THE CUMULATIVE ENVIRONMENTAL EFFECTS OF PROPOSED SMALL-SCALE HYDROELECTRIC DEVELOPMENTS IN NEWFOUNDLAND, CANADA

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By

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ABSTRACT

One of the most important issues in the field of contemporary Environmental Impact Assessment (EIA) is that of cumulative environmental effects. Despite widespread recognition of the need to assess and manage such effects, however, Cumulative Effects Assessments (CEAs) are not being widely undertaken. This can been attributed to the failure of the EIA process, as traditionally practised, to incorporate CEA, as well as a lack of suitable methodologies which actually facilitate it.

Since 1990 there has been increased interest in the development of small-scale hydroelectric facilities by the private sector in Newfoundland. While, in most cases, proposed hydro developments in Newfoundland are individually subject to environmental assessments, the current provincial EIA process does not allow for the consideration of cumulative effects. Consequently, there has been no assessment of the overall impact of this set of projects as a whole.

This study used expert opinion to assess the potential cumulative effects of eight proposed small hydro projects in insular Newfoundland on a set of eight Valued Environmental Components (VECs) - Water Resources; Fish Resources; Raptors; Waterfowl/Migratory Birds; Caribou; Moose; Furbearers/Small Mammals; and Historic Resources. This was done through the use of a modified Delphi procedure. The potential effects of each project/VEC combination were rated by 40 expert

panellists according to a set of impact evaluation criteria (i.e. impact probability; magnitude; spatial extent; temporal duration; VEC importance; and the current/pre-project state of the VEC). Taken together, these values comprised a numerical "Impact Score" for each project/VEC combination. An Impact Summation Matrix was then used to calculate an "Index of Cumulative Effect" which represented the potential overall effect of the set of projects on each of the VECs under consideration. The results of the study are discussed, as well as the implications of the proposed methodology for environmental management and resource planning.

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DEDICATION

This thesis is dedicated to the memory of my father, the late James R. Bonnell, who taught me countless lessons that were invaluable to its successful completion, including: to love and respect the natural world; to possess a strong work ethic; and to always see things through.

Thanks Dad. God bless you

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LIST OF ACRONYMS AND ABBREVIATIONS

CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Act
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Canadian Department of Fisheries and Oceans
EA Act	The Newfoundland Environmental Assessment Act (1980)
EARP	Canadian Environmental Assessment and Review Process
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPR	Environmental Preview Report
GWh	Gigawatt hour
Hydro	Newfoundland and Labrador Hydro
kW	Kilowatt
MW	Megawatt
NDEL	Newfoundland Department of Environment and Labour
NEPA	United States National Environmental Policy Act
PUB	Newfoundland Public Utilities Board
RFP	Request For Proposals
SEA	Strategic Environmental Assessment
VEC	Valued Environmental Component

Chapter One
INTRODUCTION

1.1 ENVIRONMENTAL IMPACT ASSESSMENT: A BACKGROUND

Growing recognition of the potential biophysical and socioeconomic impacts of resource development activities, and widespread realization that these effects must be addressed in the planning and management phases of such actions, led to the development of the Environmental Impact Assessment (EIA) process, and has prompted the passage of EIA legislation in numerous jurisdictions. In principle, EIA is a systematic process through which the potential environmental effects of proposed development activities are identified and addressed in the decision-making process. The Canadian Environmental Assessment Research Council (CEARC, 1988a: 1) defined EIA as:

> A process which attempts to identify and predict the impacts of legislative proposals, programs, projects and operational procedures on the biophysical environment and on human health and well-being. It also interprets and communicates information about these impacts and investigates and proposes means for their management.

The passage of the *National Environmental Policy Act* (NEPA) in 1969 in the United States is generally considered to be the starting point for formalized and legislative EIA, with many countries following suit soon after. In Canada, for example, the *Environmental Assessment and Review Process* (EARP) was established by a decision of Cabinet on December 20, 1973, and the process was later modified by a subsequent Cabinet decision on February 15, 1977. On June 22, 1984 the

Environmental Assessment and Review Process Guidelines Order-in-Council was proclaimed, which outlined and clarified the various roles, responsibilities and procedures of EARP (Couch, 1989). Efforts to reform EARP subsequently resulted in the passage of the *Canadian Environmental Assessment Act* (CEAA) in 1992 and its proclamation in January of 1995.

In the nearly 30 years since the introduction of formalized and legislative EIA, the process has evolved into one of the most prevalent forms of environmental decision-making today. This evolution is evident with regard to both increasing applications of the principles of EIA on a global scale, as well as within the process itself in terms of focus and technique. At present, EIA is a legislative requirement in 39 countries (Gilpin, 1995), and is being employed, to varying degrees, through development assistance agencies in nearly all of the remaining countries of the world (Warner, 1996). Within these jurisdictions, EIA is being applied to an ever-increasingly wide and varied range of developments (McDonald and Brown, 1995). The nature of the process itself has also evolved considerably since its inception in the early 1970s. For example, early applications of the EIA process focused almost exclusively upon the documentation of the potential biophysical impacts of individual development projects, with the primary emphasis being on the integration of environmental concerns into project design and impact mitigation. At present, however, there is increased emphasis on, for example: multidimensional EIAs which incorporate biophysical, socioeconomic and cultural issues and their potential interactions; better links between EIA and the overall resource management and planning processes; more effective public participation; the consideration of environmental effects after project implementation (i.e. post-project monitoring and auditing); and the assessment, evaluation and management of cumulative environmental effects.

One of the most important issues in the field of contemporary EIA is that of cumulative environmental change. The concept of cumulative effects is based upon the premise that the individual impacts of single, independent actions are not necessarily mutually exclusive of each other, but may accumulate in environmental systems to bring about significant environmental change. Thus, while the potential environmental impacts of a single development project may be deemed negligible, the overall effect of a series of independent projects (be they past, present or future actions) may be cumulatively significant. Accordingly, there is a growing awareness of, and interest in, the assessment and management of the potential cumulative effects of multiple development activities on a regional scale.

Despite widespread recognition of the need to address cumulative environmental change, however, comprehensive attempts at cumulative effects assessment (CEA) have been limited. This has been attributed to various analytical and administrative factors, perhaps the most significant of which are a profound lack of practical and effective CEA methodologies, as well as the apparent incapability of the EIA process, as traditionally practised, to incorporate CEA. Consequently, little attention has been given to the overall, cumulative effects of multiple, independent developments on one or more environmental components.

1.2 RATIONALE AND OBJECTIVE

Since 1990, there has been increased interest in the development of small-scale hydroelectric facilities by the private sector on the Island portion of the province of Newfoundland (the eastern-most province of Canada). The development of a hydroelectric facility is typically viewed as a single, discontinuous activity occurring within a limited spatial and temporal scale (Spaling, 1994), and in the case of small-scale hydro, often regarded as having the potential for relatively insignificant environmental impacts. However, small hydro development is a potential source of cumulative environmental change when it is (as in the case of insular Newfoundland) characterized by multiple developments within a region. Also, the potential impacts of a small hydro facility may accumulate with the effects of other past, present or future developments in an area (e.g. timber harvesting, mineral developments, etc.), such that significant cumulative effects may result. Thus, the potential environmental impacts of small hydro development must be assessed with regard to the effects (and potential effects) of other related and unrelated activities, rather than focusing exclusively upon the individual, immediate impacts of single proposals.

While, in most cases, proposed hydro developments in Newfoundland are individually subject to environmental assessments, there has been no consideration given to the potential, overall effect of this set of projects as a whole. It is the absence of the consideration of such cumulative effects that forms the rationale for the research described here.

It is, therefore, the purpose of this study to assess the potential cumulative environmental effects of proposed small-scale hydroelectric developments in Newfoundland. More specifically, it is an attempt to overcome those factors which have traditionally constrained CEA, through the development of a practical and effective CEA methodology, and the application of this technique in an attempt to overcome the shortcomings of the province's project-driven EIA process in the context of cumulative effects.

1.3 THESIS STRUCTURE

Following this Introduction, Chapter Two sets the context for the research by giving an overview of existing and proposed hydroelectric developments in Newfoundland and Labrador, as well as a description of the Newfoundland EIA process with particular reference to the assessment of hydroelectric proposals. Chapter Three is a literature review, introducing the conceptual basis of cumulative effects and CEA. It also reviews a range of existing CEA approaches and techniques, and examines the legislative basis for, and the state-of-the-art of, CEA. Finally, the chapter discusses the analytical and administrative impediments which have traditionally constrained the effective consideration of cumulative effects. Chapter

Four outlines the methodological requirements of this study and evaluates existing CEA methods in light of these specifications. It goes on to describe the CEA methodology developed and utilized in the assessment, and gives a step-by-step account of the data collection process. Chapter Five presents and discusses these results. Chapter Six evaluates the strengths and potential limitations of the proposed CEA technique. The implications for, and applicability of, the methodology and the resulting data to the consideration of cumulative effects in the resource management and planning processes are also discussed. The Chapter also presents a framework and set of recommendations for the implementation of CEA, and the thesis concludes with a further discussion of the perceived need for CEA in Newfoundland.

Chapter Two
EXISTING AND PROPOSED HYDROELECTRIC DEVELOPMENTS IN NEWFOUNDLAND AND LABRADOR

2.1 INTRODUCTION

Hydropower has had a long and rich history in Newfoundland and Labrador, and has played an integral role in the province's economic and industrial development. The first recorded hydroelectric facility in the province was established at Black River, Placentia Bay in 1898 by the Newfoundland Pulp Company (Budgell, 1993). The 5.25 megawatt (MW) Petty Harbour project, completed in 1908 by the St. John's Street Railway Company, is the oldest hydro facility currently in operation in the province. Hydroelectricity was first generated on a large scale in the early 1900s by two pulp and paper companies for their own consumption - at Grand Falls on the Exploits River and at Deer Lake on the Humber River. During the first six decades of this century, privately owned and operated small-scale hydro plants generated almost all of the electricity generated for domestic use on the Island (Baker et al., 1990). By the early 1960s there were some six private companies responsible for the generation and distribution of electricity, each of which operated in isolation from the others (Templeton and Reid, 1975).

In 1954 the Provincial Government established a public power authority known as The Newfoundland Power Commission which, in the mid-1960s, began construction of the large Bay d'Espoir hydro project on the Island's south coast, as well as a trans-Island transmission grid to interconnect this facility with the existing generating sources on the Island. The purpose of this integrated Island grid was to supply power at low rates to large, power-intensive industries, as well as at a uniform rate to the separate private companies which were operating on the Island (Templeton and Reid, 1975). In September 1966, these private utilities were amalgamated to form the Newfoundland Light and Power Company Ltd. (currently known as Newfoundland Power).

Section 15 of the *Newfoundland and Labrador Hydro Act* (1975) gives the crown corporation Newfoundland and Labrador Hydro (Hydro) (formerly the Newfoundland Power Commission) the sole and exclusive right and franchise to develop, generate and sell all power from any new hydroelectric site on the Island, subject to the existing rights of a few companies (Hydroelectric rights in Labrador, with the exception of the Churchill River, are still vested with the provincial government). Hydro's primary responsibility is the generation and transmission of bulk electrical power, and its supply to private utilities and large industrial customers throughout the province. Newfoundland Power's primary role is as a distributor of power, and the utility is therefore responsible for supplying electricity to the general public. There are, however, overlaps in both cases, as Newfoundland Power generates approximately 15 percent of the power it distributes, and Hydro distributes electricity directly to some rural areas, primarily on the Island's Northern Peninsula and south coast (Kerr, 1996a pers comm).

2.2 EXISTING HYDROELECTRIC FACILITIES IN THE PROVINCE

Within the province, Hydro owns and operates two interconnected power systems, one on the Island and the other in Labrador. The Island Interconnected System connects Hydro's generation facilities and those of Hydro's customers (primarily Newfoundland Power, Deer Lake Power and Abitibi-Price) to major load centres across the Island. The installed generating capacity of the Island Interconnected System is approximately 1,885 MW, of which approximately 62 percent is hydropower and 38 percent is thermal. The installed capacity of the Labrador Interconnected System is approximately 5,473 MW, of which the 5,428 MW hydroelectric facility at Churchill Falls comprises approximately 99 percent. Hydro also operates 31 isolated rural generation and distribution systems, totalling approximately 49,281 kilowatts (kW) in capacity (14 on the Island (30,716 kW) and 17 in coastal Labrador (18,565 kW)) (Budgell, 1993).

There are presently 39 hydroelectric facilities in the Province (Table 2.1), with a gross power generating capacity of approximately 6,856 MW. Table 2.1 also serves as the legend for Figure 2.1, which illustrates the spatial distribution of these developments. Thirty-five hydro facilities exist on the Island, with a total installed capacity of 1,184 MW (or 17 percent of the provincial total). These range in size from 0.35 MW (Newfoundland Power's Fall Pond plant) to 604 MW (Hydro's Bay D'Espoir facility). Of the 35 hydro facilities on the Island, 22 are owned by Newfoundland Power (87 MW), 8 by Hydro (899 MW), 3 by Abitibi-Price (63.5

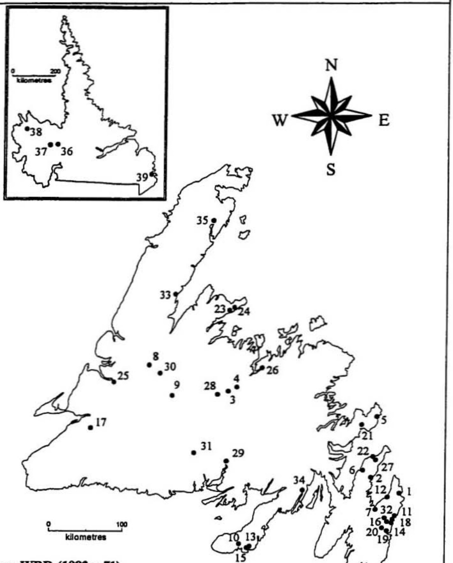
TABLE 2.1
EXISTING HYDROELECTRIC FACILITIES IN THE PROVINCE

Facility	Owner	Year Completed	Installed Capacity
Island of Newfoundland			
1) Petty Harbour	NF Power	1908	5.25
2) Victoria	NF Power	1914	0.45
3) Grand Falls	Abitibi-Price	1909	44.50
4) Bishop's Falls	Abitibi-Price	1909	17.20
5) Port Union	NF Power	1918	0.51
6) Hearts Content	NF Power	1917	2.65
7) Seal Cove	NF Power	1924	3.18
8) Deer Lake	Deer Lake Power	1925	124.65
9) Buchans (ASARCO)	Abitibi-Price	1927	1.80
10) Lawn	NF Power	1930	0.63
11) Pierres Brook	NF Power	1931	4.00
12) Topsail	NF Power	1932	2.34
13) Fall Pond	NF Power	1939	0.35
14) Tors Cove	NF Power	1942	6.75
15) West Brook	NF Power	1942	0.76
16) Rocky Pond	NF Power	1943	3.10
17) Lookout Brook	NF Power	1958	5.55
18) Mobile	NF Power	1951	11.97
19) Cape Broyle	NF Power	1952	6.40
20) Horse Chops	NF Power	1957	7.60
21) Lockston	NF Power	1955	3.00
22) New Chelsea	NF Power	1957	3.75

TABLE 2.1 (Continued) EXISTING HYDROELECTRIC FACILITIES IN THE PROVINCE			
Facility	**Owner**	**Year Completed**	**Installed Capacity**
23) Snooks Arm	Hydro	1957	0.56
24) Venam's Bight	Hydro	1957	0.36
25) Watson's Brook	Deer Lake Power	1958	9.20
26) Rattling Brook	NF Power	1958	11.50
27) Pitmans Pond	NF Power	1959	0.61
28) Sandy Brook	NF Power	1963	5.70
29) Bay D'Espoir	Hydro	1967	604.00
30) Hinds Lake	Hydro	1980	75.00
31) Upper Salmon	Hydro	1982	84.00
32) Morris	NF Power	1983	1.14
33) Cat Arm	Hydro	1985	127.00
34) Paradise River	Hydro	1989	8.00
35) Marble Brook	Hydro	1980	0.40
Labrador			
36) Churchill Falls	Churchill Falls Corp.	1971	5428.00
37) Twin Falls	Twin Falls Corp.	MOTHBALLED	225.00
38) Menihek	Iron Ore Company of Canada	1954	18.70
39) White Rock Falls/ Mary's Harbour	Mary's Harbour Hydro	1987	0.135

Source: WRD (1992a)

FIGURE 2.1: EXISTING HYDROELECTRIC FACILITIES IN NEWFOUNDLAND AND LABRADOR



After: WRD (1992a: 71)

MW) and 2 by Deer Lake Power (134 MW). Four hydro plants are located in Labrador, with a total installed capacity of approximately 5,672 MW (or 83 percent of the provincial total). These range in size from 0.135 MW (the White Rock Falls/Mary's Harbour plant) to 5,428 MW (Churchill Falls).

Budgell (1993: 27) defines small-scale hydro facilities as those "having an installed capacity of less than or equal to 15 MW". While only one small hydro plant exists in Labrador (i.e. Mary's Harbour), 28 of the Island's 35 hydro plants may be classified as small-scale, with these facilities having a combined generating capacity of approximately 108 MW. Of these 28 facilities, Newfoundland Power owns 22 (87 MW), Hydro owns four (9.3 MW), and Deer Lake Power and Abitibi-Price each own one (9.2 MW and 1.8 MW, respectively). At present, small-scale hydro accounts for approximately nine percent of the Island's hydropower generation, and 5.7 percent of the Island's total installed generating capacity.

2.3 PROPOSED HYDROELECTRIC DEVELOPMENTS IN NEWFOUNDLAND

Newfoundland has tremendous hydroelectric power generation potential due to its rugged terrain, abundant and evenly distributed precipitation, and consequently large water flows (WRD, 1992a). Although nearly all of the economically feasible large-scale hydro sites on the Island have been developed, small-scale hydro is regarded as "the most readily available source of additional electric power for the island grid system" (NDNR, 1995: 12). A comprehensive inventory carried out for

Hydro (Shawmont, 1986) identified approximately 160 as yet undeveloped, potentially viable small hydro sites on the Island. The total generating potential of these sites was estimated at over 1,000 MW, with most individual sites having capacities of less than 10 MW.

In April of 1990, Hydro announced a new policy direction concerning small-scale hydro development in Newfoundland. The policy change stated that, under certain conditions, Hydro was willing to relinquish its franchise right on undeveloped hydro sites of 10 MW or less operating at 60 percent generating capacity. Hydro also indicated its willingness to purchase the output from these facilities on a long-term contractual basis, provided that the cost of the power is not above that of Hydro's other alternatives. Private sector development of sites over 10 MW would also be considered, provided that Hydro itself did not intend to develop the site over a reasonable period of time. This policy change was intended to provide opportunities for private sector investment in the province's energy sector. This is in keeping with the Province's ***Strategic Economic Plan*** of 1992 (Government of Newfoundland and Labrador, 1992); Action 87 of the plan states that:

> The Province will put in place policies to maximize electricity generated from small hydro developments as a means of increasing economic development and reducing dependence on imported oil (p. 53).

It was also necessary that appropriate amendments be made to the Public Utilities Board's (PUB) legislation. Under the Newfoundland *Public Utilities Act*

(1989), developers with projects larger than one MW are treated as public utilities, and thus, their rates are set, or at least must be approved, by the PUB. This was identified as a potential constraint to private sector investment in small hydro development because, as a result of this legislation, the PUB had the authority to question, and possibly reset, the rate agreed upon by the developer and Hydro (Acres, 1990). Accordingly, in April 1992, the Act was amended to exclude jurisdiction over independent power producers whose installed generating at any one site was 15 MW or less, provided that the power was sold to a regulated utility. This allowed Hydro to access the resulting energy directly through the public tendering process.

In order to implement its new small hydro policy, Hydro commenced a process of issuing waivers for undeveloped small hydro sites on a "first come - first served" basis. The following guidelines were applied in issuing waivers (WRD, 1992b; Budgell, 1993):

1) The sites must have a generation capacity of 10 MW or less at 60 percent generating capacity;

2) Waivers were given only for sites which Hydro has no interest in future development;

3) Waivers were given only on a site basis, and not for an entire river or stream;

4) Each developer was permitted to hold waivers to only three sites at a time;

5) The developer must, within six months, register the proposed development with the Environmental Assessment Division, and must file an application to obtain a Preliminary Water Use Authorization from the Department of Environment;

6) The developer must file the appropriate applications for Water Use Authorization within one year of the receipt of the Preliminary Water Use Authorization; and

7) Hydro can revoke the waiver if the proposed development is found to be of greater than 10 MW at 60 percent generating capacity, with the developer being compensated for reasonable expenses incurred in its investigation of the site.

As a result of this process, a total of 36 waivers were issued to 16 individuals or companies (Table 2.2) (Budgell, 1993; Boone, 1996 pers comm; LeDrew, 1996 pers comm). For a limited number of small hydro sites, such as Star Lake in west-central Newfoundland, proponents did not require Hydro's waiver as they already possessed the water rights under previous Government grants and agreements. Also, since January 19, 1996, due to Bill 35 (which amended the Newfoundland and Labrador Hydro Act (1975) and other relevant legislation) Hydro no longer has the franchise right to all undeveloped and previously ungranted hydro sites on the Island. The development of these sites by the private sector is, however, still dependent upon the negotiation and procurement of power contracts with Hydro or another power utility (Boone, 1996 pers comm).

In some cases, projects were shelved indefinitely by their proponents soon after being released by Hydro on the basis of technical, economic or environmental feasibility. For example, Newfoundland Power was issued a waiver for the Gull Pond small hydro site on the Baie Verte Peninsula, but site visits and more detailed preliminary engineering studies indicated that the project would not provide the

TABLE 2.2
WAIVERS ISSUED FOR SMALL-SCALE HYDROELECTRIC SITES

Developer	Site	Capacity (kW)
Algonquin Power Corp.	Great Coney Arm River	4,000
Algonquin Power Corp.	D'Espoir Brook	5,000
Algonquin Power Corp.	Bottom Brook (with Diversion)	5,000
Penney Hydro Inc.	Garia Bay (Northwest Brook)	15,000
Penney Hydro Inc.	Piper's Hole River	10,000
Penney Hydro Inc.	Southwest Brook	5,100
Frontier Hydro Ltd.	Southwest River	6,000
Frontier Hydro Ltd.	Sandy Harbour River (Site 1)	5,900
Emery Construction Ltd.	Northwest Arm Brook (Site 3)	14,500
Emery Construction Ltd.	Little Harbour River	4,300
Paris & Associates Corp.	Great Cat Arm River (Site 1)	5,100
Paris & Associates Corp.	Torrent River (Site 1C)	12,000
Paris & Associates Corp.	Torrent River (Site 4)	6,000
10165 Nfld. Ltd.	George's Pond	205
10165 Nfld. Ltd.	Western Tickle	150-220
10165 Nfld. Ltd.	Lush's Pond	350
H.J. O'Connell Constr. Ltd.	Black River	3,200
H.J. O'Connell Constr. Ltd.	Parson's Pond	7,600-9,600
Hydropower Resources Inc.	Nipper's Harbour	600
Hydropower Resources Inc.	Little Coney Arm River	600
Hydropower Resources Inc.	Eastern Brook	500

TABLE 2.2 (Continued)
WAIVERS ISSUED FOR SMALL-SCALE HYDROELECTRIC SITES

Developer	Site	Capacity (kW)
NF Power	Rose Blanche Brook	2,000-3,600
NF Power	Maccles River	3,800
NF Power	Gull Pond	1,100
Hydro Resource Developments Inc.	Castor's River (Site 2)	3,200
Hydro Resource Developments Inc.	Eel Brook	777
Hydro Resource Developments Inc.	Rattling Pond Brook	540
Belle Island Power Corp.	Northwest River (Clode Sound)	6,900
BFL Consultants Ltd.	Tickle Pond/Random Island	204
Trinity Resources & Energy Inc.	Lady Pond/Hickman's Harbour Brook	526
Genoa Engineering Ltd.	Brock's Head Pond	285
Rev. John Roberts	Middle Arm Brook (Site 1)	4,400
Rev. John Roberts	Middle Arm Brook (Site 2)	3,700
Rev. John Roberts	Middle Arm Brook (Site 3)	2,000
ESI Power Corp.	Dry Pond Brook	8,739
ESI Power Corp.	King's Harbour River	7,210

Source: LeDrew (1996 pers comm).

average annual energy output originally estimated. In addition, Newfoundland Power's proposed four MW Maccles Lake project was also cancelled soon after the company was granted a waiver for the site because of strong opposition from the many cabin owners in the area (Kerr, 1996a pers comm).

Hydro regularly prepares long-term forecasts in order to establish future energy supply requirements. In anticipation of projected energy deficits in the late 1990s, Hydro issued a *Request for Proposals* (RFP) in April of 1992 for the purchase of up to 50 MW of power from privately owned and operated small-scale hydro sites. Projects were to come into service no earlier than October 1996 or later than December, 1997. Hydro then initiated a series of screening processes to determine which small hydro sites were to be developed. In November 1992, preliminary submissions were received for 31 potential projects (totalling approximately 155 MW in capacity) from 16 individuals or companies (Figure 2.2). In August of 1993, Hydro received final project proposals from 11 proponents for 11 of these 31 sites: Garia Bay (Northwest Brook); Kings Harbour River; Lady Pond; Northwest Arm Brook (Connoire Bay); Northwest River; Rattle Brook; Rattling Pond Brook; Sheffield Lake; Southwest River; Star Lake; and Torrent River (Site 1C) (these projects are shown in bold italics in Figure 2.2). Proponents were advised in January 1993 that Hydro would not be prepared to commence power purchases until late 1997.

In December 1993, after an internal review of these submissions, as well as an examination of grid interconnection requirements and project supply rates, Hydro

FIGURE 2.2: PROPOSED SMALL-SCALE HYDROELECTRIC SITES IN NEWFOUNDLAND

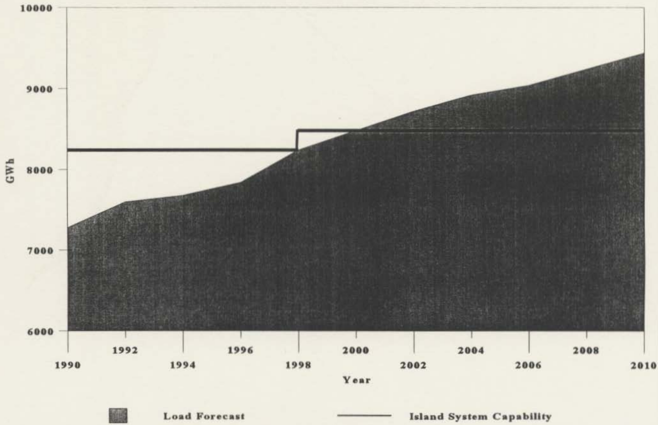
After: Budgell (1993: 41)

announced that four projects - Rattle Brook, Northwest River, Southwest River and Star Lake - (with a total capacity of approximately 38 MW) were selected for development, with a final decision to be made in June 1994 pending a further review of load requirements. In June 1994 the four proponents were advised that Hydro was prepared to sign power contracts, with projects to come into service in the Fall of 1998, subject to environmental approvals (NDNR, 1995; Boone, 1996 pers comm). In addition to these four, Newfoundland Power is also currently proceeding with the development of a 5.5 MW facility on Rose Blanche Brook.

On the basis of the most recently released forecast (July, 1994), additional generation capacity will be required by the year 2000 (Figure 2.3). Forecasting is essentially an ongoing activity at Hydro, but there has not been a practice of regularly releasing these forecasts (Bazeley, 1996 pers comm). As a result, because this forecast was complied in 1994, it does not reflect the approximately 180 MW which will be required for the proposed Voisey's Bay smelter and refinery, to be located in the Placentia Bay area of the Island (Jacques Whitford Environment, 1997). On January 17, 1997 Hydro responded to this projected deficit by issuing a second RFP for the supply of approximately 200 MW of additional energy by June of the year 2000. This RFP was, however, not restricted to small hydro developments, but included other energy options as well. In February 1997, a total of 23 *preliminary expressions of interest* were received by Hydro from 13 proponents, including proposals for thermal and wind power, as well as large and small-scale hydroelectric

FIGURE 2.3: ISLAND SYSTEM CAPABILITY vs. LOAD FORECAST (1990-2010)

(Including 38 MW from Small-Scale Hydro Developments in 1998)



Source: Newfoundland and Labrador Hydro and Newfoundland Department of Mines and Energy. (July, 1994) developments. On April 11, 1997 Hydro received final project proposals for 12 of these developments, and is also considering three of its own projects: a 170 MW Combined Cycle Generating Unit at the Holyrood Thermal Station (located in the Island's Conception Bay area), as well as the 36 MW Island Pond and 42 MW Granite Canal hydroelectric sites (both located in the south-central portion of the Island). As of September 1, 1997, no decision had been made regarding which of these projects are to be developed, and even information concerning which particular projects are being considered by Hydro is kept confidential (Boone, 1997 pers comm). Project proposals in relation to both of these RFPs are currently at varying stages of the province's EIA process.

2.4 THE NEWFOUNDLAND ENVIRONMENTAL ASSESSMENT PROCESS

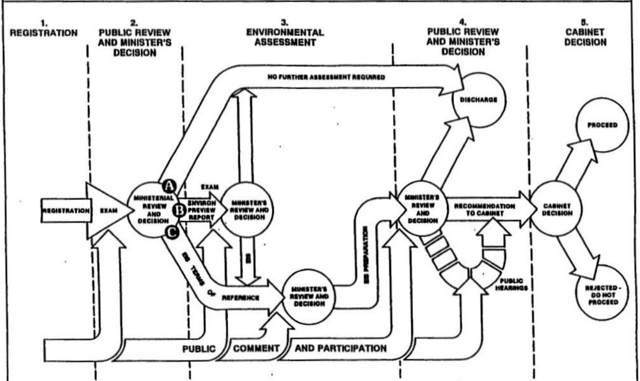
EIA is formally legislated in each of the ten Canadian provinces and in the Northwest Territories (Doyle and Sadler, 1996). In Newfoundland and Labrador, EIA legislation has taken the form of the *Newfoundland Environmental Assessment Act* (EA Act), which was passed in May 1980 and became law in November of that year. The EA Act is implemented through the *Environmental Assessment Regulations* (1984), and falls within the jurisdiction of the province's Department of Environment and Labour (NDEL), with the Department's Environmental Assessment Division coordinating the EIA process. The EA Act requires that any project which may have a significant impact upon the environment be registered with the NDEL for examination before it is allowed to proceed. No such project can be approved by any other provincial or municipal authority until it has been approved by the Department. Actions which are subject to registration under the EA Act are referred to as *undertakings*. An undertaking is defined as "any enterprise, activity, project, structure, work, policy, proposal, plan or program, that may, in the opinion of the Minister [of Environment], have a significant environmental impact..." Such activities also include the modification, extension, abandonment, demolition or rehabilitation of undertakings.

Figure 2.4 illustrates the major steps in the Newfoundland EIA process, which are summarized below (NDOE, undated):

1) **Registration**: All projects likely to have a significant impact on the environment must be registered under the EA Act. The Environmental Assessment Regulations (1984) outline the projects for which registration is required.

2) **Examination:** Within 10 days of a project's registration, the Minister of Environment must publicly announce receipt of the registration document and offer to make it available to interested members of the public. Comments on the proposal must be received within a 30 day period. Concurrently, the registration is examined by various governmental departments and agencies for examination and comment, and a recommendation is made to the Minister.

FIGURE 2.4: THE NEWFOUNDLAND EIA PROCESS



After: NDOE (undated: 18-19).

