aquaculture, the prairie provinces are net importers of trout fingerlings and table fish. Most eggs and fingerlings are imported from the North-Central United States, thus opportunities may exist to develop the fingerling and table fish market to meet local demands.

4.8.1.4 Hatchery Methods

Culturists of rainbow trout use only artificial fertilization, as this greatly increases the rate of hatching over that of natural streambed fertilization. Brooders are pond cultured until maturity, when they are stocked at low densities in small tanks covered with netting to prevent jumping. The sexes are kept separate to keep the males from fighting. However, the males may be placed downstream of females to stimulate sperm (milt) production. The milt of a male can be used to fertilize the eggs of two females, thus more brood females are kept than males.

Timing of spawning can be controlled by photoperiod and water temperature. Milt should be taken from fish that are between 2 and 4 years of age, while eggs should be taken from those that are between 3 and 6 years old. Before 2 years of age, females produce few eggs, and often become sterile after 6 years. The larger the female, the greater the number, and more importantly, the larger the size of eggs, which can also be genetically controlled. Females with large eggs should be selected, as this increases the chance of fry survival.

The technique used to release milt and eggs for reproductive purposes is called stripping. The reproductive ripeness of the brooders is frequently checked by gently gripping the abdominal vent, which releases the eggs or milt. The trout are ripe when the milt is creamy white or when the eggs are easily released. Ripe females are very delicate and require gentle and as little handling as possible. If the trout are stripped when they are not yet ripe or overripe, they may be damaged, the hatch percent may be poor, or the offspring may be weak.

Stripping is best done by two people: one to hold the fish firmly with the tail pointing down over a pan, and the other to press in downward strokes along the abdomen to release the milt or eggs. This process is a delicate one, as smears from broken eggs may coat other eggs and inhibit their fertilization. However, a single person with adequate experience can successfully perform the stripping process.

The milt is added directly to the eggs in the pan and gently mixed. Water is then added. If water is added prior to mixing, the motility of the sperm is inhibited, and the eggs swell with water, causing the **micropyle** - the site of sperm entry - to close. As an extra precaution, the trout may be gently and lightly towel-dried prior to stripping.

Fertilized eggs are placed in incubation trays in the hatchery. Trays consist of a shallow basket within a stainless steel, aluminum, fibreglass or plastic tray, and a cover. Vertical flow incubators are the most efficient use of hatchery space, in which water having a high oxygen content is pumped to the top tray and allowed to flow down to the lower trays. However, to increase aeration and remove metabolites, the water is pumped upwards within each basket, before flowing down to the next tray.

The optimal water temperature range for incubation is often reported to be 8-12°C (Klontz et al., 1979; Divanach et al., 1990; Landau, 1992); however, 5 or 6°C, which is the well water temperature in the Prairies, is considered adequate (J. Tabachek, pers. comm.). If the water has been heated (or chilled) it may be recycled; however, some culturists recommend against this action, possibly out of fear for the spread of disease.

The incubation period is expressed in degree-days, which is the average temperature multiplied by the number of days elapsed before a batch of eggs begin to hatch. For example, a 30-day hatching period at an average temperature of 10°C would amount to an incubation period of 300 degree-days. The degree-day incubation period is a function of the species and is relatively constant for each species; however it is quite variable, even within the same egg batch. For rainbow trout the period is usually between 290-330.

There are three phases of incubation. Newly fertilized eggs are highly sensitive. For example, they can be killed if directly exposed to sunlight for just a few minutes. The end of the first and the start of the second phases are marked by the appearance of eyespots. The eggs can then be gently handled with little fear of damaging them. When the eyes become clearly visible, the eggs are subjected to some form of mechanical shock, such as gentle stirring, or siphoning into a pail. Infertile eggs will rupture and turn white, and are removed to prevent the spread of fungal infection they may have acquired to healthy eggs. As an alternative to egg removal, the batch may be treated to prevent fungal growth.

Egg removal may be accomplished by using a long pipette, by transferring the batch to a salt solution in which the dead eggs will float while the eyed eggs will sink, or by separation using a light-sensitive sorting machine, which is able to differentiate the opaque dead eggs from the clear eggs. Up to 100,000 eggs per hour may be sorted this way. Hatching marks the end of the second and the start of the third phases.

4.8.1.5 Growout Operations

Once the hatched fry, also called alevins, have absorbed about three-quarters of their yolk sac, they become active and are able to feed. At this point the alevins may either be directly stocked, or held to be released later as fingerlings or yearlings. In the latter case, the fish are transferred to a small trough before the yolk sac has been completely absorbed. The alevins are introduced to a live or artificial feed and the density in the troughs are periodically adjusted to compensate for fish growth. However, if live feed is initially used, the regimen is switched to an artificial feed as soon as possible to accustom the fry to a prepared feed. Domesticated strains tend to have fewer finicky eating requirements than do wild strains.

Once the fry are accustomed to prepared feed and appear healthy and vigourous, they are moved to ponds or raceways. To minimize cannibalism and competition, the fish are graded, i.e., they are separated by size on an ongoing basis. A trout may eat another of its own kind that is half its size or less. Also, fish of a uniform size simplifies management operations such as feed calculations, and are more marketable, as market demand tends to call for a consistent, overall uniform (i.e., size, quantity and quality of) product.

Culture ponds are elongate for water flow purposes. Circular or oval tanks may also be used. Concrete raceways with approximate dimensions of 30 m X 3 are popular. Depth is usually about 1 m at one end, decreasing to about 70 cm at the other. As raceways are added in a series, the flow rate must be increased. An aerator may be required midway in the series.

Vertical raceways, also called silos have also been used for trout production. Although they are more difficult to manage and have a greater capital cost, the cost per kilogram of product may be smaller. Although total production may be about the same, the amount of water required in horizontal raceways is much greater, about three or more times than that used in silos.

Cage culture in natural or dugout ponds is the most popular system of trout rearing. In one experiment, fingerlings stocked at 1.4 kg/m^3 over one season and fed 3% of their body weight daily grew from 27 g to 88 g, having a food conversion ratio of 1.6, 100% survival rate and a daily weight gain of 3.78% over two months.

4.8.1.6 Feeds

It is widely reported that the use of dry prepared feeds is associated with increased growth and production. Growth is uniform, storage requirements are simplified and automatic-feeding dispensers can be used. There are many commercially available trout feeds, and they are being constantly improved.

Like other carnivores, trout are able to utilize proteins well. Therefore they should receive a high-protein diet (Landau, 1994). Fats are fairly well digested, but carbohydrate digestion is severely limited; thus their use in prepared trout feeds is equally limited.

It is important to note that fish cultured on prepared feeds taste differently from wild fish. The flesh in the former is white, although food additives can be used to give it the latter's characteristic pink colour. In addition, pellet-fed fish differ in taste to those fed fish offal or slaughterhouse by-products.

Commercial feeds usually come with detailed instructions regarding the required rate of feed at given fish sizes and water temperatures. These are based on many feeding experiments conducted by producers and other scientists. These rates may be slightly adjusted according to the particular strain used and its associated feeding habits.

Trout are fed 3 or 4 times daily, while fry may be fed much more often. Feeding at a rate above the recommended rate may increase growth slightly, but fish uniformity will drop, water quality may decline and feed costs will rise as nutrient utilization efficiency decreases.

There are three main trout-feeding methods. Hand feeding is simply scooping the required amount from a bag or tub and into the pond. It is time-consuming and relegated to small operations. An experienced culturist will be able to adjust the feed according to the reactions of the fish.

Large commercial farms may use **semiautomatic feeders** which shoot pellets as the device is moved alongside the pond or raceway by a truck or pulled by a tractor, or **automatic feeders** by which a timer dictates the release of a fixed weight of feed at regular intervals. Alternatively, **demand feeders** feed fish on demand, by releasing feed into the water when the fish bumps the trigger.

Currently, growth-promoting hormones similar to those currently used in the beef industry are being tested on trout. Trout receiving the hormone treatment in their diet were better able to utilize protein. Feeds containing such hormones may soon be available for trout.

4.8.2 Walleye and Perch

4.8.2.1 Introduction

The percoids (the perches) make up the family Percidae, a group of freshwater fish species native to the northern hemisphere that includes walleye (*Stizostedion vitreum*), sauger (*S. canadense*), perch (genera *Perca* and *Percina*) and many species of darters (genera *Ammocrypta*, *Etheostoma*, and *Percina*) (Robins et al., 1980). There are 25 percoid species identified in Canada (Alberta Fish and Wildlife Division, Fisheries Branch, 1985), but only a few species exist in the prairie provinces.

Most fish commonly known as perch or darters are too small to be of interest to culturists. The notable exception is yellow perch, *Perca flavescens*, valued as a sport, forage and commercial food fish in North America (Landau, 1994). Demand is primarily in the North Central US, especially in Wisconsin (Heidinger and Kayes, 1986). Research has focused on intensive recirculating systems, which are able to control water temperature for optimum growth. However, the economics are not as of yet financially favourable.

Walleye is the largest member of the perch family, and in Canada is commonly referred to as walleyed pike, pickerel and doré, french for "golden", for its scale colouring. It is also often confused with yellow perch, and a close relative, pike perch (*S. lucioperca*). Although pickerel is the name most often used synonymously with walleye, it is also applied to other species of the pike family. Other fewer commonly used names for walleye are yellow pike and yellow walleye, adding to the confusion.

Walleye is a widely distributed species, found in natural waters as far north as Great Bear Lake and the MacKenzie River to as far south as the Gulf Coast of the United States; the Rockies and the Great Lakes represent the western and eastern limit, respectively (Figure 7).

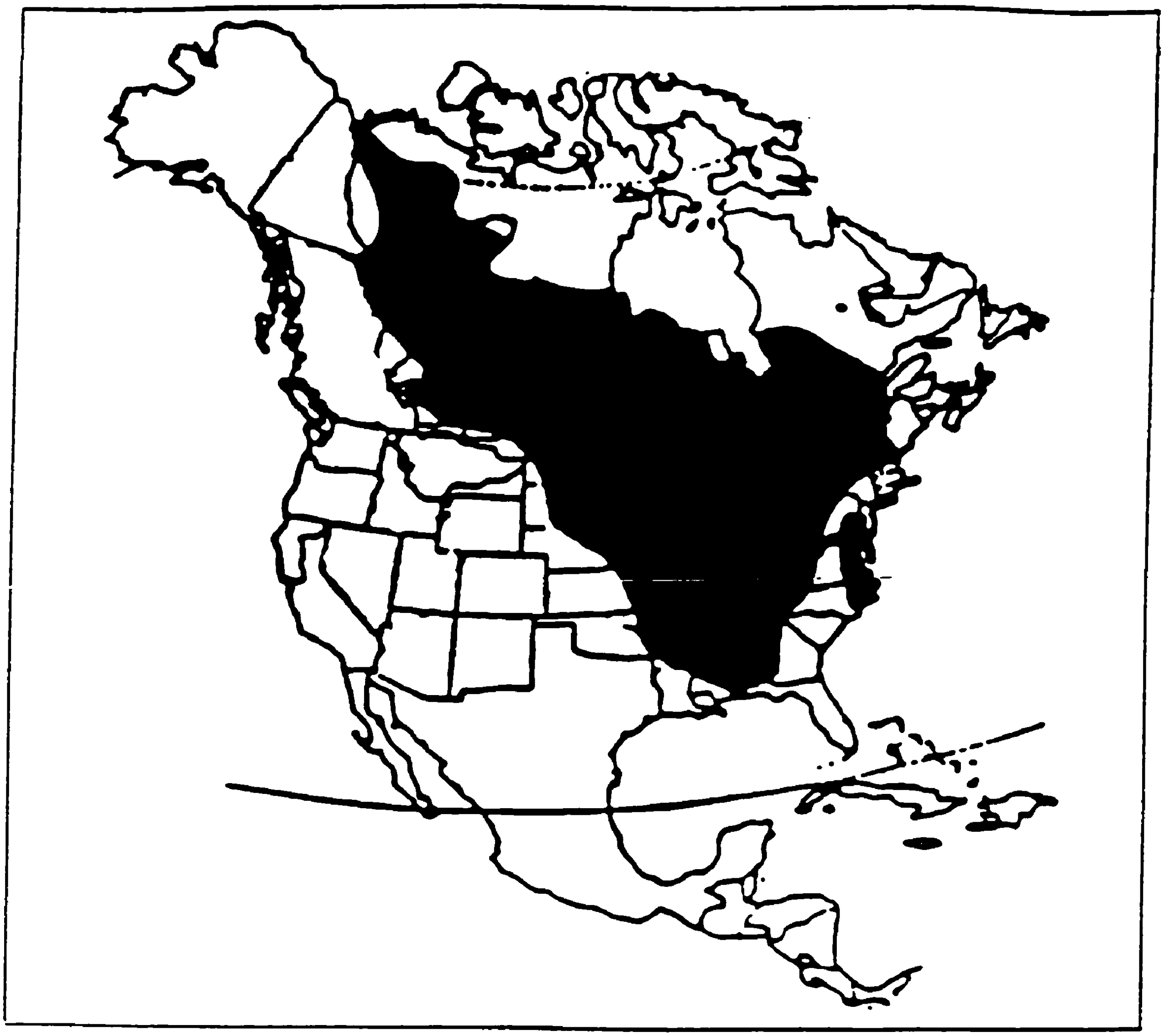

Figure 7 North American range of walleye (Source: Walker, T.A.1992)

Lake Winnipeg walleye migrate up the Red River in the fall as they pursue shiners (Walker, 1992), which are often used as baitfish where their use is allowed. These migrating walleye are called "greenbacks" by local people and are easily distinguishable from the native population by their greenish colouration, believed to be due to the limestone content of the water.

Walleye prefer shallow turbid lakes, but tolerate a wide range of water conditions, inhabiting lakes and rivers with sand or gravel bottoms, and will inhabit clear lakes that are deep enough to provide protection for their light-sensitive eyes. Technically a cool water fish, the adult growth temperature range is 12-20°C, but the fish can tolerate temperature as high as 25°C; the optimum growth range is 18-22°C.

Walleye take 3-7 years to reach sexual maturity, in proportion to water temperature. They spawn in spring, on stream or lake gravel beds as the water temperature nears 10°C. They are extremely prolific, much more so than salmonids, producing 60,000 eggs/kg. Commercially caught walleye averages 12-20 inches in length and 2-4 lbs in weight. Much of the current research is in response to the need for the enhancement of existing commercial and sport populations.

4.8.2.2 Culture Methods

Walleye fingerlings are reared for stocking purposes for commercial fisheries, lake associations, sportfishing groups and private ponds. Nets are set to catch brooders as they enter spawning beds and are retrieved at night, when walleye come to feed near the water surface. The Grand Rapids hatchery provide fry for lakes in the region, retrieving brooders from Limestone Bay, located in the most northern section of L. Winnipeg. Ripe adults are brought to the hatchery to be stripped and are then released. The fertilized eggs are incubated and hatch in two to three weeks, depending on the incubation temperature.

The eggs are very fragile and must be hardened to prevent clumping which reduces surface area, the site of oxygen exchange. Tannic acid or a protease solution is often used for hardening; other methods include surface scouring with starch or clay baths for a few hours and then delicate washing off the particles, and gentle stirring for one and a half to two hours with a soft material such as a large turkey feather (Landau, 1994).

The hardened eggs are suspended with a water current in incubation jars and hatch in 20 days at 10°C. As is the case for most species of fish, dead eggs float to the surface and can be removed. The tiny fry are 6-8 mm long. The fry are kept in ponds for a few days until their yolk sac is absorbed, and are released into natural waters, or kept until they reach the fingerling stage to reduce stress and mortality rates.

Walleye are voracious yet finicky predators, and their tastes change as they mature. The first 30 days are a critical period for the fry, when mortality rates are highest. Their diet during this period consists of zooplankton. If required, water may be fertilized to augment the zooplankton population. Fingerlings feed on aquatic insects and minnows. Adults feed on minnows, crayfish and smaller fish, including fingerlings of their own kind. At no stage are walleye bottom-feeders. Fingerlings weigh 7-8 g in two to three weeks, but cannibalism by adults can be a serious problem at this early stage.

There are three types of stocking practices, none of which are consistently successful. Results are extremely variable due to the lack of control over many environmental parameters. The two main factors involved are the natural conditions and the timing and degree of product handling during the stages of development. Product handling is largely in the control of the operator, while natural conditions are beyond the control of the operator. The three types of stocking practices are:

1. Eggs hatch in 15 days at 15°C in the hatchery or in an on-site mobile operation; larvae are immediately stocked, before feeding begins.

2. Larvae are reared on natural feed in a pond, although it may be possible to increase food (zooplankton) supply by fertilizing the pond with organic matter such as hay bales. The larvae are then pond stocked on-site or transported in plastic bags to the stocking site at the 1-1.5 inch fingerling stage.

3. As in 2. above, except the fish are either held in ponds at all times, or transported back to the hatchery at 1-2 inches and trained on artificial feed, and then raised to 6-3 inches before stocking.

Ideally, 2-4 inch sizes are preferred for stocking purposes, as the larger the fingerling, the better the chances of survival once it is in the lake. Conversely, the longer the time spent in the pond, the greater the variability in survival rates. For example, Ontario government hatcheries grew out 64,000 fingerlings/ac in one year, followed by only 10% of that the following year (Mathias, 1992). To reduce the variability in their survival rates, fingerlings would need to be brought back into the hatchery; however, such action increases the risk-of-disease element due to increased stresses associated with rearing changes and increased handling. Complete indoor tank rearing could reduce stress and disease and the accompanied loss of fingerlings due to survival and retrieval problems in pond culture (Moodie et al., 1992). Indoor rearing could also reduce or eliminate the need for drugs to combat diseases, a good selling point for increasingly health-conscientious consumers. Alternatively, 6-8 inch fingerlings could be reared for stocking purposes in recreational areas.

Once past the most critical, 30-day fry stage, walleye are quite hardy, and can be reared almost as easily as trout. Previous attempts to intensively rear walleye were failed by the natural tendency of the fish to cannibalize. Predation on smaller or weaker of its own kind is preferred by the species to artificial feed.

Another factor involved in the cannibalistic feeding habits of walleye is the tendency for tank-reared fingerlings to succumb to scoliosis of the spine. A lack of proper water movement results in improperly inflated swim bladders. The resulting exaggerated swimming movements by the fingerling to maintain its position in the water column look appetizing to others, as it resembles an injured minnow.

An intensive aquaculture study at R.A.R.C. by Loadman et al.(1989) focused on 3 problem areas: food size, food presentation and water circulation. The study involved the use of a state-of-the-art commercial size tank (2800 L, 21' X 32" X 24"), with a specially developed water flow system and automatic feeders. Constant upwelling helps orient fish in a parallel direction, reducing fish encroachment and provocation, and keeps feed in suspension longer, presenting it in a more natural manner. The underwater feed system prevents the development of a surface oil film and keeps the water surface clear. Upwelling breaks the surface tension, improving swim bladder inflation.

Feed that reaches the bottom is wasted, as the finicky fish do not bottom-feed. In the study, Biokyowa feed was used. The feed is available in various pellet sizes and retains its pellet form longer, keeping the feed suspended for a longer period of time. A fine feed (400 microns) was used for the first 4 days, then switched to 700 micron-sized feed for the remaining 26. It was discovered that pellet size and density of the artificial feed were very significant to feeding habit. However, Biokyowa is relatively expensive.

As previously mentioned, water quality is a very important factor in successful rearing of most fish species. In the R.A.R.C. study, tanks were siphoned twice daily to remove excess food. Water was recirculated through a swirl separator to remove solids, and then through a submerged down-flow gravel filter and an oxygen tower. The intricacies of this system and the associated requirement for conscientious work habits of employees reflect the importance of maintaining adequate water quality.

Successful rearing of walleye entirely indoors was achieved. The above resulted in a 47% survival rate and a product yield of 15 fish/L in 30 days, which is considered a major success. As a result and due to the prolific fecundity of the species, the authors of the study expect that 50,000 fingerlings can be reared from the tank in a single batch.

The North Central Regional Aquaculture Centre's (NCRAC) Walleye Project was conducted in partial collaboration with the R.A.R.C. study, but focused more on growout and pond techniques. The Project had achieved 37% survival in a much smaller (280 L) tank, but used much cheaper feed (Bio Trainer). For growout operations, food conversion was estimated in the 2:1 ratio at 20°C, but more feed studies are required.

4.8.2.3 Economic Overview

Historically, walleye for table use is among the most popular freshwater fish in central North America. In Canada, it is the freshwater capture species second only to whitefish by weight, but it is higher valued; much of it goes to the white table restaurant market. In 1989, the entire North American commercial catch was calculated at 20 million lb by the FFMC, which controlled 56% of this total.

Walleye is an ideal fish for most people in the US, having a firm, sweet flesh, and is often cited by consumers as the fish that doesn't taste like fish (Nickum, 1986). (Perhaps this finding could be used in a marketing ploy; for example, "Walleye: the great-tasting fish, even for people who don't like fish".) The table market is large but still undeveloped; Bob Rubin, Research and Development Director for the Chicago Fish House, a top US seafood distributor, feels that the issue is not to convince people walleye is good to eat, but rather to convince them it's worth the price. Rubin is waiting for a farm-raised product, and the firm could expand to 300,000 lb/yr. However, the producing facility would need to be relatively nearby to keep transport costs down.

Bob Summerfelt of Iowa State University and Chairman of NCRAC's Walleye Project suggested a retail range for fresh walleye fillets of US 4.80-11.00/lb (1996); Bob Rubin quoted FOB Chicago price for medium whole fresh walleye at US 2.40-2.50/lb.

There are two major costs involved in an intensive operation: feed and heating. The feed costs (Biokyowa feed) used in the R.A.R.C. walleye tank study were as follows:

- B400 @ $30.27/lb x 4 days
- C700 @ $5.45/lb x 26 days
- Total cost: $262.78/lb, over the 30 day period.

Although the Biokyowa had an increased survival rate over that of Bioproducts feed (47% and 37%, respectively) the much cheaper costs of the latter would probably justify its use over the former, depending on whether and the degree to which other factors had on survival rates. The Bioproducts' Bio Trainer feed costs in the NCRAC tank study were vastly lower, at $.75/lb. Over the same time period, total feed costs would be $22.5/lb, 11.7 times lower than the Biokyowa feed.

High heating costs suggest a need for water recirculation, so that some heat energy can be retained and reused; conversely, by-product heat systems such as those using solar power (used in the R.A.R.C. study), warm water aquifers (used in a tilapia fingerling operation in South Dakota) or heat produced by power plants or greenhouses help reduce heating costs.

Both study groups felt there is a lot of potential in the fingerling market. Jack Mathias of the Freshwater Institute (DFO) estimated a cost of up to 30 cents for a 5 inch fingerling grown entirely indoors, while rates of 10-15 cents per inch make that fish worth about 50-75 cents; for food fish, the numbers are not as good; Summerfelt estimated a cost of US 1.75/lb. For a 2 inch fingerling reared indoors and grown out to 1.25 lb in 14 months, the total cost would be approximately US 2.20

According to Summerfelt, future research is focusing on saugeye, a walleye-sauger cross. They grow faster at the same temperature, and are more docile and easier to handle, thus having fewer disease problems.

4.8.2.4 Summary

Feed costs are greatest in both walleye fingerlings and food fish production. The advantages of a farm-raised product over commercial catch are the ability to control the location of the facility, and market size and timing through temperature; at 10°C, fish can be held, while feed costs are minimal.

Walker (1992) refers to walleye as a species whose time has come with respect to aquaculture. John Nickum, Aquaculture Coordinator with the United States Fish and Wildlife Service, believes there is room for production by small scale operators, and there are several US operators who are pond-rearing fingerlings and food fish. Conversely, indoor tanks and raceway systems involve greater costs, but offer some control of survival rate, and more consistent results. However, although cooperative and separate work between NCRAC and Drs. Mathias and Moodie have solved the technical problems of intensive rearing of walleye, it is still not as of yet fail-safe relative to other commercial species, and economic aspects of such operations continue to be assessed.

4.8.3 Lake sturgeon

4.8.3.1 Introduction

Sturgeon is a very large, primitive fish (family Acipenseridae) of which there are 23 species in the world. With perhaps the exception of three species restricted to the Caspian and the Azov Seas (Doroshov, 1985) the stocks are small and continue to dwindle, and despite numerous efforts to prevent otherwise, these species are heading towards extinction. All are on the endangered list of species.

In Canada, two species that are the lake sturgeon (*Acipenser fulvescens*) and the white sturgeon (*A. transmontanus*) can be found; three others, the Atlantic (*A.*

Oxyrhynchus), the shortnose (*A. brevirostrum*) and the shovelnose (*Scaphirhynchus platorynchus*) sturgeon are other species present in North America. Due to their small numbers, high sensitivity to disturbance and value as sport fish, lake sturgeon and brook trout are designated as heritage species by the Manitoba government.

The regional species of historical significance to Grand Rapids is the lake sturgeon (McCarthy, 1988), of which its range extends to the Great Lakes basin. Over the past 50 years it has joined an ever-lengthening list of sturgeon species that, due to their decline in numbers, have little commercial importance to the freshwater fisheries industry. The major factors contributing to this decline have been overfishing and industrialization (Minister of Supply and Services, no date). Contributing biological factors, which include slow sexual maturation, high natural mortality of juveniles and sensitivity to fishing, gear allow little chance for rapid recovery of stocks after their depletion by overharvesting.

Globally, sturgeon are highly valued as a food and game fish and as a source of the unique binding substances obtained from their swimbladders. Their flesh, fresh, smoked and canned, is prized at a similar or a higher level than the most expensive salmonid fish. Their roe is processed into the black roe, or caviar, one of the most expensive luxury food items obtained from the aquatic environment. In addition, sturgeon is highly valued by the sport fishery. For example, the US recreational landings of the white sturgeon, the largest among the NA species, exceed the total commercial catch for this species.

4.8.3.2 Cultural Significance to the Grand Rapids area

Sturgeon holds a cultural and spiritual significance with the native peoples of Grand Rapids (McCarthy, 1988). The lake sturgeon is historically renowned for its abundance in the waterways of the Grand Rapids area, an abundance that no longer exists. In a major archaeological dig performed in the area in 1961-62, sturgeon remains formed the bulk of the findings. The findings indicate the site was used for sturgeon harvesting since about 2500 BC, contributing further evidence to the historical significance of the fish. In the 1700s, the first Hudson's Bay Company inlanders were awed by the sight of large numbers of lake sturgeon as they swarmed up the rapids in the summer. During this time of year, aboriginal peoples would gather along the shorelines to spearfish. At other times of the year scoop nets were used.

In terms of the aboriginal practice of using all the parts of a captured animal, the lake sturgeon is analogous to the buffalo. Native subsistence peoples were highly dependent on sturgeon, particularly for winter survival. The fish contains large quantities of oils, and it was smoked and dried to produce a fish version of pemmican, a nutritional, high-energy winter and trail food.

In addition to the sturgeon's usefulness as a staple food, its cartilage was used to make tools and instruments, from sturgeon-skin jars to needles and hooks. Isinglass, a translucent gelatine used to make glue and paint, was manufactured from the air bladder. However, the arrival of commercial fishing contributed to ending its local production and subsequent overfishing and habitat destruction has led to the fish's depletion from the many waters that once supported it.