3) Minister's Decision: Within 45 days of having received the registration, the Minister must advise the proponent of his/her decision on the proposal. This decision can take one of three forms:

i) *Proceed*: The undertaking is released from further environmental review under the EA Act. The project may proceed, subject to other applicable regulatory requirements.

ii) *An Environmental Preview Report (EPR) is required*: If the review of the registration document indicates that there is insufficient information to determine the need for further assessment, the proponent may be ordered to prepare and submit an EPR. This document would contain more detailed information about the project and estimate its potential environmental effects based upon readily available information. Guidelines to assist the proponent in preparing the EPR are issued by the Minister, and outline the specific issues and concerns to be addressed in the EPR. Draft guidelines are prepared for the Minister by an interdepartmental Environmental Assessment Committee of governmental officials that is established specifically to review the proposed project.

iii) *An Environmental Impact Statement (EIS) is required*: If an examination of the initial registration document indicates that the undertaking may result in significant environmental impacts, the proponent may be ordered to prepare and submit an EIS. As in the case of an EPR, the Minister provides guidelines for the preparation of the EIS through an interdepartmental Environmental Assessment Committee. In the case of an EIS, however, the proponent must submit detailed Terms of Reference for the EIS (based upon the approved guidelines) for the Minister's approval. This is subject to a 45 day governmental review (including a 35 day public review), similar to the original registration document. Where Component Studies are necessary to the preparation of the EIS, separate draft Terms of Reference must be prepared and submitted to the Minister for review. The EIS itself is intended to provide: a) a detailed description of the undertaking; b) a comprehensive assessment and statement of the need for the undertaking in terms of present and future demand; c) a description of the existing environment potentially at risk; d) alternatives to and within the undertaking; e) a discussion of the potential environmental impacts of the undertaking; f) mitigative measures which will be implemented to minimize adverse effects; g) a discussion of the residual impacts likely to be caused by the undertaking; h) details of a public information program; and i) details of a proposed environmental monitoring program.

The Minister must announce his decision publicly within 10 days of having advised the proponent. Between 1980 and 1994 a total of 537 undertakings were registered under the EA Act, of which 423 (78.8 percent) were subsequently released, 43 (eight percent) required an EPR, 52 (9.7 percent) required an EIS and 19 (3.5 percent) were subsequently withdrawn (Kaufhold, 1995 pers comm).

4) Proponent's Action: The Minister's decision determines one of three actions to be taken by the proponent:

i) If the project is released, the proponent seeks approval for the project from other regulatory authorities. The Minister's decision under the EA Act does not replace or override required permits or licences from other municipal, provincial or federal agencies. Pending such approval, the project is permitted to proceed.

ii) An EPR is prepared.

iii) An EIS is prepared.

5) EPR/EIS Review and Decision: Upon completion of the EPR or EIS, the proponent forwards it to the Minister, who publicly announces its receipt within 10 days and makes copies of it available to interested members of the public for review and comment. The Environmental Assessment Committee also examines the EPR or EIS and makes a recommendation to the Minister as to whether or not the document is acceptable according to the requirements outlined in the guidelines or Terms of

Reference. Once an EPR is accepted by the Minister, a decision regarding whether to release the project or require the proponent to prepare and submit an EIS is made. When an EIS is accepted by the Minister, he/she submits it to Cabinet for consideration, along with a recommendation of whether or not the undertaking should be allowed to proceed. If strong public interest or concern over the undertaking is evident, the Minister may request Cabinet to appoint an Environmental Assessment Board to hold formal public hearings on the EIS. If this occurs, and upon subsequent receipt of a formal report from the Environmental Assessment Board, the Minister makes a final recommendation to Cabinet regarding the undertaking in question. A final decision regarding the acceptance or rejection of the undertaking (with or without conditions) is made by Cabinet. When discharged by the Minister of Environment, the proponent may seek approval for the undertaking, subject to the requirements of other Acts, regulations, licences or permits at all levels of government.

Newfoundland and Labrador's EIA process is currently under review. The process has been criticized for being too closed and rigid, as well as for being excessively time-consuming and costly to undertake (Storey, 1987; LeDrew, 1989). In response to these perceived shortcomings, in 1993 the provincial Department of Environment initiated a review of the Newfoundland EIA process in consultation with private sector representatives, governmental departments and agencies and environmental stakeholders. The result was a series of proposed reforms to the process (NDOE, 1995) which represented an attempt to make it more streamlined and efficient. These included amendments to the EA Act and regulations and improvements in the administration of the process, as well as attempts to make the process more supportive and facilitative for proponents, and more open and accessible to the public. The proposed reforms were subsequently subject to a public and governmental review, but to date no action has been taken with regard to their implementation.

2.5 THE ASSESSMENT OF HYDROELECTRIC PROPOSALS

The EA Act requires that, under certain conditions, proposed hydro facilities must be reviewed through the EIA process. Schedule 1, Item 412(C) of the Environmental Assessment Regulations (1984) states that the following actions must be registered:

Hydroelectric Power Plants and Related Structures

(1) Construction of dams and associated reservoirs, where:
(a) the area to be flooded is greater that 500 hectares, or
(b) any area to be flooded is located within a Special Area as defined in Schedule 2

(2) Excavation of reservoirs where:
(a) the area to be flooded is greater that 50 hectares, or
(b) any area to be flooded is located within a Special Area as defined in Schedule 2

(3) Inter- or intra-basin water transfers

(4) Construction of hydroelectric power developments, where:
(a) the capacity is greater than one mega watt, or
(b) any portion of the development is located within a Special Area as defined in Schedule 2

As of September 1, 1997 a total of 43 hydroelectric proposals had been registered (or re-registered) under the EA Act (Table 2.3). Of these, 10 (23.3 percent) were released with no requirement for further environmental assessment, six (14 percent) required an EPR, 24 (55.8 percent) required an EIS, two (4.7 percent) were withdrawn by the proponent, and the decision regarding the need for further assessment was pending for one project as of September 1, 1997. The table also indicates the status of the environmental assessments for each of these projects, and where projects have been released from the process, the status of these projects is given (i.e. operational, under construction, on-hold). The assessments of 10 hydro projects were active as of September 1, 1997, and these proposals were at varying stages of the EIA process. Of the 16 projects which had been released or approved, 12 (75 percent) were operational or under construction (or construction was scheduled to begin by the end of 1997).

The data also illustrate the increased interest in the development of small-scale hydro facilities by the private sector in Newfoundland since 1990. Prior to 1990, Hydro was the proponent of 13 of the 14 (92.9 percent) hydro projects registered under the EA Act, the only exception being Mary's Harbour Hydro's 0.135 MW

TABLE 2.3
HYDROELECTRIC PROPOSALS REGISTERED UNDER THE EA ACT

Project	Proponent	Date Registered	EIA Status	Project Status
Hinds Lake	Hydro	Apr 1978	EIS Approved	Operational
Upper Salmon	Hydro	Jul 1978	EIS Approved	Operational
Roddickton/Marble Brook	Hydro	Jul 1978	Released	Operational
Cat Arm	Hydro	Sept 1978	EIS Approved	Operational
Dry Pond Brook	Hydro	Oct 1979	EPR Submitted; EIS Called (Inactive)	-
Lake Michael	Hydro	Oct 1979	EIS Inactive	-
Pinware River	Hydro	Feb 1980	EIS Inactive	-
Paradise River	Hydro	Sept 1985	EIS Approved	Operational
Mary's Harbour	Mary's Hr Hydro	Mar 1986	Released	Operational
West Salmon Dam Gated Spillway	Hydro	Dec 1986	Released	Operational
Island Pond	Hydro	Apr 1987	EIS Approved (Must re-register - 3 year time limit exceeded)	-
Granite Canal	Hydro	May 1987	EIS Inactive	-
Hinds Lake Diversion Project	Hydro	Nov 1987	EIS Inactive	-

Table 2.3 (Continued) HYDROELECTRIC PROPOSALS REGISTERED UNDER THE EA ACT				
Project	**Proponent**	**Date Registered**	**EIA Status**	**Project Status**
Round Pond	Hydro	Jan 1988	EIS Inactive	-
Greenwood/Grand Falls	Abitibi-Price Inc.	Jun 1990	EIS Inactive	-
Victoria Low Saddle Dikes and Burnt Dam Modifications	Hydro	Sept 1990	Released	Operational
Lower Churchill (Gull Island - Muskrat Falls)	Hydro	Nov 1990	EIS Inactive	-
Sop's Arm	10165 Nfld. Ltd.	May 1991	Released	On Hold
Jackson's Arm	10165 Nfld. Ltd.	May 1991	Released	On Hold
Garia Bay (Northwest Brook)	Penney Hydro Inc.	Jul 1991	EPR in Progress	-
Rose Blanche Brook	NF Power	Sept 1991	EPR Approved	Construction planned for 1997
Swift Current/Piper's Hole River	Penney Hydro Inc.	Nov 1991	Withdrawn	-
Rattle Brook	Algonquin Power Corp.	Nov 1991	Released	Construction planned for 1997
NW Arm Brook (Connoire Bay)	St. Mary's Bay Hydro Corp.	Feb 1992	EIS in Progress	-
Torrent River	Paris & Associates Dev. Corp	Feb 1992	EIS Inactive	-

TABLE 2.3 (Continued) HYDROELECTRIC PROPOSALS REGISTERED UNDER THE EA ACT				
Project	**Proponent**	**Date Registered**	**EIA Status**	**Project Status**
Southwest Brook (Gisbourne Lake)	Penney Hydro Inc.	Apr 1992	Withdrawn	-
Great Cat Arm	Paris & Associates Dev. Corp.	Apr 1992	EIS Inactive	-
D'Espoir & Bottom Brooks	Algonquin Power Corp.	May 1992	EIS Inactive	-
Southwest River (Port Blandford)	Frontier Hydro Dev. Ltd.	Aug 1992	EPR in Progress	-
Southwest Brook (Resubmitted)	Penney Hydro Inc.	Nov 1992	EIS Inactive	-
Northwest River (Clode Sound)	Belle Island Power Corp.	Nov 1992	EIS in Progress	-
Little Harbour River	St. Mary's Bay Hydro Corp.	Apr 1993	EIS Inactive	-
Star Lake	Abitibi-Price/CHI Hydro Inc.	Jun 1993	EIS Approved	Under Construction
Forteau Brook	Southern Labrador Power Corp.	Apr 1994	EIS Inactive	-
Torrent River (Site 1C)	Torrent Small Hydro Corp.	Mar 1995	EIS in Progress	-
Silver Mountain	Deer Lake Power Corp.	Nov 1996	EIS in Progress	-
Star Lake Hydro Project Dam Realignment	Abitibi-Price/CHI Hydro Inc.	Dec 1996	Released	Under Construction

Table 2.3 (Continued)
HYDROELECTRIC PROPOSALS REGISTERED UNDER THE EA ACT

Project	Proponent	Date Registered	EIA Status	Project Status
Granite Canal (Resubmitted)	Hydro	Feb 1997	EPR in Progress	-
Island Pond (Resubmitted)	Hydro	Feb 1997	EPR in Progress	-
Grand Falls Turbine Generator (Beeton Unit)	Abitibi-Price	Feb 1997	Released	On-Hold
Sheffield Lake	Deer Lake Power Corp.	Feb 1997	EPR in Progress	-
Southwest River (Phase II)	Frontier Hydro Dev. Ltd.	Feb 1997	Released	On-Hold
Kamistastin	Kamistastin Hydro Inc.	Feb 1997	Decision Pending	-

Source: Environmental Assessment Division, Department of Environment and Labour. Government of Newfoundland and Labrador (1997).

facility in southeastern Labrador. However, from January 1, 1990 to September 1, 1997, a total of 29 hydro proposals were registered, of which 25 (86.2 percent) were the undertakings of private companies.

As of September 1, 1997, the five small hydro projects currently slated for development on the Island were each at varying stages of the province's EIA process:

1) Northwest River: this project was registered on November 9, 1992, and an EIS was called on March 5, 1993. The proponent prepared and submitted the EIS in September 1995 (Genergy Inc., 1995), and was subsequently ordered to prepare and submit an EIS Addendum. This Addendum is currently being prepared by the proponent (Germain, 1996 pers comm).

2) Rattle Brook: the project was registered under the EA Act on November 4, 1991, and released from further assessment in 1992. Construction of the project is scheduled to begin in late 1997, with plant commissioning expected for the end of 1998 (Kerr, 1996b pers comm).

3) Rose Blanche Brook: the proposal was registered by Newfoundland Power on September 30, 1991; an EPR was ordered, which was submitted in February 1994, and subsequently revised and resubmitted in May 1995 (Northland Associates Ltd., 1995). The project was released from further environmental assessment on June 29, 1995, but must obtain approval from the federal Department of Fisheries and Oceans (DFO) before being allowed to proceed. It is anticipated that the project will be approved by DFO in the near future, and the proponent is hoping to begin construction of the facility in late 1997 (Kerr, 1997 pers com).

4) Southwest River: this project was registered on August 26, 1992, and an EPR is being prepared by the proponent (Tucker, 1996 pers comm).

5) Star Lake: the project was registered under the EA Act in June 1993, and an EIS was called. The EIS (Jacques Whitford Environment, 1996) was submitted in January 1996, and an EIS Addendum was submitted by the proponent in May of 1996. The project was released from the EIA process in late 1996 and is currently under construction.

There appeared to be no clear relationship, however, between the consideration of small hydro projects for development by Hydro and the registration of such projects under the EA Act. For example, as indicated in Tables 2.2 and 2.3, some proponents registered their project(s) under the EA Act soon after being issued a waiver for the site by Hydro; indeed, in some cases projects were registered even before Hydro's initial RFP of 1992. Conversely, of the 11 projects for which Hydro received final project proposals in 1993, several projects that would require registration have yet to be registered under the EA Act. The EIAs of several of these projects (e.g. Garia Bay (NW Brook), NW Arm Brook (Connoire Bay), and Torrent River 1C) have, however, each been extremely active despite the fact that they were not selected for development by Hydro in relation to the 1992 RFP, and their proponents have yet to secure power contracts with Hydro in relation to the 1997 RFP. Thus, although specific details regarding those projects selected for development in relation to Hydro's latest RFP have yet to be released, recent EIA activity in the province reflects the possibility that additional small hydro projects may be developed in the near future.

While in most cases proposed small-scale hydro developments in Newfoundland are individually subject to environmental assessments, the current provincial process does not allow for the consideration of the potential cumulative effects of this set of projects as a whole. Leeder (1993: 150) states that "each small hydro proposal is reviewed [through the EIA process] on a case-by-case basis, as issues are site and project dependent." While there is undoubtedly some variation in the potential for, and the relative significance of, some impacts and issues from project to project, the proposed developments have the potential to collectively affect common *Valued Environmental Components* (VECs) (such as water, fish, or wildlife resources). Thus, while the environmental impacts associated with each individual project may be considered relatively insignificant, the overall, cumulative effect of a set of small hydro projects on the environment of the province as a whole might be quite significant. Accordingly, some consideration must be given to the potential cumulative environmental effects of this set of projects, including those currently being developed, as well as those which will likely be developed in the future.

Chapter Three
CUMULATIVE EFFECTS AND CUMULATIVE EFFECTS ASSESSMENT

3.1 INTRODUCTION

One of the most important and widely discussed concepts in the field of contemporary EIA is that of cumulative environmental effects (Peterson et al., 1987). This increased interest in CEA is reflected in the vast amount of literature that has been produced in relation to the subject in recent years. This chapter presents a review of the existing cumulative effects and CEA literature, including an introduction to the concept of cumulative environmental change, a review and evaluation of existing CEA approaches and methodologies, and an overview of current practice in the assessment, evaluation and management of cumulative effects.

3.2 CUMULATIVE ENVIRONMENTAL EFFECTS

Despite the extensive treatment of the concept of cumulative environmental change in the EIA literature, no widespread, universally accepted definition of the term *cumulative environmental effect* has emerged (CEARC and USNRC, 1986; Bedford and Preston, 1988; Spaling and Smit, 1993; Court et al., 1994; Hegmann and Yarranton, 1995). Various definitions have been proposed, including:

> The impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions...Cumulative impacts can arise from individually minor but collectively significant actions (USCEQ, 1978 40 CFR section 1508.7).

> Cumulative impact is the totality of the incremental impacts over time, i.e., the sum of incremental or synergistic effects caused by all current and reasonably foreseeable actions over time and space (Vlachos, 1982: 64).

> Cumulative impacts are those that result from the interactions of many incremental activities, each of which may have an insignificant effect when viewed alone, but which may become cumulatively significant when seen in the aggregate. Cumulative effects may interact in an additive or synergistic way... (Dickert and Tuttle, 1985: 39).

> Cumulative impacts result from the accumulation of many human activities whose impacts, although not individually measurable, together sum to significant adverse effects (Childers and Gosselink, 1990: 455).

> [T]he essence of "cumulative impacts" involves:
>
> 1) the existence of additive or incremental impacts arising from...a single undertaking or from a number of separate projects in such a way that the impacts occur so frequently in time or space so that they cannot be assimilated;
>
> 2) the interactive or synergistic impacts of a number of undertakings; and
>
> 3) at least the potential for the existence of *de minimus* impacts (i.e. impacts which, although individually... minor..., in composite are significant (Bardecki, 1994: 356-357).

> Cumulative effects refer to the accumulation of changes in environmental systems over time or across space in an additive or interactive manner (Spaling, 1994: 232).

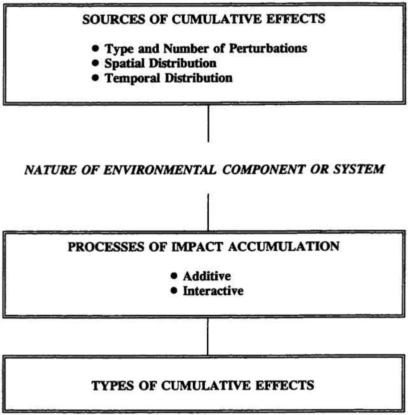
The sample definitions given above span the nearly two decades since the issue of cumulative effects became a prevalent one in the field of EIA. While differing slightly, all make reference to one or more of the following three concepts which, according to several authors (Spaling and Smit, 1993; Spaling, 1994; Smit and Spaling, 1995) form the basis for a causal model of cumulative environmental change:

1) the source(s) of impact; 2) the processes by which impacts accumulate to bring about cumulative effects; and 3) types of cumulative effects (Figure 3.1).

3.2.1 Sources

Potential sources of cumulative effects are numerous and diverse. Cumulative effects can result solely from human activities, or from the accumulative effects of human-induced stress and natural events and processes (Salwasser and Samson, 1985; Weaver et al., 1987). Human-induced perturbations are, however, most often the major sources of cumulative effects (Spaling and Smit, 1993). Cumulative effects may originate from a single project or activity that is spatially and/or temporally repetitive, or from multiple actions acting upon a common resource. The harvesting of a forest stand at rates which exceed forest regeneration rates is an example of a single activity which is both spatially and temporally repetitive, and thus, which may bring about cumulative effects. Cumulative effects are, however, more commonly associated with multiple sources of environmental disturbance; the overall impact of two or more independent actions which collectively affect the status of an environmental component or system (Cocklin et al., 1992a). When cumulative effects are the result of two or more independent actions, these may be related or unrelated in nature. An example of the former would be the development of multiple hydroelectric projects in an area. An example of the latter would be the development of a hydroelectric facility, a forest access road network and agricultural activity within a watershed area.

FIGURE 3.1: A CONCEPTUAL FRAMEWORK OF CUMULATIVE ENVIRONMENTAL CHANGE



Adapted from Spaling (1994: 243)

In both cases, the set of actions as a whole may result in potentially significant cumulative effects on water quality.

Sonntag et al. (1987) distinguish four types of human activities according to their number, type and spatial and temporal distribution, each of which may contribute to cumulative effects:

> **1) Single activity:** a single project or event usually completed in a short time-period and spatially well contained. (e.g. the construction of a hydroelectric dam).
>
> **2) Multi-component activity:** a single project or event with a number of components being developed in sequence or simultaneously. (e.g. the development of a hydroelectric project, comprising a dam, transmission corridor and access roads).
>
> **3) Multiple activity:** a regional development involving the construction of several facility types of a varied nature over an extended time period. (e.g. developing an entire river basin with a variety of types of development, such as mining, transportation and hydro developments).
>
> **4) Global activity:** an activity that is dispersed over space and time with characteristics that make it of global concern. (e.g. the emission of atmospheric pollutants from worldwide sources).

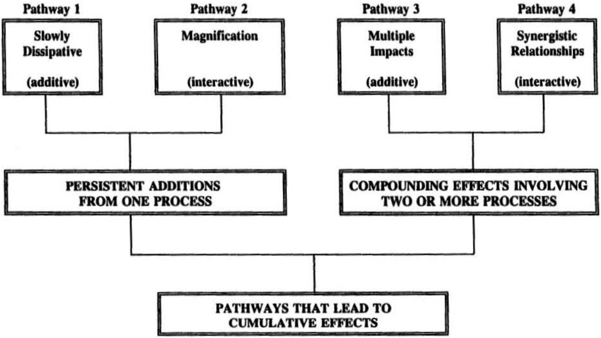
This classification illustrates the number and diversity of potential sources of cumulative effects. Specific actions that may result in cumulative effects can occur locally and in the short-term, or over large spatial extents and long time-horizons (Sonntag et al., 1987), or some combination of these. It is the characteristics of these source(s) (i.e. their type, number, and distribution in time and space) and the nature of the environmental component or system in question that determines the process(es) through which impacts accumulate, and consequently, the nature of the resulting cumulative effect (See Figure 3.1).

3.2.2 Processes of Accumulation

Cumulative effects result from the accumulation of environmental impacts in an additive or interactive manner. Additive (also known as "incremental" or "linear") impact accumulation occurs when two or more impacts collectively act upon a common environmental component or system such that the overall, cumulative effect is equal to the sum of the individual impacts which have contributed to it. An example of this type of impact accumulation would be the development of multiple hydroelectric facilities within a region, such that the incremental impacts of each project contribute to a potentially significant cumulative effect on the region's caribou resources. Interactive (also known as "synergistic" or "non-linear") impact accumulation refers to the accumulation of impacts in such a manner that the overall effect is quantitatively or qualitatively different (and thus fundamentally more complex) than the sum of the impacts of the individual disturbances. An example would be the development of multiple hydro plants within a single watershed, such that the zones of impact of two or more individual projects overlap spatially, resulting in an overall effect on a caribou herd that is of greater significance than the sum of the individual disturbances. As indicated, the specific process(es) by which impacts accumulate to bring about cumulative effects is determined by the characteristics of the origin(s) of the individual impacts and the nature of the environmental component or system in question (Spaling and Smit, 1993) (See Figure 3.1).

Peterson et al. (1987) present a classification of the basic functional pathways that contribute to cumulative effects (Figure 3.2). Four pathways are specified, and are differentiated according to sources of change (single or multiple actions) and type of impact accumulation (additive or synergistic processes). Cada and Hunsaker (1990) subsequently modified this framework slightly to address the specific environmental effects resulting from hydroelectric developments, and give relevant examples of each pathway. Pathways One and Two result from a single source of perturbation. Pathway One results from the persistent effects of a single project on a particular environmental component. An example would be repeated changes in water temperature as a result of the creation of a hydro reservoir. Also, when a single hydro facility has multiple effects, potential interactions between them may bring about cumulative effects. Accordingly, Pathway Two is also characterized by a single project or activity, but in this case, effects accumulate synergistically. For example, the creation of a hydro reservoir can alter water temperatures, lower dissolved oxygen concentrations and introduce contaminants such as heavy metals. Each of these can individually affect aquatic biota, but they can also accumulate synergistically (e.g. the toxicity of some contaminants can be intensified by high water temperatures and low dissolved oxygen levels).

FIGURE 3.2: FUNCTIONAL PATHWAYS THAT CONTRIBUTE TO CUMULATIVE EFFECTS



Source: Peterson et al. (1987: 5).

Pathways Three and Four result from the accumulation of the effects of two or more projects. Pathway Three occurs when the environmental effects of multiple actions accumulate in an additive manner, an example of which would be the development of multiple hydro projects on different streams in a basin. In this case, although no interaction occurs between the effects of individual projects, they collectively result in a potentially significant decline in the area's fish resources. Finally, Pathway Four occurs when the effects of multiple actions interact in a synergistic manner. An example would be water temperature alterations, decreases in dissolved oxygen concentrations and the introduction of contaminants as a result of multiple hydro projects, such that the effects of each project accumulate synergistically with those of the others. In this case, the resulting cumulative effect on aquatic biota would be greater than the sum of the impacts of the individual projects. Peterson et al. (1987) emphasize that these pathways are, however, not necessarily mutually exclusive of each other, and in some environmental systems several pathways may function simultaneously. The result is a myriad of possible outcomes with regard to particular types of cumulative effects.

3.2.3 Types of Cumulative Effects

Various classifications of types of cumulative environmental effects have been proposed (e.g. Bain et al., 1986; Baskerville, 1986; CEARC and USNRC, 1986; Sonntag et al., 1987; CEARC, 1988b; Lane et al., 1988). These typologies typically include reference to one or both of the concepts discussed above (i.e. sources of impact and processes of accumulation), the spatial and temporal characteristics of the effects themselves, or some combination of these concepts.

Stull et al. (1987), for example, distinguish two types of cumulative effects on the basis of their sources. *Homotypic* effects originate from multiple developments of the same type, such as a series of hydro dams. *Heterotypic* effects are caused by multiple developments of different types (e.g. the cumulative effects of a hydro project, forest harvesting, and industrial activity). Irving et al. (1986) identified three types of cumulative effects on the basis of processes of impact accumulation. The first is an *Additive* (or incremental) impact, where the cumulative effect is equal to the sum of the incremental impacts of each project. An example might be the loss of lacustrine habitat in isolated basins, such that no interaction occurs between individual projects or their impacts. The second type are *Supra-Additive* (or synergistic) effects, where cumulative effects are greater than the sum of the individual impacts alone (as discussed above). Finally, *Infra-Additive* (or antagonistic) cumulative effects occur when a resource is exposed to a series of impacts in such a manner that the total cumulative effect is less than the sum of the individual impacts. An example might be the development of two dams on a single stream, where each is expected to act as a complete barrier to fish migration. In this case, the downstream dam would negate the impact of the upstream dam as no fish would be able to reach it; thus, the overall effect would be equal whether one or both dams are built.

CEARC and USNRC (1986) devised the following typology, further refined by Sonntag et al. (1987) and CEARC (1988b) (cited in Spaling and Smit, 1993). Eight types of cumulative effects are identified, and are differentiated primarily on the basis of their spatial and temporal attributes:

1) Time-crowded perturbations: Characterized by frequent and repetitive impacts to an environmental system which exceeds its temporal capacity to recover. (e.g. the repeated harvesting of a forest stand at rates which exceed regeneration rates).

2) Space-crowded perturbations: Characterized by a high spatial density of environmental impact, such that impacts overlap. (e.g. habitat fragmentation in forests or estuaries).

3) Compounding/Synergism: Occurs when two or more perturbations interact to produce qualitatively or quantitatively different environmental change. (e.g. the chemical interaction of atmospheric pollutants to produce smog, a substance more toxic than each of its individual constituents).

4) Time Lags: Delays in experiencing effects. (e.g. exposure to a carcinogenic substance usually requires long-term exposure before symptoms are evident).

5) Space Lags: Environmental change which occurs at some distance from the source. (e.g. the deposition of acid rain at some distance from a thermal power plant).

6) Triggers and Thresholds: Disruptions to an environmental system which fundamentally alter that system's behaviour and/or structure. (e.g. continued increases in carbon dioxide levels are expected to alter the global climate system).

7) Indirect effects: Secondary impacts arising from a primary activity. (e.g. the release of mercury into reservoirs created for hydroelectric production).

> **8) Nibbling:** Incremental or decremental forms of environmental change that usually involve one or more of the above categories. (e.g. the gradual loss of coastal areas due to piecemeal shoreline development).

Despite the number of definitions and typologies developed in relation to cumulative environmental change, the underlying concept is that individual environmental impacts are not necessarily mutually exclusive of each other, but may accumulate in environmental systems to bring about significant cumulative effects on the biophysical and socioeconomic environments. Cumulative effects may originate from the impacts of a single activity, or the impacts of two or more related or unrelated actions, and result from the accumulation of these impacts in an additive and/or interactive manner.

3.3 THE ASSESSMENT OF CUMULATIVE ENVIRONMENTAL CHANGE

Much of the EIA literature indicates a widespread recognition of the need to effectively assess and manage cumulative effects. CEA has been viewed by many authors as an important prerequisite to effective and comprehensive environmental management, and some have argued that the consideration of cumulative effects is appurtenant to the implementation of the concept of sustainable development (e.g. Rees, 1988; 1995; Jacobs and Sadler, 1990; Beanlands, 1992; Cocklin et al., 1992a; Clark, 1994). While the concept of cumulative effects is not a new one, practical and systematic attempts to address cumulative effects are quite a recent phenomenon, and are primarily the result of the recent introduction of a legislative requirement for CEA in several jurisdictions. In the United States, for example, regulatory amendments to, and judicial interpretations of, NEPA require federal agencies to consider potential cumulative effects in their EISs (see Herson and Bogdan, 1991). In Canada, the initial cabinet directive which established EARP in 1973 (and subsequent revisions) did not explicitly require CEA, resulting in cumulative effects being considered in only a limited number of assessments and resource development decisions (see Spaling and Smit, 1993). As part of the reform of the Canadian EIA process, however, the CEAA requires that all environmental assessments consider cumulative effects. Section 16(1) of the Act states that:

> **Every screening or comprehensive study of a project and every mediation or assessment by a review panel shall include a consideration of the following factors:**
>
> > (a) The environmental effects of the project, including...any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;
> > (b) The significance of the effects referred to in paragraph (a).

The CEAA also makes reference to cumulative effects in Section 19(5), which specifies that class screening reports must also take into account cumulative environmental effects. Cumulative effects are not explicitly defined in the Act. However, a reference guide (FEARO, 1993) developed specifically for the CEAA provides some direction on their assessment.

Several environmental assessments conducted in Canada (both before, but primarily since, the passage of the CEAA) have included the consideration of cumulative effects. Some examples include, for example, a joint federal-provincial EIA of proposed Low Level Air Defence Training in New Brunswick (WMS Associates Ltd., 1990). The Guidelines issued in relation to this assessment required that cumulative effects be considered in evaluating the potential environmental impacts of three alternative training areas. Also, in 1989 a joint federal-provincial review board held hearings in relation to the proposed Alberta-Pacific pulp mill, to be located north of Edmonton, Alberta within the Peace-Athabasca watershed (Alberta Environment, 1990). The principal environmental issues of concern were the potential cumulative effects of effluent discharges into waterbodies. Similarly, a joint federal-provincial environmental assessment panel formed in 1992 to review five mining proposals in Northern Saskatchewan appointed an independent team of specialists to assist in the identification of cumulative effects that could have occurred from impact interactions between projects and other activities in the area (Ecologistics, 1992). Some more recent examples include, for example, an EIA submitted in 1995 by the Alberta Energy Company Ltd. and TransCanada Pipelines Ltd. in relation to their proposed Express Pipeline project in southeastern Alberta, which addressed the potential cumulative effects of the loss and fragmentation of native prairie habitats (Priddle et al., 1996). Also, an EIA submitted in 1996 in relation to the proposed Cheviot Coal Mine Project in western Alberta (BIOS, 1996) included an analysis of potential cumulative effects on ungulates and mammalian carnivores.

Several long-term regional studies in Canada have also incorporated the consideration of cumulative effects. For example, the Hudson Bay Programme is a collaborative research programme designed to identify the cumulative effects of human activities (particularly hydroelectric development) on the aquatic systems of the Hudson and James Bay region (Okrainetz, 1994; Sallenave, 1994). Similarly, a long-term planning strategy initiated in 1991 for the protection and management of the Oak Ridges Moraine (a prominent landform in southern Ontario) included a cumulative effects study and the development of a long-term cumulative effects monitoring strategy (Ecologistics, 1994). Cumulative effects were also considered, for example, in the Northern River Basins Study in northern Alberta (NRBS, 1993; 1995), and through the development of a Cumulative Effects Monitoring System for the Niagara Escarpment Plan Area in southern Ontario (MacViro, 1994).

The above assessments and studies have all, to varying degrees, incorporated the consideration of potential cumulative environmental effects. The particular approach and technique employed, however, often varies considerably between CEAs.

3.3.1 CEA Approaches and Techniques

CEARC and USNRC (1986) and Shoemaker (1994) noted that CEAs typically take one of two perspectives. Some assessments take a *Top-down perspective*, focusing on the development activities that bring about cumulative effects, such as multiple hydroelectric developments (e.g. FERC, 1985; Leathe and Enk, 1985; Simon, 1986; LaGory et al., 1989; Patterson et al., 1991; Sears and Yu, 1994) or forest management practices (e.g. Klock, 1985; Sample, 1991; Zeimer et al., 1991). Others assume a *Bottom-up perspective*, in which cumulative effects are assessed in relation to a particular VEC (e.g. Weaver et al., 1987; Power, 1996; Bolstad and Swank, 1997) or environmental system (e.g. Bunch and Reeves, 1992; MacViro, 1994; Ecologistics, 1994; ESSA, 1994; Keith, 1994; 1995). The applicability of each of the two perspectives is, of course, determined by the nature and objectives of the particular assessment itself.