4.8.3.3 Bio-life history

The biology and life history of sturgeon species are not very well understood, as they are different from all other fish. Unique morphological characteristics have been retained over the millennia, most obvious of which are the five rows of surficial bony scutes that cover the body. Experimental studies on rearing sturgeon are performed worldwide and have had a long history, especially in the former USSR.

The historical weight average for lake sturgeon is 15.2 kilograms but it has been known to grow to 200 kilograms (T. Dick, pers. comm.). They can live as long as 150 years, but they usually do not reach sexual maturity for 20 to 25 years of age or more. The long maturation period and spawning cycles, up to 7 years for females, result in an extremely low reproductive rate. This rate is a major factor in the vulnerability of lake sturgeon populations to overfishing and habitat destruction; they are easily depleted and extremely difficult to restore.

All 23 species of sturgeon migrate to spawn in gravel beds. While many species are either **anadromous** - a fish species that migrates upstream from salt waters to fresh waters during certain seasons to breed - or **semi-anadromous** - living in estuaries and brackish water lakes and migrating to rivers for spawning - the lake sturgeon inhabits only freshwater lakes and rivers, and usually migrates upriver for spawning, although they will migrate downstream to get to spawning sites.

The time it takes for sexual maturation to occur is more dependent on size than age. Different stocks of the same species can mature at almost twice the rate of others. Sturgeon spawn several times over their lives, but the **gametogenic cycle** - the time from one period of readiness to spawn to the next - lasts more than one year, and is about twice as long in females than in males. The periods are usually 4 to 6 and 2 to 3 years, respectively.

Ova are broadcast during spawning in fast flowing water. Shallow river sites with a rocky or gravel bottom are preferred. The eggs have numerous micropyles - sites where sperm can enter. Therefore, a density of sperm that is too high can lead to overfertilization and abnormal fry.

Following fertilization and contact with water, the ova develop a highly adhesive coat, which helps them to stick to bottom substrate as they are dispersed. Thus sand or silt, which have a low surface area available for adherence, is not suitable for spawning.

The optimum water temperature range for spawning and embryonic and larval development is relatively narrow - 10-20°C, depending on the species; for lake sturgeon it is 11-17°C . Hatching occurs soon after fertilization, 5-10 days in most species. Newly emerged larvae are 8-12 mm long. Feeding begins 8-14 days posthatch, and in this time the fish nearly double in length. Metamorphosis, i.e., transformation into juveniles, which are morphologically similar to adults, occurs at 20-30 days posthatch. Juveniles stay near the lower reaches of the river for up to several years.

Fry larvae feed on zooplankton while juveniles feed on insect larvae. Adult sturgeon have a carnivorous diet of bottom-dwelling organisms such as worms and crustaceans, including the occasional crayfish.

Growth rate is highly dependent on environmental conditions such as water temperature, availability of food and a corresponding factor, competition. Other interdependent factors that can also affect growth rates are dissolved oxygen, salinity and ionic composition, due to the limited ability of the sturgeon to regulate oxygen uptake and salt water balance. After spawning, sturgeon lose 40 percent of their dry matter content and probably even a higher percent of body calories.

4.8.3.4 Culture Methods

The main purpose for the culture of lake sturgeon is for restocking purposes. Ripe males and females can be captured in spawning grounds. A large, soft belly is a good indication of a ripe fish. Alternatively, they may be brought to maturity by simulating conditions for spawning. To do so, a relatively strong current may be circulated through a small concrete or earthen pond or raceway. The sexes are kept separate to control spawning.

Hormones from sturgeon pituitary glands have been used to stimulate and hasten the maturity of both sexes. The extract is injected as soon after capture as possible to induce ovulation and spermiation, and to improve the ovulatory success of females. Glands are stored in acetone after dehydration.

Milt or eggs can be released by applying gentle pressure on the abdomen. In most operations, as the size of the fish makes handling difficult and only partial stripping can be accomplished due to the structure of the oviduct, the fish is first killed and the eggs are released by opening the abdomen. However, techniques to keep the fish alive during a Caesarean section have been developed and are now becoming commonplace.

Very large females produce several million eggs, but they mature at different rates. However, most are in the correct developmental stage for fertilization as soon as they are released (T. Dick, pers. comm.). Eggs are stripped and collected in a pan and washed for a few minutes to remove blood and mucus. After washing, a small amount of water is added and the eggs are immediately milted and hand mixed. Semen is first diluted with hatchery water at a 1:200 ratio to avoid polyspermic fertilization. However, this ratio is only a rough estimate of the optimum dilution, as sperm densities in the semen are highly variable. Semen can be stored in refrigeration for at least 24 hours or for up to 7 days in pure oxygen, prior to insemination, without any noticeable decrease in fertilization efficiency.

The eggs are allowed to stand for a few minutes, in which time fertilization takes place and hardening begins. The eggs become highly adhesive within a few minutes after fertilization. A second washing removes excess sperm and coating from the eggs which could stick to the hatching vessel. Conversely, a 20- to 30-minute wash to remove the adhesive material using a solution containing 10 percent chalk or powdered clay can be performed.

During incubation, fungal diseases are the greatest potential problem, especially 2-3 days after fertilization. Types of egg treatments include a malachite green solution at a concentration of 1:200,000.

Hatching may take place in jar incubators, or in a river in incubators hung on lines. The eggs are inspected and cleaned of any silt deposits. Incubation time is a relatively short period of about 90 degree-days, and the yolk sac is absorbed in 5 to 10 days. Fry released at this early stage have a very high mortality rate, so they are usually cultured for a few more weeks, the time dependent on the method used and the desired end product. The fish may be kept in ponds, or circular or floating rectangular tanks at fairly high densities and over a short culture period of 2 to 3 weeks. During this time, the yolk sac is absorbed. In the tank system, the fish may then be fed planktonic crustaceans, worms and insect larvae. Afterwards they are released for stocking or transferred to a pond for further growth. Conversely, the pond technique may begin directly with sac fry, bypassing the tank stage. The ponds are fertilized and stocked at 4-6 fish/m^3 for 4-6 weeks. The fish are lake stocked when they reach 1.5 to 3.5 g.

CH. V - RESULTS AND DISCUSSION

Chapter V will present and discuss the results of the study, including the evaluation of community interest, assessments of existing and defunct local and regional operations, ground survey assessment, interviews with experts and consideration of alternative possibilities with respect to the feasibility of aquaculture in the Grand Rapids area.

5.1 COMMUNITY INTEREST

Consultations with the community indicate a disinterested attitude. Two public meetings (Appendix B) failed to attract people to generate discussion. However, a brief questionnaire (Appendix E) at the GRFAC meeting was answered by 12 of 22 people present. The results showed that those fishers who participated thought aquaculture could be important for their community (Table I). Growing fish for sale (Acceptable-10; Not acceptable-0; No Answer-2) or for fee-for-fishing (9-1-2) was more acceptable than growing fingerlings (6-3-3), and extensive aquaculture in naturally occurring waterbodies was fully supported (12-0-0). Extensive aquaculture in man-made waterbodies (8-2-0), or growing fish in cages (7-3-0) or tanks (8-2-0) received less support.

Table I Questionnaire Results of the Grand Rapids Fishermen's Association Cooperative Meeting Regarding Aquaculture, 29/08/95

Questionnaire Section	Answer*		
B. Perspectives	Yes	No	No Answer
Have you ever heard of aquaculture or fish-growing before today?	9	3	0
Do you think aquaculture is a good idea?	11	1	0
Do you feel that this study is important to the community?	11	1	0
Would you be interested in attending a meeting to discuss the findings?	11	1	0
Do you feel that the study will affect you in any way?	11	1	0

C. Concerns: How do you feel about: 1. Product Definition	Acceptable	Not Acceptable	No Answer
Growing fingerlings for sale?	6	3	3
Growing fish for sale?	10	0	2
Growing fish so that tourists can pay to fish for them?	9	1	2

C. Concerns: How do you feel about: 2. Type of Operation	Acceptable	Not Acceptable	No Answer
Fish grown in natural ponds and lakes?	12	0	0
Fish grown in man-made lakes?	8	2	0
Fish grown (and fed) in underwater cages?	7	3	0
Fish grown (and fed) in above-ground tanks?	8	2	0

* of 72 GRFAC members, 22 attended; of these, 12 participated in questionnaire.

5.2 CONSIDERATIONS FOR THE GRAND RAPIDS SITUATION

5.2.1 The Road to Grand Rapids: Tourist Potential and Put-and-take Operations

The following section briefly describes Grand Rapids in infrastructural and spatial contexts and how these may affect the tourist potential of a put-and-take operation within the region.

The resurfacing of PTH 6 to Thompson in the 1950s and 1960s substantially decreased the isolation of a large part of Northern Manitoba by providing vehicular access to Winnipeg. It may have been expected that improved access to northerly recreational fishing facilities would increase tourism to the Grand Rapids area, and direct sales and services would increase the local economic base and help sustain community businesses; however, the isolation of northern communities including Grand Rapids and facilities in the area considered to be barely adequate are such that they severely limit tourist potential (Damas and Smith Limited, Engineers, Planners and Project Managers, 1976).

Recreationalists and others destined for Northern Manitoba and departing from a locale situated south of Grand Rapids such as Winnipeg and the United States have a choice from two main travel routes: the Interlake route by PTH 6, and the more meandering but scenic route along the western part of the province by PTH 10, through and around Riding Mountain National Park and Dauphin Lake. PTH 10 is accessed from Winnipeg by the Yellowhead Route. This highway provides access to recreational sites at Clearwater Lake Provincial Park, Cormorant Provincial Forest and Grass River Provincial Park,

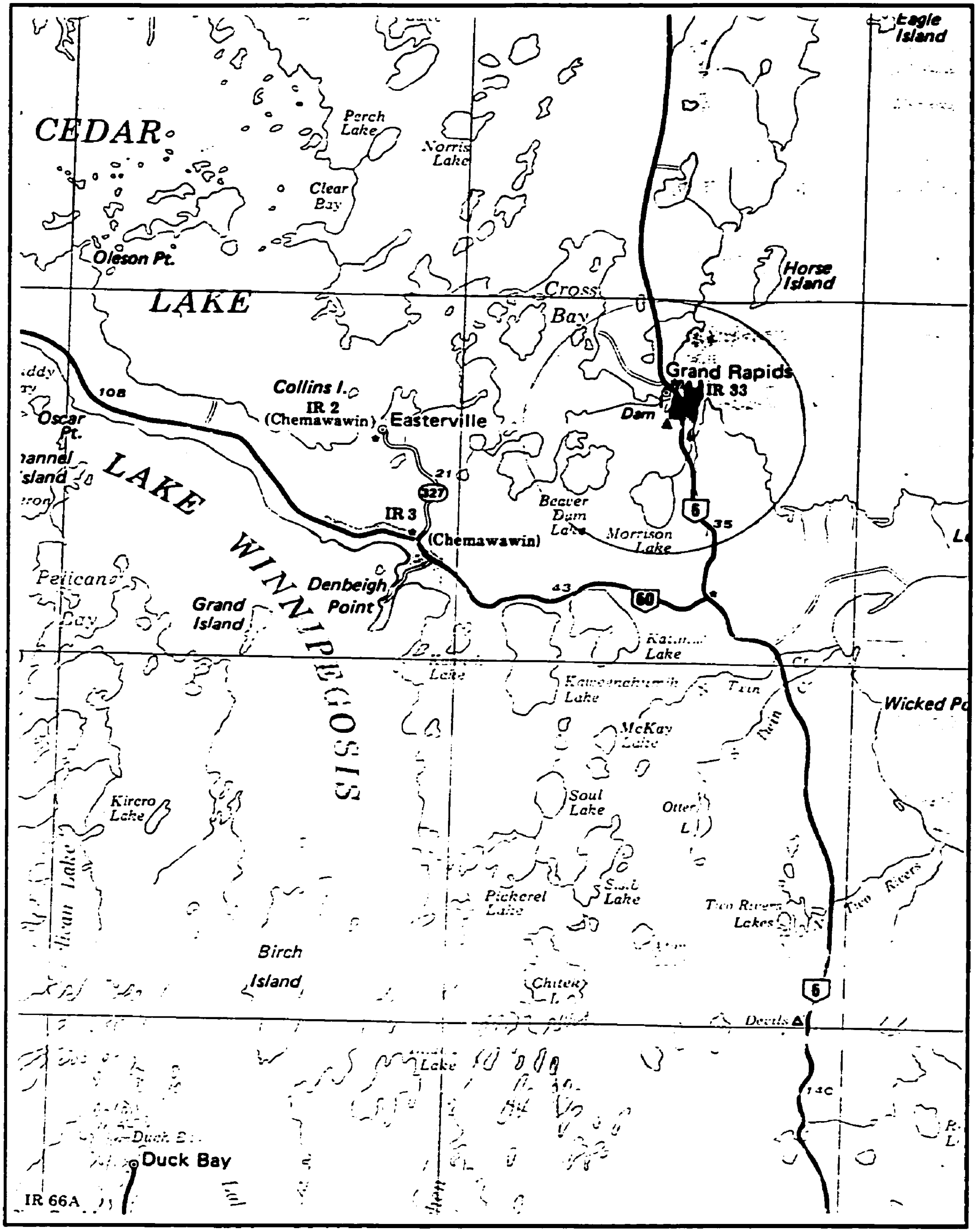

Figure 8 PTH 6, the highway to Grand Rapids, Manitoba and other towns of Northern Manitoba. (Source: Manitoba Hydro)

situated between the relatively large population centres of The Pas and Flin Flon (Figure 8).

In the twenty years since the report published by Damas and Smith Limited, a number of fishing camp operations have been run in the area, and while some are currently in place, it appears that little has changed in terms of tourist potential. A number of public and private facilities exist north of Grand Rapids, including those at Paint River Provincial Recreational Park situated about 30 km south of Thompson. In any event, these may contribute to lowering the tourist industry potential of Grand Rapids. In addition, the relatively new PTH 60 lies between Cedar Lake and Lake Winnipegosis, passing by IR no.3 in Easterville (Chemawawin). The highway diverts traffic from PTH 6 at a juncture thirty-five km south of Grand Rapids, and ends at PTH 10 at a point seventy-five km south of The Pas and near several provincial parks in the vicinity.

Fly-in fishing enthusiasts (and the money they spend) completely by-pass towns such as Grand Rapids on their way to more remote northerly facilities. Recreationalists with a large spending capacity may tend to be more attracted to remote areas with relatively luxurious amenities and the increased costs they command.

5.3 ASSESSMENT OF THE CURRENT STATUS OF AQUACULTURE IN MANITOBA AND THE GRAND RAPIDS AREA

5.3.1 Regional Operations in Southern Manitoba

The investigation of regional operations indicates that few, if any, of these are economically viable (Table III). Most regional operations fail due to poor planning and market definition, and insufficient scale. Experts agree that an adequate business plan that identifies and comprehends a pre-defined market is a key requirement to viability (Appendix I).

A related requirement is that a sufficient scale is used. Although there are operations that exist mainly for purposes of personal recreational. the managers of these may also believe they can make a small profit. Most regional operations have been of a small scale (Table II) and many were initiated with little thought towards a business plan. In the 1970s, as part of a farm diversification initiative and in an effort to make use of marginal and non-agricultural lands, the federal and provincial strategy included the development of extensive aquaculture in pothole lakes. However, most pothole lakes are too shallow and thus too warm in the summer. In addition, operators often had inadequate management skills and expertise in aquaculture. Some operators may only have a very vaguely defined market in mind, such as a few local potential consumers. A public perception that it is easy to grow and sell fish exists, that it is a simple matter of stocking a few fish in the lake, letting them grow and coming back to harvest them at the end of the growing season, contributed to the general economic failure of the initiative. In fact, high levels of technical, financial and marketing expertise are required, while a vague or nonexistent business plan and poor management skills result in economic failure.

Some larger scale operations having many components that are required for a successful operation have also failed due to a lack or an inadequacy in one or two key requirements (Table III). Some, such as AgPro Fish Farms, had large funding reserves or were subsidized in some way (e.g., water cost subsidy), easing the "growing pains" experienced by fledgling commercial enterprises. In either case, the results have often been the same: operations ran out of time to prove their viability before funding and subsidies were withdrawn, and other less risky or potentially more lucrative ventures proved more attractive, resulting in their demise.

Of the three larger scale operations investigated, two are now defunct (Table II and III). The third, Arctic Aquafarms and Garson Sportfishing Park, continues to operate. However, due to the inability to meet with the owner/manager, information on the economic status and viability of the operation could not be obtained. Of those experts in the industry who were familiar with the operation, the consensus was that such an expansive, yet, in their opinion, poorly planned operation could not be economically viable (Appendix I).

Rockwood Aquaculture Research Centre was owned and operated by the Federal Government. As the name indicates, the facility was used mainly for experimental research and technical support and outreach for the industry. As such, the economic framework of the facility is not suitable for analysis.

In the early 1990s the federal government announced a transfer of funding and support away from freshwater aquaculture to coastal concerns. This meant that federal support for aquaculture research in central Canada largely disappeared. The Centre no longer provides technological transfer support to players in the aquaculture industry, including any existing and future operations at Grand Rapids. The R.A.R.C. facility has been privatized and is now called Glacier Springs Fish Farm. The company has maintained its links to the Freshwater Institute. The two managers have a great deal of management and technical expertise, and experts in the industry are cautiously optimistic as they follow the progress of the operation.

In the case of the AgPro Fish Farms, a municipal subsidy helped meet water use and discharge requirements for the company. Nonetheless, huge overhead costs, inadequate initial business planning and expertise, and a steep learning curve took their toll. Despite becoming what eventually appeared to be a viable operation, the company closed its doors after six years in operation, apparently just when it was reaching its break-even point: considering the amount of financial and technical risk involved in the capital intensive tank operation, perhaps the company felt that the profit potential of the industry was insufficient, and funds could be put to more lucrative commercial enterprises elsewhere. This viewpoint would corroborate that of an economic expert surveyed during the study (Appendix I).

Table II Profile of Regional Operations in Southern/Central Manitoba

Name/location - status; relative scale; type of operation, spp./market; comments
Arctic Aquafarms/Garson Sportfishing Park, Garson - ongoing; larger/3-6 people; hatchery/ponds; RBT, BT, AC; fingerlings, growout, fee-for-fishing; owner/operator difficult to contact, apparently unwilling to disclose operation information; large overhead, capital; DNR/industry do not believe it is possible for this operation to be economically viable
AgPro Fish Farms, Winnipeg - ended 1994; larger/5 people; intensive RBT and AC for Canadian/export table market; although reportedly breaking even after six years of operation, decided to end, perhaps company decided to redirect funds into other more lucrative/less risky investments
NCN1, Garson area - ended 1995; small/1 person; now hobbyist only; extensive RBT growout for local market
Oak Hammock Fish Farm, Gunton/R.M. Rockwood - ongoing; small/1 person; intensive - two 4'x12' diam. tanks, AC and RBT; growout for local market; local reports of "off" flavour have surfaced in past, indicating poor management
North °40 Fish Farm, near Gimli - ongoing; small/1 person, hobbyist; extensive RBT growout; despite hobbyist operation emphasis, appears to be very well managed
RARC, Gunton/R.M. Rockwood - ended 1996, privatized (Glacier Springs Fish Farm); federal government owned, intensive experimental hatchery, nine spp. of fish; larger scale; redirection of government funding away from freshwater aquaculture research in Central Canada to coastal concerns ended centre's funding
Rockwood Springs, Gunton/R.M. Rockwood - ongoing; extensive RBT, AC fee-for-fishing; medium; recent summerkill event, algal blooms are indicative of poor management
Sal-tro Industries, near Gimli - ongoing; medium/3-4 people; extensive RBT fee-for-fishing; expanded, added new pond in 1995 to meet increasing demand, indicative of economic success, good management
Wildwood Trout Hatchery, Labroquerie - ended 1993/1994; small-medium/2-3 people; intensive RBT, AC growout, then egg/fingerling market; owner/operator experienced personal/financial difficulties, bankruptcy
RBT=rainbow trout; BT=brook trout; AC=arctic charr

Table III Commercial Aquaculture in Manitoba - Overview and Assessment

Criteria / Operation	Ended/ Ongoing	Time Period (years)	Type of System*	Relative Size/Scale of Operation	Key Variable(s) to:	
					Success **	Failure **
Arctic Aquafarms/ Sportfishing Park	Ongoing	6+	I(F)/ E(P)	Large	E?	
AgPro Fish Farms	Ended	6	I(G)	Large		E?
NCN1, Garson	Ended	Unkn.	E(G)	Small	S	E
Oak Hammock Fish Farm	Ongoing	5	I(G)	Small	S	
RARC	Ended	14	I(F,G)	Large		N/A
Sal-tro Industries	Ongoing	3+	E(P)	Medium	E?, S	
Wildwood Hatchery	Ended	4	I(F,G)	Medium		T, S
Grand Rapids Area and Northern Manitoba						
Beaver Dam L., Morrison L.	Periodic (Ended)	-	E(G)	Small		T
Foot Print L.	Ongoing	8	E(P)	Small	T	
Honeymoon L.	Ongoing.	4+	E(G)	Small	S, E?	
Island L.	Ended	1	E(G)	Small		T
Turnaround L. (Leaf Rapids)	Ongoing	8+	E(G)	Small	S	

* I = intensive (hatchery, raceways, tanks, cages)
E = extensive (ponds, small lakes, borrow pits, dugouts)
(G) = grow-out market
(F) = fingerling market
(P) = put-and-take market

** Success/Failure with respect to:
E = economic variable
T = technical variable
S = socio-cultural, sociological variable
(Note that a success or failure in one variable is not necessarily correlated to that of any other variable; a question mark after a key variable code indicates significant uncertainty in the conclusion)

Table IV Synopsis of Interviews with Experts - Choice of A. Species/Product and B. Scale/Type

A. Species/Product
Rainbow Trout is the most feasible, and perhaps the only realistic choice • most domesticated, hardy of all cultured species - that is, most easily cultured, least risky cultured species • able to withstand sub-optimal temperatures, crowding and other stress factors, thereby able to be produced at high densities, requiring the least amount of technical expertise • even, predictable growth-rate • most literature, research; technology, industry is well developed, already in place; high technical/technological transfer, ability to liaison with industry experts • readily available egg/fingerling supply • bottom line: the least risky operation, having the fastest growing curve potential for new operators
Arctic Charr is probably not technically feasible • due to its high value, robustness and consumer appeal, arctic charr may be the future species of choice for freshwater culture; however, biological factors and technological constraints continue to hinder progress in Canada; although these factors impose technical modifications to existing culture methods, charr is cultured using basically the same methods as for other salmonids • very susceptible to stress caused by temperatures outside the narrow, optimum range; Grand Rapids area may be too warm, increasing risk of a "total disaster" (e.g., huge die-off due to stress, disease) • slow growing; may be very difficult to achieve target weight of 8-10 oz. for seasonal pan-size market, 2-4 lbs for year-round market; extremely variable growth and very slow growing, especially after first year, even under optimal conditions • some problems with genetic diversity; difficulties in acquiring eggs/fingerlings of the appropriate strain of broodstock (AgPro Fish Farms had these difficulties); not enough stock available, worldwide (the new facility, Glacier Springs, may have adequate supplies of the desired strain for the region) • risk of "total disaster" event, or general failure higher than some other choices

A. Species/Product

Walleye may have potential in the future

- but some experts feel that culture techniques are still too new, particularly for novices
- some experts expressed marketing problems: "why compete with the identical or better wild product?"; others felt this not to be an issue, and felt that the market in Winnipeg alone could be big enough to consume the product . . .
- walleye would require greater technical expertise than the culture of RBT and AC

Perch culture is currently under development or being done in the US

- but are even more finicky and skittish than walleye
- the technology is new, thus would require greater technical expertise

B. Scale/Type: Extensive vs. Intensive Aquaculture

In general, it is felt that extensive aquaculture is not economically feasible

- experts expressed there was a need for a large-scale, intensive operation to be successful; can't "go in halfway"
- but some experts felt that perhaps a small side operation could make a small profit; however, successful only as a secondary means of income, e.g., as part of a diversified employment income strategy or diversified operation, as is increasingly done in agriculture

In Grand Rapids, would need to find the right bio-technical conditions, including human resources and accessibility; those experts who were sufficiently familiar with the area felt that the availability of these conditions is very limited

Intensive aquaculture is, in general, the only way to go for profit venture - cage culture or tank/raceway. If not technically feasible, forget it. However, one expert, who grew up in the G.R. area, felt that aquaculture is too difficult if not impossible to make a living off; only a seasonal operation could be viable, serving as a secondary means of income

5.4 ASSESSMENT OF THE FEASIBILITY OF AQUACULTURE IN THE GRAND RAPIDS AREA

5.4.1 General Requirements for a Financially Successful Aquaculture Operation in The Grand Rapids Area

In view of the findings from the study, for any hypothetical aquaculture business venture to succeed in Grand Rapids, the following is a list of requirements:

- the technical aspects of this operation are socially acceptable to the community; and community involvement is embedded within the venture from the onset
- owner/operators make use of all available relevant government programs
- a well-developed business plan, including the identification of predefined market(s) for a high-value, value-added product, is in place prior to any major capital investment
- this operation is viewed as a long term business venture and is run at a scale that is sufficiently large so that investors can expect a reasonable return on investment in the long run
- manager and operator knowledge, skills and commitment are sufficiently developed within employees
- managers of this operation apply all available practices that minimize risks of technical and economic failure, at the expense of some profit potential, at least in the short term
- expert consultation is made available through technology transfer programs, i.e., with the Freshwater Institute and other government agencies, as well as through ties with well-managed private businesses such as Glacier Springs (previously, the Rockwood Aquaculture Research Centre)

5.4.2 The Grand Rapids Hatchery: Interviews with Experts

The provincially owned Grand Rapids hatchery is subsidized by Manitoba Hydro and employs two community members for most of the year. The hatchery is used for various Northern lake stocking programs initiated by the province and Manitoba Hydro. The subsidy includes annual support funding and free maintenance costs by way of the services of technicians from Manitoba Hydro who have become, over the years, very adept and knowledgeable in the workings of the hatchery. The true value of these free services is very high and cannot be overlooked. Because of the high operating costs involved, due mainly to maintenance and heating costs, the hatchery is seen by most experts as an economic liability (Table V), and could not be used as part of an economically viable operation. However, it may be useful as part of an expanded rehabilitation program geared toward public interest and continued aboriginal mitigation.