Also, various authors (Hubbard, 1990; Spaling and Smit, 1993; Smit and Spaling, 1995) have noted the tendency of CEA researchers and practitioners to adopt either an analytical (e.g. Horak et al., 1983; Baskerville, 1986; Clark, 1986; Bedford and Preston, 1988; Gosselink and Lee, 1989; Bronson et al., 1991), or planning approach (e.g. Vlachos, 1982; Mentor, 1985; Hirsch, 1988; Stakhiv, 1988; 1991; Bardecki, 1990; Hubbard, 1990; Colnett, 1991; Davies, 1991). Smit and Spaling (1995) contend that the analytical approach to CEA is the most prevalent of the two, and emphasizes data collection and analysis with the assumption being that better information regarding cumulative effects will yield better decisions. In this regard, CEA is viewed primarily as an extension of the analytical component of traditional EIA. In contrast, a planning approach to CEA emphasizes the link between CEA and regional resource planning. This approach is used to evaluate alternative actions based upon explicit social goals and management objectives, and subsequently, to identify and implement those resource development alternatives which minimize potential adverse cumulative effects, or, at least, maintain them at acceptable levels.

The following sections review a selection of existing analytical and planning CEA methods. This discussion is not intended to present an exhaustive review and evaluation of available CEA techniques, as this has been done elsewhere (e.g. Horak et al., 1983; Stull et al., 1987; 1988; Lane et al. 1988; Stakhiv, 1988; 1991; Cocklin et al., 1992b; Hunsaker and Williamson, 1992; Leibowitz et al., 1992; Canter and Kamath, 1995; Hegmann and Yarranton, 1995; Smit and Spaling, 1995). For example, in a major review of CEA techniques, Smit and Spaling (1995) classify methods according to "both their analytical verses planning orientation, and their principal tool or structure of analysis." (p. 85). This discussion is, however, restricted to those CEA methods that are most commonly referred to in the literature.

3.3.1.1 Analytical Methods

Examples of CEA methods which represent an analytical approach to CEA include the following:

i) Modelling: As discussed earlier, the wide spatial and temporal scales at which cumulative effects originate and become evident, and the complexity with which they accumulate in environmental systems, make them inherently difficult to understand

and predict. As models provide simplified representations of complex systems, they allow for a greater understanding of system dynamics, and can thus facilitate the analysis of the cumulative effects of multiple perturbations upon such systems. For example, Weaver et al. (1987) developed a model to assess cumulative effects on grizzly bears which was designed to "quantify individual and collective effects of land uses and activities in space and time, and...to provide managers with an analytical tool for evaluating alternative decisions" (p. 366). Also, Zeimer et al. (1991) applied an ecological modelling approach based upon data from coastal Oregon and northwestern California to simulate and analyze the cumulative effects of timber harvesting and road construction activities on stream bed conditions in four hypothetical 10,000 ha forested watersheds. Similarly, Power (1996) adopted a modelling framework to assess the nature and extent of the cumulative effects of exploitation and toxicant stressors on brook trout (*Salvelinus fontinalis*). Sidle and Sharpley (1991) conclude that models simulating ecosystem processes and ecosystem response variables are effective tools in studying cumulative effects, and that such methods are "needed to address the temporal and spatial issues intrinsic in cumulative effects analysis." (p. 3).

ii) Spatial Analysis: Various authors have commented upon the applicability of Geographical Information Systems (GIS) technology to CEA (e.g. Walker et al., 1986; Johnston et al., 1988; Sebastiani et al., 1989; Cocklin et al., 1992b; Johnston, 1994). "A GIS is a system for the storage, retrieval and manipulation of spatial data" (Cocklin et al, 1992b: 59). The applicability of GIS technology to CEA stems from its ability to map and record changes in the spatial distribution of environmental phenomena over time. Sebastiani et al. (1989), for example, used a spatial analysis approach to map changes in land use and environmental characteristics over a 37-year period in Laguna La Reina, Miranda State, Venezuela. Walker et al. (1986) used geobotanical and automated mapping techniques in a study of cumulative effects in the Prudhoe Bay Oilfield, Alaska. Johnston et al. (1988) used GIS technology to assess cumulative effects to wetlands in Minnesota. Also, Bolstad and Swank (1997) used a GIS approach to assess the cumulative effects of land-use practices on water quality in the Coweeta Creek area, located in the Appalachian Mountains of western North Carolina. "Geographic Information Systems provide a practical means of conducting CI [cumulative impact] assessments because of their ability to compile, process, and evaluate data collected over a long time period and for a large geographical area." (Johnston et al. 1988: 1609). This is a requirement for CEA because cumulative environmental change is often characterized by extensive spatial and temporal scales, with regard to the sources of impact and the effects themselves.

iii) Landscape Analysis: A landscape approach to CEA involves the use of various measurable indices of ecological structure and function within a landscape unit to assess cumulative environmental effects. Gosselink and Lee (1989), for example, used such an approach to study cumulative effects in bottomland hardwood forests using various indicators of landscape structure (i.e. forest loss, contiguity and pattern) and function (i.e. change in stream discharge, change in water residence time, trends in stream nutrient concentrations, nutrient loading rates and native biotic diversity). Measured changes in these values represented cumulative effects on the landscape unit. Similarly, Gosselink et al. (1990) used a number of landscape indices (i.e. forest structure and land use, stream discharge, water quality, breeding bird surveys and Christmas bird counts) to characterize the Tensas River basin in northeastern Louisiana at the landscape level, and to assess changes to ecosystem health brought about by cumulative environmental change.

iv) Matrices: Interactive Matrices use matrix multiplication and aggregation techniques to sum the additive and interactive effects of a set of projects. A cumulative effect score for any configuration of projects is calculated by adding derived impact values which represent project-specific impacts, and adjusting this score to account for interactions among projects and their effects. For example, the Argonne Multiple Matrix methodology was developed to assess the potential cumulative effects of multiple hydroelectric projects (Bain et al., 1986). The methodology consists of three phases: analysis, evaluation and documentation. In the analysis phase, expert opinion is used to assign impact ratings which indicate the effect of each project on specific environmental components. In addition, weightings are assigned to each component which reflect its relative importance, and coefficients are developed which account for potential interactions between individual projects and impacts. These data are subsequently entered into matrices to calculate a cumulative effect score for each potential project configuration. In the evaluation phase, all possible project configurations are screened on the basis of potential cumulative effects, with the intent being to identify a preferred project configuration. In the final phase, the expected impacts of the selected project configuration are documented. Interactive matrices have primarily been utilized in assessing the potential cumulative effects of multiple hydroelectric developments within a single basin (e.g. Emery, 1986; O'Neil and Witmer, 1988; Witmer and O'Neil, 1988; LaGory et al., 1989).

O'Neil and Witmer (1988), for example, used an interactive matrix to assess the potential cumulative effects of 15 proposed hydroelectric developments on elk and mule deer in the Salmon River Basin in central Idaho. Five habitat parameters were identified as being important to the maintenance of elk and mule deer populations in the area, and which were likely to be affected by hydroelectric development: 1) permanent loss of habitat; 2) blockage of migration routes; 3) disturbance, including temporary displacement, poaching and abandonment; 4) loss of special areas (e.g. winter range); and 5) loss of cover. Criteria were established for various levels of impact for each parameter, ranging from zero (no impact) to four (high impact). For example, for the permanent loss of habitat component, a score of zero was assigned where no loss of habitat was expected; a score of one represented less that 10 acres of lost habitat; a score of two represented a loss of greater than 10 acres but less than 40 acres, etc. For each project, the sum of the five habitat component scores yielded an impact value which represented its potential effect on elk and mule deer (equal importance weights were assigned to each of the five habitat components). It was determined that only migration blockage had the potential to be affected in an interactive manner, and thus, criteria were defined for interaction coefficients for this habitat component only (ranging from zero to one). The total cumulative effect score for a particular set of projects was derived by summing the impact scores for individual projects, and then adjusting for these potential interactions.

v) Expert Judgement: Some CEA techniques rely almost exclusively upon the opinions of experts. This is due, in part, to the fact that very often sufficient information does not exist to facilitate an objective and scientifically rigorous approach to CEA. Often the practical constraints facing the CEA practitioner (such as limited time, resources and/or expertise) prohibit the collection of the often large amount of data required for the use of more rigorous methodologies. Thus, the assessment and evaluation of potential cumulative effects on the basis of best professional judgement is very often the most practical and feasible alternative. For example, Raley et al. (1987), recognizing that a quantitative approach would not be possible, gathered the opinions of experts in a workshop setting to develop a qualitative framework to assess the cumulative effects of external threats to the

Flathead River Basin portion of Glacier National Park. Similarly, Williamson et al. (1987) used the opinions and problem-solving abilities of a group of resource management experts to identify cause-and-effect linkages in a CEA of water quality problems in Chesapeake Bay. Two workshops were used to identify important environmental problems in Chesapeake Bay (e.g. declines in canvasback ducks and submerged aquatic vegetation), and to determine the principal causes of these problems. Based upon these findings, required actions were identified (e.g. providing special management for critical areas), and an overall plan of corrective action was formulated. As illustrated in these examples, in "data-poor" situations it is often necessary to rely upon the opinions of experts in conducting a CEA by gathering and using their insights in as systematic a manner as possible. However, in cases where professional judgement has been used in CEA, the type and level of expert opinion utilized, and the manner in which it is gathered, often varies considerably between applications.

In summary, the techniques described above reflect an analytical approach to CEA, with their primary emphasis being upon information gathering and analysis.

3.3.1.2 Planning Methods

As previously suggested, a planning approach to CEA emphasizes the link between CEA and regional resource planning. Several examples of specific techniques which reflect this approach are discussed in this section.

i) Multi-criteria Evaluation: This technique uses utility theory to compare and rank alternative courses of action (Smit and Spaling, 1995). As such, it can be used to evaluate the relative desirability (utility) of alternative actions on the basis of potential cumulative effects. First, a set of alternative actions and multiple objectives (target resources) are identified. Second, a numerical rating of the relative importance of each objective or potentially affected resource is assigned. Next, each alternative course of action is rated or quantified on the basis of its potential effect on each of the target resources under consideration. Finally, the relative utility of each alternative action is computed (using a linear formula) on the basis of its potential cumulative effects on the target resources. Jourdonnais et al. (1990), for example, used multi-attribute trade-off analysis to evaluate the potential cumulative effects of various stream regulation scenarios in the Flathead River Basin, Montana. An interagency task force (the Flathead Working Group) was used to evaluate alternative discharge and lake-level scenarios on resources cumulatively affected by steam regulation. The process involved the numeric valuation of impacts to target resources for each stream regulation scenario, with impact indices calculated using expert opinion. Individual values were then summed to reflect the potential cumulative effects of each scenario. This allowed for the quantitative comparison of the potential cumulative effects of each alternative regulation scenario, thereby achieving a compromise or "least impact" alternative. This method is well suited to a planning approach to CEA, as it allows for the proactive consideration of cumulative effects in decision-making.

ii) Linear Programming: These models use mathematical equations to find optimal solutions to problems. The main characteristic of linear programming is the optimization of one variable at the cost of all others within predetermined bounds (Stull et al., 1987). As a CEA technique, linear programming identifies resource allocations (solutions) which are feasible on the basis of specified environmental constraints, and then specifies optimal allocations on the basis of potential cumulative effects (Smit and Spaling, 1995). Stakhiv (1988; 1991), for example, used a model based on linear programming to investigate the potential cumulative effects of various stream regulation scenarios on a series of environmental attributes (e.g. dissolved oxygen, production of detritus) in a hypothetical estuarine bay-wetlands system. Four steps were involved: 1) the definition of a set of development-conservation objectives against which alternative actions and policies could be evaluated; 2) the forecasting of expected growth and development scenarios that were in keeping with the desired goals; 3) the definition of a set of biophysical constraints according to a developed theory or model of system response to natural and anthropogenic stress; and 4) the specification of a set of environmental protection standards and criteria that served as minimal environmental constraints (i.e. defining system carrying capacity), upon which the evaluation of potential cumulative effects could be based. In short, the model sets constraints and development objectives according to the carrying capacity of the system and choices made for development or preservation, respectively. The model sets limits on the acceptable amount of development on the basis of potential cumulative effects, and thus, represents a planning approach to CEA.

iii) Target Approach: This technique involves the identification of indicators of environmental quality and the establishment of allowable targets or thresholds for these indicators. From a planning perspective, these are then used to assess and evaluate the cumulative effects of existing and future development in a region. Dickert and Tuttle (1985) used a land disturbance target approach to assess the cumulative effects of urban development in a California coastal watershed area (Elkhorn Slough). They defined a land disturbance target based on erosion susceptibility to evaluate the cumulative effect of future land development projects on estuarine sedimentation. Their approach included the evaluation of erosion susceptibility, the measurement of existing land disturbance, the establishment of a land disturbance target and the comparison of existing and target land disturbance values. These were then used to identify areas where existing land uses exceeded the land disturbance target, such that future developments could be evaluated on the basis of potential cumulative effects.

In short, each of these methodologies extend the scope of CEA to incorporate the broader activity of comprehensive regional planning.

Conflicts arise in the literature regarding which of these two methodological approaches should form the basis for CEA. Baskerville (1986: 9), for example, contends that "cumulative environmental impact assessment requires scientific rigour if it is to be truly useful." In contrast, some maintain that a comprehensive regional planning approach is vital to the effective consideration of cumulative effects (e.g. Mentor, 1985). Several authors, however, insist that CEA requires a mix of methods, and that an amalgamation of the analytical and planning approaches to CEA is necessary to effectively assess, evaluate and manage cumulative environmental change (Lane et al., 1988; Smit and Spaling, 1995). Cocklin et al. (1992b: 57) state that "CEA, like most resource evaluation exercises, will benefit from what might be called methodological eclecticism - the use of several methods of analysis rather than seeking to develop a 'one-step' comprehensive system." Similarly, Spaling and Smit (1993: 594) state that:

> [O]ne approach does not preclude the other, and for effective management they are both essential. For example, a planning approach to CEA can provide the regional context for assessing the cumulative significance of any proposed human activities at the site level. Conversely, a scientific analysis of cumulative environmental change attributable to past, present, or anticipated development actions provides information pertinent to the setting of environmental, economic, and social goals for planning and to the evaluation of alternative courses of action...Each approach can yield a particular contribution to the analysis, assessment, and management of cumulative environmental change.

Indeed, various CEA researchers and practitioners have made use of both the analytical and planning approaches, or at least, discuss the applicability of the information they compile for regional resource planning. For example, Klock (1985) developed a CEA model to evaluate the potential cumulative effects of forest practices on downstream aquatic ecosystems, and concludes that "the model is particularly useful for evaluating forest practice options within a watershed during planning." (p. 241). Also, the Argonne Multiple Matrix methodology discussed earlier (Bain et al., 1986) was referred to as an analytical technique because of its emphasis on data acquisition and analysis. However, the method was designed as a means of selecting an optimal configuration of projects on the basis of potential cumulative effects, and thus, facilitates the proactive consideration of cumulative effects in the decision-making process. Similarly, McAllister et al. (1996) developed and used both a water quality model and a planning and management model to determine the optimal sizes and locations of marinas in a hypothetical North Carolina estuarine system, such that dissolved oxygen and fecal coliform water quality standards were maintained. Thus, while most CEA techniques can be loosely characterized according to their analytical or planning orientation, most utilize, or at least facilitate, both an analytical and a planning approach to CEA.

The preceding sections have presented an overview of the conceptual and methodological aspects of cumulative effects and CEA. The following section presents a discussion of current practice in the assessment of cumulative effects.

3.3.2 Current Practice in CEA

As indicated, most of the literature reflects a widespread recognition of the necessity of assessing and managing cumulative environmental change, and indeed, some attempts at CEA have been made in recent years. CEAs are, however, being carried out neither regularly nor adequately. This has been attributed to several analytical and administrative factors, including various methodological issues, as well as the apparent incapability of the EIA process, as traditionally practised, to effectively incorporate CEA.

3.3.2.1 Methodological Issues

Several authors maintain that effective CEA has been constrained by a profound lack of methodologies which actually facilitate it (e.g. Contant and Ortolano, 1985; Bain et al., 1986; Murthy, 1988; Cada and Hunsaker, 1990; Beanlands, 1992; Canter and Kamath, 1995; Damman et al., 1995; Dixon and Montz, 1995). These authors contend that the cumulative effects literature is predominantly theoretical, with little in the form of methodological guidance on how to conduct a CEA. While some CEA techniques have been proposed (as indicated above), methodological approaches to CEA are very much in a state of evolution at present. Moreover, existing CEA techniques are generally deficient in several respects. Damman et al. (1995: 436) state that "There tends to be more consensus on the concept of cumulative environmental effects than on practical ways to identify and evaluate them." They go on to summarize the perceived deficiencies of existing techniques by stating that:

> 1) Many methods require data that may not be available.
>
> 2) There is considerable dependency on quantitative modelling - not all environmental effects can be easily quantified.
>
> 3) Some methods are difficult to follow and duplicate.
>
> 4) Approaches to assessing the significance of cumulative effects are limited.
>
> 5) Methodologies are often not practical given available time and budget allocations.
>
> 6) Some methods are complex and may not be readily understood by the implementing agency or the public.

As a result of these general deficiencies, the majority of the CEA methods proposed to date remain at the conceptual stage, or have been utilized in hypothetical situations only. As many have yet to be applied to an actual assessment, their applicability and practical utility remains untested. In the limited number of attempts at CEA that have been made, the methodologies employed very often contrast sharply to those being proposed in the literature.

In the case of the recent Canadian CEAs referred to earlier, for example, in assessing the potential cumulative effects of proposed Low Level Air Defence Training Areas in New Brunswick, WMS Associates Ltd. (1990) relied exclusively upon literature reviews, expert consultation and the professional judgement of the study team, due to a lack of practical and applicable CEA techniques (Barnes and

Westworth, 1994). The potential cumulative effects of each alternative training area was subjectively evaluated by the study team; natural and anthropogenic stressors which may have been limiting VEC populations (e.g. white-tailed deer) were considered in the context of potential project activities and impacts, thereby allowing for the evaluation of the potential for proposed training activities to contribute to cumulative effects. Similarly, the Hudson Bay Programme made use of the published literature, traditional ecological knowledge and expert judgement in identifying and evaluating potential cumulative effects (Okrainetz, 1994; Sallenave, 1994). Also, in the case of the Alberta Express Pipeline EIA discussed earlier, the proponent contended that it was forced to place considerable reliance on subjective assessment approaches, given the absence of definitive and practical CEA methodologies (Priddle et al., 1996; Dupuis and Hegmann, 1997).

In reviewing the CEA literature, Ecologistics (1992) were unable to find a methodology which could be utilized in their assessment of the cumulative effects of proposed uranium mines in Northern Saskatchewan. They found available techniques to be impractical and stated that:

> In the absence of [a] proven cumulative effect assessment (CEA) methodology, we were faced with the need to develop an approach which accommodates the practical requirements and constraints of this assignment...The specific approach was tailored to accommodate the quality of available information... (p. 1-17, 1-18).

The CEA adopted a pathways approach to identify potentially significant linkages among ecosystem components. Project-specific impact predictions, readily available information and best professional judgement were used to identify instances where the impacts of one project or activity (including past, present or proposed mining projects, as well as other unrelated activities within the study area) could interact with the effects of one or more others (such as through surface water, ground water or the atmosphere). Based upon their best professional judgement, the study team assessed whether identified VECs were at risk with regard to potential cumulative effects. The significance of potential cumulative effects was then subjectively evaluated by the study team on the basis of various criteria (i.e. areal extent, frequency and duration and certainty in prediction) (Ecologistics, 1992; Damman et al., 1995; Hegmann and Yarranton, 1995).

Some exceptions to this generalization do exist, however. The Oak Ridges Moraine Area cumulative effects study (Ecologistics, 1994) utilized a relatively rigorous approach based on GIS overlays, aquatic modelling techniques and professional judgement to identify areas and situations where the potential cumulative effects of multiple development activities could significantly affect identified VECs (e.g. aquatic, terrestrial and visual/cultural resources, and resource utilization). Similarly, the CEA conducted in relation to the Cheviot Coal Mine Project utilized a cumulative effects model based on a GIS to estimate the potential effects of habitat change on grizzly bears, wolves and cougars. The model used existing regional habitat data, original research conducted over a single field season, as well as information regarding existing developments in the region to quantify the predicted effects of the developments on these species (BIOS, 1996). Despite extensive quantitative analysis, however, conclusions regarding the long-term implications of the derived data were based primarily upon the professional judgement of the study team (Dupuis and Hegmann, 1997).

As illustrated in these examples the particular techniques being utilized in contemporary CEAs often differ substantially from those being proposed in the literature, especially in terms of their emphasis on impact quantification and overall rigour. Most rely heavily upon existing information, and ultimately, the subjective assessment and evaluation of cumulative effects by the study team. However, as these case studies illustrate, the nature of the specific technique(s) employed often varies considerably between assessments. The appropriateness of a particular CEA methodology, and the validity of the above general criticisms of CEA methods, are determined by the nature, objectives and often quite distinct methodological requirements of the particular assessment itself. In short, the utility of a specific CEA method is dependent upon such factors as the nature of the problem, the underlying purpose of the CEA itself, access to and quality of information, and available resources (Smit and Spaling, 1995).

Also, although the deficiencies noted above are, for the most part, applicable to the range of existing CEA techniques as a whole, some methods are characterized by particular shortcomings (and indeed, strengths) which are somewhat specific to them (e.g. some have weak spatial and/or temporal resolution, while some are able to consider multiple VECs or types of cumulative effects). Again, the degree to which these factors impede or facilitate effective CEA is quite study-specific. Accordingly, the following chapter begins with an overview of the nature and methodological requirements of this study, and evaluates particular CEA approaches and techniques in light of these specifications.

The overall complexity and subsequent impracticality of most CEA methodologies appears unavoidable because, as indicated above, cumulative effects themselves are inherently complicated, and this suggests a degree of methodological complexity (Cocklin et al., 1992b). This, in turn, often brings about the need for large amounts of high quality baseline data and a thorough understanding of the structure and dynamics of the environmental system in question. These data requirements are further compounded by the often extensive spatial and temporal bounds required for CEA. It is, however, these very characteristics that have limited the utilization of most proposed CEA techniques. Given the limited degree to which cumulative effects have traditionally been addressed, this trend is likely to continue if CEA techniques continue to be exceedingly complex, impractical, and of limited applicability and adaptability. As a result, there is an overwhelming need for the development and refinement of CEA techniques which are both effective and comprehensive, as well as being practical and in keeping with the methodological requirements of contemporary CEAs and the practical constraints facing CEA practitioners. As argued by Damman et al. (1995: 452) "Ultimately, for CEA to become normative in environmental impact assessment and to become integrated in...planning, ***practical*** methodologies must become available to the practitioner." (Emphasis added). In general, what is required is the development of CEA methods which:

i) Are able to consider multiple, independent projects and their potential cumulative effects on multiple VECs;

ii) Allow for the aggregation of project-specific impacts to facilitate the assessment and evaluation of overall cumulative effects;

iii) Are able to make use of available, or at least, readily obtainable data;

iv) Can function at the extensive spatial and temporal scales required for CEA, as well as being somewhat flexible with regard to specific scales of analysis; and

v) Are practical and useable, and which yield information that is understandable and useful in the decision-making process.

In short, a balance between comprehensiveness and rigour, and the utility, practicality and adaptability of CEA techniques must be achieved.

3.3.2.2 EIA and Cumulative Effects

Notwithstanding the perceived shortcomings of existing CEA techniques, administrative and institutional impediments have also constrained the assessment of cumulative environmental change. More specifically, the EIA process, as traditionally practised, has not facilitated the consideration of cumulative effects. As such, it is generally acknowledged that CEA is not an effective part of the EIA process as it is carried out anywhere (Cocklin et al., 1992b). For example, in a review of EISs related to energy developments, Reed et al. (1984) found that, for the most part, analyses of cumulative effects were cursory and presented few data to support conclusions, and that the consideration of cumulative effects appeared to have had little influence on the overall decision-making process. A review and analysis of 100 EISs in the United Kingdom by Jones et al. (1991) indicated that only 14 included any consideration of impact interactions. Also, a review of 89 EIAs by McCold and Holman (1995) indicated that only 35 made even any mention of cumulative effects, and a similar study by Burris and Canter (1997) revealed that cumulative effects were referred to in less than half of the 30 EIAs reviewed. Both of these recent studies also indicated that even in the limited number of cases where cumulative effects were mentioned, they were typically not assessed or documented in a systematic or comprehensive manner. Finally, in a recent survey of EIA practitioners in the United States (Cooper and Canter, 1997), respondents indicated that the issue of cumulative effects was addressed in only about one-half of the EIAs with which they were familiar. In short, cumulative effects have traditionally not been effectively addressed through the EIA process, and there is little indication that the recent emergence of interest in CEA has done much to rectify this situation. Several factors have contributed to the apparent inability of the EIA process, as conventionally practised, to effectively address cumulative effects.

The first such limiting factor is the fact that, in many jurisdictions, existing EIA legislation contains no direct, formal requirement to consider cumulative effects. In Canada, for example, although the CEAA requires the consideration of cumulative effects as a legislative requirement, the process applies only to proposals for which the federal government is the direct proponent or makes a financial commitment, or which are located within an area of federal jurisdiction (Couch, 1989). Of the 10 Canadian provinces and one territory with formal EIA legislation, only Alberta and British Columbia explicitly require CEA. Some provinces (i.e. Saskatchewan, Manitoba, Quebec, New Brunswick and Prince Edward Island) take the view that the requirement to assess cumulative effects is implied or is explicit in various interpretative guidelines which have been produced to aid EIA practitioners, while others (i.e. Northwest Territories, Ontario, Nova Scotia and Newfoundland) have no explicit or implied requirement to address cumulative effects (Doyle and Sadler, 1996). Indeed, the Newfoundland EA Act contains no requirement to identify or address cumulative effects, and even the recently proposed reforms to the process (NDOE, 1995) do not include any consideration of cumulative effects. The failure of the proposed reforms to address cumulative effects has been viewed by many as a major shortcoming (e.g. NEIA, 1995; NLFL, 1995; Bryant, 1996; Von Mirbach, 1996). Little or no consideration is therefore given to potential cumulative effects in the EIAs undertaken in Newfoundland, due in part to the lack of a legislative basis for CEA in the province.

The nature of the EIA process itself, as traditionally practised, has also contributed to its apparent incapability to effectively address cumulative environmental change. EIA has predominantly been a project-driven exercise, in which proposed actions are reviewed on a case-by-case basis. It is, however, generally acknowledged that assessing projects on an individual basis does not lend itself to CEA (CEARC and USNRC, 1986; Peterson et al., 1987; Cada and Hunsaker, 1990; Hundloe et al., 1990; Contant and Wiggins, 1991; Cocklin et al., 1992a; Gibson, 1993; Spaling and Smit, 1993; Damman et al., 1995; Ortolano and Shepherd, 1995).

Conventional EIA, although project-driven, tends to focus upon a limited range of projects and activities. The EIA process is typically not an all-inclusive one, as legislation is often designed to exclude projects which are considered to have the potential for relatively insignificant environmental impacts. As a result of this *screening* mechanism, some proposed actions fall outside of the EIA process altogether. Proposed hydro developments in Newfoundland that are of less than one MW capacity, for example, are exempt from environmental assessment. Between 1980 and 1994, the Newfoundland Environmental Assessment Division received 1,264 inquiries regarding whether or not developments required registration under the EA Act. Of these inquiries, only 537 (42.5 percent) of the projects required registration, of which 423 (78.8) percent were subsequently released with no need for further assessment (Kaufhold, 1995 pers comm). When the impacts of a seemingly environmentally benign undertaking accumulate with the impacts, and potential impacts, of other actions (whether past, existing or proposed), these individually negligible effects may become cumulatively significant. This concept has been referred to as *The tyranny of small decisions* (Odum, 1982), or *Destruction by insignificant increments* (McTaggart-Cowan, 1976; Gamble, 1979). However, due to the project-specific nature of conventional EIA, such cumulative effects are usually not addressed.

The spatial and temporal scales of project-specific assessments also contribute to their ineffectiveness in the context of cumulative effects. Assessments typically focus upon narrow spatial scales (usually confined to the immediate project site), and thus consider only the immediate, site-specific impacts of the action. As a result, little or no consideration is given to spatially extensive impacts, or to the impacts of other adjacent activities with which a project's effects may interact. Similarly, the temporal bounds of most assessments seldom extend beyond the implementation phase of the individual project under consideration, and as such, little consideration is usually given to long-term or delayed effects, or to potential impact interactions with the effects of past or future projects. This is, however, not sufficient for CEA because cumulative effects are often characterized by extensive spatial and temporal scales with regard to both their source(s) and the effects themselves.

Project-level EIAs are typically "a time and site-specific response to a specific proposed action" (LeDrew, 1989: 3). As a result, the EIA process typically functions in isolation from the overall resource management and planning processes. By assessing development proposals on an individual basis rather than as part of a larger programme or policy, the result is often a rather fragmented and segregated management framework. In the case of small-scale hydro development in Newfoundland, for example, while most projects are individually subject to EIA, each is being proposed by a separate proponent which is by and large operating independently of the others. As a result, individual proponents (and thus project-level EIAs) are unable to effectively consider the potential cumulative effects of the set of small hydro developments as a whole. The consideration of cumulative effects in project-level EIA is often limited by the lack of knowledge regarding other developments, and a lack of control over these proposals (Montgomery, 1990). Environmental assessment processes are thus "not yet able to deal with issues for which a single proponent is lacking...In the absence of such a driving force, the process is generally unable as presently constituted to deal with cumulative impacts..." (LeDrew, 1989: 2). As a result, environmental change that is the result of multiple, diverse sources has generally fallen outside of the scope of EIA as it is practised in most countries (Cocklin et al., 1992a).

Also, from a planning perspective, EIAs are triggered by project-specific proposals and thus, are carried out in relation to actions that have been already designed and selected for development. Such assessments therefore often occur too late in the planning process to ensure that all alternatives to the proposed action are given adequate consideration (Hundloe et al., 1990; Lee and Walsh, 1992; Wood and

Dejeddour, 1992). As such, the role of EIA is not to contribute to comprehensive environmental planning, but rather it becomes a reactive mechanism designed to predict the potential environmental impacts of a project and propose measures by which these impacts can be mitigated. Consequently, project EIAs are usually an "add-on to planning processes already on-going, rather than elements built in to comprehensive integrated development planning" (Munroe, 1986: 25). In contrast, it is generally acknowledged that CEA requires a comprehensive, anticipatory and integrated planning approach (Ballard et al., 1982; Vlachos, 1982; James et al., 1983; Mentor, 1985; Stakhiv, 1988; 1991; Bardecki, 1990; Contant and Wiggins, 1991; Gibson, 1993; Conacher, 1994; Brown and McDonald, 1995; McDonald and Brown, 1995).

In summary, EIA, as conventionally practised, is ineffective at addressing cumulative environmental change. Reviewing projects on an individual basis tends to lead to a rather reactive and reductionistic approach to impact assessment and environmental management and planning. In contrast, CEA requires the expansion of this focus to include the potential, overall effect of multiple (and often quite diverse) sources of potential impact, as well as often complex impact interactions and spatially and temporally widespread impacts. Accordingly, it requires a more holistic, and spatially and temporally extensive, approach to impact assessment than that which has traditionally been achieved through the EIA process.

3.4 SUMMARY OF THE CUMULATIVE EFFECTS LITERATURE

To summarize the existing cumulative effects and CEA literature, environmental impacts may interact through additive or interactive processes to bring about cumulative environmental change. Cumulative effects may result from the accumulation of the effects of one activity that is spatially and/or temporally repetitive, or more commonly, from the overall effect of two or more independent actions. Cumulative effects exhibit distinct spatial and temporal attributes with regard to both their source(s), as well as the characteristics of the effects themselves. They are thus remarkably diverse and complex in nature, making them inherently difficult to predict, evaluate and manage.