Table V Status and Assessment of The Grand Rapids Hatchery as Evaluated by Experts

GOVMH1

- hatchery fisheries agreement: government facility, operated; MH funded; MH is viewed as a client, with a corporate/citizen interest, i.e. not legislated to do so
- renewed agreement: five year/$635 000 from 1995-2000 (see schedules A and B)
- vision: three species:
  - stocking whitefish in Cross L.
  - recovery of walleye stock in G.R.
  - apply the technology to rear and stock sturgeon

GOVMGMT1

- built, run by province in mid-'80's; funded by MH
- 1989/90: five-year agreement - MH paid out $60 000 initial + 90 000/yr = $510 000
- shut down over three winters due to structural damage; $300 000 to get back up again
- new agreement to yr. 2000 - plans for each year, plus departmental stocking of trout in Northern areas
- hatchery operating expenses v. high due mainly to hydro heating/lighting($60 000/yr); facility is "overdone, complicated, a monster to run - huge pumps, etc...."
- hydro technicians have "figured out how to maintain"; don't charge for maintenance, as part of the deal
- would serious doubt continuing operating facility without MH funding
- no longer a demand for walleye stocking, except for MH's purposes - other lakes under departmental jurisdiction have either recovered or it is felt that stocking is not the solution

PRIVECON2

- MH funded hatchery for province, for mitigative measures
- MH funded five-year agreement re: costs to run hatchery, programs - renewal 1996
  - stock Cross L. with lake whitefish, sturgeon [however, aboriginal communities losing interest in whitefish? -see GOVMGMT2's comments below]
  - L. Manitoba stocked with walleye - major spawning grounds [however, difficult to tell if this is useful, successful, i.e., how many fish survive, how to measure?]
  - last two springs, sturgeon-rearing

GOVMGMT2

- aboriginal communities losing interest in whitefish:
- low-price fish
- lots of tiny pinbones
- already present in abundance [however, recall quality problems - disease, cysts]
- cultural heritage species not as important to young people: changing tastes
- competition from Great Lakes?
- residual effect from Mercury scare?

GOVMH#	government agency employee with Manitoba Hydro
GOVMGMT#	government agency employee; natural resources bio-economist background with at least 6 years experience in aquaculture or fisheries management field
PRIVECON#	private company employee; natural resources bio-economist, or economist background with at least 9 years experience in aquaculture or fisheries management field

5.4.3 Technical Assessment of Sites in The Study Area: Ground Survey

The field work included a ground survey of the area conducted as a preliminary analysis of the suitability of the area for various types of aquaculture, in the contexts of: small-scale/extensive and large-scale/intensive operations; instruction/awareness; tourism/recreation, or; combinations of these.

Saskatchewan River Bed and Spillway

The Saskatchewan River Bed was assessed for its potential as an extensive fingerling grow-and-release operation for walleye. Concurrent work by Manitoba Hydro was done to assess the potential to use the bed in the spring as a spawning habitat for walleye, after it was seen that spawning occurred during the spring of 1992 when a head cover failed necessitated that the spillway be open. Channel improvements have been made and a walleye spawning channel has been successfully operated for 3 years as ongoing research continues.

Lake Winnipeg

Various sites along the shore were investigated for their appropriateness as cage culture feasibility. These were deemed to be too shallow and unprotected from storms which would cause damage to cages and allow fish to escape. The area is also susceptible to vandalism and poaching.

Harbour Bay

Harbour Bay was deemed to be too shallow and unprotected for cage culture. Penning the area was briefly considered and rejected due to: the outlet is too long across, therefore fencing is economically, and probably technically impractical; in addition, the high cost of rotenone and the inability to remove 100 percent of predators (particularly pike but also walleye, trout, etc.) in the water body are other important factors. Complete removal of predatory species is difficult to do by seining, even in the smallest of ponds, and numerous inlets into the system would allow their subsequent return in seasons with above average precipitation; tanks along the shore would require hydro power for pumping, construction of sheltering facilities and some form of protection from vandalism and poaching, all of which would drive costs of such an operation beyond economic viability.

Local Ponds

The information and data gathered from the site surveys of the area (Appendix G), interviews with experts in the field (Tables IV and V; see Appendix I for more detail), local knowledge (Table VI) and the empirical data from the regional DNR office (Table VII) indicate that there are few viable possibilities for extensive aquaculture in the Grand Rapids area. Many ponds and lakes in the area have been investigated by local fishers and test stocked by DNR. Most of these water bodies were technically deficient in one or more key requirements: for example, water quality, lake morphology or the absence of predatory species. The few lakes that may meet the requirements are currently used in extensive operations, of which one, Foot Print Lake, may be marginally viable. There has not been an attempt at a large scale operation in the area.

Table VI Traditional Ecological Knowledge of Local Lakes Regarding Extensive Culture Possibilities

Beaver Dam L.
- flows into Morrison L., to L. Winnipeg
- suckers (mullet) galore
- yet, unlike Morrison L., few jacks, and suckers in Beaver L. only eat shrimp

Foot Print L.
- about 15' at North end; South end shallow
- fluctuates with flooding from forebay
- farmed (put-and-take) rainbow trout sometimes has swampy taste

Honeymoon L.
- good tasting farmed rainbow trout

Jackpine L. (36 mi north of Grand Rapids)
- 16-18'; beautiful lake
- lots of jackfish; no foodfish except small perch Family
- rough road 2 mi off highway

McKay L.
- about 7' deep
- various species, but no jackfish
- bulrushes all the way through lake
- fluctuates with flooding from forebay

Mechiso L
- outlet to Eating Point Creek, to L. Winnipeg
- swampy, shallow

Morrison L.
- lots of jackfish, stomachs full of mullet

Toboggan L.
- 16' deep
- no jackfish
- plenty of shrimp, almost as much as Foot Print L.
- fish have a swampy taste, like Foot Print L. can have
- fluctuates with flooding from forebay

Island , Robertson and Zigzag L.
- 7' at most
- plenty of jackfish
- high ground and low accessibility

5.4.4 Consideration of Aquaculture Alternatives for the Grand Rapids Area

Despite the potentially formidable limitations of the area discussed thus far, a broader survey of the aquaculture industry in Canada suggests that a number of developmental opportunities are worthy of examination that is more intensive.

Regardless of the alternative, the motivation or goal of development must be made clear, and none can be successful without strong entrepreneurial and community commitment. Examination of past attempts to develop aquaculture in the province indicates that careful analysis of all pertinent factors is required prior to any development initiative. Any initiative must stand the test of comparison with other local or regional alternatives, and acceptability to the community. Aquaculture experts in the Province re-enforce this observation.

A lack of community involvement would impede development and lead to failure. It is imperative that there are community initiative and involvement from the onset. Interested members, stakeholders and key members of the community need to be identified and involved in all stages of the development. (For example, community stakeholders may include members of The Grand Rapids Fisherman's Association Cooperative (GRFAC)). Identification and discussion of alternatives must be generated. A community-driven venture wherein stakeholders are immersed in decision-making processes, perhaps with the aid of a consultant which would facilitate discussion with the community and identification of key players, would generate further interest, provide the opportunity for further assessment and ultimately, greatly improve the likelihood and degree of success.

Three alternatives that were considered for the Grand Rapids area are:

- *Cage culture production of rainbow trout ("steelhead salmon") in the Grand Rapids Generating Station forebay.* This alternative is based upon what may be a successful and sustainable production facility in operation at Lake Diefenbaker at Riverhurst, Saskatchewan. Although the site was not visited due to time and monetary constraints, information was found in the literature. The facility, a subsidiary of Saskpool, is capital intensive, uses cage culture technology and employs a manager, a technician and about twenty fish processing workers. Some two million to three million lb of rainbow trout are produced annually. Cage culture, a system that has aspects of both extensive and intensive aquaculture, involves a flexible mesh-net suspended from a floating framework, and floating walkways provide access to the cages (Figures 3 and 4). The rainbow trout are harvested at the 6-8 lb size and marketed as steelhead salmon in the Seattle area. Each fillet is vacuum-packed and frozen, or shipped fresh, in this highly efficient and automated facility. However, although the operation is considered state-of-the-art and an important asset to the regional economy, profitability and viability are unknown, and whether or not and by how much the parent company subsidizes the operation. The lesson offered by this study is that only large-scale, capital intensive, well-managed operations with sophisticated marketing are likely to work. However, the large capitalization and subsidization requirements may be one barrier, and the present status of the human resources (i.e., the lack of available, skilled technical personnel) in the Grand Rapids area is another.

- *Conservation enhancement through restocking and tourist attraction.* This alternative is operative and successful at a number of locations in the US and Europe, and may lend itself to a mix of public and private sector investment. For example, aboriginal eco-tourism is a federal government priority through Western Diversification, while INAC may be willing to provide funding for a feasibility assessment study. In this alternative, the role of the Grand Rapids Hatchery in conservation is expanded, as well as its attraction as a tourist destination for campers, "RVers" and snowmobilers, including the provision of sportfishing alternatives during winter and summer. The objectives of job creation, year-round activity and the development of an educational program around the facility supplement the conservation option. However, the existing facility is considered by many experts to be a "white elephant," due to maintenance costs and other factors (Table V; Appendix I), and such a multiple objective operation would be a challenge to set up and run, and would require ongoing subsidization.

- *Aquaculture for stocking and enhancement.* There is ongoing concern in Manitoba regarding the sustainability of fisheries in a number of lakes, including Lake Winnipeg, Lake Manitoba and Lake Winnipegosis. Studies have identified a number of factors that contribute to declining fish production, and a provincial fish and wildlife sustainability strategy has been proposed, in which fishery enhancement was one area to be considered. Although Grand Rapids is well located to respond to opportunities that may arise, and restocking of walleye, sturgeon and other species may be useful for providing long-term sustainability in some smaller waterbodies, the benefits of stocking larger lakes are probably insignificant if not non-existent (the expression "a drop in the bucket" may be highly applicable). It is clear that a facility that aims at growing fingerlings for stocking will continue to operate at a subsidy, and provide very limited opportunities for local employment.

CH. VI - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

Although aquaculture can never replace the role of natural stocks, as production from natural fish stocks of the world continues to decline, there is increasing pressure to view and utilize aquaculture as a way of supplementing production. To this end, aquaculture has met with varying degrees of success. However, relative to many other industries, aquaculture is a high-risk business venture with the potential for moderate returns on investment, and many economic initiatives have ended in failure. Despite these possible deterrents, aquaculture has been economically successful in parts of Canada. In a few rural areas, it has been successfully utilized to create and supplement employment incomes of community members and those in the industry agree that there is room for further development in some areas.

Grand Rapids, Manitoba is an historic region with a diverse community situated along the Saskatchewan River near the outlet to Lake Winnipeg. The local economic base of Grand Rapids is relatively small, while new employment opportunities are scarce. Aquaculture has offered social and economic improvement opportunities to communities with limited economic alternatives. The purpose of this study was to identify the types of freshwater aquaculture systems that might be technically feasible, financially viable and socially acceptable in the Grand Rapids area. The work includes an extensive literature review of aquaculture; site visits to aquaculture operations, interviews with personnel, and search for relevant technical and economic data in southern Manitoba; site visits to potential aquaculture locations in waterbodies in the vicinity of Grand Rapids; meeting, presentation and discussion with the Grand Rapids Band Council and the Grand Rapids Fishermen's Cooperative Association, and; interviews with aquaculture experts from the Federal and Provincial governments and industry.

6.2 CONCLUSIONS

Interviewed experts agreed that an adequate business plan that identifies and comprehends a predefined market of sizeable scale is a key requirement to viability. However, the overview of freshwater aquaculture in Canada, and more specifically the investigations of regional aquaculture operations indicated that few of these operations are financially viable. Most regional operations failed due to technical inadequacies, poor planning and market definition, and insufficient scale. Most operations are small-scale extensive (traditional pond/lake stocking and growout) systems; yet most regional pothole lakes are too shallow, and therefore too warm in the summer. Managers of failed operations often had inadequate management skills and expertise, and may only have had a vaguely defined market in mind. A public perception that growing and selling fish is easy may have contributed to these difficulties, when in fact, technical, managerial and marketing expertise are required, while a nonexistent business plan and poor management skills lead to economic failure.

Some larger scale, intensive operations having many components required for a successful operation have also failed, due to a lack or an inadequacy in one or two key requirements. In such cases, many of these facilities ran out of time to prove their viability before the company decided to close the operation and redirect funding to other lower-risk or more profitable ventures.

The assessment of aquaculture initiatives in Manitoba suggested that successes have been transitory and limited by a number of factors, including technical difficulties, lack of technical support, market acceptance, disease control, scale of production, regulatory problems, and quality control. Private ventures are mostly small-scale and directed at production for local use or sportfishing. The withdrawal of technical support by the federal government precipitated the closure of R.A.R.C. The facility can no longer play a role in technological transfer for the industry.

The data gathered from the study showed that few viable possibilities for extensive aquaculture exist in the Grand Rapids area. Community members have undertaken several initiatives involving small-scale extensive aquaculture in the past. Many ponds and lakes in the area have been investigated by local fishers and test stocked by DNR. Most of these water bodies were technically deficient in one or more key requirements for viability. The few lakes that may meet the requirements are currently used in extensive operations, of which one may be marginally viable. A large-scale operation has not been attempted in the area, while the Grand Rapids hatchery was seen by most experts as an economic liability, and may not be used as part of an economically viable operation.

Consultations with the community indicated an indifferent or disinterested attitude. Public meetings failed to attract people and generate discussion. However, a brief questionnaire handed out during a GRFAC meeting was answered by 12 of 22 fishers present. The results showed that fishers thought aquaculture could be important for their community, and indicated that growing fish for sale or for fee-for-fishing was more acceptable than growing fingerlings. Extensive aquaculture in naturally occurring waterbodies was fully supported by the twelve participants, while doing so in human-made waterbodies, or growing fish in cages or tanks received slightly less support.

The experience with aquaculture in Southern Manitoba and the Grand Rapids area indicated that smaller or mid-sized facilities for growing fish for sale are not viable. With respect to the Grand Rapids area, hatcheries and aquaculture facilities operated for conservation, education or tourism objectives may be possible but would require ongoing subsidies. Three alternatives were identified but at present none meet the criteria of technical feasibility, financial viability and social acceptability, as set out in this study. Technical barriers and lack of available, skilled technical human resources impede success. Community indifference to aquaculture is currently the greatest impediment to success. At present, aquaculture as an economic endeavour has little or no potential for success in the Grand Rapids area with respect to the criteria set out in this study.

6.3 RECOMMENDATIONS

In view of the above, it is recommended that until members of the community show genuine interest and initiative in aquaculture, Manitoba Hydro discontinue this avenue as a mitigative and community developmental measure. In the event that interest does increase, any future assessments regarding aquaculture in the Grand Rapids area must include initial and ongoing community input and representation to succeed, through consultation, workshop and other community development initiatives. It is also recommended that, in the event that such an increase in interest does arise, Manitoba Hydro continue to monitor the freshwater aquaculture industry, specifically its growth and success, by maintaining contact with DNR, Fisheries Branch and the Department of Fisheries and Oceans.

Plate 10 Members of The Grand Rapids Fisherman's Association Cooperative, employed by Manitoba Hydro during fishery off-season

Plate 11 Lake sturgeon in the Grand Rapids Hatchery aquarium

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PERSONAL COMMUNICATIONS

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APPENDICES

APPENDIX A: COMMON AND SCIENTIFIC NAMES OF FISH REFERRED TO IN THE PRACTICUM

Common Name	Scientific Name
F. Acipenseridae	
Atlantic sturgeon	*Acipenser Oxyrhynchus*
Lake sturgeon	*Acipenser fulvescens*
Shortnose sturgeon	*Acipenser brevirostrum*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
White sturgeon	*Acipenser transmontanus*
F.Percidae	
Darter	*Ammocrypta*, *Etheostoma*, and *Percina spp.*
Pike perch	*Stizostedion lucioperca*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*
Yellow perch	*Perca flavescens*
F.Salmonidae	
Arctic charr	*Salvelinus alpinus*
Arctic grayling	*Thymallus arcticus*
Atlantic salmon	*Salmo salar*
Brook trout	*Salvelinus fontinalis*
Inconnu	*Stenodus leucichthys*
Whitefish and Cisco	*Prosopium* and *Coregonus spp.*
Rainbow trout	*Oncorhynchus mykiss*, previously *Salmo gairdneri*

APPENDIX B: METHODOLOGY USED FOR THE ASSESSMENT OF REGIONAL OPERATIONS

OTHER REGIONAL OPERATIONS
Types of Operations, Marketing, Comparisons

- refer, compare info to FFMC figures
- context: applicability to GR area

Part 1: Telephone interview - to obtain general idea, information to determine, justify the validity of and set parameters for a visit
- to determine the type and scale of operation, and, as much as possible, market data - is it worth visiting? If so, ask for an appointment for tour and a more in-depth personal interview - use schedule for second trip to Grand Rapids (tentative EDT: Monday, July 31/95)

Criteria:
- comparison to GR, possibilities
- species: focus on RBT; secondary focus on walleye
- types of operations e.g.
    - dugout/pond culture of RBT (one, maybe two good representative operations would suffice)
    - tank operations with source of natural water body feed
    - hatchery systems

- any other similar operations more near to Winnipeg or on way to/from GR?

1. Type/size (scale) of Operation
    - spp/use (market)
    - system/scale
        - production numbers/sizes

2. Physical parameters of area (inasmuch as known by the manager)
    - soil type
    - water body parameters
        - physical parameters: temperatures, flow rates; weed management
        - chemical parameters: Dissolved oxygen,

Part II - Tour/Personal Interview

1. Type of Operation
a) System - ext vs int. - how long operating?
b) # of people - hours/full/part time, seasonal/annual, positions
c) fresh/fresh-frozen? Who? How delivered?
d) How started? Why? Consulted any help? Who? For what?

2. Marketing and economics
a) any specific strategy, or "just winged it", learn as you go?
b) Target market
c) numbers sold (kg/tonnes/annum); price/fish or lb
d) Operating/Production costs ($/lb) vs. return ($/lb)
e) initial startup/capital costs
f) transportation costs
g) other

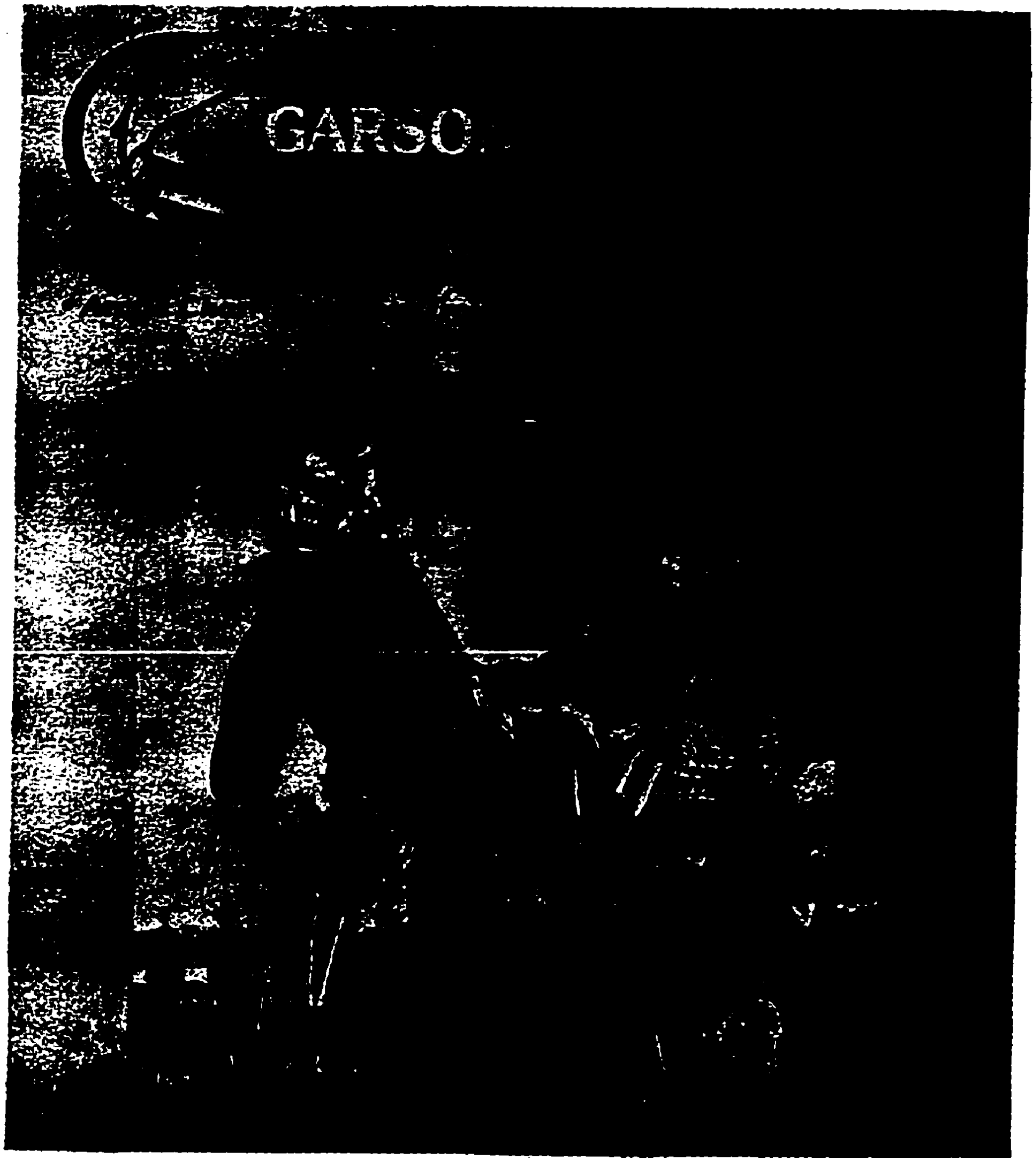
3. Unexpected difficulties/pleasantries
a) Most difficult part
b) specific problems? How overcome?
c) bonuses/surprises? Intangibles?

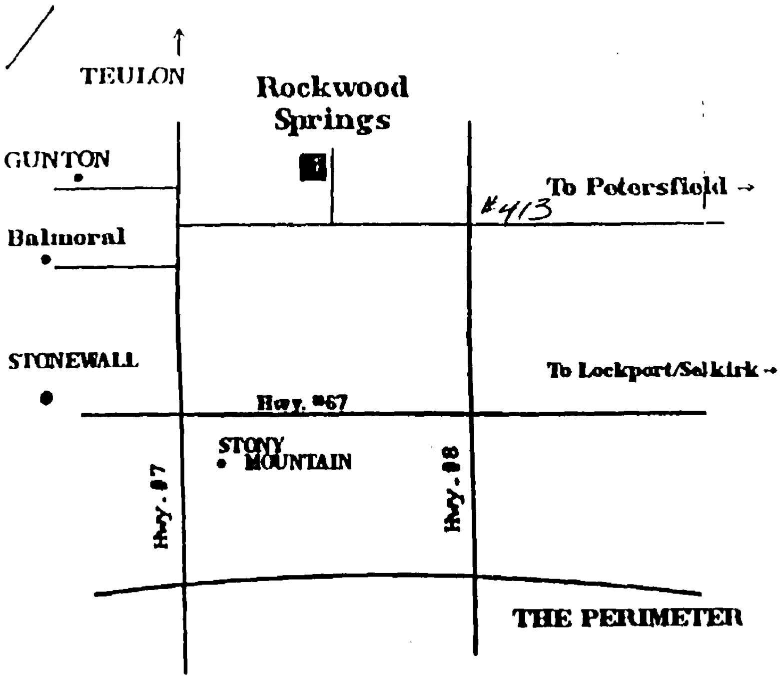
Grabbag
- watch for bias: Dreamer/BSer, or serious business-oriented entrepreneur? Operation well-managed?
- if level of expertise is sufficient, ask for their perception of the aq, in general and the GR area situation
- perception of the most important parts of a successful operation - key to success in aq

Without asking directly, try to determine what considerations were taken in the initial decision to start-up

- physical
- marketing
- what makes this operation special; any advantages in position/system/area?

APPENDIX C: ADVERTISEMENTS, PAMPHLETS FOR REGIONAL AQUACULTURE OPERATIONS





32 km (20 miles) North of the Perimeter off Hwy. #7 or #8. Look for signs on Petersfield Road.

RATES – plus $3.30/lb live wt for fish you keep.

ONE ADULT (with one child) – $10.00 PER DAY
ONE ADULT (two or three children) – $15.00 PER DAY
FAMILY (two adults and one or two children) – $20.00 PER DAY
FAMILY (two adults and three or four children) – $25.00 PER DAY

GROUP RATES ARE AVAILABLE UPON REQUEST.

CALL 237-0810

To Reserve an Ice Hut or for further information on upcoming derbys and events.

SPORT FISHING PARK OF THE PRAIRIES

Experience Fantastic Fishing in an Attractive Setting just Minutes from Winnipeg!

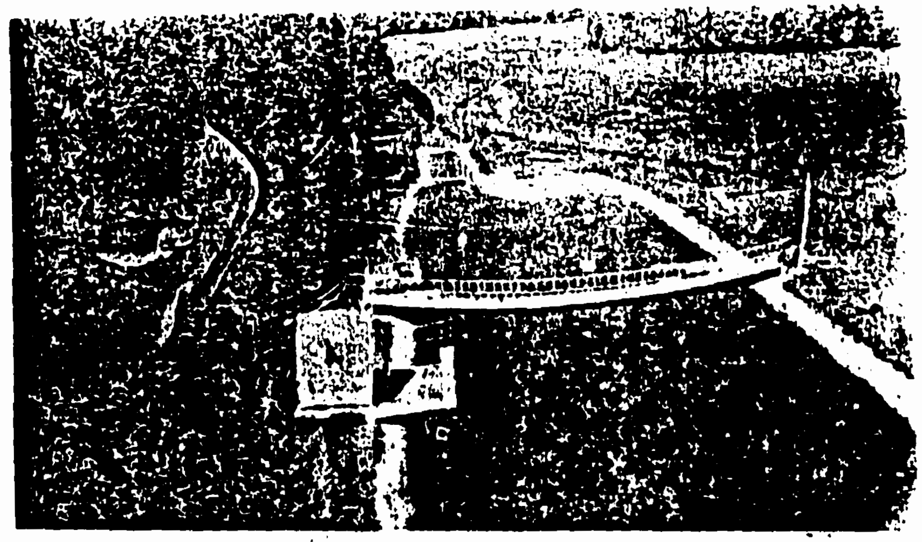
Catch Rainbow, Brown and Brook Trout as well as Arctic Char from a Clear Spring-fed Pond.

A YEAR LONG FISHING EXPERIENCE FOR THE WHOLE FAMILY.

Casting, Bait Fishing, Fly Fishing, Ice Fishing
Catch and Keep or Catch and Release
No Fishing Licence Required

WE GUARANTEE YOU WILL CATCH FISH

[illegible] the rainbow



Bewsky's four-year old pond is home to 750 fish this year.

BY SHEL ZOLKEWICH

> "Nobody can believe the growth I get out of my fish."

ARNES — Steve Bewsky isn't interested in finding the pot of gold. He's more concerned with the rainbows. Rainbow trout, that is, and Kokanee salmon and Arctic char.

The Arnes fish farmer isn't looking for a monetary return from his vast investment of time and energy. The pond is his hobby, open for angling only to friends and customers of his Winnipeg business, as long as they make an appointment first. The rules may seem harsh but they have to be considering what's at stake. Bewsky grows big fish; tasty fish, and in record time, and it has professionals in the business shaking their heads in amazement.

"Nobody can believe the growth I get out of my fish," said Bewsky who points out that the secret is simply a clean place for his 750 fish to eat and grow.

"That's the difference between a fish pond that's clear and clean as opposed to one that filled with algae and weeds."

Bewsky has created a weed-free, oxygen-rich, feed-abundant environment for his fish with some trial-and-error engineering and some ingenious home-made devices.