While the conceptual and theoretical basis of cumulative environmental change is well developed in the literature, comprehensive attempts at CEA have been limited. CEA has traditionally been constrained by various analytical and administrative impediments, including a lack of practical and effective methodologies, as well as the apparent incapability of the predominantly project-driven EIA process to incorporate CEA. Accordingly, this study is an attempt to overcome these constraints through methodological development, and the application of this technique to the case of small-scale hydro development in Newfoundland in an attempt to overcome the shortcomings of the province's predominantly project-driven EIA process in the context of cumulative effects. The following chapter describes the specific CEA technique which was developed and utilized in this research.

Chapter Four
APPROACH AND METHODOLOGY

4.1 INTRODUCTION

As indicated throughout, the purpose of this study is to assess the potential cumulative environmental effects of proposed small-scale hydroelectric developments in insular Newfoundland. This chapter outlines the methodological requirements of the assessment, and evaluates a range of existing CEA techniques in light of these specifications. This is followed by an overview of the CEA methodology developed and utilized in the study, as well as a step-by-step account of the data collection process.

4.2 METHODOLOGICAL REQUIREMENTS OF THIS ASSESSMENT

As previously suggested, the specific technique (or combination of techniques) suitable for a CEA is very much determined by the nature and objectives of the assessment itself, and consequently, on its often quite distinct methodological requirements. In short, there are no general rules for the selection of a CEA technique, as the appropriateness and applicability of a particular method is quite study-specific. Such factors as the type, number and temporal and spatial distribution of the potential sources of impact, the process(es) of impact accumulation likely to occur, and consequently, the type(s) of cumulative effects being assessed must be considered in selecting an appropriate method. In the context of this assessment, these factors are characterized as follows:

i) Sources: This study takes a "top-down perspective" to CEA, as it focuses upon the development activities which potentially bring about cumulative environmental change (i.e. proposed small-scale hydro developments in Newfoundland). The particular small hydro projects to be considered (and the rationale for selecting them) are discussed in Section 4.4.1.

ii) Impact Accumulation: Although interactive impact accumulation is most often associated with cumulative effects, it represents only one of the possible ways in which such effects can result from multiple hydroelectric developments, and indeed, may be the least likely to occur in many situations (Cada and Hunsaker, 1990). Cada and Hunsaker (1990) also note that the spatial component is an important factor in determining the potential for interactive impact accumulation, because hydro projects and their impacts must be in close proximity to each other to interact. They go on to state that when multiple hydro developments "are relatively isolated from each other...it is often most reasonable to assume that cumulative impacts will be ***additive***." (Emphasis added) (p. 8). The objective of this study is to assess the potential cumulative effects of small hydro developments on a provincial scale, rather than within a single basin; accordingly, it focuses solely upon potential additive cumulative effects. The potential for synergistic or antagonistic interactions between the impacts of proposed small hydro projects will, however, be addressed in a later section.

iii) Types of Cumulative Effects: With regard to the typologies of cumulative effects presented in the previous chapter, this study assesses potential *additive*, *homotypic* cumulative effects (i.e. those resulting from the accumulation of the incremental impacts of a set of independent but similar actions). The type of cumulative effect most analogous to that being considered in this study is therefore that of relatively small-scale, incremental environmental changes, referred to as *nibbling* by CEARC and USNRC (1986).

Given these characteristics, the following are proposed to be the methodological requirements of this assessment. First, the particular technique employed must be capable of assessing the potential cumulative effects of multiple, independent (but similar) projects (rather than those of a single action that is spatially and/or temporally repetitive). The methodology must also be capable of considering multiple VECs, rather than focusing exclusively upon one environmental component. This is necessary as the objective of this study (as outlined in Chapter One) is to assess the potential cumulative effects of small hydro development on the "environment of the province", rather than a single target resource. The provincial scope of the assessment requires that the methodology employed be capable of functioning at an extensive spatial scale, as well as being somewhat flexible with regard to specific scales of analysis. In terms of temporal scale, it must also be capable of considering those projects currently being developed, as well as projects which may be developed in the future.

Because the nature of the assessment was such that multiple projects and VECs must be considered on a provincial scale, the data requirements of this assessment were quite significant. Consistent, quantitative baseline data were, however, not available in relation to most small hydro projects proposed for the Island. As small hydro proposals were at varying stages of the planning and EIA processes, in many cases intensive baseline surveys had not been conducted. Therefore, project-specific impact predictions had to be formulated on the basis of a limited amount of available information, and/or data which were readily obtainable. It also required a technique which allowed for the "aggregation" of these project-specific impacts, such that the overall, additive effect of the set of projects on each of the VECs to be considered could be assessed. The nature of the assessment therefore required that numerical values which represented the relative significance of potential project-specific impacts be assigned, despite a profound lack of existing quantitative baseline data on which to base these impact predictions.

In terms of overall methodological approach, the nature and objectives of this assessment required that it initially adopt an analytical approach to CEA. As indicated, a set of small hydro projects had already been selected for development on the Island in relation to Hydro's 1992 RFP at the time that this study was initiated. This research is, however, based upon the premise that effective CEA does indeed require an amalgamation of the analytical and planning approaches. Accordingly, the utility of the information gathered for the proactive consideration of potential cumulative effects in decision-making will be explored in a later section.

Bedford and Preston (1988: 758) contend that "If effects are strictly additive, then no new scientific approaches are required for cumulative impact assessment." Given the nature and methodological requirements of this assessment, however, most available analytical CEA techniques were found to be inappropriate and/or impractical. For example, most analytical methods require substantial amounts of high quality, quantitative baseline data and/or a thorough understanding of the structure and dynamics of the environmental system under consideration (Mains, 1987; Stull et al., 1987; Canter and Kamath, 1995; Smit and Spaling, 1995). While these techniques may be useful in "data-rich" situations, a lack of available, quantitative data prohibited the use of most of these methods in this assessment. Some existing CEA methods are unable to function at the extensive spatial scale required for this assessment (e.g. modelling), and some are able to effectively consider only a single target resource (e.g. interactive matrices), which also limited their utility in this study. Almost all existing methods were found to be unacceptable for practical reasons as well, as they are excessively complex, time consuming and costly to undertake, especially given the large data requirements and extensive spatial and temporal scopes of this assessment.

Given the nature and objectives of this assessment, and shortcomings of existing CEA techniques (both in the context of the requirements of this study and in general), the use of expert opinion was deemed to be the most practical and feasible alternative. Therivel and Morris (1995: 303) contend that perhaps the most practical approach to CEA would be to "list all the relevant projects on one axis of a matrix, and environmental components on the other, and summarize each project's impacts on the environmental component in the relevant cell." Indeed, such an approach was, although relatively simple, deemed appropriate for this assessment because it focused exclusively upon the potential additive (i.e. non-interactive) cumulative effects of proposed small hydro developments. In short, as a result of the nature and objectives of the assessment, and a lack of existing quantitative baseline data, a CEA methodology based upon expert judgement and the use of a simple impact summation matrix was developed and utilized in the study. Expert opinion regarding potential project-specific impacts was gathered through a modified Delphi procedure.

4.3 THE DELPHI TECHNIQUE

The Delphi method is a systematic, iterative survey technique which is based upon the independent contributions of a group of experts (Leitch and Leistritz, 1984). Linstone and Turoff (1975: 3) define Delphi as:

> A method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem.

The technique was developed in the early 1950s by researchers at the RAND Corporation, and was named after the oracle at Apollo's shrine at Delphi, Greece. Its purpose is to "obtain the most reliable consensus of opinion of a group of experts...by a series of intensive questionnaires interspersed with controlled opinion feedback." (Dalkey and Helmer, 1963: 458). It is designed for use in situations where, as in this assessment, large data requirements and a lack of available quantitative data prohibit the use of traditional analytical solutions, and it is therefore necessary to rely upon the opinions of experts and to use their insights in as systematic a manner as possible (Coates, 1975; Dodge and Clark, 1977; Murray, 1979; Rowe et al., 1991). The objective is to organize a structured communication process which attempts to derive a consensus of opinion from an expert panel regarding the occurrence and potential consequences of future events. In short, Delphi is a means of aggregating the collective opinions of a group of experts in order to improve the quality of decision-making (Delbecq et al., 1975).

The process typically begins with the identification of the working problem or issue to be considered, and the selection of those experts that will constitute the expert panel. Usually, the researcher uses multiple iterations of surveys to facilitate data collection, with each iteration referred to as a *Round*. The Round One survey sometimes consists of an "open-ended" questionnaire which seeks the particular opinions of each participant regarding the issue(s) under consideration, although in most cases a structured questionnaire is used throughout (Rowe et al., 1991; Woudenberg, 1991). Upon completion and return of the Round One questionnaires, the researcher compiles and reviews the responses and formulates the Round Two questionnaire. In the second and each subsequent round, participants are provided with a statistical summary of the results of the previous round, and in some cases the actual comments provided by panellists in relation to their responses are also fed back to the panel as a whole. Individual panellists are thus given the opportunity to reconsider their responses in light of the responses of the group as a whole. Previous experience with the Delphi technique indicates that over successive iterations, individual responses tend to converge toward a consensus. The Delphi procedure typically continues until maximum consensus is reached among panellists concerning the issue(s) under consideration.

Thus, four primary features characterize the Delphi process: 1) anonymity; 2) iteration; 3) controlled feedback; and 4) the statistical aggregation of the individual responses (Dalkey, 1967; Pill, 1971; Rowe et al., 1991; Woudenberg, 1991):

i) Anonymity - The use of questionnaires allows individual panellists to remain anonymous. The Delphi procedure is intended to prevent the dysfunctional elements of group interaction which may often lead to inaccurate results. Group pressure to conformity and the dominance of strong personalities may often lead to pressure to accept the opinions of a dominating minority, even when the opinions of such persons are incorrect or inferior (Pill, 1971; Riggs, 1983; Woudenberg, 1991). By allowing individual panellists to formulate their responses privately, the Delphi technique is designed to avoid these negative aspects of group interaction. Delphi therefore ensures that the opinion of each panellist is represented in the final response. Also, through successive iterations, anonymity gives panellists the opportunity to reevaluate and subsequently alter their own responses without fear of 'losing face' with others.

ii) Iteration - The underlying premise behind the Delphi technique is that iteration will cause members of the panel to shift their responses towards the "correct response". More specifically, over subsequent rounds, those with the weakest predictive ability may be expected to shift their responses towards the opinions of those who are most accurate (Dietz, 1987). As a result, over subsequent rounds the group forecast may be expected to move towards higher accuracy. The number of iterations used in the Delphi process is quite variable between applications, ranging from two to ten rounds (Woudenberg, 1991). However, it seldom extends beyond two or three iterations, and most change in experts' responses is typically evident in the first or second iteration (Dietz, 1987; Rowe et al., 1991). Maximum consensus is usually achieved after two to three rounds (Dalkey and Helmer, 1963; Huckfeldt and Judd; 1974; Linstone and Turoff, 1975; Dodge and Clark, 1977), and where individual judgements fail to converge, the underlying reasons for such disagreement typically become evident (Freeman and Frey, 1992).

iii) Controlled Feedback - In the second and each subsequent round, individual panellists are informed of the opinions of other group members. This feedback typically takes the form of a statistical summary of the response of the group as a whole. However, as indicated, the actual arguments of panellists whose responses differ significantly from the group response are also sometimes fed back to the panel as a whole. By presenting the group response over a number of rounds, individual panellists are given the opportunity to subsequently change their opinions, if appropriate. Those who find the group response, or the arguments of deviating panellists, more compelling than their own should, subsequently, modify their own responses (Woudenberg, 1991).

iv) Statistical Group Response - At the conclusion of the Delphi procedure, the group forecast is obtained through the statistical aggregation of the individual panellists' responses. The median response is typically reported as the group forecast, as it is not strongly influenced by outlying samples (Dietz, 1987; Rowe et al., 1991).

The Delphi technique has been applied in a variety of disciplines, and thus, to the forecasting of a wide range of phenomena (see Brockhaus and Mickelsen, 1976; Worsham, 1980; Gupta and Clark, 1996). The extensive use of the Delphi procedure has been attributed to the fact that the method is extremely versatile, and can be adapted to the requirements of virtually any study which requires the use of expert opinion and the quantification of subjective variables in forecasting (Coates, 1974; Parente et al., 1984; Preble, 1984; Gupta and Clark, 1996).

Various authors have, for example, commented upon the applicability of the Delphi technique to natural resource management and planning (e.g. McAllister, 1980; Bakus et al., 1982; Mitchell, 1989). Earle et al. (1981), for example, used the technique to gain insight into community perceptions concerning soil conservation practices. Bardecki (1984) used a Delphi survey of 300 landowners in Southern Ontario to examine their experiences with, and attitudes towards, wetlands; the results of this study were subsequently used to assess the implications of various policy alternatives. Leitch and Leistritz (1984) used Delphi to identify and rank emerging environmental and natural resource issues in 13 Rocky Mountain and Great Plains States in the U.S. Pease (1984) used the technique to collect land and water-use information in Linn County, Oregon and Skagit County, Washington. Schuster et al. (1985) used Delphi in a study of the quality of elk habitat in Western Montana. Clark and Stankey (1991) used a Delphi process to identify critical issues that should be considered in implementing effective forest management strategies. Gulez (1992) presented a method based upon the Delphi technique to evaluate and select areas for National Park status. Egan et al. (1995) used a Delphi process in combination with mail surveys and focus groups to evaluate the relationships between the forest stewardship ideals embraced by private forest owners and the management of their forests. As these select examples illustrate, applications of the Delphi procedure in the fields of resource management and planning have been widespread and diverse. Mitchell (1989: 63) offers suggestions concerning the applicability of the Delphi technique in this context:

> The Delphi technique offers a means to identify the occurrence and consequences of events in the future. Such estimates could then be used when forecasting demands for or supplies of natural resources, or in anticipating future natural resource problems...[Thus], resource analysts and managers are finding that the Delphi technique is a useful aid for identifying the probability of future conditions and for then assessing the implications for resource allocation decisions.

More in keeping with the context of this study, the applicability of the Delphi technique to EIA and CEA has been noted by a variety of authors (e.g. Coates, 1974; Miller and Cuff, 1986; Dietz, 1987; Stull et al., 1987; Praxis, 1988; Thompson, 1990; Stauth et al., 1993; Hegmann and Yarranton, 1995). Smil (1975), for example, used the Delphi technique to study the potential environmental impacts of future energy developments. Richey et al. (1985b) used Delphi in the design of a program to monitor the potential environmental effects of electric power generation facilities. Freeman and Frey (1992) proposed the use of a modified Delphi procedure to assess and compare the potential social impacts of alternative natural resource policies.

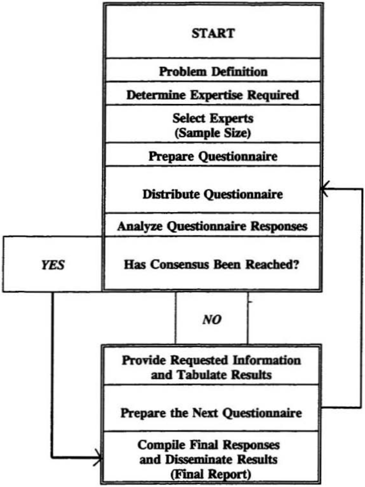
Vizayakumar and Mohapatra (1992), used an eclectic approach (which included a Delphi survey) to assess the environmental impacts of a coalfield in India. Busch (1996) used Delphi to assess and evaluate aquatic habitat degradation in Lake Ontario; the technique was chosen because "Data on biological, chemical, and physical anthropogenic changes were scattered, patchy, and disjointed." (p. 113). Mohorjy and Aburizaiza (1997) used a two round Delphi survey and a consensus building workshop to derive a consensus of opinion from a panel regarding the environmental impacts of an effluent control system in Jeddah, Saudi Arabia. The utility of Delphi in this context stems from the fact that the EIA process itself is inherently a predictive exercise, and because very often impact predictions must be made in the face of inadequate or incomplete information.

The following section describes the application of the Delphi procedure in this assessment.

4.4 METHODS

Figure 4.1 illustrates the principal steps in the Delphi procedure. Despite the extensive amount of literature that has been produced in relation to the technique, and its widespread application in numerous disciplines, there is little in the form of methodological guidance on how to conduct a Delphi (Preble, 1984). This is likely due to the fact that, in most cases, the method must be modified according to the nature and objectives of each particular study to which it is applied. The following

FIGURE 4.1: THE DELPHI PROCEDURE



Source: Riggs (1983: 90).

sections give an account of the adaptation and step-by-step utilization of the Delphi technique in this study.

4.4.1 Problem Definition

As indicated, the first step in the Delphi procedure is the identification of the particular issue or problem to be considered. While the general issue being addressed in this study is the potential cumulative environmental effects of proposed small hydro facilities in insular Newfoundland, it was also necessary to identify those particular small hydro projects and environmental components which would be considered.

As discussed previously, 160 potentially viable small-scale hydro sites have been identified on the Island (Shawmont, 1986). In response to Hydro's 1990 policy change regarding small hydro development and its willingness to purchase the power from these facilities on a long-term contractual basis, a number of these sites have been proposed for development by the private sector. Also, while five small hydro projects had been selected for development at the time that this study was initiated (i.e. Northwest River, Rattle Brook, Southwest River and Star Lake, as well as Newfoundland Power's Rose Blanche Brook facility), there is a strong possibility that further sites will be developed in the future. Thus, while these five projects obviously required consideration in this assessment, it was also necessary to attempt to predict which projects would potentially be developed in the future.

It must be remembered that this study was initiated approximately one year prior to the issuance of Hydro's second RFP in January 1997, and thus, there was considerable uncertainty at that time regarding which particular sites would be developed in the event of another RFP being issued. Indeed, even at the conclusion of the study, details regarding which small hydro projects were being considered in relation to Hydro's 1997 RFP were not yet available. It was noted in Chapter Two that Hydro received final project proposals for 11 projects in August 1993, of which four projects were subsequently selected. Because the remaining seven projects were being considered by Hydro in the final screening phase of its initial RFP, they were likely the most technically and economically feasible of the identified sites, and thus, deemed to be the most likely to be resubmitted to Hydro in the event of another RFP. Accordingly, a total of 12 proposed small hydro developments were initially identified for consideration in this assessment, including those 11 projects being considered for development by Hydro in 1993, as well as the Rose Blanche Brook project.

It was also necessary to identify those particular environmental components which would potentially be affected by the cumulative effects of these projects. To this end, an extensive review of the existing literature pertaining to the environmental impacts of hydroelectric developments in general, as well as the existing EIA literature produced in relation to small-scale hydro developments in Newfoundland, was undertaken. As indicated in Table 4.1, a total of 21 VECs were identified, including various biophysical, socioeconomic and cultural resources.

TABLE 4.1: VECs POTENTIALLY AFFECTED BY SMALL HYDRO DEVELOPMENT IN NEWFOUNDLAND	
Category	**VEC**
Biophysical Resources	Water Resources
	Vegetation and Soils
	Riparian Flora
	Rare or Threatened Flora
	Fish Resources
	Raptors
	Waterfowl
	Migratory Birds
	Caribou
	Moose
	Black Bear
	Furbearers
	Small Mammals
	Rare or Threatened Fauna
Socioeconomic and Cultural Resources	Timber Harvesting
	Commercial Fisheries
	Angling
	Hunting/Trapping
	Tourism
	Aesthetics
	Historic Resources

As a result, 12 projects and 21 VECs were initially identified for consideration in the assessment, giving a total of 252 *project/VEC combinations*.

4.4.2 Selection of the Expert Panel

Following the identification of the particular issue to be considered, the next step in the Delphi procedure is the identification of the particular requirements of the study with regard to level and type of expertise, and subsequently, the selection of those experts that will constitute the Delphi panel. This assessment required the participation of individuals who had expertise in relation to the potential environmental impacts of small-scale hydroelectric developments, and who had a knowledge of one or more of the identified VECs in the vicinity of one or more of the proposed projects.

A review of the existing EIA literature produced in relation to small-scale hydroelectric developments in Newfoundland led to the development of a preliminary list of individuals who met the expertise requirements of the study, and thus, could be considered potential expert panellists. Also, a series of informal interviews were carried out with senior personnel in each of the organizations represented on the list in order to identify other individuals who might be considered "qualified" to participate in the study. The identification of potential expert panellists was structured to ensure the representation of all provincial and federal agencies, interest groups, private sector consultants and academics likely to have a knowledge of the potential effects of one or more of the projects on one or more of the VECs initially identified.

All potential expert panellists were mailed a *Panellist Information Form* (Appendix A) which identified the researcher, informed them of the rationale and objectives of the study, and provided an overview of the methodology to be employed. Potential panellists were also provided with a map showing the locations of the 12 small hydro projects that were to be considered in the study, as well as a list of the 21 VECs initially identified. The importance of each person's participation in the study as an expert panellist was emphasized, and anonymity was assured. They were then asked to indicate whether or not they would be willing to participate in the study, and each respondent (regardless of whether or not they agreed to participate) was also asked to identify up to six other individuals who, in their opinion, might be qualified to take part in the study.

Several authors caution that participants in a Delphi survey may not have expertise in relation to all of the questions posed, as those who are invited to participate are often knowledgeable in very specific areas (Gordon and Helmer, 1964; Fusfeld and Foster, 1971; Hill and Fowles, 1975; Riggs, 1983). This was especially the case in this assessment, as the number and diversity of VECs and the extensive spatial scale of the assessment required the participation of panellists with a wide and varied range of expertise. Accordingly, a 252 cell matrix, with the 12 small hydro projects under consideration listed across the horizontal axis and the 21 initially identified VECs listed vertically, was included in the Panellist Information Form (see

Table 1, Appendix A). Each cell in the matrix represented a particular project/VEC combination, and those who agreed to participate were asked to indicate which combinations they would be capable of commenting upon with regard to potential impacts. More specifically, for each VEC which they had expertise, panellists were asked to:

> 1) Mark an ***X*** in those cells corresponding to project/VEC combinations for which they were familiar with the small hydro project, and would be capable of commenting upon the potential impact of that project on that particular VEC;
>
> 2) Indicate with an ***O*** those cells corresponding to projects with which they were unfamiliar, but had a knowledge of the VEC in the vicinity of the project, and thus, would feel capable of commenting upon potential impacts if provided with a project summary; and
>
> 3) Mark ***N/A*** in those cells where, in their opinion, the VEC was not present in the vicinity of a project, and therefore, would not be affected.

This scheme was used merely to ensure that panellists did not exclude project/VEC combinations for which they were unfamiliar with the project but would be able to predict potential impacts on the basis of their knowledge of the VEC in that area, and/or combinations for which the panellist felt that the VEC would not be affected because of its absence from the area. Panellists were not given a maximum or minimum number of project/VEC combinations for which they could indicate an ability to comment upon.

A self-addressed stamped envelope was included with the package, and potential panellists were asked to return the form within one week of receiving it (regardless of whether they agreed or declined to participate). In the seven-week period between June 12 and July 31, 1996, a total of 123 potential expert panellists were invited to participate in the study.

4.4.3 Round One

Of the 123 individuals who were invited to participate in the study, 85 (69.1 percent) responded to the request, of which 49 (57.6 percent) agreed to participate. A total of 1,385 project/VEC combinations were indicated by these 49 expert panellists, ranging from one to 192 per panellist, or a mean of 28.3 combinations.

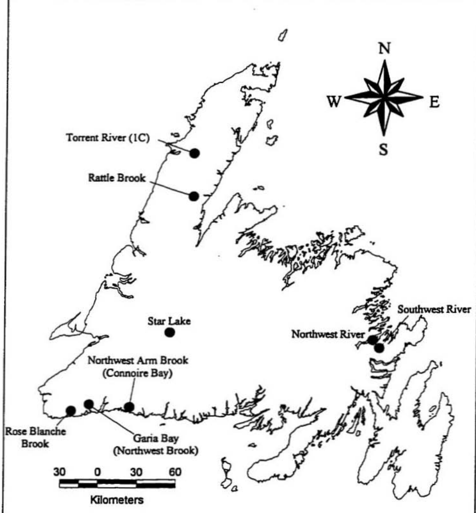
Although 12 proposed small hydro developments were initially to be considered in the study, details regarding the specific characteristics of four of these projects (Kings Harbour River, Lady Pond, Rattling Pond Brook and Sheffield Lake) could not be obtained. Unlike the other eight projects, these had not been registered under the EA Act at the time this study was initiated, and as a result, project descriptions for these developments were not available to the public. An attempt was made to obtain descriptions of the four projects from Hydro, but specific details regarding the projects were considered privileged information, and thus, could not be released (Boone, 1996 pers comm). Attempts to obtain project details directly from the projects' proponents also proved unsuccessful. Consequently, only eight of the projects initially identified (i.e. Garia Bay (Northwest Brook); Northwest Arm Brook (Connoire Bay); Northwest River; Rattle Brook; Rose Blanche Brook; Southwest

River; Star Lake; and Torrent River (Site 1C)) were considered in the CEA (Figure 4.2). It should also be noted that although the Torrent River project (27 MW) is not classified as a small-scale hydro development, *per se*, it was proposed as a 15 MW facility when being considered by Hydro in August 1993. However, it was subsequently redesigned in 1994, increasing its potential generating capacity (Torrent Small Hydro Corp., 1995). It is this modified project proposal that is currently being subject to the Newfoundland EIA process, and which was considered in this assessment.

As a result of this reduction in the number of projects being considered, three panellists were no longer able to participate, as they had indicated an ability to comment only upon the potential impacts of one or more of the four projects dropped from consideration.

As suggested previously, EIA activity in relation to the Garia Bay, NW Arm Brook and Torrent River projects indicated the possibility that these sites may be developed in the future. The Kings Harbour River project had, however, not been registered under the EA Act by the conclusion of this study despite the fact that it would have required registration before being permitted to proceed. It should, however, be emphasized that although the activity (or inactivity) of the EIAs of individual small hydro proposals was used as an indicator of their potential for future development, as indicated in Chapter Two there was apparently not a clear relationship between the consideration of projects by Hydro and their registration

FIGURE 4.2: PROPOSED SMALL HYDRO PROJECTS UNDER CONSIDERATION



under the EA Act. Also, some projects (e.g. Lady Pond and Rattling Pond Brook) would not have required registration at all as they would have installed capacities of less than one MW. Thus, these projects may well have the potential for future development, but because they would have been exempt from registration, this was very difficult to assess. The proponents of each of these projects were contacted in order to determine the current status of the proposals, but these attempts also proved unsuccessful. The five MW Sheffield Lake project was, however, registered under the EA Act in February 1997 (nearly one year after this study was initiated), as was a proposal for an additional two MW facility on the Southwest River (presumably in relation to Hydro's 1997 RFP). In short, although the assessment attempted to consider those projects which were currently being developed as well as "reasonably foreseeable future" small hydro projects, it was extremely difficult to predict those particular sites which would be developed with any degree of certainty.

The necessity of a preliminary scoping exercise to determine the important issues and environmental components that should be addressed in an environmental assessment has long been recognized (e.g. Beanlands and Duinker, 1983; Wolfe, 1987). While 21 potentially affected VECs were initially identified, it was also necessary to reduce this number considerably to ensure that the scope of the study remained manageable. While the 21 target resources initially identified have, to varying degrees, all been identified as potential issues in the assessment of small hydro proposals in the province, it was decided to focus the CEA on the following eight VECs: 1) ***Water Resources***; 2) ***Fish Resources***; 3) ***Raptors***; 4) ***Waterfowl/ Migratory Birds***; 5) ***Caribou***; 6) ***Moose***; 7) ***Furbearers/Small Mammals***; and 8) ***Historic Resources***. While not an exhaustive list, these VECs were selected because they were found to be those most often raised as potential issues in project-level EIAs, and thus, those most often associated with the impacts of small hydro developments on the Island. Consequently, eight proposed small hydro projects and eight VECs remained under consideration, giving a total of 64 project/VEC combinations. Based on this revised number, the 46 remaining panellists had collectively indicated an ability to comment upon 480 project/VEC combinations, ranging from one to 50 combinations per panellist, or a mean of 10.4.

A means by which expert opinion could be used to assign numerical impact values which represented the relative significance of the impact of each project on each of the target VECs was also required. This was necessary so that these project-specific impact scores could be entered into a matrix and summed to assess the potential additive cumulative effects of the set of projects as a whole. This was accomplished by having panellists rate the potential impact of each project/VEC combination indicated on the basis of a set of impact evaluation criteria. Based on the findings of a review of the literature pertaining to the evaluation of the significance of environmental impacts (e.g. Sharma et al., 1976; Andrews et al., 1977; Prasartseree, 1982; Beanlands and Duinker, 1983; Haug et al., 1984; Duinker and Beanlands, 1986; Thompson, 1990; Canter and Canty, 1993) the following criteria were selected:

1) The **Probability** that the VEC in question would be affected by the proposed development;

2) The **Magnitude** of the potential impact;

3) The **Spatial Extent** of the potential impact;

4) The **Temporal Duration** of the potential impact;

5) The **Importance of the VEC** in question to decision-making;

6) The **Current/Pre-project State of the VEC** (i.e. its resilience or sensitivity to further stress due the impacts of past or present anthropogenic activities with which a project's impacts may interact, and/or natural conditions and variability).

The Round One questionnaire package included a cover letter which thanked panellists for agreeing to participate in the study, and further outlined the specific details of the methodology to be employed. The package itself consisted of the following three documents (Appendix B):

DOCUMENT A: Each panellist was forwarded brief project descriptions and maps for each small hydro project for which he or she had indicated an ability to comment upon. These project summaries were based upon the most recent EIA documentation available for each project as of August 1, 1996.

DOCUMENT B: In order to ensure that impact ratings would be consistent between panellists, Document B presented definitions of each of the evaluation criteria and associated impact ratings.

DOCUMENT C: The questionnaire itself comprised a separate question sheet for each identified project/VEC combination. For each combination, panellists were instructed to rate the potential impact on the basis of the impact evaluation criteria discussed previously. **Impact Probability** was rated on a ten-point scale from zero to 100 percent; **Impact Magnitude** (*Negligible, Minor, Moderate* or *Major*), **Spatial Extent** (*Site-specific; Local, Regional* or *Provincial*), **Temporal Duration** (*Short-Term, Medium-Term, Long-Term* or *Prolonged*), and the **Current State of the VEC** (i.e. *Resilient, Low Sensitivity, Medium Sensitivity* or *High Sensitivity*), were each rated on four-point scales. **VEC Importance** was evaluated in two ways - the importance of the VEC in relation to other VECs in the same project area, and its importance in relation to the same VEC in other project areas. In both cases, VEC Importance was rated on a five-point scale (ranging from *Not at all Important* to *Very Important*).

For each question sheet, participants were instructed to circle the number which corresponded to their best estimate for each of the seven impact evaluation criteria. In cases where panellists felt that a VEC was not present in a particular project area, and thus could not be affected by the project, they were asked to circle *Zero Percent* under Impact Probability and disregard the remaining questions on that sheet. In cases such as this, the panellist's responses for each of the evaluation criteria were assigned a value of zero in formulating the overall group response. For each impact rating (or series of ratings) panellists were invited to give a brief summary of the rationale for their response(s). Finally, for each of the small hydro projects which they had commented upon, panellists were asked to rate their level of knowledge of that project prior to receiving the questionnaire. Because the projects were at varying stages of the EIA process, in order to keep "all things equal" panellists were asked to give impact ratings which did not consider proposed or possible impact mitigation measures. Also, in order to maintain the anonymity feature of the Delphi procedure, panellists were asked to refrain from discussing their responses with others.

As a result, with the exception of the Round One cover letter and Document B, the specific materials each panellist received varied considerably; the nature of the questionnaire package being determined by the particular project/VEC combinations which they had initially identified.

Pre-testing of the initial Round One questionnaire took place during the week of August 12, 1996. Preliminary questionnaires were sent to two randomly selected panellists for review, with a request for comments and suggestions and an indication of the amount of time it took to complete each question sheet. The questionnaire was also reviewed by a number of non-participating individuals in order to ensure that questions and instructions were clear and understandable. No significant changes were made to the Round One package as a result of this pre-testing. However, two potential problem areas were noted. The first was that panellists were being asked to assign static numerical values to impacts that were likely to be quite variable over space (e.g. an impact may be major in one part of the affected area, but minor in another), over time (e.g. an impact may be moderate during project construction, but negligible during project operation) and/or, where applicable, within a *VEC Category* (e.g. one species of Raptors may be more severely affected than another), etc. To alleviate this problem, the instructions for Round One were revised slightly; panellists were asked to assign impact ratings which reflected the maximum score likely for each of the seven impact evaluation criteria (e.g. in cases where one species of affected Waterfowl was deemed relatively unimportant but another was considered to be very important, panellists were instructed to give a score of "five").

Those involved in the questionnaire pre-test also expressed concern over the length of time it would take to complete the questionnaire, and felt that this might result in a high drop-out rate. It was therefore decided to place a limit on the number of question sheets that each individual panellist would be required to complete. Based upon the time it took for the pre-testing panellists to complete each sheet, and their opinions regarding a suitable upper limit, a maximum of 16 project/VEC combinations was decided upon. Five of the 46 panellists had indicated more than 16 project/VEC combinations (ranging from 18 to 50). For these five panellists, the 16 combinations for which they had indicated, or were understood, to have the greatest expertise were selected. In cases where this number was greater than 16, a total of 16 of these combinations were selected at random. Where this number was less than 16, additional combinations were randomly selected out of the remainder of those they had indicated.

Thus, 46 individuals comprised the study's expert panel in Round One. Collectively, they received a total of 379 question sheets (ranging from one to 16 sheets per person, or a mean of 8.2). Round One questionnaires were mailed to the 46 expert panellists on Wednesday September 4, 1996. Reminder letters were sent to non-respondents approximately three weeks after the questionnaires were mailed, and further reminder letters were sent at approximately two-week intervals until November 6, 1996.

4.4.4 Round Two

Forty of the 46 panellists (87 percent) completed and returned their Round One questionnaires, with surveys being received between September 12, 1996 and January 13, 1997. Returned question sheets totalled 320, or 84.4 percent of the 379 question sheets forwarded to the panel as a whole in Round One.

Comments given by several panellists in relation to their responses revealed that in some cases, panellists were formulating their impact predictions on the basis of very differing assumptions, and may have been interpreting questions quite differently. For example, while panellists were asked to disregard impact mitigation measures, some assumed that the proponent would adhere to any applicable laws, regulations, etc., while others apparently did not. Also, some panellists rated the Temporal Duration of impacts on the basis of the number of years over which the disturbance itself would occur, while others predicted the time it would take for the VEC, once initially affected, to return to its pre-project state. Several authors caution that the misinterpretation of questions can seriously undermine the accuracy and utility of the results of a Delphi survey (Gordon and Helmer, 1964; Hill and Fowles, 1975; Sackman, 1975; Leitch and Leistritz, 1984), and that where questions are open to differing interpretations, the accuracy of a group forecast derived from the aggregation of these responses may be severely compromised. While only a limited number of comments were provided by panellists in Round One, it was possible that these variations in assumptions and interpretation may have been widespread within the panel as a whole. As a result, the observed variability in individual responses in Round One may, in some cases, have been due to these factors rather than actual differences of opinion regarding potential impacts. As more emphasis was placed on the quality of the data obtained than on merely attempting to obtain a consensus, Round Two of the study was quite unlike that of a traditional Delphi survey. Instead of being given a statistical summary of the Round One group responses, panellists were provided with a set of more stringent instructions which were intended to define the particular assumptions to be made in rating potential impacts, as well as to clarify any other apparent misinterpretation of the questions being posed.

Also, for each question sheet, panellists were given their own Round One responses, as well as a summary of the comments and rationales given by other panellists in relation to their impact ratings. As only a limited amount of information could be included on each question sheet, comments were edited and summarized considerably. In cases where two or more panellists provided similar comments, these were paraphrased and listed only once. Also, general comments such as "The impact on Moose will be negligible" or "Water Resources will not be affected" (i.e. which gave no indication of the rationale behind them) were not included. Comments were not intended to represent particular impact ratings, but simply to share the information given by individual panellists with others commenting upon that project/VEC combination. Participants were asked to note that the comments given were not necessarily a comprehensive list of all factors which should be considered in rating potential impacts, and that where several comments were presented they might, in fact, be quite conflicting. They were also advised that they were free to agree or disagree which any of the comments given, and that if unsure of the applicability and/or validity of a particular comment they should disregard it when formulating their Round Two responses. In short, in Round Two of the study panellists were asked to reevaluate their Round One responses in light of a set of more explicit assumptions and further instructions, as well as the comments provided by other panellists (Appendix C).

On Monday November 18, 1996, Round Two questionnaires were mailed to the 36 panellists who had returned Round One by that date. Reminder letters were again forwarded to those as yet unresponding panellists after three weeks, and then at approximately two week intervals until January 20, 1997. Four additional Round One questionnaires were received after November 18; Round Two questionnaires were sent to these panellists the day following the receipt of Round One (even though the Round One comments provided by these panellists could obviously not be fed back to the panel as a whole).

4.4.5 Round Three

Round Two questionnaires were received from all of the 40 participants, giving a response rate of 100 percent. Questionnaires were received between November 22, 1996 and January 31, 1997. These Round Two results were tabulated, and preliminary statistical analysis was performed. More specifically, the median response for each of the seven impact evaluation criteria for each project/VEC combination was calculated.

Each participant's Round Three questionnaire, like that in each of the two previous rounds, consisted of a separate question sheet for each of those project/VEC combinations being considered by that panellist. On each question sheet, panellists were provided with their own Round Two ratings, as well as the median responses of all panellists commenting upon that project/VEC combination. Based on this information, they were asked to reevaluate (if necessary) their Round Two ratings in light of the group responses and record their Round Three responses (even if unchanged). Finally, in cases where their Round Three response continued to differ from the median, panellists were invited to give a brief explanation of why, in their opinion, the "correct" rating should be higher or lower than the Round Two group response (Appendix D).

Round Three questionnaires were mailed to the 40 expert panellists on Monday February 3, 1997. Reminder letters were again sent to non-responding panellists after three weeks, and then at two week intervals until April 7, 1997. Questionnaires were received from all but one of the 40 panellists, giving a Round Three response rate of 97.5 percent (The researcher was later informed that this panellist had passed away in early March). Surveys were received between February 5 and May 8, 1997, and returned question sheets totalled 314, or 98.1 percent of the 320 sent.

4.4.6 Termination of the Delphi Procedure

The Delphi procedure was terminated after Round Three. Although the Delphi literature provides little guidance in determining when maximum consensus has been achieved, or even the extent of consensus required, at this time a general stability of responses had been attained, and few new ideas and comments were proposed in Round Three to form the basis for feed-back in subsequent rounds. It was also becoming increasingly difficult to obtain completed questionnaires from all participants. The median Round Three response for each evaluation criteria therefore represented the final impact predictions for each project/VEC combination.

On May 14, 1997, the 39 panellists who had completed and returned all three questionnaires were sent a letter of appreciation for their participation in the study.

Panellists were also forwarded some of the preliminary results of the assessment in histogram form, and were invited to submit any comments or queries they might have with regard to these results. No substantive feedback was received from participants regarding these results.

4.5 SUMMARY

Given the nature and methodological requirements of this study, and the shortcomings of existing CEA techniques (both in general and in the context of these specifications), expert judgement was deemed to be the only practical and feasible methodological alternative. A modified Delphi technique was used to gather the opinions of expert panellists in as systematic a manner as possible; participants were asked to rate the potential impact of identified project/VEC combinations on the basis of a set of impact evaluation criteria. The following chapter presents the results of the Delphi survey, and describes how these individual group forecasts were combined into a single impact score for each project/VEC combination. It also describes the matrix technique used, and presents and discusses the results of these impact summations.

Chapter Five
RESULTS AND ANALYSIS

5.1 INTRODUCTION

This chapter presents and analyses the results of the Delphi survey. More specifically, it presents the final (Round Three) data, and describes the specific techniques used for data aggregation and analysis. It first examines these results with reference to potential project-specific impacts (i.e. the potential effect of each project on the set of VECs as a whole). This is followed by an assessment of the potential cumulative effects of the set of eight projects on each of the eight VECs under consideration, including the identification of those VECs most significantly affected, and an analysis of the degree to which the impacts of individual projects contribute to these potential cumulative effects. Where possible, the discussion also includes reference to the qualitative information provided by panellists throughout the course of the Delphi survey (including the identification of specific areas of agreement and disagreement between participants). The chapter concludes with an analysis of the potential cumulative effects of small hydro development in Newfoundland at differing spatial and temporal scales.

5.2 DATA AGGREGATION

Table 5.1 presents the set of definitions provided to expert panellists for each of the seven impact evaluation criteria and associated impact ratings.

TABLE 5.1: IMPACT EVALUATION CRITERIA AND ASSOCIATED IMPACT RATINGS

IMPACT PROBABILITY: The probability (in percent) that the VEC in question will be affected by the proposed small hydro development.

IMPACT MAGNITUDE*: The degree of impact.

1) **Negligible:** A change to the VEC that is indistinguishable from natural variation.

2) **Minor:** A reversible change to the VEC's normal or baseline condition, usually restricted to a particular facet of the environment. The fundamental integrity of the VEC is not threatened.

3) **Moderate:** A reversible change to the VEC's normal or baseline condition, with a medium probability of second order effects on other environmental components. The fundamental integrity of the VEC(s) is not threatened.

4) **Major:** An irreversible change to the VEC's normal or baseline condition, with a high probability of second order effects on other environmental components. The fundamental integrity of the affected VEC(s) is threatened.

SPATIAL EXTENT*: The geographical extent over which the VEC will be affected.

1) **Site-specific:** Effect will be confined to the project development area.

2) **Local:** Effect will be confined to the project area and immediate environment.

3) **Regional:** Effect will occur within and beyond the development area and immediate environment, affecting a defined territory surrounding the proposed development.

4) **Provincial:** Effect will occur across the province.

TABLE 5.1 (Continued): IMPACT EVALUATION CRITERIA AND ASSOCIATED IMPACT RATINGS

TEMPORAL DURATION*: The period of time over which the VEC will be affected.

1) Short-term: Effect may persist less than two years from the onset of disturbance.

2) Medium-term: Effect may persist from two to less than five years from the onset of disturbance.

3) Long-term: Effect may persist from five to less than ten years from the onset of disturbance.

4) Prolonged: Effect may persist ten years or more from the onset of disturbance.

VEC IMPORTANCE: The relative importance of the VEC (considering both its direct and indirect importance):

i) Its importance compared with the <u>same VEC</u> in <u>other project areas</u>.

ii) Its importance compared with <u>other VECs</u> in the <u>same project area</u>.

Both were rated on five-point scales ranging from 1 (*Not at all important*) to 5 (*Very Important*).

CURRENT STATE OF THE VEC: The pre-project state of the VEC (due to the natural conditions and/or the impacts of other past or present human activities).

1) Resilient: VEC is quite resilient to impact, due to its natural condition and/or the lack of other adjacent human activities.

2) Low Sensitivity: VEC has a low susceptibility to impact, due to its natural condition and/or the impacts of other adjacent human activities.

3) Medium Sensitivity: VEC is moderately susceptible to impact, due to its natural condition and/or the impacts of other adjacent human activities.

4) High Sensitivity: VEC is highly susceptible to impact, due to its natural condition and/or the impacts of other adjacent human activities.

***Source: NDOE (1995: 3-4).**

Upon its conclusion, the Delphi procedure generated a single group forecast value (in the form of the median Round Three rating) for each of these evaluation criteria for each of the 64 project/VEC combinations under consideration. These results are presented in Tables 5.2 to 5.8. In terms of the format of each table:

i) The eight VECs under consideration are listed along the vertical axis;

ii) The eight small-scale hydro projects are listed along the horizontal axis using the following abbreviations:

GB	Garia Bay (Northwest Brook)
NWAB	Northwest Arm Brook (Connoire Bay)
NWR	Northwest River
RB	Rattle Brook
RBB	Rose Blanche Brook
SWR	Southwest River
SL	Star Lake
TR	Torrent River

iii) Each cell presents the Round Three group forecast (i.e. the median response) for that project/VEC combination.

TABLE 5.2: IMPACT PROBABILITY[*] (Median Round 3 Ratings)

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	100%	100%	100%	100%	100%	100%	100%	100%
Fish Resources	100%	100%	100%	90%	100%	100%	100%	100%
Raptors	50%	50%	45%	40%	50%	40%	25%	45%
WF/Migratory Birds	100%	50%	20%	20%	75%	10%	60%	75%
Caribou	25%	80%	10%	25%	30%	25%	70%	85%
Moose	70%	60%	45%	30%	30%	40%	30%	30%
FurBr/Sm Mammals	100%	50%	80%	85%	80%	50%	70%	35%
Historic Resources	40%	25%	75%	35%	17.5%	10%	70%	60%

[*]The probability (in percent) that the VEC will be affected by the proposed small hydro development.

TABLE 5.3: IMPACT MAGNITUDE (Median Round 3 Ratings)								
VEC	**GB**	**NWAB**	**NWR**	**RB**	**RBB**	**SWR**	**SL**	**TR**
Water Resources	3	3	3	2	2.5	2	3	3.75
Fish Resources	3.5	3	4	3	3	3	4	3.5
Raptors	2	2	1.5	2.5	2	2	2	2.5
WF/Migratory Birds	2	2	1	2	2.5	1	3	3.75
Caribou	2	3	1	2	2	1	3	3
Moose	2	2	1.5	2	1	2	1	2
FurBr/Sm Mammals	2	2	2.5	3	2	2	3	2
Historic Resources	4	2.75	4	2.5	2	1	4	4

KEY: 1) Negligible Impact 2) Minor Impact 3) Moderate Impact 4) Major Impact

TABLE 5.4: SPATIAL EXTENT (Median Round 3 Ratings)								
VEC	**GB**	**NWAB**	**NWR**	**RB**	**RBB**	**SWR**	**SL**	**TR**
Water Resources	2	2	2	1.5	2	2	3	2
Fish Resources	2	2	2.5	2	2	2	3	2.5
Raptors	1	2	1	1.5	2	1	1	1.5
WF/Migratory Birds	2	3	2	2.5	2.5	1	3	4
Caribou	1	2	1	2	2	1	2.5	2.5
Moose	1	2.5	1.5	1	1	1	1	2
FurBr/Sm Mammals	2	2	2.5	2	2	2	3	2
Historic Resources	1	1	1.5	1	1	1	3	1

KEY: 1) Site-specific Impact 2) Local Impact 3) Regional Impact 4) Provincial Impact

TABLE 5.5: TEMPORAL DURATION (Median Round 3 Ratings)

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	4	4	4	4	4	4	4	4
Fish Resources	4	4	4	4	4	4	4	4
Raptors	1	1	1	1.5	1	1	1	1
WF/Migratory Birds	3	4	2	2.5	3.5	4	4	4
Caribou	2.75	4	2	2	4	1	4	4
Moose	4	2	1.5	2.5	4	1	3	4
FurBr/Sm Mammals	1	2	2	3.5	1	2	4	2
Historic Resources	4	4	4	4	4	4	4	4

KEY: 1) Short-term Impact 2) Medium-term Impact 3) Long-term Impact 4) Prolonged Impact

TABLE 5.6: VEC IMPORTANCE [Compared with other areas]* (Median Round 3 Ratings)								
VEC	**GB**	**NWAB**	**NWR**	**RB**	**RBB**	**SWR**	**SL**	**TR**
Water Resources	2	2	4	2	3	2	4	3
Fish Resources	3	3	4	3	2	3	4	4
Raptors	3	5	2	4	3	2	2.5	3.5
WF/Migratory Birds	3	3	2	1.5	3	1	3	4.75
Caribou	2	4	2	2	2	2	4.5	4
Moose	2	2	2	2	2	2	2.5	2
FurBr/Sm Mammals	2	2	3.5	4.5	2.5	3	5	2.5
Historic Resources	3	3	3.5	2.25	3	3	4.5	4

***Rated on a five-point scale ranging from 1 (*Not at all important*) to 5 (*Very Important*)**

TABLE 5.7: VEC IMPORTANCE [Compared with other VECs]* (Median Round 3 Ratings)								
VEC	**GB**	**NWAB**	**NWR**	**RB**	**RBB**	**SWR**	**SL**	**TR**
Water Resources	3	2	4	2.5	3.5	3	4	3.5
Fish Resources	3.5	3	5	3	2	3	4	4
Raptors	3	4	3	4	3	2	2.5	3.5
WF/Migratory Birds	3	3	2	2	3	2	3	4.75
Caribou	3	5	2	2	3.5	2	5	4
Moose	2	2.5	2.5	2	2	2	2.5	2
FurBr/Sm Mammals	2	2	3	4.5	2.5	3	5	2.5
Historic Resources	4	3	3.5	2.25	2	2	5	3.75

***Rated on a five-point scale ranging from 1 (*Not at all important*) to 5 (*Very Important*)**

TABLE 5.8: CURRENT STATE OF THE VEC (Median Round 3 Ratings)								
VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	2	2	4	2	3	3	3	3
Fish Resources	4	3	4	3	3	3	4	3
Raptors	3	3	3	3.5	3	3	3.5	3.5
WF/Migratory Birds	3	4	3	3	3.5	3	3	4
Caribou	2.5	3	2	2	2	2	3	2.5
Moose	1	2	1	1	2	1	1	2
FurBr/Sm Mammals	2	2	3.5	3.5	2	3	4	2.5
Historic Resources	2.5	2.25	3	1.5	2	2	3	2

KEY: 1) Resilient 2) Low Sensitivity 3) Medium Sensitivity 4) High Sensitivity

Individual forecasts for each project/VEC combination were subsequently aggregated to derive a single *Impact Score* for each combination:

$$\mathbf{I_aVEC_i = P_i(M_i \times SE_i \times TD_i) \times CS_i}$$

Where;

$\mathbf{I_aVEC_i}$ = The relative significance of the potential impact of Project a on VEC i

$\mathbf{P_i}$ = The Probability that VEC i will be affected by Project a

$\mathbf{M_i}$ = The Magnitude of the effect of Project a on VEC i

$\mathbf{SE_i}$ = The Spatial Extent of the effect of Project a on VEC i

$\mathbf{TD_i}$ = The Temporal Duration of the effect of Project a on VEC i

$\mathbf{CS_i}$ = The Current State of VEC i in the vicinity of Project a

As a result, individual impact scores ranging from zero (*No Impact*) to 256 (*Maximum Impact*) were derived for each of the 64 project/VEC combinations. Each score represented the potential level of impact of a specific project on a particular VEC. These data were entered into the summary matrix shown in Table 5.9.

For each combination, median group responses for VEC Importance were scaled from zero to one and subsequently used to generate impact scores which reflected the relative importance of the VEC in question. These "adjusted" values were subsequently used to derive project-specific and cumulative effect indices, the results of which are discussed in the following sections.

TABLE 5.9: CALCULATED IMPACT SCORES FOR EACH PROJECT/VEC COMBINATION

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	48.00	48.00	96.00	24.00	60.00	48.00	108.00	90.00
Fish Resources	112.00	72.00	160.00	64.80	72.00	72.00	192.00	105.00
Raptors	3.00	6.00	2.03	7.88	6.00	2.40	1.75	5.91
WF/Migratory Birds	36.00	48.00	2.40	7.50	57.42	1.20	64.80	180.00
Caribou	3.44	57.60	0.40	4.00	9.60	0.50	63.00	63.75
Moose	5.60	12.00	1.52	1.50	2.40	0.80	0.90	9.60
FurBr/Sm Mammals	8.00	8.00	35.00	62.48	6.40	12.00	100.80	7.00
Historic Resources	16.00	6.19	54.00	5.25	2.80	0.80	100.80	19.20

5.3 PROJECT-SPECIFIC IMPACT INDICES

By multiplying calculated impact scores for each project/VEC combination by their associated **VEC Importance** (*Compared with the same VEC in other project areas*) (VECImp1) scalars, these scores were adjusted for the relative importance of the VEC in that area:

$$\mathbf{I_a VEC_i \times VECImp1_i}$$

Where;

$\mathbf{I_a VEC_i}$ = The potential impact of Project a on VEC i

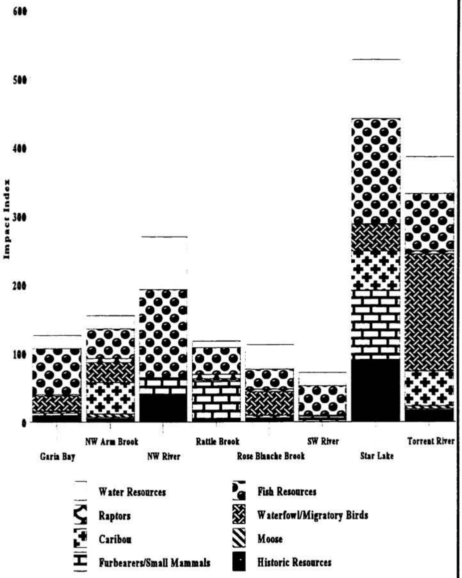
$\mathbf{VECImp1_i}$ = The Importance of VEC i in the vicinity of Project a (*In relation to the same VEC in other project areas*)

These impact scores were subsequently entered into a matrix (Table 5.10). For each small hydro project, individual impact scores for each of the eight VECs were summed to derive *Project-Specific Impact Indices* which represented the overall effect of each individual project on the set of VECs as a whole. Table 5.10 also presents these summations, and ranks the eight projects in terms of their overall impact index (with one being the most significant and eight being least). Project-specific impact indices are also presented in graph form in Figure 5.1. Impact indices for individual projects were quite variable, ranging from 71.80 (Southwest River) to 528.43 (Star Lake). The sum of the eight project-specific impact indices was 1768.27, with a mean score of 221.03. The following section discusses the calculated impact indices for each project in descending rank order.

TABLE 5.10: IMPACT SCORES (Scaled with VEC Importance 1 Ratings)

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	19.20	19.20	76.80	9.60	36.00	19.20	86.40	54.00
Fish Resources	67.20	43.20	128.00	38.88	28.80	43.20	153.60	84.00
Raptors	1.80	6.00	0.81	6.30	3.60	0.96	0.88	4.14
WF/Migratory Birds	21.60	28.80	0.96	2.25	34.45	0.24	38.88	171.00
Caribou	1.38	46.08	0.16	1.60	3.84	0.20	56.70	51.00
Moose	2.24	4.80	0.61	0.60	0.96	0.32	0.45	3.84
FurBr/Sm Mammals	3.20	3.20	24.50	56.23	3.20	7.20	100.80	3.50
Historic Resources	9.60	3.71	37.80	2.36	1.68	0.48	90.72	15.36
Σ	**126.22** (5)	**154.99** (4)	**269.64** (3)	**117.82** (6)	**112.53** (7)	**71.80** (8)	**528.43** (1)	**386.84** (2)

FIGURE 5.1: PROJECT-SPECIFIC IMPACT INDICES



i) Star Lake (528.43): The score for this project comprised nearly 30 percent of the sum of all eight project-specific impact indices (1768.27), and was 139 percent greater than the mean score of the eight projects (221.03). Impact scores for individual VECs associated with the project were quite variable, ranging from 0.45 (Moose) to 153.60 (Fish Resources), with a mean of 66.05. Scores for Water Resources, Fish Resources, Caribou, Furbearers/Small Mammals and Historic Resources were each relatively high for this development, collectively comprising approximately 92 percent of the project's index.

ii) Torrent River (386.84): This project's score comprised 22 percent of the sum of the eight project-specific indices, and was 75 percent greater than the mean of these eight values. Impact scores for individual VECs in relation to this project ranged from 3.50 (Raptors) to 171.00 (Waterfowl/Migratory Birds) (with a mean of 48.36), but were the most variable between VECs of any of the eight projects under consideration. The project's impact score in relation to Waterfowl/Migratory Birds was by far its highest, itself accounting for 44 percent of the project's index. Impact scores for Water Resources, Fish Resources and Caribou were also each relatively high for the project, with values for these VECs collectively comprising nearly one-half of the project's overall score. In contrast, impact scores for Raptors, Moose and Furbearers/Small Mammals were quite low in comparison to those for other VECs.

iii) Northwest River (269.64): The index for this project was approximately 22 percent greater than the mean of the impact values of all eight projects, and comprised 15 percent of the sum of these eight scores. Impact scores for individual VECs associated with this project were also quite variable, ranging from 0.16 (Caribou) to 128.00 (Fish Resources), with a mean of 33.71. Scores for Water Resources and Fish Resources each comprised approximately 28 and 47 percent of the project's index, respectively. Values representing the potential effects of this project on Furbearers/Small Mammals and Historic Resources were also relatively high, and collectively accounted for 23 percent of the project's overall score. Impact values for Raptors, Waterfowl/Migratory Birds, Caribou and Moose were each relatively low in comparison to those for other VECs, together comprising less than one percent of the project's overall impact index.

iv) Northwest Arm Brook (Connoire Bay) (154.99): This project's impact index was considerably less than the mean value for the set of projects as a whole, and comprised less than nine percent of the sum of the eight projects' impact scores. Impact values for individual VECs ranged from 3.20 (Furbearers/Small Mammals) to 46.08 (Caribou), with a mean value of 19.37. The project's potential impact on Caribou accounted for nearly 30 percent of its overall score. Impact values for Fish Resources and Waterfowl/Migratory Birds were also relatively high for this project, accounting for approximately 28 and 19 percent of the project's index, respectively.

Values for Furbearers/Small Mammals and Historic Resources were the lowest in relation to this project, together comprising less than five percent of the project's impact index.

v) Garia Bay (Northwest Brook) (126.22): The impact index for this project was also considerably less than the mean score of all eight projects, and comprised only seven percent of the sum of these indices. Scores for individual VECs ranged from 1.38 (Caribou) to 67.20 (Fish Resources), with a mean of 15.78. The project's potential impact on Fish Resources comprised over one-half of its overall score, and its potential effects on Water Resources and Waterfowl/Migratory Birds collectively comprised approximately 32 percent. Impact values in relation to the remaining five VECs were each relatively low; with a mean of 3.64, scores for these VECs collectively accounted for less than 15 percent of the project's overall impact index.

vi) Rattle Brook (117.82): This project's overall impact index was approximately 47 percent less than the mean of the eight project-specific impact scores, and comprised less than seven percent of the sum of these indices. Impact scores for individual VECs ranged from 0.60 (Moose) to 56.23 (Furbearers/Small Mammals), with a mean value of 14.73. By far the greatest impact score associated with this project was that for Furbearers/Small Mammals, which, in itself, accounted for nearly one-half of the project's overall impact value. Impact scores in relation to the remaining seven VECs ranged from 0.60 (Moose) to 38.88 (Fish Resources), with a mean of 8.80.

vii) Rose Blanche Brook (112.53): The impact index for this project was only approximately one-half of the mean score of the set of eight projects, and comprised approximately six percent of the sum of the eight project-specific impact indices. Impact scores for individual VECs ranged from 0.96 (Moose) to 36.00 (Water Resources), with a mean of 14.07. Impact values for Water Resources and Waterfowl/Migratory Birds were each relatively high in relation to those for other VECs, together accounting for approximately 63 percent of the project's overall index. The lowest impact values associated with this project were those for Moose and Historic Resources, which collectively comprised only approximately two percent of the project's impact index.

viii) Southwest River (71.80): This project's impact index was 60 percent less than the mean of the eight project-specific impact indices, and comprised only four percent of their sum. Scores for individual VECs in relation to this project ranged from 0.20 (Caribou) to 43.20 (Fish Resources), with a mean of 8.98. The project's potential effects on Water and Fish Resources comprised approximately 27 and 60 percent of its total score, respectively. With the exception of its relatively high score for Furbearers/Small Mammals (7.20), the project was deemed to have the potential for relatively insignificant impacts upon other wildlife VECs and Historic Resources;

impact scores for these five VECs were each less than one, and together comprised only approximately three percent of the project's impact index.

In summary, individual small hydro projects were found to vary considerably in terms of the relative significance of their impact on the set of eight VECs as a whole. Also, there was, in most cases, considerable variation between projects regarding those VECs potentially the most and least significantly affected. The preceding analysis is very much in keeping with the focus of traditional EIA, as it focuses upon the potential impacts of individual development activities upon a set of target resources. However, as the primary objective of this study was to assess the potential cumulative effects of this set of projects, the following section presents an analysis of the results of the CEA.

5.4 CUMULATIVE EFFECT INDICES (ALL PROJECTS)

By multiplying calculated impact scores for each combination (as given in Table 5.9) by their associated **VEC Importance** (*Compared with other VECs in the same project area*) (VECImp2) scalars, individual impact values for each project/VEC combination were derived which represented the potential impact of each project on each VEC, adjusted for the relative importance of the VEC in relation to others in the project area:

$$\mathbf{I_a VEC_i \times VECImp2_i}$$

Where;

$\mathbf{I_a VEC_i}$ = The potential impact of Project a on VEC i

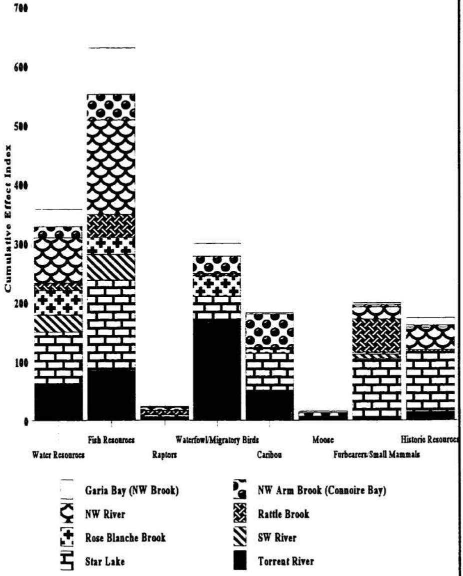
$\mathbf{VECImp2_i}$ = The Importance of VEC i (*In relation to other VECs in the same project area*)

These results were entered into the matrix shown in Table 5.11. Impact scores for each of the 64 project/VEC combinations ranged in value from 0.16 (Northwest River - Caribou) to 171.00 (Torrent River - Waterfowl/Migratory Birds), with a mean of 29.36. For each of the eight VECs, impact scores for the eight projects were summed to derive a series of *Cumulative Effect Indices*; more specifically, row summations yielded numerical values which represented the potential additive effect of the set of eight projects on each of the VECs under consideration. These indices are also presented in Table 5.11, and are ranked in order of significance as well (with one being most significant and eight being the least). Figure 5.2 illustrates these indices in graph form.

TABLE 5.11: IMPACT SCORES (Scaled with VEC Importance 2 Ratings)

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR	Σ
Water Resources	28.80	19.20	76.80	12.00	42.00	28.80	86.40	63.00	**357.00 (2)**
Fish Resources	78.40	43.20	160.00	38.88	28.80	43.20	153.60	84.00	**630.08 (1)**
Raptors	1.80	4.80	1.22	6.30	3.60	0.96	0.88	4.14	**23.70 (7)**
WF/Migratory Birds	21.60	28.80	0.96	3.00	34.45	0.48	38.88	171.00	**299.17 (3)**
Caribou	2.06	57.60	0.16	1.60	6.72	0.20	63.00	51.00	**182.34 (5)**
Moose	2.24	6.00	0.76	0.60	0.96	0.32	0.45	3.84	**15.17 (8)**
FurBr/Sm Mammals	3.20	3.20	21.00	56.23	3.20	7.20	100.80	3.50	**198.33 (4)**
Historic Resources	12.80	3.71	37.80	2.36	1.12	0.32	100.80	14.40	**173.31 (6)**

FIGURE 5.2: CUMULATIVE EFFECT INDICES FOR EACH VEC



As illustrated, cumulative effect indices for individual VECs ranged in value from 15.17 (Moose) to 630.08 (Fish Resources). The sum of these eight indices was 1879.10, with a mean of 234.89.

The following sections present and discuss these results. They assess the potential cumulative effect of the set of projects on each VEC individually, and for each VEC, include an analysis of the relative contribution of each project's impact score to the VEC's cumulative effect index. These results are also discussed in relation to the comments and rationale statements provided by expert panellists throughout the course of the Delphi procedure. It should be noted, however, that while in each round participants were invited to give a brief summary of the rationales behind their responses, the amount of such information provided was relatively limited. Also, by its very nature the Delphi procedure highlights areas of, and the reasons for, disagreement between individual panellists. As a result, most of the qualitative information gathered throughout the study reflected the opinions of dissenting panellists. The qualitative information presented in this section will, therefore, be limited to general areas of agreement among panellists (i.e. where such comments apparently reflect the shared opinions of the group as a whole), and thus, may not explain variability in overall impact scores or individual ratings between projects or VECs. The sections will, however, also identify major areas of disagreement between expert panellists, as reflected in the comments provided. Cumulative effect indices for individual VECs are discussed in descending rank order.