One of the biggest problems with fish ponds is stagnant water that becomes too warm. Fish stop eating and the weeds start growing. Bewsky drilled a well and installed a pump that is capable of churning out 3000 gallons an hour. The water is kept between 58 and 61 degrees Fahrenheit and cold water is pumped in when things get too w[illegible].

"In some po[illegible] the middle of June the water is too warm and they stop feeding," Bewsky said.

A set of turbines keeps the water moving at a speed of three to four miles and hour and adds vital oxygen to the pond. Bewsky also adds Aquashade to his pond, a product which cuts the sun's rays and prevents algae growth. The bottom of the pond is vacuumed twice a year to remove dead leaves and debris.

The pond measures 55 by 110 feet, is 10 feet, four inches deep and could sustain between 50 and 60 fish without extra feed, Bewsky said. But the 25 salmon, 225 char and 500 trout get fed twice daily by an automatic feeding device; one of Bewsky's inventions. Feed pellets are dropped via a converted meat grinder onto a fan which spreads the food across the pond. A timer runs for half an hour in the morning and half an hour in the evening, supplying three pounds of food to the stock every day.

"An Arctic char can live for two years without eating and a trout can live for a year, but they just won't grow," Bewsky pointed out.

But Bewsky's fish do grow. There are about 130 trout that are running between three and six pounds.

"The biggest one taken last year was five pounds, 10 ounces and it was 26 inches long," he said.

The Arctic char and salmon have been less visible, so Bewsky isn't sure about their growth records.

"The first of September last year was the last contact I had with the char. There are also 25 salmon which nobody has seen or heard from since the day I put them in; April 10, 1990; no communications whatsoever," he said.

Bewsky boasts zero losses in his pond summer or winter, a problem which plagues many pothole fish farmers. He attributes that to the good water quality and strict rules about catch and release practices.

"Catch and release is 100 per cent outlawed at my place. The majority of the fish won't live. They are stressed and stunned and a lot die within a couple of weeks."

Bewsky is looking forward to a season of doing some fishing instead of fine-tuning the devices which make the pond so successful. It's taken three seasons of 30 and 40-hour weekends to get the pond up and running, but it's been time well spent, Bewsky said.

"As far as a stress reliever, it's the best thing. It totally takes my mind off things. In this recession, you've got to have something else. We just sit down, chew the fat and fish," he said.

Sport-fishing park north of the city hopes to get more bites

Angling for big bucks

By Murray McNeill
Business Reporter

THE MIDDAY sun is beating down and a stiff breeze is blowing off the water as Domenico Costantini casts his line and slowly begins reeling it in.

"Usually the best time to catch these guys is early in the morning or at four or five o'clock in the afternoon," Costantini says in reference to the rainbow trout and arctic char he knows are lurking somewhere below the surface.

As he reels in his empty line and prepares to cast again, there's a loud splashing sound off to his right.

"Those ones you hear jumping are usually the rainbows," he explains. "When you see a lot of them jumping, they're not biting. They're just playing around."

He was right. On that particular day, there was a lot of jumping but not much biting going on at the Rockwood Springs Sport Fishing Park of the Prairies.

But then again, that's the nature of sport fishing — some days the fishing is great, some days it's not so great.

That's also pretty much sums up the way business has been for Costantini and 11 other investors since they opened Rockwood Springs just over a year ago. Some days it's been great, and some days it's been not so great.

"A lot of it is weather-based," Costantini explains.

"If it's raining, you get nobody coming out. And other days, if it's nice out, you can get 40 or 50 people."

But the ups and downs of the business don't discourage Costantini. He said his father, who owns his own concrete firm in Winnipeg and is a fellow investor in Rockwood Springs, warned him that it usually takes four or five years for a new venture to become firmly established.

So with that thought in mind, Costantini and his partners are considering making further improvements to Rockwood Springs over the next couple of years — things like adding a children's play area, laying down more sod, and planting more trees.

Second pond

They may even add a second pond on the 34-hectare site, which is situated about 32 kilometres north of Winnipeg between Highways 7 and 8.

As for why he and his fellow entrepreneurs decided to open a sport-fishing pond, Costantini said one of the other partners had worked for a similar business in Ontario and thought the concept could work here. But he didn't have enough money to do it himself, so he began recruiting other partners for the project, including Costantini, who now acts as the group's spokesman.

The 13 people who eventually became involved in the project (one has since dropped out) each invested $5 000 of their own money to get it off the ground, Costantini said. As well, the group obtained a loan through the Federal Business Development Bank, he added.

The partners buy trout and char from local fish hatcheries and stock the pond with them.

Costantini estimates there are about 400 char and about 600 trout in the 1.5-hectare pond at the moment.

He said seven or eight of the partners, who all have other full-time jobs, take turns running Rockwood Springs. The pond is open mainly on the weekends, although they do take reservations for weekday outings, as well.

ADMISSION FEES range from $10 per day for one adult (with one child) to $25 per day for a family of two adults and three or four children. Group rates are also available upon request.

Costantini said a fishing licence is not required to fish at Rockwood Springs. Park patrons have the option of returning their catch to the pond or taking it home with them. However, if they opt to keep it, they have to pay a fee of $4 per pound.

Costantini said patrons so far have ranged from experienced fisherman who want to try out some new equipment to groups of Scouts and school children.

Although Manitoba has hundreds of lakes where people can go fishing, Costantini believes Rockwood Springs is an attractive alternative for those people who have neither the time nor the inclination to drive longer distances to get to a regular lake.

Rockwood Springs Sport Fishing Park of the Prairies

Founded: 1993

Product or Service: A year-round sport fishing pond stocked with rainbow trout and arctic char. Fishing enthusiasts can try their hand at casting, bait fishing, and fly fishing during the warmer weather, and ice fishing during the winter months. Fish that are caught can be released or taken home.

Partnership: Domenico Costantini, Mario Costantini, Ric Costantini, Robert Costantini, Angelo Costantini, Gabe DiMarco, Dino Alecci, Graham Campbell, Robert Jenion, Gavin Houston, Lino Cerqueti, and Luciano DiGirolamo.

FOR SALE

LIQUIDATION OF FISH FARM EQUIPMENT
FORMERLY WILDWOOD TROUT HATCHERY

CUSTOM STAINLESS STEEL HATCHERY TROUGHS WITH TRAYS

EWOS FEEDERS WITH TIMER

DEMAND FEEDERS

COMPRESSED AIR FEEDERS

5th WHEEL TRAILER WITH INSULATED FIBREGLASS 900 GALLON FISH TRANSPORT TANK

15 K.V.A. STANDBY GAS GENERATOR, WISCONSIN 4 CYLINDER/ WINPOWER- WITH ZENITH AUTOMATIC CONTROL SYSTEM

400 GALLON STAINLESS STEEL INSULATED MILK TANK ADAPTED FOR FISH TRANSPORTATION

Y.S.I. 51B OXYGEN METER

AGITATOR AERATORS

ALL ENQUIRIES TO DAVID SAMUELS
PHONE/FAX 204-424-5605

APPENDIX D: COMMUNITY NEWSLETTER - ADVERTISEMENT OF TOWN MEETING

VOLUME XXII

the GRAND RAPIDIAN

ISSUE XVIi

AUGUST 25, 1995

NOTES FROM THE LITTLE MINNOW DAY CARE.........

The Little Minnow Day Care will be reopening for the 1995/96 year on Monday, August 28, 1995. The Day Care has a limited number of spaces available for anyone who might be requiring daycare services. We provide quality care for your child/ren in a happy and learning environment.

The following is our schedule of daycare fees:

	HALF DAYS	FULL DAYS
INFANTS (12 weeks - 2 years)	$13.20	$26.40
PRESCHOOLERS (2 years - 6 years)	$ 9.20	$18.40

We also have partial and fully subsidized positions available. We are now taking applications for the 1995/96 season. Spaces are available on a first-come-first serve basis. Anyone requiring further information, with regards to applying for a space, please call Susan at 639-2476 or 639-2596.

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Attention, community members of the Grand Rapids area:

AQUACULTURE FEASIBILITY STUDY IN THE GRAND RAPIDS AREA

Jacques Lagasse, candidate for
the Master of Natural Resources Management degree

Natural Resources Institute
University of Manitoba

The purpose of this Master's Thesis study is to perform a preliminary evaluation that will assist in determining what types of aquaculture exist that are technically feasible, economically viable and socially acceptable, with respect to the Grand Rapids area.

Two meetings have been scheduled, so that community members are given adequate opportunity to attend:

Tues., Aug. 29, 7:00 P.M. at the Drop-In Centre, Grand Rapids Indian Reserve

Wed., Aug. 30, 7:00 P.M. at the Roman Catholic Hall, L.G.D. Grand Rapids

The meetings are of an informal nature. The study will be presented and community members will be invited to ask any questions they may have. This will be followed by an opportunity to fill in a survey questionnaire to express your opinions and any concerns you may have, which will be included in the study, in strict confidence. The survey will also include a section that asks for your knowledge of the area's water bodies. In this regard, Elders and members of the community who are knowledgeable in the area's water resources and fish habitat are strongly encouraged to attend.

Your attendance at either of the meetings would be greatly appreciated so that your input and any concerns you may have can be documented, in strict confidence.

Thank you.
Jacques Lagasse

APPENDIX E: COMMUNITY INTEREST QUESTIONNAIRE

AQUACULTURE FEASIBILITY STUDY IN THE GRAND RAPIDS AREA -

QUESTIONNAIRE

Community Perspectives and Concerns

The following section refers to your thoughts about the study. It seeks to gain community input and perspectives, and get an idea of the level of community interest. Please answer or comment on the sections that you feel are important. Your answers and comments will be held in strict confidence.

A. Study Information

For the following questions, please mark an X where it applies.

When did you first hear about this study?
Within the last 7 days ___
Between 7 and 30 days ___
Longer than 30 days ago ___

How did you first hear about this study?
From a community member ___
On a community billboard ___
In The Grand Rapidian ___

B. Perspectives of the study

Answer Yes or No to the following questions. Please add any comments you may have at the bottom or on the back of this page.

	YES	NO
Before today, have you ever heard of aquaculture or fish-growing?	___	___
Do you think aquaculture is a good idea?	___	___
Do you think that the study is important to the community?	___	___
Do you feel that input from the community is important to the study?	___	___
Are you interested in knowing what the findings of the study are?	___	___
Would you be interested in attending a meeting in April with myself, other representatives of the community and representatives of Manitoba Hydro to discuss the findings?	___	___
Do you feel that the study will affect you in any way?	___	___

If so, how? Please use the back of the page if you need more space for any of the questions.

____

____

C. Concerns of the study

Fish can be grown as fingerlings for sale (selling hatched fish to others so they can grow them), as fish for sale to eat, or as fish for tourists to fish for them.

How do you feel about:

	Acceptable	Not Acceptable
Growing fingerlings for sale?	____	____
Growing fish for sale?	____	____
Growing fish so that tourists can pay to fish for them?	____	____

Fish can be grown in natural ponds and lakes, in man-made lakes (dugouts), or in buildings (hatcheries). They can be left to grow on their own, or they can be fed fishfood in underwater cages, or in above-ground plastic tanks.

For the following questions, please mark an X where ever it applies. Add any comments that you may have afterwards.

How do you feel about:

	Acceptable	Not Acceptable
Fish grown in natural ponds and lakes?	____	____
Fish grown in man-made lakes?	____	____
Fish grown (and fed) in underwater cages?	____	____
Fish grown (and fed) in above-ground tanks?	____	____

Additional comments on any of the above (use back of sheet if required):

____

____

____

Are there any other concerns or comments you may have regarding aquaculture or the study?

____

____

____

Do you feel that you have considerable knowledge and experience in some local water bodies and fish habitat, for instance, through experience as a fisherman or long-term resident of the community? Yes____ No____

If yes, may I contact you or send you a questionnaire regarding information about the Grand Rapids local water resources that is not readily available? Yes____ No____

If yes, please leave your name on the list that will be sent around at the meeting, or with a member of the Band Council, or the Mayor of Grand Rapids. A questionnaire will be distribute to you.

Thank you for your participation in this questionnaire. Your input is very much appreciated.

APPENDIX F: DOCUMENT OF CRITERIA USED FOR SITE EVALUATION

APPENDIX G: FIELD NOTES, RAW DATA RE: TECHNICAL ASSESSMENT, SITE EVALUATION

Grand Rapids Generating Station/Saskatchewan River area

Forebay

- icing over prevents cage culture; shelter is inadequate to protect cages from storms
- perhaps tank culture along shore, if room and shelter for this; however, it appears that this is not the case

Tailrace/downstream Sask. river section (between tailrace and bridge)

- the tailrace water flows at a rate that does not allow ice to form, even on the coldest days and at the lowest flow rates. However, these flow rates constitute a physical impediment to cage culture
- hatchery manager Gary Hobbs mentioned tailrace water 20°C (already), uses well water to cool (aquifer is 5°C all year)
- Cage culture
    - if flowrate is too great ,which it appears to be, plus clogging by debris, suspended and floating particles will cause drag on cages, distorting and destroying cages. Prevention measures would include daily cleaning, or at least several cleanings per week, which is labour intensive and expensive
    - according to TEK the downsteam river section (near the bridge) ices over in the winter, preventing cage culture as a bio-technically feasible option. Barring ice formation, flow rates are still too high.
    - gravity fed, lined ponds, using built up dyke to create depth (or tanks?)
    - man-made ponds, with liner - reasonably level ground required, otherwise too costly
    - soil requirements, topography needs to be evaluated, need for relatively flat land; clay soil, otherwise liner required
    - accessible quantities and qualities (i.e., clay) soil to build dyke walls that "create depth" for the pond
    - dugouts may not be feasible due to soil type and ease of excavation (limestone - excavation problems, costs are high)

Further downstream - bank along communities near mouth of L. Winnipeg

- long-term vision: perhaps a series of small, dyke-formed ponds, with capabilities to incorporate e.g., a future walleye system on an experimental basis. Starting with a single pond for a rainbow trout pilot project, with ongoing assessment of social, economic and technical aspects. If it is deemed that the operation has potential for success in all three categories of success, the project can then be expanded to include more ponds, and perhaps different species

- site would need to be relatively flat, lowland, near shoreline preferable; however, if site is not suitable, perhaps could run line through culvert past highway to site that is otherwise suitable?
- advantages may include:
  - ease of access and protection, including fencing
  - ease of management - smaller ponds easier to harvest, feed, drain/clean, etc.
  - hedging risk: eggs in different basket, chances are that if one goes wrong, not all will fail; however, this configuration would also increase the level of expertise and management requirements, thus increasing overall risk of operation failure, and initially offsetting any hedging advantage... would need to assess a smaller pilot project, go from there...