5.4.1 Fish Resources

The calculated cumulative effect index for Fish Resources was 630.08, the highest of any of the eight VECs considered in the study. The VEC's cumulative effect index was nearly 170 percent greater than the mean of all eight VEC indices, and comprised approximately one-third of the sum of these eight values (i.e. the total cumulative effect of the set of projects on the set of eight VECs as a whole).

Issues raised throughout the course of the study in relation to the potential impact of small hydro developments on Fish Resources included: the disruption of fish migration as a result of dam construction and operation; fish habitat loss due to stream dewatering and the inundation of stream habitats; reduced habitat quality due to changes in water quality and river morphology; the disruption of food production and transport; fish mortality due to passage through turbines; and increased exploitative pressure due to increased access. It was generally agreed that while the overall significance of impacts on Fish Resources would vary considerably between projects, the VEC would almost certainly be affected in all cases. Accordingly, Impact Probability values for Fish Resources were 100 percent for all but one of the eight small hydro projects under consideration. Also, Impact Magnitude forecasts in relation to Fish Resources were, as a whole, the highest of any of the eight VECs, and were reasonably consistent between projects (ranging from three (moderate) to four (major), with a mean of 3.38). Most panellists agreed that potential impacts on the VEC were numerous and diverse, but were perhaps the most difficult to predict.

One panellist stated that:

> Small hydro projects may potentially have numerous impacts on fish populations. However, some (e.g. the effects of siltation) are well studied, while others (such as the effects of thermal variations) are less understood.

Spatial Extent values for this VEC were, as a whole, among the highest of those for either VEC. It was generally agreed that the impacts themselves would extend beyond the immediate project sites due to the migratory nature of the anadromous species within this VEC category, and because changes to water quality and quantity (which would indirectly affect Fish Resources) would also be somewhat extensive. As a result, Spatial Extent values were also fairly consistent between projects, ranging from two (local) to three (regional), with a mean rating of 2.25. Also, as projects were expected to operate in perpetuity, Temporal Duration ratings were four (prolonged) for all eight projects. Several panellists, however, disagreed that the fish populations would be permanently affected by such developments. Some stated that salmonids would adjust rather quickly to altered water flows, and that negligible long-term effects would be expected. In comparison to other target resources, VEC Importance ratings were the highest overall for Fish Resources (with a mean of 3.44), and were only moderately variable between projects. Similarly, Current State of the VEC ratings were also the highest for this VEC as a whole, but again were only moderately variable between projects (ranging from three to four, with a mean score of 3.38).

Impact scores for individual projects for Fish Resources were, however, quite variable between projects, and indeed, were the most variable of either of the eight VECs being considered. Impact values ranged from 28.80 to 160.00, with a mean of 78.76. The Northwest River facility was deemed to have the potential for the most significant impact on Fish Resources. It was generally agreed that the river contained very significant Fish Resources, and that salmon in the area, while increasing in numbers at present, would be severely affected by the proposed development. More specifically, various experts stated that the project would interrupt fish migrations, and would reduce water flows over a major spawning area (i.e. immediately below Northwest Falls). There was, however, some disagreement regarding the availability of alternate spawning habitat in the river. While some stated that there is a limited amount of habitat in the river (with the exception of that within the immediate impact zone), others felt that suitable spawning habitat is located throughout the river in numerous locations. Also, while some panellists were concerned that the project would bring about fluctuations in the water levels of Northwest Pond that would alter the productivity of the littoral area, others felt that there would be no such fluctuations, and that there would be a possible increase in pond production as a result of the project which would offset fish losses in the dewatered area. It was noted by most that the Northwest River's Fish Resources are very important to recreational fisheries and tourism in the area.

With an impact score of 153.60, Star Lake ranked second in terms of the significance of its potential impact on Fish Resources. Most panellists were in general agreement that the lake supports a large and potentially valuable piscivorous brook trout population, and that the project would significantly affect this resource by increasing the water level of the lake and causing it to fluctuate considerably. Impact scores for the proposed Northwest River and Star Lake facilities comprised 25 and 24 percent of the VEC's cumulative effect index, respectively, thereby collectively accounting for approximately one-half of the total cumulative effect of the set of eight projects on Fish Resources.

The Torrent River project's impact score (84.00) was also relatively high, as was that for Garia Bay (78.40). There was, however, considerable disagreement regarding the presence and abundance of Fish Resources in each of these areas. For example, while some panellists felt that the Garia Bay area contains a significant fish population, others stated that, in their opinion, there is probably not a major population in the impact zone due to the topography of the area. Also, while the panel as a whole deemed Garia Bay's Fish Resources to be in a highly sensitive and relatively unhealthy state at present, some contended that, to the best of their knowledge, fish in the area are currently not subject to any other types of natural or anthropogenic stress. With regard to the Torrent River project, several panellists noted that without an intensive survey of the area to be dewatered it was extremely difficult to predict the impact of the project on Fish Resources. Impact scores for these two projects collectively accounted for approximately 26 percent of the VEC's cumulative effect index.

Impact scores in relation to Fish Resources for the other four projects were each relatively low, and ranged in value from 28.80 (Rose Blanche Brook) to 43.20 (Northwest Arm Brook and Southwest River), with a mean of 38.52. With regard to the Rose Blanche Brook facility, several panellists stated that it is unlikely that fish are abundant in the project area given the steepness of the terrain. However, it was noted that trout populations in the upper reaches of the watershed could be affected by fluctuating water levels in the headpond, and that anadromous fish are present immediately downstream of the proposed development. Similarly, most panellists were in general agreement that the Southwest River project site appears to be a relatively poor fish habitat because of a near vertical waterfall located approximately 300 m downstream of the development. It was, however, agreed by most that while maps suggest accessability to sea-run fish in the Rattle Brook area, more baseline data would be needed regarding this watershed and the particular species present in order to confidently predict the potential impact of the project. The impact scores for these four projects collectively accounted for only approximately 24 percent of the potential cumulative effect of the set of eight projects on Fish Resources.

5.4.2 Water Resources

Water Resources ranked as the second most significantly affected VEC with regard to the potential cumulative environmental effects of the set of small hydro projects. The cumulative effect index for Water Resources was 357.00, approximately 52 percent greater than the mean of the eight cumulative effect scores, and comprising approximately 19 percent of the sum of these indices.

Various issues were raised by panellists throughout the study regarding the potential effects of small hydro developments on Water Resources. These included impacts on water quality as a result of flooding and the construction and maintenance of project structures (e.g. through sedimentation and erosion, pollution, changes in water temperature, mercury upleach from flooded vegetation, etc.). Also, it was stated by several panellists that, while no actual abstraction or removal of water would occur as a result of the projects, in all cases the spatial and temporal water flow patterns would be permanently rearranged and altered. As a result, group forecasts for Impact Probability were 100 percent for all eight small hydro projects, and Temporal Duration scores of four (prolonged) were given for each. Similarly, given the mobile nature of the resource, and the fact that impacts on water quantity and quality would therefore likely extend outside of the immediate project areas and into other parts of the watersheds, individual scores for Spatial Extent ranged from 1.5 to three.

Potential secondary impacts on other VECs and on other users of the resource were also raised as potential issues. In several cases these indirect effects were cited as the rational for relatively high Spatial Extent impact ratings (i.e. indirect effects on other VECs/resource users would extend the impact zone beyond the immediate project area), as well as relatively high scores for Impact Magnitude (see definitions given in Table 5.1). The applicability and potential significance of each of these issues was, however, quite site-specific, and thus, ratings for most of the evaluation criteria varied somewhat from project to project. Impact Magnitude scores, while generally higher than those for other VECs, were moderately variable from project to project (ranging from two to 3.75, with a mean value of 2.78). It was generally agreed that while the potential impacts of such developments on water quantity were quite clear, impacts on water quality and resource inter-dependencies (i.e. indirect effects on other VECs) were very difficult to predict. VEC Importance scores for Water Resources were, as a whole, somewhat high in relation to other VECs, but were quite variable between projects (ranging from two to four, with a mean of 3.2). There was, however, often considerable disagreement regarding the inherent value and importance of the Water Resource itself. While several panellists felt that, in and of itself, the VEC cannot be considered important (i.e. it is only important as it sustains other VECs), others stated that Water Resources must be considered important in their own right, and that "Water should not be considered unimportant simply because it is the VEC being exploited." Finally, Current State of the VEC scores for Water Resources were moderately high compared with those for other VECs, but were among the most variable between projects (implying that the condition of an area's Water Resources is very much dependent upon the amount and type(s) of past and present anthropogenic activity).

Impact scores for Water Resources in relation to individual projects ranged from 12.00 to 86.40, with a mean score of 44.63. Overall, impact scores were somewhat less variable from project to project for Water Resources than those of most of the other VECs. The Star Lake project (86.40), was deemed to have the potential for the most significant impact on Water Resources. Issues raised in relation to the potential impact of this project included: the extensive dewatering and alteration of existing water flows in the area due to construction of the main dam, the diversion of part of the Otter Brook flow, and the saddle dam at the northeast extremity of the lake; and the fact that the development would result in raised and fluctuating water levels in the lake which may significantly affect the quality of the resource and the aquatic life it sustains. In addition, Water Resources in Star Lake were deemed by most panellists to be quite important, as the area contains a regionally significant fish population and is used extensively for water-related recreational activities.

With a score of 76.80, the Northwest River project ranked second with regard to the significance of its potential impact on the VEC. Like Star Lake, the Water Resource in this area was deemed quite important, as it is used extensively for recreational activities and supports a significant fish population. The Torrent River project had an impact score of 63.00 in relation to this VEC. Various panellists expressed concern over the relatively large storage area and extensive amount of water diversion associated with this project. In total, impact scores for these three projects accounted for approximately 63 percent of the VEC's cumulative effect index.

Impact scores for the remaining five projects were somewhat lower, and ranged from 12.00 to 42.00 (with a mean score of 26.20). Values for the Garia Bay and Southwest River facilities were equal (28.80), and the Northwest Arm Brook project had a score of 19.20. The lowest of these five scores was that of the Rattle Brook facility (12.00). The impact score for the Rose Blanche Brook facility (42.00) was, however, slightly higher than those of the other four projects; this was due in part to its relatively high VEC Importance rating, as most panellists agreed that the VEC was quite important in this area because the project would be located upstream of a protected water supply. Impact scores for these five projects collectively comprised only approximately 37 percent of the VEC's cumulative effect index.

5.4.3 Waterfowl/Migratory Birds

The overall cumulative effect index for Waterfowl/Migratory Birds was 299.17, 27.4 percent greater that the mean of all eight cumulative effect indices. The VEC ranked as the third most significantly affected, and the potential cumulative effect on this VEC comprised approximately 16 percent of the overall effect of the set of projects on the set of eight VECs. Issues raised in relation to the potential impacts of small hydro developments on Waterfowl/Migratory Birds included: the potential loss of stream and wetland habitats through dewatering and flooding; the destruction of shoreline habitat; the interruption of movement and migration; bird mortalities at transmission lines; and increased disturbance and exploitative pressure due to increased access and increasing knowledge of the distribution of local populations.

It was also noted by some panellists that the manipulation of natural water levels associated with small hydro developments may actually result in positive impacts on the VEC because it may lead to the creation of more favourable open-water habitats for some species. Several panellists, however, expressed concern that there is currently a profound lack of existing baseline data regarding the presence/absence or abundance of Waterfowl/Migratory Birds and habitat in most of these areas, which limited their ability to confidently predict impacts on this VEC.

Impact Probability and Magnitude ratings differed considerably between projects, ranging from 10 to 100 percent, and from one to 3.75, respectively. These ratings were generally the highest and most variable for these evaluation criteria of either of the eight VECs. This was because, as noted by most panellists, the potential presence and abundance of Waterfowl/Migratory Birds varies greatly between project locales due to variations in the presence and abundance of suitable habitat, and impacts varied in potential magnitude due to differences in the characteristics of individual projects. Overall, Spatial Extent ratings in relation to this VEC were also the highest and most variable between projects (ranging from one (site-specific) to four (provincial)). This was, according to most panellists, due to the highly migratory nature of some species within this VEC category, and differences in the particular species potentially affected by individual projects. Temporal Duration ratings were also relatively high overall, but were only moderately variable from project to project; as noted by most experts, exploitative pressure resulting from the projects would be of long-term duration, and habitat loss would, for the most part, be permanent.

In general, Waterfowl/Migratory Birds were considered somewhat less important than most of the other VECs under consideration. However, importance ratings for this VEC varied considerably between project locales (ranging from two to 4.75, with a mean value of 2.84). Finally, Current State ratings for this VEC were, as a whole, significantly higher and somewhat less variable between projects than those for most other VECs. It was noted by most panellists that waterfowl are heavily pursued in Newfoundland, and thus, most populations are already in a highly sensitive state.

Impact scores for individual projects in relation to Waterfowl/Migratory Birds ranged from 0.48 (Southwest River) to 171.00 (Torrent River), with a mean score of 37.40. Individual scores for this VEC were the most variable between projects of any of the eight VECs under consideration. The Torrent River project was, by far, deemed to have the potential for the most significant impact on Waterfowl/Migratory Birds; its impact score (171.00) accounted for approximately 57 percent of the VEC's cumulative effect index. Indeed, the impact score for this combination was the highest of either of the 64 project/VEC combinations under consideration. Panellists apparently agreed that the Torrent River area supports a regionally significant population of Harlequin Duck (*Histrionicus histrionicus*), which has been designated as an endangered species in eastern Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). According to one panellist, as many as six nesting pairs are believed to inhabit the area. One panellist, however, contended that while the species is unquestionably of great importance, the actual impact of this project would be minimal, and therefore expressed concern that the presence of this endangered species in the area may be skewing impact ratings into an unnecessarily high range.

While considerably lower than that for the Torrent River project, impact scores in relation to this VEC for the Star Lake (38.88), Rose Blanche Brook (34.45), Northwest Arm Brook (28.80), and Garia Bay (21.60) projects were also relatively high, with a mean score for these four projects of 30.93. Some respondents stated that the Star Lake area is believed to support extensive and productive lacustrine marsh and fluvial marsh habitats which may be important areas for waterfowl. Similarly, some experts stated that the reservoir area of the Rose Blanche Brook project appears to support productive fluvial marshes that most likely sustain significant waterfowl use. The Northwest Arm Brook (Connoire Bay) area was said to be a significant area for staging and wintering waterfowl, notably Black Ducks (*Anas rubripes*), which are, according to one panellist, of international conservation concern and quite sensitive to disturbance. There was, however, considerable disagreement regarding the use of the Garia Bay project area by waterfowl. For example, while one panellist stated that the river valley is used extensively in the spring by migrating geese, another stated that there is no particularly important habitat in the area, and thus, probably low concentrations of waterfowl. Several participants noted, however, that there is considerable uncertainty regarding the existence and quality of waterfowl habitat in this area. These four projects collectively comprised 41.4 percent of the cumulative effect index for this VEC.

Relatively low impact scores were given for this VEC in relation to the Rattle Brook (3.00), Northwest River (0.96) and Southwest River (0.48) projects. While no comments were given in relation to the Rattle Brook project, it was generally agreed that there is not a major waterfowl presence at or below the proposed Northwest River project site, as waterfowl utilize only the section of the river upstream of Northwest Pond. It was also noted that the site is currently accessible by road, and that the project would therefore not bring about increased access and hunting pressure. With regard to the Southwest River project, it was stated that waterfowl typically inhabit only the estuary/Clode Sound portion of the river, and thus, the project is unlikely to have a significant impact because tidal action is more important to the area's waterfowl than freshwater levels. Impact scores for these three projects collectively comprised only 1.5 percent of the VEC's cumulative effect index.

5.4.4 Furbearers/Small Mammals

The cumulative effect index for Furbearers/Small Mammals was 198.33, 16 percent less than the mean of the eight indices. The VEC ranked as the fourth most significantly affected by the potential cumulative effects of the set of projects, and its index accounted for approximately eleven percent of sum of the eight indices. Issues raised throughout the survey regarding the potential impacts of small hydro developments on Furbearers/Small Mammals included: the permanent destruction and/or inundation of habitat (particularly wetland habitat which is used extensively by various species within this category); increased disturbance and exploitative pressure due to increased access; potential indirect effects on other wildlife species because some small mammals (such as voles, shrews, hares, etc.) are the basic prey for a number of predators; and potential indirect effects on other resource uses (i.e. hunting and trapping) as some species have economic and recreational value in some areas.

Impact Probability scores for the VEC were, as a whole, somewhat high in relation to other VECs (ranging from 35 to 100 percent, with a mean of 68.75), and were higher overall than those for the other wildlife VECs being considered. This was because, as noted by several panellists, small mammals and furbearers are often tied to waterways and ponds, increasing the probability of project/VEC interactions. Also, it was noted that because there are a broad number of species within this VEC category, some individuals will almost certainly be affected in each case. Impact Magnitude scores were moderately high and somewhat less variable than those of most other VECs (with a mean score of 2.31). Spatial Extent ratings were also relatively high for Furbearers/Small Mammals, but were, along with those for Fish Resources, the least variable from project to project. Temporal Duration forecasts ranged from one (short-term) to four (prolonged), with a mean score of 2.19. Overall, Temporal Duration values for this VEC were quite low in relation to those for other VECs, but were among the most variable between projects. While some panellists felt that, in most cases, furbearers and small mammals would adapt rather quickly to changes in the environment brought about by these projects, most recognized that impact duration would depend upon the nature of the projects themselves, and the particular species affected. Furbearers/Small Mammals were generally regarded as somewhat less important than most of the other VECs, but importance scores for the VEC were among the most variable between individual projects (ranging from two to five, with a mean score of 3.06). Finally, Current State scores for this VEC were, in general, moderately high, but were the most variable from project to project of either of the eight VECs.

Impact scores for individual projects were extremely variable for this VEC, ranging from 3.20 to 100.80, with a mean value of 24.79. Impact scores for the Garia Bay, Northwest Arm Brook, Rose Blanche Brook and Torrent River projects were remarkably constant and relatively low (averaging 3.28). It was generally agreed that only relatively low quality Furbearers/Small Mammal habitat is found in these areas, as well as no particularly important or vulnerable species. Collectively, these four project comprised less than seven percent of the VEC's cumulative effect index.

Impact scores for the other four projects were relatively high, ranging from 7.20 (Southwest River) to 100.80 (Star Lake), with a mean of 46.31. These four projects together comprised approximately 93 percent of the VEC's cumulative effect index. Comments given in relation to the potential impacts of these projects on Furbearers/Small Mammals indicated that the endangered Pine Marten (*Martes americana*) is believed to inhabit each of these areas. The Star Lake development itself accounted for over one-half of the potential cumulative effect of the set of projects on Furbearers/Small Mammals. Panellists were apparently in agreement that the Star Lake area contains a relatively large and important population of the species.

Similarly, the Rattle Brook and Northwest River projects each had relatively high scores for this VEC, as Marten are believed to inhabit these areas as well. While the impact score for this VEC in relation to the Southwest River project was also relatively high, there was some disagreement among panellists regarding the potential for Marten to be located in this area. Some panellists stated that given the known existence of the species in the vicinity of the adjacent Northwest River project, Marten very likely inhabit this area as well. Other panellists, however, disagreed strongly, and one respondent stated that:

> Since this area is on the fringe of the Maritime Barrens Ecoregion, Pine Marten are not likely to be as prevalent in this area as in the lower Northwest River watershed.

Also, with regard to the potential effects of such developments on Marten in general, some panellists stated that, being an endangered species, Marten are highly susceptible to impact and are very sensitive to any type of disturbance. In contrast, others felt that, while the species is unquestionably of great importance:

> Marten are typically a very resilient species vis-a-vis this type of disturbance (noise, etc.). It's habitat loss and the accidental capture of Marten that negatively affect the species, not the type of disturbance associated with these types of projects.

This lead one panellist to express concern that, as in the case of Harlequin Ducks in the Torrent River area, the presence of Pine Marten in several of these areas may be skewing impact ratings into an unnecessarily high range.

5.4.5 Caribou

The cumulative effect index for Caribou (*Rangifer tarandus*) was 182.34, making it the fifth most significantly affected VEC. The index was 22.4 percent less that the mean of the eight indices, and accounted for only approximately 10 percent of their sum. Issues raised in relation to the potential impacts of small hydro developments on Caribou included: the loss of terrestrial habitat; alterations to the spatial distribution and abundance of animals in the vicinity of the project and the interruption of Caribou migration patterns (i.e. avoidance of the area by animals); the interruption of calving/post-calving activities; and potential harassment of animals and increased exploitative pressure as a result of increased access.

Perhaps more so than with regard to either of the eight VECs, the comments provided by panellists indicated that there was widespread disagreement regarding the potential impacts of small hydro developments (and development in general) on Caribou. For example, one panellist stated that:

> Observations and research indicate that Caribou do not co-exist adjacent to human activities. They will alter their migration routes significantly, and will no longer use the area surrounding the development.

In contrast, another stated that:

> Studies have shown Caribou to be quite resilient and adaptable to small developments such as these. Caribou will always be aware of these projects, but it is unlikely that they will avoid them.

It was, however, generally acknowledged that impacts on this VEC will vary temporally, depending on the phase of the development and the time of year.

Impact Probability and Magnitude scores for Caribou varied considerably between projects. It was agreed that the potential for, and severity of, project/VEC interactions differed greatly according to the existing environments of the individual project areas (i.e. the abundance, type and distribution of Caribou habitat and the location of individual projects in relation to migration corridors), and the specific characteristics of the individual projects themselves (e.g. the length of the transmission corridor, etc.). Impact Probability ratings ranged from 10 percent to 85 percent (with a mean of 43.75), and Impact Magnitude scores ranged from one (negligible) to three (moderate) (with a mean of 2.13). Spatial Extent ratings also differed considerably between projects, and Temporal Duration scores were the most variable from project to project of either of the eight VECs (ranging from one (short-term) to four (prolonged)). As a whole, Caribou were regarded as being of great importance in relation to other VECs, but again, ratings for this VEC were the most variable between projects of any VEC (ranging from two to five, with a mean of 3.31). Current State scores for Caribou were, however, quite consistent from project to project (ranging from two (low sensitivity) to three (moderate sensitivity), and were somewhat lower overall than those for most of the other VECs.

Impact scores in relation to individual projects for Caribou ranged from 0.16 to 63.00, with a mean value of 22.79. The Star Lake development was found to have the potential for the most significant impact on Caribou; with an impact score of 63.00, it alone accounted for approximately 35 percent of the VEC's cumulative effect index. One panellist stated that:

> The Star Lake area is the main migration corridor for the Buchans Plateau Caribou Herd. Fall and spring movements of this herd of 3,000+ animals occur through the immediate area. Animals spend spring, summer and early fall on the Buchans Plateau, and spend winter on or towards the south coast.

According to most panellists, the herd is one of the most important and vulnerable on the Island, and Caribou "are unquestionably the VEC of importance on the Buchans Plateau". It was also noted that hunters and outfitters in the area rely heavily on the herd. With regard to the Current State of the VEC in the Star Lake area, most panellists agreed that human impact on the area's Caribou has increased steadily in recent years (e.g. logging activity, transmission lines, all-terrain vehicle activity, etc.), and that all of these factors have reduced habitat availability and altered migration patterns.

The second highest impact score (57.60) was in relation to the Northwest Arm Brook (Connoire Bay) project. Panellists stated that a major Caribou migration corridor passes through the area as the La Poile Herd migrates to the south coast in the winter (especially to the Connoire Bay area), and that animals use the area extensively for both over-wintering and calving/post-calving activities. The project's excavated channels and penstock were viewed by some as potential obstructions to this migration. Other issues raised in relation to this project's potential impact on Caribou included an increase in human access as a result of the construction of a wharf and road, and possible habitat destruction resulting from the use of tracked vehicles to maintain the project's transmission line. The La Poile Herd was described as being one of the largest herds on the Island, and therefore of significant importance. With an impact score of 51.00, the Torrent River project was found to have the potential for the third most significant impact on Caribou. Several panellists noted that Caribou use the project area at various times of the year, and that calving is known to occur to the immediate north of Pike's Feeder Pond. However, it was acknowledged by most that very little is known about the use of this area by the species, and that further study is required to determine calving range size. In total, impact scores for these three projects comprised approximately 94 percent of VEC's cumulative effect index.

Relatively low impact scores for Caribou were derived for the five remaining projects. The proposed Rose Blanche Brook and Garia Bay developments had impact scores of 6.72 and 2.06, respectively. Most panellists agreed that, while some Caribou do inhabit these areas, they are basically beyond the western extent of the La Poile Herd. It was, however, noted that while past surveys appear to indicate low use of the area by Caribou, additional baseline information would be necessary to address any uncertainty. The Rattle Brook project had a relatively low impact score (1.60), and it was noted that while some Caribou may utilize the area, very little is known about their status in the project vicinity. At least one panellist felt that there is an increasing number of animals in the area, increasing the probability of future project/VEC interactions. The lowest of the eight impact scores for this VEC were in relation to the Northwest River (0.16) and Southwest River (0.20) developments. With regard to the Northwest River project, it was generally agreed that few (if any) animals inhabit the immediate development site, as the majority of the Middle Ridge Herd utilize the area above Northwest Pond (i.e. the Bay du Nord Reserve) to the northwest of the project area. For the same reason, the adjacent Southwest River project was found to have the potential for a relatively insignificant impact on the VEC; it was again generally agreed that project activity would be more focused in non-Caribou habitat, and that the gorge to be flooded is not normally used by Caribou. Impact scores for these five projects collectively accounted for less than six percent of the VEC's cumulative effect index.

5.4.6 Historic Resources

With a cumulative effect index of 173.31, Historic Resources ranked as the sixth most significantly affected VEC. The score for this VEC was 26 percent less than the mean of the eight indices, and comprised approximately nine percent of their sum. The comments provided by expert panellists throughout the course of the study indicate the possibility that small hydro development on the Island could disturb or destroy archaeological sites and artifacts.

As a whole, Impact Probability scores in relation to this VEC were the lowest of either of the VECs under consideration, but were among the most variable between projects. Impact Magnitude values for Historic Resources were generally among the highest of either of the VECs, as well as being the most variable from project to project. It was noted by one panellist that:

> Impacts on fragile Historic Resources are usually severe...Although a site or artifact may not be completely destroyed by such developments, portions of it are often severely disturbed.

Similarly, another expert stated that:

> If there is an archaeological site in the area, then the severity of the impact is typically quite high. Archaeology is one of the few disciplines that has to deal with that **IF**.

Impact Probability and Magnitude ratings, therefore, varied greatly between projects, depending upon the perceived archaeological potential of the individual project areas. For each of these projects it was noted that if impact predictions were to be made with any degree of confidence, intensive archaeological surveys would be required.

Spatial Extent scores were, as a whole, the lowest of either VEC; in almost all cases potential impacts were predicted to be confined to the immediate project site, given the stationary nature of Historic Resources as compared with other, more mobile VECs. Panellists also agreed that if Historic Resources were affected by such developments the impact will be permanent and irreversible. Accordingly, Temporal Duration ratings for all eight projects were four (prolonged impact). As a whole, Historic Resources were regarded as moderately important as compared to other VECs, but scores for this VEC were also among the most variable between projects. Finally, Current State scores for Historic Resources were generally much lower than those for most of the other VECs. One panellist stated that "If buried, Historic Resources are usually reasonably well protected from surface disturbance." However, there was once again considerable variability in scores from project to project, as the current state of an area's archaeological resources was said to depend upon the amount, extent and type(s) of past and present anthropogenic activity. Also, most panellists remarked that it is almost impossible to assess the importance and current state of archaeological resources until they have been located, identified and examined.

Impact scores for individual projects were relatively variable, ranging from 0.32 (Southwest River) to 100.80 (Star Lake), with a mean score of 21.66. The Star Lake development was, by far, thought to have the potential for the most significant impact on Historic Resources. Panellists were apparently in agreement that the development area is rich in archaeological resources, and that such resources would likely be severely affected by the proposed project. Several panellists went on to state that of particular concern is that raised water levels associated with the project would destroy evidence of lake-side occupation. Some also expressed strong disagreement with the findings of a Stage One Archaeological Assessment conducted in relation to the project's EIA (Schwarz, 1993). One panellist stated that:

> A very intensive archaeological survey of the area should have produced evidence of Aboriginal occupation but did not. This is surprising, given the observed movement of Caribou across the lake and the fact that many archaeological sites exist at nearby Red Indian Lake.

Similarly, another stated that:

> Star Lake was surveyed only along the shore-line. No surveys were conducted on the higher terraces in the area; these are where Archaic sites would most likely be located.

The impact score for the Star Lake project comprised 58 percent of this VEC's cumulative effect index.

The proposed Northwest River project (37.80) ranked second with regard to the significance of its potential impact on Historic Resources, although there was considerable disagreement between panellists regarding the archaeological potential of the area. Some panellists stated that, based upon recent archaeological surveys in and around Terra Nova National Park, there are almost certainly archaeological sites at the mouth of Northwest River, and possibly at several sites along the river itself. However, several felt that there was likely nothing of historical significance in the area. One panellist, for example, commented that:

> Archaeological surveys have been carried out in this area, but no evidence of archaeological resources was found. Given past cultures, it is very unlikely that any sites will be located upstream. Thus, Historic Resources will not be affected by this development in my opinion.

It was acknowledged by most, however, that the possible prehistoric occupation of the area requires more intense study. The Torrent River project had an impact score of 14.40. Several experts commented that various parts of the project area have the potential to contain Historic Resources, including the dam and powerhouse sites, as well as several sites along the proposed transmission line and access road routes (especially where they cross water). Similarly, one panellist stated that:

> Local information confirms that the Torrent River area is a good area for Caribou hunting and fishing. It is, therefore, likely that prehistoric peoples saw this area in the same light. However, archaeological sites will be difficult to find because they will be small, and the terrain is difficult.

This lead one panellist to state that, in his opinion, a full archaeological survey should be carried out in relation to the EIA of this project. The Garia Bay project (12.80) ranked fourth in terms of its potential impact on Historic Resources. Taken together, these three projects accounted for approximately 38 percent of the VEC's cumulative effect index.

Relatively low impact scores for this VEC were given in relation to the Northwest Arm Brook (3.71), Rattle Brook (2.36), Rose Blanche Brook (1.12) and Southwest River (0.32) projects; panellists commented that neither of these areas would be expected to contain archaeological resources. With regard to the Southwest River project (i.e. the project with the lowest impact score for this VEC), one panellist stated that:

> The area appears to be one of low archaeological potential. Disturbance due to the project appears to occur above the limits of a salmon run or Aboriginal travel.

Similarly, another expert stated that:

> There is a high probability of archaeological sites along the Southwest River. However, it is unlikely that such resources will be affected by the project, as no activities are planned for the mouth of the river (the most likely location of such sites).

There was, however, quite often considerable disagreement regarding the archaeological potential of the remaining project areas. Taken together, these four projects collectively comprised only approximately four percent of the VEC's cumulative effect index.

5.4.7 Raptors

The cumulative effect index for Raptors was 23.70, the second lowest of the eight scores and approximately 90 percent less than the mean of these indices. Potential impacts on Raptors comprised little over one percent of the potential, overall effect of the set of projects on the set of eight VECs as a whole.

Issues raised regarding the potential effects of small hydro developments on Raptors included: increased human access and disturbance; potential bird mortalities at transmission lines; and the loss of nesting sites and habitat. One panellist also commented that Raptors may actually be positively affected as a result of hydro developments, given the possible creation of nesting habitat through transmission line construction. Raptors were also thought to have the potential to be indirectly affected by these developments, as impacts on Fish Resources may affect the hunting and feeding activities of some species. However, it was generally agreed that Raptors are naturally rare on the Island, and that any given site may or may not have individuals present. As a result, Impact Probability scores for this VEC did not exceed 50 percent for either of the eight projects, and were among the least variable between projects. Actual scores ranged from 25 to 50 percent, with a mean of 43.13. Impact Magnitude forecasts were, in most cases, Minor, and were generally lower than those for other VECs (as well as being the least variable between projects). Spatial Extent scores were "local" or lower for all projects, as it was generally agreed that when impacts would occur, they would most often be restricted to the immediate vicinity of the project itself. Also, most panellists felt that while the construction phases of small hydro facilities may be disturbing, Raptors typically habituate rather quickly to human presence, and thus, the existence of the final project structures probably would not constitute much disturbance. Accordingly, Temporal Duration forecasts for Raptors were typically "short-term", and this trend was quite consistent from project to project. Raptors were, however, deemed to be relatively important overall in comparison to other VECs, because they are, as indicated above, naturally rare, and were deemed by some to be good indicators of ecosystem health. There was little variability in VEC Importance scores for this VEC between project areas. It was also noted that Raptors are naturally sensitive to certain types of perturbation (both past and present) because they are top-level predators. Accordingly, Current State scores for this VEC were, as a whole, relatively high compared to those for other VECs, and were the least variable from project to project (ranging from three to 3.5).