<u>Harbour Bay</u>

- boat trip with 2 council members, G. McKay and Ron Ballentine, driven by Constable Flowers, RCMP
- preliminary (i.e., rough measurements of) depths were taken in areas where indicated to be the deepest points as indicated by TEK, near centre of bay, although it appeared we were closer to the east shoreline. Measurements were taken by ropeline measurement on the drop-anchor
- results indicate harbour is too shallow for cage culture, under 10 metres. It also probably ices over - verify with TEK.

APPENDIX H: INTERVIEWS WITH EXPERTS - QUESTIONNAIRE

Pre-interview

- free-form style of interview
- assurances of contact for quotes, etc., prior to print;
    - i.e., you will be consulted prior to the use or inclusion of anything said during the interview in the study, to ensure that you are not misquoted or misinterpreted...
    - opportunity to speak "off the record" now or at any time during the interview, will not be included, simply for insight and guidance
- explain purpose, objectives of interviews with experts:
    - to gain insight into the subject matter
    - to corroborate or negate my own findings in field studies
- practicum familiarization, objectives (present now or pre-submit abstract):
    - a preliminary assessment of the feasibility of aquaculture in GR area;
    - i.e., the study is fundamentally a paper report, with a focus or bias towards bio-technical and financial aspects of various forms of systems and species applicable to aquaculture in Central Canada - objectives include a literature review that assesses regional aquaculture operations and their applicability to the Grand Rapids area, to assess community interest (see next point), a preliminary ground survey of area, identify potentially feasible operations, to reduce possibilities to a "short list", assessment of skills required and their availability for each proposed operation and to make recommendations to the community and MH, which provided funding for the study
    - in keeping with the courses and disciplines taught at the Natural Resources Institute, the study includes a socio/cultural component - community level of interest, perspectives, concerns and ongoing consultation with band councillors, fishermen, etc.

recent and current status of aquaculture industry, to

- identify what still needs to be addressed, and further research that will be required, for each scenario.

Interview

I. Background Information of Interviewee

1. Level and Area of Expertise
    - ascertain the interviewee's specific area(s) of aquaculture expertise and suitability for discussion of various topics and scenarios with respect to freshwater aquaculture in Central Canada:

1.1 Exact name and title (business card available?)

1.2 What is your specific area(s) of expertise in aquaculture (e.g. Bio/technical, Economic/Financial/Managerial, Socio-cultural)? How did you come to acquire this expertise?

2. Familiarity with the Grand Rapids area

- ascertain the interviewee's suitability for discussion of various scenarios that reflect actualities regarding potential aquaculture operations in the Grand Rapids area:

2.1 Were you previously familiar with the Grand Rapids area? If yes:

2.1.1 Type of familiarity:

- specifically, with what aspects with respect to aquaculture in the Grand Rapids area are you familiar: geo/hydrological, meteorological (climate records), bio-technical (e.g., knowledge of water bodies, terrain); anthropological, socio-cultural (e.g., ancestral history, traditional knowledge, community history); socio-economic (e.g., status/standard of living, employment conditions, levels of education/training, etc.)

2.1.2 History of familiarity:

- how did you come to this familiarity (e.g., worked on such-and-such project in such-and-such capacity; lived in or near the area; occasionally/frequently visited community members or for recreational purposes)

2.1.3 Degree of familiarity:

- to what degree do you consider this/these type(s) of familiarity(ies) (none or very limited, some familiarity, very familiar)

<u>II. Technical and Economic Characteristics of and Requirements for an Ideal Operation</u>

- ascertain what is (are) the key variable(s) to succeed, both for aquaculture in general and with respect to specific types of operations; and ascertain "where the interviewee is coming from" (bias check)

1. In general, what are the technical and economic characteristics of or requirements for a successful aquaculture operation? i.e., What is/are the key variable(s) that determine whether or not an aquaculture operation is successful?

1.1 Technical Requirements

1.2 Economic Requirements

1.3 Key Variable(s)

<u>III. Site Analysis - Proposed Operations</u>

1. Discussion of various scenarios in the Grand Rapids area

- present and discuss various scenarios (use maps and if possible, slides as required), including:

- species/product
- aquaculture vs. wild stocks
- extensive aquaculture in nearby lakes
- cage culture (e.g., in the forebay; in the Saskatchewan River after the tailrace)
- man-made dugouts along bank (e.g., behind hatchery)

- Harbour Bay enclosure
- any others brought forth during the interview

2. Present and future research
- for each scenario, ascertain what further information:
    - is required during the course of this study;
    - to be acquired in the future, as a follow up to the study
    [- compare what has been done so far to what should have been or still needs to be done - is there any essential information missing?]
    [- if yes, can this information still be attained during the course of the study, or is this information not attainable, i.e., due to time or budgetary constraints, and that would lead to (new) delimitations or caveats that need to be pointed out in the practicum; i.e., any problems with the study?]

<u>IV. Summary: Bottom Line, Best Alternatives, Requirements to Succeed</u>

a) Do you think an aquaculture operation (i.e., any scenarios presented or brought forth during the interview) is feasible in GR? [Y,N] Why or why not? (Focus on specific variable - see the following heading/examples)

<u>Heading</u>	<u>Examples</u>
Tech/bio-tech	- Sask. River too fast; climate too cold (short season - also overlap with Economic); - licensing problems - (e.g., bait fish might work, but not able to do in area) - technical expertise lacking in community, require training
Economic	- health regulations require that the proposed operation have a processing plant, imposing capital costs that render the proposed facility unfeasible) - Market not there; too competitive
Socio-cultural	- community not acceptable of certain practices - husbandry of animals; genetic manipulation of fish,...

b) - If Yes, what are the requirements for such an operation to succeed? ("Yes, as long as...")
- If No, are there factors that could change or be changed, that would make a particular operation viable? ("No, but, if such and such were to happen....")

APPENDIX I: INTERVIEWS WITH EXPERTS - SUMMARY RE: AQUACULTURE FEASIBILITY IN THE GRAND RAPIDS AREA

GOVRES1: fish physiology applied to aquatic and environmental toxicology and aquaculture; visited Grand Rapids occasionally

- RBT probably the only choice
- viability would require a community-oriented, integrated multi-active/diversified operation of sizable scale, that develops awareness, involvement and expertise in the various aspects of aquaculture; involving the province (stock rehabilitation or enhancement) and a very high-value product at the rates and times required by an export market

GOVRES2: worked and associated with GR hatchery, good familiarity with and understanding of socioeconomic status

- RBT, possibly charr if water cold enough, the only realistic considerations
- extensive aquaculture - not adequate in terms of producing a high quality product
- cage culture - water flow too fast or variable in river; winter ice barrier; Harbour Bay not deep enough or adequately sheltered
- if possible, gravity feed from reservoir offers huge advantage over many producers - production tank farm: covered in-ground tanks and drainage out to river, e.g., land behind GR hatchery; two ponds, alternate times of drainage and cleaning for continuous operation; need to assess ability to reduce waste
- buy eggs or very early fingerlings; don't have to worry about broodstock
- available consultation with specialist(s) disease control and other technical aspects - ongoing liaison with aquaculture specialists, i.e., must access and maintain network of advice and consultation
- funding - with/without capital startup costs
- identify markets - white-cloth beyond Winnipeg -Toronto reasonably close; also assess Minneapolis, Montreal - what is already available in each market; if comparable product available, e.g., premium salmon, need an advantage over these
- predictable quantity/quality product, customized to a specific (gourmet) market, i.e., high-quality, value-added (premium) product, shipped fresh; live to filleted, market within 24 hours

GOVRES3: managed aquaculture research, pilot project in marketing; involved in fisheries co-management; technical transfer; well aware of socioeconomic issues in Grand Rapids

- RBT is the obvious choice, but highly competitive market and relatively low price product; seriously consider alternatives to RBT; perhaps better to speak in terms of product - high-value export market, e.g., a smoked product, RBT or perhaps whitefish; perch butterfly fillet market in US - eggs now commercially available

- however, RBT good to get feet wet, see if you like it, can do it, learn from and gain experience
- match the technology to the objective - ideal: low-cost aquaculture and first class processing to produce a superior value-added product that meets a well-defined or "induced" market demand that is currently and expected to be under supplied
- to succeed requires high commitment from the onset and for the long haul; the company's number one interest and source of income, not simply as a "side-line"; focus on developing, optimizing the business through planning and dedication
- single season - eggs vs. fingerling - 2"-3" fingerling to market size in couple months should be no problem; however, buying, transport of these cut into profits
- raise for stocking fly-in fishing - sports club from US and Ontario - make contacts; lake would have to have no in/outflow, and be big enough to land a plane yet small enough to make stocking worthwhile; would have to be a very unique operation, that is both rustic and natural yet lavish and posh, to attract US sports clubs; nice lodging, good food, well maintained, aesthetically pleasing
- walleye the species of choice, or really big RBT; would only need a few hundred or thousand large fish, wouldn't need the hatchery; the value of these fish would be many times more than that of the grocer/restaurant market; however, it would essentially be a one-time deal, just to stock the lake - not really aquaculture, then
- area is probably too shallow for cage culture, prone to muddy flavour

GOVMGMT1: stock enhancement; consultant, fish biologist; familiar with native cultural aspects with respect to fishing (what they may and may not accept as a reasonable means of making a living)

- RBT the only consideration with respect to species/product
- if season length adequate, perhaps an extensive operation as a secondary means of income for fingerling or table export market; large-scale intensive operation involving facility/water heating not economically viable - heating, broodstock operation costs and competition prohibitive
- need for outside start-up funding
- cage culture, and perhaps gravity fed forebay water through raceway, add circulation tanks, the only possible viable independent systems
- partnership with province scenario? - produce fingerlings in hatchery, as an aside to the other provincial uses
- Socio-cultural component: dedication, commitment by all people involved required

<u>GOVMGMT2</u>: resource economist; aquaculture licensing; policy development program; familiar with general socioeconomic status of Grand Rapids, but never involved in any way

- rainbow trout or if possible, charr; but rainbow trout culture easier - hardier, more suited to culture; technology is already available, well-developed
- however, an extremely competitive industry, very difficult for small operation to succeed; need volume involving high capital/operating expenditure, e.g., large cage culture operation; however, this increases risk, required level of expertise, management skills, . . .
- Northern pond operations - problem with distance to larger markets; quality problems
- must identify, define and market high-value end-product to a well-defined, substantial market
- need entrepreneurial spirit, enthusiasm for the long haul

<u>PRIVECON1</u>: assisted in developing and organizing company with mandate: to develop viable commercial aquaculture in Manitoba pothole lakes using rainbow trout; identify impediments; never studied or visited GR

- despite the difficulties involved in a commercial aquaculture operation, it is still quite possible to be successful using rainbow trout; mid-scale operations can work
- need to access fresh market; need handling plant, to harvest over an extended season, a number of weeks to assure an adequate supply of uniform quantity/quality product, packaged in the manner the market demands; therefore, a higher investment is required than just an operation that simply grows fish
- requires entrepreneurship, dedication to the operation, deep interest beforehand; able to seek out and use technical expertise, able to listen to and understand the engineer and the various "-ologists"; competent business (accounting, management, marketing) skills
- however, the relatively high risks and the amount of energy and capital involved leads one to believe that perhaps such an operation is not as attractive as other investments; that there are other enterprises involving less risk or more profit potential

<u>PRIVECON2</u>: fisheries management; economic analysis of commercial fishery; market definition for a private aquaculture operation; well informed and associated with Grand Rapids community and the key players of the fishery

- objective a) economic/commercial, requiring product volume - intensive, industrial therefore precludes extensive operation:
    - rainbow trout: if steady supply, high quality; need to out compete to large grocer export markets; however, low water temp. = low growth/conversion; alternative heating costs prohibitively high

  - need to assess economics of raceway operation
  - investor funding, convincing business plan that demonstrates an adequate return on investment; commitment; product/market definition and management, economic scale
- objective b) R&D, mitigation - to investigate technological feasibility of sturgeon restocking program and walleye; however, doubt if Manitoba Hydro interested in R&D, looking for more practical applications (objective a)
- regardless of objective, need community involvement, negotiation, commitment
- Q: what does government plan to do with hatchery; how to turn hatchery into asset from liability, what role can hatchery play, e.g., perhaps province can turn hatchery over to LGD Grand Rapids, MH continue paying costs over a certain period, e.g., 10 years, while paying it off; but would need to assess viability of such a move, have a good business plan in place, sufficient technical expertise, labour in place [Not a viable solution, according to another GOVMGMT, but perhaps a partnership of a sort is possible; would need to discuss further with all stakeholders. . . .]

<u>Codes</u>

GOVRES#	government agency employee; research scientist background with at least 15 years experience in aquaculture field
GOVMGMT#	government agency employee; natural resources management or bio-economist background with at least 6 years experience in aquaculture or fisheries management field
PRIVECON#	private company employee; aquaculture economist or bio-economist background with at least 9 years experience