Impact scores for individual projects ranged from 0.88 to 6.30, with a mean of 2.96. These scores were, however, the least variable from project to project of either of the eight VECs under consideration. Few comments were provided in relation to the potential impact of specific projects on Raptors. It was, however, generally agreed that the south coast of the Island has relatively high numbers of Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*) and other species. For example, it was noted that the Northwest Arm Brook area has a relatively high Eagle population, but that nesting sites in the region are at a premium. It was also stated that the increased vessel traffic in the Bay and along the coast associated with this project may negatively affect Raptors. Accordingly, this project's impact score (4.80) accounted for approximately 20 percent of the VEC's cumulative effect index. There was, however, considerable disagreement regarding the presence and abundance of Raptors in the Garia Bay area. While some panellists felt that the area is an important Eagle wintering area and may contain Ospreys and perhaps, for example, the Rough-Legged Hawk (*Buteo lagopus*), others stated that there were relatively low Raptor densities in the area, and that the VEC occurs in relatively higher densities throughout most of the Island. Impact scores for the Rose Blanche Brook and Torrent River projects each accounted for approximately 15 and 17 percent of the VEC's cumulative effect index, respectively.

Relatively low impact scores for Raptors were given in relation to the proposed Northwest River, Southwest River and Star Lake developments, with these projects collectively comprising less than 13 percent of the VEC's cumulative effect index. With regard to the potential impact of the Northwest River project on this VEC, it was stated that while increased activity may disrupt feeding and breeding activities on a short-term basis, the majority of the area's Raptors hunt at or near the mouth of the river, with no known nest sites located in the vicinity of the project. The Star Lake development had the lowest impact score in relation to this VEC (0.88); it was generally agreed that there are very few (if any) Raptors in the proposed development area.

5.4.8 Moose

The cumulative effect index for Moose (*Alces alces*) was 15.17, making it the least significantly affected by the potential cumulative effects of the set of proposed small hydro projects. The index for Moose was approximately 94 percent less than the mean of all eight indices, and was 98 percent less than the highest cumulative effect index (i.e. that of Fish Resources). It comprised less than one percent of the sum of the eight cumulative effect indices. Potential issues raised in relation to the impacts of small hydro developments on Moose included vegetation removal and inundation resulting in a loss of Moose habitat (especially critical wintering habitat), and increased disturbance, harassment and hunting pressure due to increased access.

It was generally acknowledged by participants that while Moose are fairly common and can be found (to varying degrees) in almost all areas of the Island, they are seldom significantly affected by small developments such as these. As a result, Impact Probability scores were, overall, quite low in comparison to those for other VECs (with a mean of 41.88 percent), and were generally less variable between projects. Similarly, Impact Magnitude scores for the VEC were, as a whole, the lowest of any of the eight VECs under consideration (with a mean of 1.69), and were among the least variable from project to project. Spatial Extent forecasts were also relatively low (with a mean score of 1.38) and only moderately variable between projects as compared to those of most other VECs. However, Temporal Duration scores, although generally lower than those for most other VECs, were among the most variable between projects. There was apparently widespread disagreement among panellists regarding the potential duration of the impacts of such developments on Moose. While some panellists felt that Moose would be affected by the construction phases of such developments only (e.g. blasting, etc.), others stated that, in their opinion, impacts on the species would be prolonged because of the permanent destruction of habitat and increased access associated with some projects.

It was also stated that with over 150,000 Moose on the Island, and the fact that the species appears to be quite resilient to the effects of most development activities (e.g. they can be found in large numbers along major highways, etc.), the VEC cannot be considered as important as other, more significant resources. Accordingly, Moose were, in general, deemed to be the least important of the eight VECs (with a mean rating of 2.19), and VEC Importance values for the species were by far the least variable between projects. Finally, with regard to Current State scores, Moose were deemed to be the most resilient of any of the eight VECs under consideration, with scores for individual projects ranging from one (resilient) to two (low sensitivity), with a mean of 1.38.

Impact scores for individual projects in relation to Moose ranged from 0.32 (Southwest River) to 6.00 (Northwest Arm Brook), with a mean score of 1.90. Impact scores for individual projects were, with the exception of those for Raptors, the least variable between projects of either the eight VECs being considered. Few comments were given by panellists regarding the impacts of individual projects on this VEC. However, it was generally agreed that the Star Lake area does not contain particularly good Moose habitat, and accordingly, its impact score comprised less than three percent of the VEC's cumulative effect index. Almost all of the comments provided in relation to this VEC, however, reflected areas of disagreement between panellists. For example, with regard to the potential impact of the Southwest River project (0.32), although some panellists felt that animals may inhabit the river valley, others stated that the project should have no ill effect on the species because the gorge to be flooded is not normally utilized by Moose. Similarly, with regard to the Northwest River project, some panellists felt that the area is used extensively by Moose and contains good habitat, while others apparently disagreed. One panellist, for example, stated that:

> Wintering and other important habitat is sufficiently distant from the project. With the exception of the wetland area to the north of the site, habitat is poor throughout the area.

Although the Northwest Arm Brook project had the highest impact score for Moose (comprising nearly 40 percent of the VEC's cumulative effect index), there was also considerable disagreement regarding the status of Moose in this area. Similarly, while some panellists stated the impact of the Garia Bay project on Moose would be insignificant, others felt that Moose were very abundant in river valleys in the area, and that the project would overlap quite a large proportion of the limited amount of wintering habitat available in the area.

5.4.9 Summary

Cumulative effect indices for individual VECs ranged in value from 15.17 (Moose) to 630.08 (Fish Resources), with a mean of 234.89. Variability in impact scores can, in part, be explained by differences in the very nature of the VECs themselves (e.g. their presence/absence and abundance, their relative importance, their responses to single and multiple sources of environmental stress, etc.). Also, there was often considerable variation in the contribution of individual projects towards these potential cumulative effects.

Despite the fact that only a limited amount of qualitative information was provided by expert panellists in relation to their responses, the comments that were given do allow for insight into the potential impacts of small hydro development (both in general as well as with regard to individual projects) upon each of the VECs being considered. These comments also allowed for the identification of major areas of disagreement among panellists, including differences of opinion regarding baseline conditions (e.g. the presence/absence, abundance, importance, etc. of particular VECs in specific areas), as well as differences of opinion regarding specific impact processes.

5.5 CUMULATIVE EFFECT INDICES (OTHER PROJECT CONFIGURATIONS)

Environmental issues with regard to cumulative effects, and their relative significance, often vary considerably at differing spatial and temporal scales. The preceding section assessed the potential cumulative effects of a set of eight small hydro projects on a provincial scale, including projects currently being developed as well as those that may be developed in the future. This section examines the potential cumulative effects of various other configurations of these projects.

5.5.1 Spatial Configurations

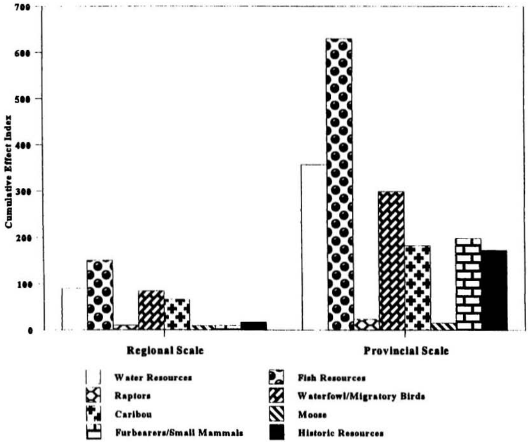
While the locations of the eight proposed small hydro developments under consideration are indeed quite spatially dispersed, at least one distinct cluster of projects can be discerned - namely, the three projects located on the Island's southwest coast: Garia Bay (Northwest Brook), Northwest Arm Brook (Connoire Bay) and Rose Blanche Brook (see Figure 4.2). The potential cumulative effects of this sub-set of projects are examined in this section as a case study.

Cumulative effect indices for the set of three projects on the Island's southwest coast (and for the set of eight projects as a whole) are presented in Table 5.12 and in graph form in Figure 5.3. The table also gives significance rankings for each of the indices for each project set, and the percentage of each configuration's overall cumulative effect score (i.e. the sum of the eight indices) that each index comprised.

TABLE 5.12: CUMULATIVE EFFECT INDICES
(Spatial Configurations)

VEC	3 SW Coast Projects (Regional Scale)	All 8 Projects (Provincial Scale)
Water Resources	90.00 (2) **20.54%**	357.00 (2) **19.00%**
Fish Resources	150.40 (1) **34.32%**	630.08 (1) **33.53%**
Raptors	10.20 (6) **2.33%**	23.70 (7) **1.26%**
Waterfowl/Migratory Birds	84.85 (3) **19.36%**	299.17 (3) **15.92%**
Caribou	66.38 (4) **15.15%**	182.34 (5) **9.70%**
Moose	9.20 (8) **2.10%**	15.17 (8) **0.81%**
Furbearers/Small Mammals	9.60 (7) **2.19%**	198.33 (4) **10.55%**
Historic Resources	17.63 (5) **4.02%**	173.31 (6) **9.22%**
Σ	**438.26**	**1879.10**

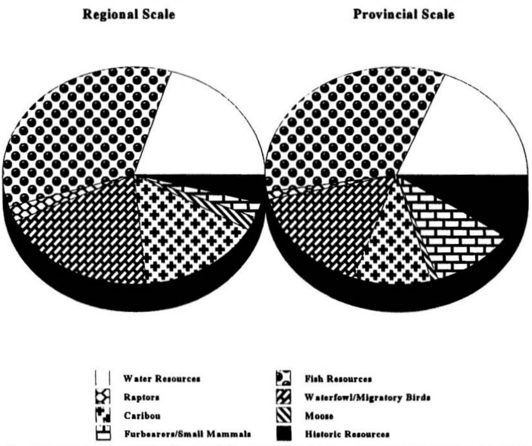
FIGURE 5.3: CUMULATIVE EFFECT INDICES (SPATIAL CONFIGURATIONS)



Cumulative effect indices in relation to the set of three small hydro projects ranged in value from 9.20 to 150.40, with a mean of 54.78. With a cumulative effect index of 150.40, Fish Resources ranked as the VEC potentially most significantly affected by this set of projects, Water Resources (90.00) ranked second, and Waterfowl/Migratory Birds (84.85) and Caribou (66.38) each ranked third and fourth, respectively. Taken together, scores for these four VECs accounted for nearly 90 percent of the sum of the eight cumulative effect indices of this set of three projects (438.26). Cumulative effect indices for the four remaining VECs were considerably lower; Historic Resources ranked as the fifth most significantly affected VEC, while Raptors, Furbearers/Small Mammals and Moose each ranked sixth, seventh and eighth, respectively. Indices for these four VECs ranged from 9.20 to 17.63, with a mean score of 11.66. Taken together, these four indices accounted for less than 11 percent of the overall potential cumulative effect of the set of three projects on the set of eight VECs.

Table 5.12 also allows for the comparison of cumulative effect indices and significance rankings for each VEC between project configurations. Figure 5.4 presents cumulative effect indices for each project set as a percentage of the sum of the eight indices for that configuration. The relative significance of potential cumulative effects between VECs was somewhat similar between the two sets of projects. Rankings were the same for four of the eight VECs at the two scales of observation. For both configurations, potential cumulative effects on Fish Resources

FIGURE 5.4: THE RELATIVE SIGNIFICANCE OF CUMULATIVE EFFECT INDICES (SPATIAL)



were the most significant, followed by Water Resources. Cumulative effect indices for these VECs comprised approximately 34 percent and 21 percent of the potential cumulative effect of the set of three projects on the set of VECs, respectively (similar but slightly higher than that for the set of eight projects). In both cases, Waterfowl/Migratory Birds ranked as the third most significantly affected VEC. Again, however, the index for this VEC comprised a higher percentage of the overall cumulative effect score for the set of three projects. Also, at both the provincial and regional scales, Moose ranked as the VEC least significantly affected; the cumulative effect index for Moose comprised only about two percent of the overall effect of the set of three projects on all eight VECs. This too was higher, however, than that for the eight project configuration (0.81 percent).

Potential cumulative effects on Raptors, Caribou and Historic Resources were each of greater relative significance at the regional scale, with each VEC's ranking differing by one unit as compared to those for the set of eight projects as a whole. As a percentage of each project set's overall cumulative effect score, however, values for Raptors and Caribou were each higher at the regional scale, while that for Historic Resources was considerably lower. Cumulative effect indices for these three VECs collectively comprised approximately 21.5 percent of the overall cumulative effect score for the set of three projects, somewhat similar to the proportion of the overall cumulative effect score of the set of eight projects that these indices comprised (20.2 percent). By far the most notable difference in the relative significance of potential cumulative effects between configurations was in relation to Furbearers/Small Mammals. While the VEC's cumulative effect index ranked fourth in significance at the provincial scale, it ranked as the second least significantly affected VEC at the regional scale. The cumulative effect score for this VEC comprised only approximately two percent of the sum of the eight cumulative effect indices for the three project set, compared with nearly eleven percent at the provincial scale.

The sum of the eight cumulative effect indices for the three southwest coast projects (438.26) comprised approximately 23.3 percent of the sum of the eight indices of the set of eight projects as a whole (1879.10). With regard to individual VECs, this ranged from 4.8 percent (Furbearers/Small Mammals) to 60.6 percent (Moose). With eight VECs under consideration, and a maximum possible impact score of 256 for each project/VEC combination, the maximum possible overall cumulative effect score for the set of eight projects was 16,384, as compared to 6,144 for the set of three projects. The sum of the eight cumulative effect indices for the set of eight projects (1879.10) was approximately 11.5 percent of its maximum possible value, while that for the set of three projects proposed for the southwestern portion of the province (438.26) was approximately 7.1 percent of its maximum value.

5.5.2 Temporal Configurations

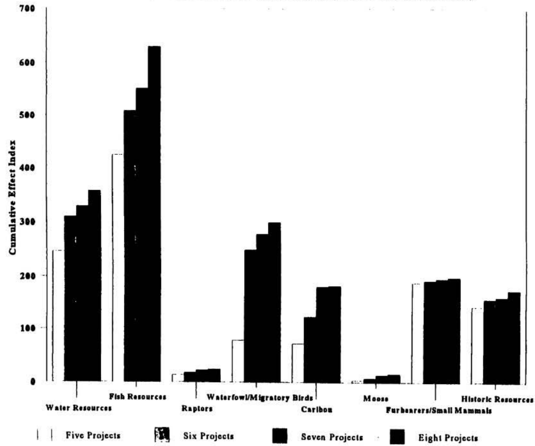
This section assesses the potential cumulative effects of small hydro developments in the province from a temporal perspective. As indicated earlier, it is generally acknowledged that the assessment and management of cumulative environmental change requires an anticipatory and comprehensive planning approach. Accordingly, in this section the results of the study are analyzed to determine the degree to which the relative significance of the potential cumulative effects of small-scale hydro development in the province vary temporally, according to the specific configuration of projects under consideration. This is done in order to assess the potential applicability of the information generated to a planning approach to CEA.

Table 5.13 presents cumulative effect indices and relative significance rankings for each of the eight VECs for a series of temporal configurations of small hydro projects (indices are presented in graph form in Figure 5.5). As indicated earlier, five of the eight small hydro projects being considered in this study are currently being developed. Column two of Table 5.13 presents indices for each of the eight VECs in relation to these five projects alone. Cumulative effect scores for individual VECs in relation to this project configuration ranged from 3.09 to 424.48, with a mean score of 145.85. Fish Resources (424.48) ranked as the VEC potentially most significantly affected by this set of projects, with its index comprising approximately 36 percent of the sum of the eight indices for this set of projects. Water Resources (246.00) ranked second, Furbearers/Small Mammals (188.43) ranked third, and Historic Resources (142.40) ranked as the fourth most significantly affected VEC, each accounting for approximately 21, 16 and 12 percent of the sum of these eight indices, respectively. Scores for these four VECs collectively comprised approximately 86 percent of the

TABLE 5.13: CUMULATIVE EFFECT INDICES (Temporal Configurations)							
VEC	5[1] Projects	6[2] Projects	% Increase	7[3] Projects	% Increase	8[4] Projects	% Increase
Water Resources	246.00 (2)	309.00 (2)	25.61%	328.20 (2)	6.21%	357.00 (2)	8.78%
Fish Resources	424.48 (1)	508.48 (1)	19.79%	551.68 (1)	8.50%	630.08 (1)	14.21%
Raptors	12.96 (7)	17.10 (7)	31.94%	21.90 (7)	28.07%	23.70 (7)	8.22%
WF/Migratory Birds	77.77 (5)	248.77 (3)	219.88%	277.57 (3)	11.58%	299.17 (3)	7.78%
Caribou	71.68 (6)	122.68 (6)	71.15%	180.28 (5)	46.95%	182.34 (5)	1.14%
Moose	3.09 (8)	6.93 (8)	124.27%	12.93 (8)	86.58%	15.17 (8)	17.32%
FurBr/Sm Mammals	188.43 (3)	191.93 (4)	1.86%	195.13 (4)	1.67%	198.33 (4)	1.64%
Historic Resources	142.40 (4)	156.80 (5)	10.11%	160.51 (6)	2.37%	173.31 (6)	7.97%
Σ	**1166.81**	**1561.21**	**33.80%**	**1728.20**	**10.70%**	**1879.10**	**8.73%**

[1] The five projects currently being developed (NW River, Rattle Brook, Rose Blanche Brook, SW River, Star Lake).
[2] The five projects currently being developed + the Torrent River project.
[3] The six projects listed above + the NW Arm Brook (Connoire Bay) project.
[4] The set of eight small hydro projects as a whole.

FIGURE 5.5: CUMULATIVE EFFECT INDICES (TEMPORAL CONFIGURATIONS)



sum of the eight cumulative effect indices for this set of five projects. Relatively low cumulative effect scores were derived for the remaining four VECs, ranging from 3.09 (Moose) to 77.77 (Waterfowl/Migratory Birds), with a mean score of 41.38. Indices for these four VECs collectively accounted for only 14 percent of the overall cumulative effect score of this set of projects, ranging from 0.3 percent to 6.7 percent. The sum of the eight cumulative effect scores for the set of five projects was 1166.81. With eight VECs and five projects under consideration, the maximum possible overall cumulative effect score for this project configuration was 10,240; therefore, the overall score for this set of projects was approximately 11.4 percent of its maximum possible value.

As discussed in Chapter Two, while five of the eight proposed small hydro developments under consideration in this study are currently planned for development, there is a strong possibility that further sites will be developed in the future. Accordingly, the third column of Table 5.13, for example, presents cumulative effect indices for a set of six projects (i.e. the five projects discussed above, as well as the proposed Torrent River project). While the Torrent River project had yet to be selected for development at the time of this study, it was arbitrarily chosen from the three remaining projects and added to the five project configuration to assess the degree of change in cumulative effect indices (and the relative significance of potential cumulative effects between VECs) if an additional small hydro project was to be developed in the future. When the Torrent River project was added to the set of five projects, relative significance rankings for five of the eight cumulative effect indices remained unchanged. Potential cumulative effects on Waterfowl/Migratory Birds were of relatively greater significance for the set of six projects, while those on Furbearers/Small Mammals and Historic Resources were relatively less significant. The fourth column in the Table shows the percent increase in each index when the Torrent River project was added. While the overall sum of the eight cumulative effect indices for the set of six projects (1561.21) was approximately 34 percent greater than that for five project configuration, indices for individual VECs were quite variable in terms of their percent increase. Increases in individual cumulative effect indices ranged from 1.86 (Furbearers/Small Mammals) to 219.88 percent (Waterfowl/Migratory Birds), with a mean increase of 63 percent. In total, the sum of the eight cumulative effect indices for this configuration of projects was approximately 12.7 percent of its maximum possible value of 12,288.

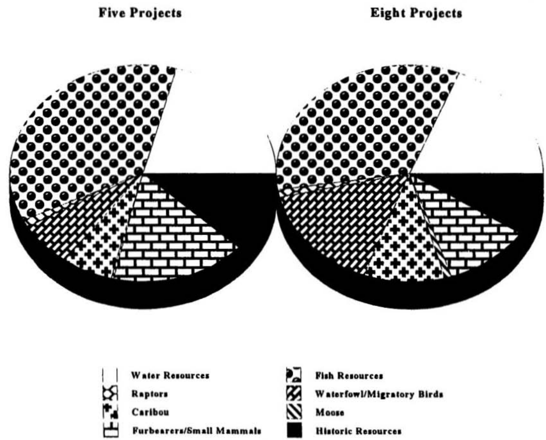
Column five of Table 5.13 gives cumulative effect indices for each VEC when a seventh project is added to the project configuration (arbitrarily selected as the Northwest Arm Brook development). As can be seen from the Table, significance rankings remained unchanged for six of the eight VECs with the addition of this seventh project. Potential cumulative effects on Caribou were, however, of relatively greater significance for this temporal configuration, while potential effects on Historic Resources were relatively less significant. Column six presents the percent increase in each cumulative effect index when this project is added to the configuration. The sum of the eight cumulative effect indices for this set of seven projects (1728.20) was approximately 11 percent higher than that for the set of six projects (and approximately 48 percent greater that the overall cumulative effect of the set of five projects on the set of VECs). Increases in individual scores ranged from 1.67 (Furbearers/Small Mammals) to 86.58 percent (Moose), with a mean increase of 24 percent. In total, the sum of the eight cumulative effect indices for this configuration of projects was 12 percent of its maximum possible score of 14,336.

Column seven of Table 5.13 gives cumulative effect indices and significance rankings for each of the eight VECs in relation to the set of eight small hydro projects as a whole (as discussed in Section 5.4). Column eight indicates the percent change in individual cumulative effect indices when the Garia Bay project is added to the set of seven projects discussed above. The sum of the eight cumulative effect indices for the set of eight projects was 1879.10, an increase of less than nine percent over that of the set of seven projects. Relative significance rankings were the same for all eight of the VECs for both configurations. Increases in individual cumulative effect indices ranged from 1.14 (Caribou) to 17.32 percent (Moose), with a mean increase of 8.4 percent. As indicated earlier, the sum of the eight indices for the set of eight projects as a whole was approximately 11.5 percent of its maximum possible value of 16,384.

Finally, columns two and seven of Table 5.13 allow for the comparison of cumulative effect indices for both the set of five projects currently being developed and the set of eight proposed small hydro projects as a whole. With the inclusion of the three additional projects to the set of five projects currently being developed, the sum of the eight cumulative effect indices increased by approximately 61 percent. Increases in cumulative effect scores for individual VECs ranged from five percent (Furbearers/Small Mammals) to 391 percent (Moose), with a mean increase of approximately 130 percent.

Figure 5.6 presents cumulative effect indices for both of these temporal configurations as a percentage of each project set's total score (again, the sum of the eight indices for that configuration). As indicated, potential cumulative effects on four of the eight VECs (i.e. Water Resources, Fish Resources, Raptors and Moose) were of relatively similar significance between these project sets. Cumulative effect indices for these four VECs collectively comprised approximately 59 percent of the sum of the eight indices for the set of five projects, as compared to 55 percent for the set of eight projects as a whole. Potential cumulative effects on Waterfowl/Migratory Birds and Caribou were, however, of greater relative significance for the set of eight projects as compared to the set of five. Taken together, indices for these two VECs accounted for approximately 26 percent and 13 percent of the sum of the eight indices for the set of eight and the set of five projects, respectively. Potential cumulative effects on Furbearers/Small Mammals and Historic Resources were of relatively lower significance for the set of eight projects as a whole as compared to the set of five projects currently being developed.

FIGURE 5.6: THE RELATIVE SIGNIFICANCE OF CUMULATIVE EFFECT INDICES (TEMPORAL)



Chapter Six
DISCUSSION AND CONCLUSIONS

6.1 INTRODUCTION

Despite widespread recognition of the need to effectively assess and manage cumulative environmental change, the unfortunate reality is that CEAs are being carried out neither frequently nor adequately. As discussed previously, this can be attributed to several methodological and institutional/administrative impediments, the most significant of which are a lack of practical and effective CEA methodologies, and the incapability of the EIA process, as traditionally practised, to incorporate CEA. This study is an attempt to overcome these constraining factors in the context of small-scale hydro development in Newfoundland through the development of a practical and effective CEA technique, and its application in the assessment of the overall, cumulative effects of the set of projects as a whole in order to overcome the shortcomings of the province's predominantly project-driven EIA process. This chapter is an evaluation of the success with which the study achieved these objectives.

The chapter begins with a review and evaluation of the strengths and potential limitations of the CEA methodology developed and utilized in this assessment. It goes on to place the assessment within the context of the province's small hydro decision-making process (i.e. the application of the principles of impact assessment to the set of projects as a whole, rather than exclusively at the project level). This is followed by a proposed CEA Framework and a series of recommendations for the integration of CEA into the resource management, planning and impact assessment processes. The thesis concludes with a further discussion of the need for CEA in Newfoundland.

6.2 EVALUATION OF THE CEA METHODOLOGY

This section presents an evaluation of the CEA methodology developed and utilized in this study with regard to both its strengths and potential weaknesses.

6.2.1 Strengths

The proposed CEA methodology offers several pragmatic and theoretical advantages, both in relation to this particular assessment and in the context of CEA in general. Perhaps most importantly, it allowed for the assessment of the potential cumulative effects of the set of small hydro projects despite this study's large data requirements, and a lack of existing quantitative and compatible baseline data. By using expert opinion gathered through a modified Delphi procedure, the methodology is able to make use of available and readily obtainable information, and this information is obtained and synthesized in an effective and relatively systematic manner. Also, impact predictions are based upon the most up-to-date information available, as data are obtained directly from the experts themselves. The use of written questionnaires administered through the Delphi procedure also allows for anonymity among these individual panellists, preventing many of the dysfunctional aspects of group interaction discussed earlier.

This information is gathered without actually having to physically bring these experts together, making the technique extremely cost-effective. The use of questionnaires also allows panellists to complete the questionnaires in their own time and at their own pace, presumably resulting in increased consideration being put into the formulation and reevaluation of individual responses. The iterative nature of the Delphi technique facilitates the compilation of a great deal of quantitative and qualitative information, and the procedure itself also serves as a forum for information exchange between panellists. Iteration also allows for the identification of areas of apparent misinterpretation on the part of individual panellists, and as a result, enables the researcher to clarify any such misinterpretation in order to ensure that it is not maintained in the study's final results.

The Delphi technique also facilitates an interdisciplinary approach to CEA, which is viewed by many as an important prerequisite to the effective consideration of cumulative effects (e.g. Horak et al., 1983; CEARC, 1988b; Keith, 1994; 1995; Canter and Kamath, 1995). This was particularly necessary in the case of this assessment, as the number of projects and VECs being considered required the participation of experts with an extensive and varied range of expertise. Through the use of an expert panel, a wide variety of opinions were brought to bear on the issues under consideration, and the nature of the Delphi procedure ensured that all opinions were represented in the final results. As noted earlier, however, in some cases Delphi participants may not be equally knowledgeable in all areas touched upon by the questions. In this study panellists were able to initially identify those particular project/VEC combinations for which they were capable of commenting upon with regard to potential impacts. This reduced the potential for a possible distortion of the results due to a lack of expertise in particular areas.

Also, by its very nature, the Delphi procedure serves to highlight particular areas of disagreement between individual panellists. Indeed, as indicated in the previous chapter, several areas of dissent were identified throughout the course of the study. For example, in some cases there was considerable disagreement regarding existing baseline conditions in relation to particular project/VEC combinations (e.g. the archaeological potential of the Northwest River project area). Also, a general lack of knowledge regarding the existing environments of particular project areas in general was also evident; the Garia Bay area, for example, appears to require a great deal of further study and baseline inventory. In some cases, even where panellists were in general agreement regarding the baseline, they differed considerably in their opinions regarding the potential impact of specific projects, as well as small hydro developments in general, on one or more of the VECs under consideration (e.g. the impacts of hydro developments on Caribou or the endangered Pine Marten; the adaptability of Fish Resources to alterations in water flow patterns; etc.). Accordingly, the methodology allows for the identification of particular areas and impact processes which require further study and analysis in order to more accurately predict potential impacts.

As discussed previously, this assessment also required a means by which these expert judgements could be used to assign numerical values which represented the relative significance of the potential impact of each project on each of the VECs. As stated by Hirst (1984), one of the most difficult issues in the transfer of scientific information to the requirements of decision-making is the question of how to quantify poorly-defined information. Some of the more rigorous quantitative methods, such as interactive matrices, use expert opinion to predict and quantify impacts (e.g. the number of hectares of wildlife habitat destroyed by each project) in order to sum these values to derive cumulative effect scores. Such an approach was clearly not feasible in the context of this study given the lack of available information on which to base these predictions. Through the use of structured questionnaires and an impact rating scheme, the methodology yielded a series of numerical values which represented potential project-specific impacts, thereby allowing for the aggregation of the impact scores of multiple projects to give an indication of the relative significance of overall, cumulative effects. Cada and Hunsaker (1990: 8) contend that a lack of adequate data and regional models have impeded the quantification of cumulative effects, but that the "quantification of impacts is desirable because it supports an objective...evaluation of alternatives." In contrast, Damman et al. (1995) criticize existing CEA methods by stating that in most cases there is considerable dependency on quantitative modelling, despite the fact that not all environmental impacts can be easily quantified. They go on to note these techniques rarely facilitate the evaluation of the significance of potential effects. Similarly, Williamson et al. (1987: 379) state that:

> In cumulative impact assessment it is tempting to evaluate what is readily quantifiable yet not meaningful. Usually, the difficulty is to evaluate what is meaningful but not readily quantifiable.

Although the technique proposed here results in the "semi-quantification" of potential impacts, it assigns impact ratings to what is essentially qualitative information. As a result, it allows for the consideration of some of the more intangible impacts (and aspects of impact significance) which cannot be readily quantified using existing analytical approaches. The underlying purpose of the procedure was to yield a series of impact scores which **represented** the relative significance of potential impacts, not to arrive at some absolute, exact measure of the impacts themselves. Through the use of a set of impact evaluation criteria, the consideration of the significance of potential impacts is essentially "built-in" to the methodology, through the consideration of such factors as VEC Importance directly within the impact predictions themselves.

The use of a numerical rating scheme based on a set of common evaluation criteria also allowed for multiple VECs of a somewhat varied nature to be considered simultaneously in the assessment. As noted by Swihart and Petrich (1988), in order for certain types of VECs (and thus, some of the more intangible types of impacts) to receive commensurate consideration in such assessments, impacts must not only be quantified, but be quantified on the basis of common analytical units. This is, however, rarely possible in the context of more rigorous and quantitative CEA techniques, as the particular units of measure used in such quantification are very often appropriate to only a single VEC (e.g. changes in dissolved oxygen concentrations; percentage of forest cover lost, etc.). In this study the potential impacts of each of the 64 project/VEC combinations were rated on the basis of a set of common impact evaluation criteria that was equally applicable to all of the target resources under consideration. This allowed for the comparison of impact scores, and thus, the relative significance of potential impacts, between projects and between VECs.

Finally, the technique also allows the potential cumulative effects of other configurations of projects to be considered, thereby facilitating the analysis and evaluation of potential cumulative effects at various spatial and temporal scales. Although the study did not explicitly address potential interactive impact accumulation due to its provincial scale, certain areas and spatial configurations of projects where such accumulation is possible were identified throughout the course of the assessment. For example, it was found that the three small hydro projects proposed for the southwest portion of the Island, would, to varying degrees, all potentially affect the La Poile Caribou Herd. Leitch and Leistritz (1984: 33) state that "Results of the Delphi process often will suggest specific elements which warrant more detailed study through the application of alternative tools, such as quantitative models." Thus, while the particular CEA technique developed and used in this assessment did not allow for the assessment of such synergisms, the nature of the methodology is such that it facilitates the identification of particular areas and spatial configurations of projects where such interactive accumulation is possible, and which should thus be subject to further assessment. This could perhaps be accomplished through the use of other existing CEA techniques (such as modelling, for example), which are designed for application at the regional scale, and which are capable of addressing non-linear impact accumulations.

In summary, the technique developed and used in this study represents a practical, useable and relatively uncomplicated CEA methodology. In the context of this study, it was able to consider multiple projects and VECs despite a lack of quantitative baseline data, and was able to function at the extensive spatial and temporal scales required for the assessment. As indicated in the preceding chapter, the methodology allows for the assessment and subsequent evaluation of the potential project-specific impacts of each individual development on the set of VECs as a whole. However, more in keeping with the cumulative effects focus of this study, these results also allow for the assessment of the additive effect of the set of projects as a whole, or any configuration of such projects, on each of the target resources being considered.

6.2.2 Potential Issues

Despite the aforementioned strengths of the proposed CEA methodology, several potential limitations and shortcomings of the technique developed and utilized in this assessment must also be acknowledged and addressed. While its ability to incorporate expert judgement and to utilize this information in assigning numerical impact scores are, as previously suggested, regarded as its primary strengths, these factors also form the basis of the potential weaknesses of the methodology.

6.2.2.1 Subjectivity

Perhaps the most fundamental potential limitation of the technique is that it is based upon the rather subjective assessment of potential environmental impacts by a panel of experts. As a result of this subjectivity, there is a danger that impact predictions may, in some instances, be based as much upon errors in judgement and partiality as on fact and impartiality. For example, as indicated, impact scores for Furbearers/Small Mammals were relatively high in relation to several of the proposed projects, as was that for Torrent River - Waterfowl/Migratory Birds (due to the presence of the endangered Harlequin Duck in the area). Individual impact ratings for these combinations were, however, among the most controversial between panellists. Some apparently gave extremely high scores for all or most of the evaluation criteria in relation to these combinations for no reason other than the presence of particular species, while others argued that, in most cases, the impacts themselves would not be severe. For example, most agreed that the Star Lake area contains a significant population of the endangered Pine Marten, and some panellists contended that the presence of the species would bring about a major impact on Furbearers/Small Mammals. In contrast, others, while recognizing the importance of the species, argued that the impact on Marten would be relatively minor, or at least, no more severe than that on other species. This lead several panellists to express concern that the presence of certain species in particular project areas may have resulted in unnecessarily high impact scores for some combinations.

Indeed, various authors have expressed concern that panel size and composition (e.g. panellists' employment type, geographic location, prior knowledge of the issue(s) being considered, etc.) may compromise the accuracy of the results of the Delphi procedure (e.g. Hill and Fowles, 1975; Sackman, 1975; Woundenberg, 1991; Gulez, 1992). Table 6.1 presents the employment types of the 123 panellists who were invited to participate in the study, and of the 40 panellists who comprised the expert panel, and also gives a breakdown of the 320 individual question sheets distributed in each round. As indicated in the table, Government Employees comprised nearly one-quarter of the panel of 40 (the highest proportion of either of the four employment types), and completed nearly 60 percent of the question sheets distributed. Participants were also found to have varying degrees of self-reported prior knowledge of the projects/issues upon which they were commenting, which in some cases may have compromised the degree of objectivity with which they formulated

TABLE 6.1: PANELLISTS' EMPLOYMENT TYPES			
Employment Type	**Invited to Participate**	**Panel**	**Question Sheets**
Government Employees	81 (65.9%)	23 (57.5%)	190 (59.4%)
Academics	15 (12.2%)	7 (17.5%)	43 (13.4%)
Private-Sector Consultants	22 (17.9%)	7 (17.5%)	62 (19.4%)
Interest Group Members	5 (4.1%)	3 (7.5%)	25 (7.8%)
TOTAL	**123 (100%)**	**40 (100%)**	**320 (100%)**

and reevaluated their responses. This was even further complicated by the numerous potential combinations of these characteristics (e.g. consultants that were actively involved in a project's EIA; government employees that were familiar with the project prior to being involved in this study; academics that were unfamiliar with the project, etc.). Also, because the EIAs for several of the small hydro projects being considered were active (and often highly controversial) both before and during the data collection process, media reports and the results of these assessments may also have shaped the opinions of some panellists regarding potential impacts.

The Delphi literature provides little guidance in this regard. Despite the sheer volume of literature produced in relation to the technique, there is no established method for defining an "expert" (Judd, 1972; Delbecq et al., 1975; Linstone and Turoff, 1975), and little guidance on selecting an appropriate panel size (Richey et al., 1985a). This potential shortcoming was, however, apparently unavoidable given the nature and methodological requirements of this study. Due to the number and diversity of projects and VECs being considered, a large and diverse range of expertise was required to carry out this assessment. Panel dominance by Government Employees was apparently unavoidable, as it was primarily individuals within this group who had the type, level and diversity of expertise required to participate in the study. The selection of those potential panellists that would be invited to participate in the study was done in as systematic a manner as possible, but the researcher obviously had little control over which particular experts would subsequently agree to participate in the study. Given the relatively small number of experts initially identified as potential panellists, and who subsequently agreed to participate in the study, it was not possible to randomly select those individuals that would constitute the expert panel.

Most authors acknowledge that it is difficult, if not impossible, to determine the true subjectivity of each panellist with any degree of confidence (Bowden, 1989; Gupta and Clark, 1996), and that the overall subjectivity of a Delphi panel varies from application to application of the method (Woudenberg, 1991). While a total of 40 experts participated in the study, this group was separated into a series of sub-panels, as panellists only commented upon those particular project/VEC combinations for which they had initially indicated an ability to do so. While this is a perceived strength of the CEA technique, the result was, in effect, a series of 64 individual Delphi surveys being conducted. As illustrated in Tables 6.2 and 6.3, these individual panels were extremely variable in size (ranging from two to 17, or a mean of five experts per panel) and composition (i.e. employment type, prior knowledge of projects, and the various combinations of these traits). Because of this variability, the potential for, and degree of, partiality and judgement error also likely varied between these panels. This, in turn, may have contributed to differences between impact scores, and because the analysis of the study's results focused primarily upon the comparison of these scores and the resulting indices between projects, VECs and particular project/VEC combinations, may have influenced the interpretation of the

TABLE 6.2: PANEL SIZES AND COMPOSITIONS (By Employment Types)								
VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	2 - / 5 / 3 -	2 - / 5 / 2 1	2 2 / 9 / 3 2	2 - / 4 / 2 -	2 1 / 4 / 1 -	2 1 / 7 / 4 -	2 2 / 7 / 2 1	2 1 / 6 / 2 1
Fish Resources	2 4 / 8 / 1 1	2 3 / 7 / - 2	3 9 / 17 / 2 3	2 3 / 7 / 1 1	2 4 / 7 / - 1	3 5 / 11 / 2 1	2 6 / 11 / 1 2	2 7 / 10 / - 1
Raptors	- 2 / 3 / 1 -	- 3 / 3 / - -	- 3 / 4 / 1 -	- 2 / 2 / - -	- 3 / 3 / - -	- 3 / 5 / 2 -	- 4 / 4 / - -	- 2 / 2 / - -
WF/Migratory Birds	- 2 / 3 / 1 -	- 3 / 4 / - 1	- 3 / 5 / 1 1	- 1 / 2 / 1 -	- 2 / 2 / - -	- 2 / 3 / 1 -	- 3 / 4 / 1 -	- 4 / 4 / - -
Caribou	- 3 / 4 / 1 -	- 3 / 5 / 1 1	- 2 / 5 / 2 1	- 3 / 4 / 1 -	- 3 / 4 / 1 -	- 3 / 4 / 1 -	- 5 / 6 / 1 -	- 4 / 4 / - -
Moose	- 3 / 5 / 2 -	- 3 / 4 / - 1	- 3 / 6 / 2 1	- 4 / 4 / - -	- 3 / 3 / - -	- 3 / 4 / 1 -	- 5 / 5 / - -	- 3 / 3 / - -
FurBr/Sm Mammals	- 4 / 5 / 1 -	- 4 / 5 / - 1	- 4 / 6 / 1 1	- 4 / 4 / - -	- 4 / 4 / - -	- 4 / 5 / 1 -	- 6 / 7 / 1 -	- 4 / 4 / - -
Historic Resources	1 1 / 3 / 1 -	1 1 / 4 / 2 -	1 2 / 4 / 1 -	- 1 / 2 / 1 -	1 2 / 4 / 1 -	2 2 / 5 / 1 -	1 3 / 5 / 1 -	2 1 / 5 / 2 -

# Academics		# Government Employees
	Number of Panellists	
# Consultants		# Members of Interest Groups

TABLE 6.3: PANEL SIZES AND COMPOSITIONS (By Prior Knowledge of Project)

VEC	GB	NWAB	NWR	RB	RBB	SWR	SL	TR
Water Resources	3 1 5 1 -	2 2 5 1 -	6 3 9 - -	- 2 4 2 -	1 2 4 1 -	3 3 7 1 -	3 3 7 - 1	- 6 6 - -
Fish Resources	2 1 8 5 -	1 2 7 4 -	10 6 17 1 -	- - 7 7 -	2 1 7 4 -	2 6 11 3 -	5 4 11 1 1	1 5 10 4 -
Raptors	2 - 3 1 -	2 - 3 1 -	3 - 4 1 -	- - 2 2 -	1 - 3 2 -	1 3 5 1 -	2 1 4 - 1	1 - 2 1 -
WF/Migratory Birds	1 - 3 2 -	1 - 4 3 -	4 - 5 1 -	- - 2 2 -	- - 2 2 -	- 2 3 1 -	1 - 4 2 1	1 2 4 1 -
Caribou	2 1 4 1 -	1 3 5 1 -	4 1 5 - -	- - 4 4 -	- 2 4 2 -	- 4 4 - -	3 2 6 - 1	2 - 4 2 -
Moose	3 - 5 2 -	2 1 4 1 -	5 - 6 1 -	- - 4 4 -	- 1 3 2 -	- 3 4 1 -	2 2 5 - 1	1 - 3 2 -
FurBr/Sm Mammals	1 1 5 3 -	1 1 5 3 -	3 1 6 2 -	- - 4 4 -	- - 4 4 -	- 3 5 2 -	4 2 7 - 1	1 - 4 3 -
Historic Resources	1 1 3 1 -	- 2 4 2 -	1 1 4 2 -	- 1 2 1 -	- 2 4 2 -	- 2 5 3 -	1 2 5 1 1	1 3 5 1 -

# Actively Involved in Project's EIA		# Familiar With Project
	Number of Panellists	
# Unfamiliar With Project		# Which Gave No Rating

study's results.

Although panellists were asked to comment upon only those particular combinations for which they had the required type and level of expertise, VEC Importance ratings were based upon the relative significance of the VEC in comparison to the same VEC in other project areas, and in relation to other VECs in the same project area. This required each panellist to have at least some knowledge of the particular VEC in question in all eight project areas, and for each project that they had commented upon, some knowledge of the presence/absence and relative importance of each of the other seven VECs. This assumption may, in some cases, have been unfounded, and may thus have introduced a degree of judgement error. It may also be argued that when commenting upon the relative importance of a particular VEC in relation to other VECs in a project area, panellists may be somewhat partial towards the particular VEC for which they have expertise, although some of the comments received by panellists in this study appeared to indicate that this was often not the case.

Given the relatively small size of most individual panels, it was not possible to statistically test the degree to which panel size and composition influenced the results of the study through the introduction of judgement errors and/or partiality. It is, however, recognized as being a potential limitation of the CEA technique in this application. The degree to which a particular panellists' judgement errors and/or partiality influenced particular impact scores was, however, obviously quite panel-specific, as it was determined by the size of the panel as a whole, the presence (or lack) of such partiality among other panellists, and the subsequent distribution of the responses of the panel as a whole around the "correct" response. Again, while this issue could presumably be rectified through the random selection of expert panellists, this was clearly not possible in this assessment given the limited number of experts within each individual sub-panel.

6.2.2.2 Differences in Opinion, Interpretation and Assumptions

The separation of participants into sub-panels also presents potential problems with regard to legitimate differences of opinion regarding the significance of potential impacts (i.e. those not based on partiality or judgement errors). As indicated in the preceding chapter, in some cases there were distinct areas of disagreement between individual panellists, and subsequently, between panels. For example, it was noted that there was considerable disagreement between panellists regarding the potential duration of the impact of small hydro developments on Moose. Panels were, in some cases, dominated by those who felt that short-term impacts on Moose would result, while in others, most experts maintained that these impacts would be prolonged. Thus, the impact score for Moose for *Project A*, for example, may be 25 percent greater than that for *Project B* on the basis of this difference of opinion alone, rather than due to actual differences in the significance of potential impacts on the VEC between projects. Again, because the primary focus of the analysis of the study's results was the comparison of individual impact scores, this factor may have influenced the interpretation of the study's results.

The separation of participants into sub-panels also presents possible problems with regard to information-sharing between panellists. While the anonymity feature of Delphi is regarded as one of the technique's primary strengths, Milkovitch et al. (1972) caution that it may result in a loss of valuable information because panellists are not permitted to interact directly. This was especially evident in this assessment. In Round Two of the procedure, within each sub-panel participants were provided with a summary of the comments and rationales provided by other expert panellists in relation to their impact ratings. In some cases, qualitative information may have been provided in relation to a particular combination which was applicable to one or more other combinations as well. However, because panellists were not able to "interact" with those outside the particular panels of which they were a part, this information was not made available to other panels for which it may have been useful or relevant. While general comments regarding the potential impacts of small hydro developments on a particular VEC were fed back to all relevant panels (e.g. "Raptors typically habituate to human presence rather quickly; thus, impacts should be of short-term duration."), in most cases it was unclear to the researcher whether or not comments were meant to refer to other projects, VECs or combinations. As a result, in some cases experts may not have been able to benefit from the knowledge of panellists outside of their particular sub-panel(s), and to subsequently reevaluate and adjust their own predictions accordingly. This too may have contributed to variability in impact scores between some project/VEC combinations.

Also, definitions for the various evaluation criteria and associated impact ratings, as well as the factors to be considered in impact prediction, were open to a certain degree of interpretation on the part of individual panellists. Various measures were taken to ensure that impact ratings and overall impact scores and indices were consistent between panellists and panels. For example, panellists were provided with a set of standardized definitions for each impact evaluation criteria and associated impact ratings. These were, however, sometimes interpreted somewhat differently within and between panels. For example, the definitions given for the various degrees of *Impact Magnitude* are very much based upon the notion of the "fundamental integrity" of the VEC in question. This concept was sometimes found to be interpreted quite differently (especially with regard to Water Resources), and formed the basis for disagreement between some panellists, and in some cases, possibly the differences in impact scores between combinations.

Various attempts were made to clarify any apparent areas of misinterpretation, as well as to ensure that panellists were formulating their impact ratings on the basis of the same set of assumptions. For example, while panellists were asked to disregard proposed impact mitigation measures, they were asked to assume that the proponent would adhere to any applicable legislation. However, panellists apparently differed considerably in their knowledge of relevant regulations, laws, acts, etc., as well as in their opinions regarding the potential effectiveness of this legislation in impact mitigation. In addition, having participants disregard mitigative measures may have contributed to excessively high impact ratings in relation to some project/VEC combinations that would not reflect actual impact levels if projects were allowed to proceed. This, in turn, may have resulted in artificially high impact scores for some projects and VECs in relation to others. For example, the highest cumulative effect index for either of the eight VECs was that for Fish Resources. Several panellists, however, expressed concern that by not considering mitigative measures, impact ratings in relation to this VEC may have been unrealistically high. One panellist stated that:

> Impact predictions regarding Fish Resources MUST consider impact mitigation measures. Hydro dams are a complete impediment to both upstream and downstream fish passage!...I believe that certain mitigation/enhancement measures will be implemented in all cases, and that these will be highly effective.

This was, however, necessary in the context of this assessment because the projects under consideration were at varying stages of the EIA process, and again, the primary focus of the analysis was the comparison of impact scores and overall indices between projects and VECs.

There were also differences of opinion regarding what factors should be considered in identifying and assessing potential impacts. For example, some panellists differed, not only in their opinions regarding existing baseline conditions, but also to what extent future variability in the baseline (due to both natural and scores.

Ideally, all of the 40 participants would have had the required expertise to comment on all 64 of the project/VEC combinations under consideration. This would at least have ensured that each of the factors discussed above were equally represented in each of the sub-panels, thereby allowing for a more reliable comparison of impact scores between combinations. Given the extensive and varied range of expertise required for this assessment, and the fact that it was necessary to limit the number of question sheets that each panellist would be expected to complete, this was, however, clearly not possible.

Each of the potential limitations discussed above are, although unfortunate, apparently unavoidable issues in the use of expert opinion. As emphasized throughout, the use of expert opinion was the only feasible and practical alternative in this assessment given the lack of available quantitative baseline data upon which to base impact predictions. Numerous authors have, however, commented upon the essentially subjective nature of EIA in general (e.g. Matthews, 1975; Bacow, 1980; Susskind and Dunlap, 1981; Beatie, 1995; Mostert, 1996), but most also recognize the importance of professional judgement in all aspects of the process. Indeed, various authors have commented upon the importance and applicability of professional judgement and expert panels to CEA (e.g. Vlachos, 1982; Stull et al. 1987; Armour and Williamson, 1988; Barnes and Westworth, 1994; Hegmann and Yarranton, 1995; Kalff, 1995; Abbruzzese and Leibowitz, 1997). A recent survey of EIA practitioners in the United

States (Cooper and Canter, 1997), for example, revealed that *professional judgement/expert opinion* is considered the most important and useful of the available CEA methodologies, and is by far the most commonly used. The use of expert opinion, although admittedly less than ideal in some respects, is likely to continue to play an integral role in the assessment and evaluation of cumulative environmental change. The key is to recognize these potential shortcomings, and to interpret and utilize the resulting data cautiously and accordingly.

6.2.2.3 Nature of the Impact Ratings

Other potential limitations of this methodology relate to the nature of the impact ratings themselves. As indicated, the methodology allows for the semi-quantification of impacts; scores are assigned which represent the relative significance of the potential effect of each project on each of the VECs under consideration. It may be argued, however, that this exercise results in an oversimplification of the inherent complexity of environmental impacts. As noted by Bain et al. (1986: 5) "One challenge in cumulative impact assessment is to consolidate information without losing essential details." This technique is used to assign single, static numerical values to impacts that are, in reality, likely to be quite spatially and temporally variable. For example, the Magnitude of an impact may be variable over space (e.g. impacts on Water Resources may be minor downstream of the facility's tailrace, but major in the dewatered zone); over time (e.g. impacts on Caribou may be moderate during project construction but negligible during the operation phase); and also within a *VEC Category* (e.g. one species of Raptors may be more severely affected than another). Individual VECs are also likely to vary in their relative importance across space, over time and between species (e.g. depending on the area, the Furbearers/Small Mammals category may include voles, otters and beavers, as well as the endangered Pine Marten). Also, while the term "Current State" implies a VEC's condition at a specific point in time, it may also vary spatially within an impact zone and between specific species in an area. Indeed, this potential limitation is evident in relation to all of the impact evaluation criteria used. In order to ensure that data would be consistent and compatible, panellists were asked to assign impact ratings which reflected the **maximum** level of impact likely. This may, however, have resulted in an oversimplification of impact levels in some cases, and thus, scores may not represent the inherent complexity of the effects themselves. The nature of the impact evaluation criteria was also such that potential positive impacts were not explicitly considered in the impact ratings; in most cases, however, panellists' comments revealed that experts were "factoring in" such positive impacts when formulating their impact predictions.

The evaluation criteria themselves varied considerably with regard to the level of quantification involved. For example, while Temporal Duration ratings specified the number of years it would take for the VEC, once affected, to return to its pre-project condition (See Table 5.1), VEC Importance was rated on the basis of a rather arbitrary five-point scale. The use of a set of rather qualitative impact evaluation criteria raises concerns about consistency in impact scores between projects and VECs. For example, Spatial Extent ratings ranged from *site-specific* to *provincial*, but individual project areas often differed considerably in size. For example, the project area for the proposed Northwest River small hydro project is approximately 0.25 km^2, while that for the Star Lake development is approximately 21.95 km^2. The use of such qualitative evaluation criteria therefore makes the comparison of impact scores between projects somewhat difficult in some cases. Had the study been able to make use of more rigorous and quantitative measures (such as the number of hectares of ungulate habitat destroyed, or the potential increase in sediment concentrations) these shortcomings would have been avoided. Given the nature and requirements of the assessment, however, such quantification was clearly not possible.

In mathematically combining individual ratings to derive a single impact score for each project/VEC combination, each evaluation criterion was deemed to contribute equally towards overall impact significance. For example, all else being equal, a major, short-term impact and a negligible, long-term impact were deemed to be of equal significance. Also, the nature of the ratings is such that, for example, a major impact is deemed to be *33.3 percent more significant* than a moderate impact. While a weighting scheme which reflects the relative importance of each value towards overall impact significance would effectively deal with this potential problem, there is little or no guidance in the literature in this regard. This problem could possibly be overcome by initially asking expert panellists to rate the relative importance of each of the evaluation criteria; however, opinions will likely vary greatly between panellists, and especially, between VECs and particular project areas.

Finally, while the proposed CEA technique generates numerical values which represent potential impacts for each combination, these ratings are ordinal measurements. The values are subsequently used to derive impact scores through mathematical functions which are typically used for interval and ratio type data. Although the generation of impact ratings of this nature was unavoidable in the context of this assessment, the technique's use of calculations that are normally not considered applicable to ordinal data requires great caution. This feature is also recognized as a potential limitation of the methodology.

6.2.3 Summary

A lack of appropriate CEA methodologies has traditionally been a major impediment to the effective consideration of cumulative environmental change. Generally speaking, most existing CEA methodologies are excessively complex, impractical, and of limited applicability and adaptability. The desirable features of a CEA methodology, as defined by Irving et al. (1986), are that the technique should:

1) Enable multiple developments to be considered;

2) Be practical, while at the same time yielding understandable results that would aid in the decision-making process;

3) Be adaptable to allow for the consideration of a vast array of possible site-resource-impact combinations;

4) Feature flexible boundaries in terms of time and space;

5) Enable the aggregation or tallying of incremental and/or interactive impacts to give an indication of overall, cumulative effects; and

6) Allow for differential levels of resolution (i.e. a general, extensive analysis of potential cumulative effects, while still allowing for intensive site and project-specific impact assessments).

As illustrated in the preceding discussion, the technique developed and utilized in this study meets, to varying degrees, all of these criteria. It therefore satisfies the general requirements of an effective and practical CEA methodology despite the limitations discussed above. Also, most of these potential issues were unanticipated at the time this study was initiated. They would, however, likely be resolved with further applications of the technique.

The technique was capable of dealing with the nature and objectives of this particular assessment, as well as its demanding and somewhat distinct methodological requirements. Perhaps most importantly, however, it yields practical, useful and understandable results that can be used to integrate the consideration of potential cumulative effects into the impact assessment, planning and overall decision-making processes.

6.3 THE ASSESSMENT IN CONTEXT - BEYOND PROJECT-SPECIFIC EIA

As indicated throughout, in addition to methodological issues, the nature of the EIA process itself has also been a constraining factor in CEA. EIA has been a predominantly project-driven exercise, in which projects are assessed individually rather than as part of a larger programme or policy, and this has contributed to its apparent inability to effectively address cumulative environmental change. There has, however, recently been increased interest in the application of the principles of impact assessment to higher-order levels of the decision-making process - namely programmes, plans and policies.

Although there is often some overlap, there generally exists a tiered forward planning process, which begins with the formulation of a policy, followed by a plan at the second tier, and by a programme at the end:

> A policy may thus be viewed as the inspiration and guidance for action, a plan as a set of coordinated and timed objectives for implementing the policy, and a programme as a set of projects in a particular area (Wood and Dejeddour, 1992: 8).

Figure 6.1 illustrates the various stages of this process in the context of small-scale hydroelectric development in Newfoundland. As discussed in Chapter Two, in April of 1990 Hydro announced a new policy direction in which it was willing, under certain conditions, to relinquish its franchise right on undeveloped small hydro sites, and that it would be willing to purchase the output from these facilities on a long-term contractual basis. It was this new policy direction that set the stage for the

FIGURE 6.1: THE NEWFOUNDLAND SMALL HYDRO DECISION-MAKING PROCESS

Policy	**April, 1990: Hydro Relinquishes Franchise Rights for Undeveloped Small Hydro Sites** **To Purchase Power on a Contractual Basis**
Plan	**Process of Issuing Waivers** **April, 1992: Request for Proposals (50 MW)**
Programme	**5 Projects (38 MW) Currently Being Developed** **+ Possible Future Projects**
Project(s)	**• Northwest River** **• Rattle Brook** **• Southwest River** **• Star Lake** **+ Potential Future Projects**

development of these facilities by the private sector on the Island portion of the province. In order to implement this policy, it then began a process of issuing waivers for undeveloped small-scale hydro sites, and issued a *RFP* in April 1992 for the purchase of up to 50 MW of power from private developers (the Plan). Then, based upon a series of screening processes, Hydro announced that four projects totalling approximately 38 MW were to be developed (i.e. the Programme), with individual projects to come into service in 1998, pending environmental approvals. To date, however, environmental assessments for these proposed facilities have been exclusively at the project level, rather than at higher-order stages of the decision-making hierarchy.

"EIA tiering" entails the introduction of the principles of impact assessment in a linked and coordinated manner into each significant stage of this process (Lee, 1982), and indeed, the concept of Strategic Environmental Assessment (SEA) is currently receiving a great deal of interest world-wide. Therivel et al. (1992: 21-22) define SEA as:

> The formalized, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives...and using the findings in...decision-making.

Therivel (1993) identified three types of policies, plans or programmes to which SEA can be applied:

1) *Sectoral* (e.g. waste disposal, forestry, transportation, energy)

2) *Regional* (e.g. regional land-use plans)

3) *Indirect* (e.g. science and technology, financial/fiscal policies)

Various advantages of SEA have been proposed in the literature; most in keeping with this study, however, it is generally acknowledged that impact assessments at higher-order stages of the decision-making hierarchy allow for the more effective consideration of potential cumulative environmental change (Lee and Walsh, 1992; Therivel et al., 1992; Wood and Dejeddour, 1992; Partidario, 1993; 1996a; Therivel, 1993; Clark, 1994; Court et al., 1994; Sadler, 1996; Therivel and Partidario, 1996). Lee and Walsh (1992: 130) state that "Project-level EIAs should be sensitive to the phenomenon of cumulative impacts, but they are unlikely to be satisfactorily handled in the absence of earlier sectoral and/or area-wide environmental assessments." Similarly, Ortolano and Shepherd (1995) contend that one reason why cumulative effects continue to be unaddressed is that the programmatic EIA is one of the few approaches for effectively dealing with them. This study is, in essence, an attempt to *push the assessment up a tier* from the project level to the programme level. Sigal and Webb (1989) contend that the application of EIA at the programme level is particularly appropriate for assessing the impacts of actions that are similar in nature and extensive in spatial scale, particularly those with the potential for cumulative effects (such as small-scale hydro developments in Newfoundland).

It was argued in Chapter Three that various factors have contributed to the apparent inability of the EIA process, as traditionally practised, to effectively consider cumulative effects. In the context of this study, assessing environmental impacts at the programme level serves to alleviate these shortcomings. For example, the EIA process is typically not an all-inclusive one; as a result, some undertakings fall outside of the process altogether, or are released without formal assessment, despite the fact that the overall effect of a series of such developments may be cumulatively significant. As indicated, the Rattle Brook project considered in this study was released from the province's EIA process without a formal assessment as it was deemed to have the potential for relatively insignificant environmental impacts. Relatively small projects that are not individually expected to bring about significant impact (but which may collectively do so) are more effectively dealt with at the policy, programme or policy level (Lee and Walsh, 1992). This study assessed the potential, overall environmental impact of the province's "small hydro programme" as a whole; as such, even projects which are not thought of as having the potential for significant environmental impacts in their own right are included in the assessment, and thus, their contributions toward potentially significant cumulative effects are considered.

Also, because project-level EIAs have traditionally focused rather restrictively upon the site-specific impacts of individual development proposals, they are inherently unable to encompass the extensive spatial scales required for CEA. Conducting the assessment at the programme level allows for the consideration of multiple, spatially wide-spread sources of potential impact (i.e. all of the projects which comprise the programme) and subsequently, the potential cumulative effects of these actions.

It is also generally acknowledged that the effective consideration of cumulative environmental change requires an integrated and anticipatory management and planning approach. In contrast, the predominantly project-driven EIA process has traditionally functioned in isolation from the broader activities of resource management and development planning. In the case of small hydro development in Newfoundland, individual projects are being proposed and developed by numerous private sector developers rather than by a single proponent. Indeed, much of the concern over cumulative effects stems from the segmentation of development activities into multiple, smaller projects (Merson and Eastman, 1980; Eckberg, 1986). This has resulted in a rather fragmented development and management framework, in which individual proponents have no little or no control over other projects. By assessing these proposed developments as part of a larger programme, cumulative effects can be more effectively addressed through a management system that is both integrated and comprehensive. Also, from a planning perspective, SEA allows for the consideration of potential cumulative effects (and indeed, environmental issues in general) at relatively early stages of the decision-making process. In contrast, project-level EIA has traditionally not facilitated such a proactive planning approach. It has predominantly been a rather reactive mechanism designed to predict and address the potential impacts of selected developments, rather than as a tool for the effective and timely implementation of broad environmental objectives. SEA allows for the consideration of environmental issues (and potential cumulative effects) in the

formulation of policies, plans and programmes, rather than attempting to respond to such issues at the project level. For example, potential cumulative effects could have been considered in the selection of those particular projects that will comprise the Island's small hydro programme, thereby resulting in an anticipatory and proactive approach to the management of potentially significant cumulative environmental change.

Conflicts arise in the literature regarding the role of the EIA process itself with regard to cumulative environmental change. Robilliard (1986: 107), for example, contends that:

> [C]omprehensive, environmentally based planning is an appropriate substitute for the entire impact assessment, including the generally poorly focused assessment of cumulative impacts. This is an argument for the "top-down" view as the only correct way to live.

In contrast, LeBlanc (1994: 6) maintains that:

> [T]he assessment of cumulative environmental effects should not radically alter the EIA process. Actually, the assessment of cumulative environmental effects should be considered as EIA, only better, more comprehensive, more effective, and therefore an exciting step forward in the evolution of its practice.

The implementation of CEA at higher-order stages of the decision-making hierarchy (through, for example, the application of the proposed CEA technique at the programme level) is not intended as a replacement for project-level EIA and the consideration of cumulative effects within these assessments. Indeed, as noted by Lawrence (1994), while there is clearly a need for regional planning and management initiatives to address potential cumulative effects, it is essential that a CEA perspective be incorporated into project-level assessments as well.

The CEA methodology developed and utilized in this assessment is, for example, capable of considering only very specific sources and types of cumulative effects. As a result, the study focused primarily upon the potential additive cumulative effects of a series of related projects on a provincial scale, and was thus spatially extensive and sectoral in nature. However, effective CEA often requires both a sectoral and a regional approach. While, the CEA technique allowed for the assessment of the additive cumulative effects of small hydro developments at the regional scale (i.e. spatial configurations), comprehensive CEA must also consider other potential sources and types of potentially significant cumulative effects which were not considered in this assessment. Indeed, as noted by Ballard et al. (1982: 5):

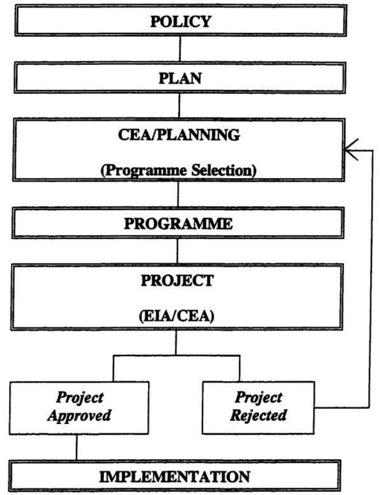
> Environmental problems, and the policies needed to address them, differ regionally. This perspective often is lost in environmental assessments directed towards a particular industry, such as electric utilities...

Thus, while the overall effects of a small hydro development "programme" may be cumulatively significant and must therefore be assessed, on a regional scale the impacts of individual projects may accumulate (through additive or interactive processes) with the effects of other past, present of future developments (including unrelated activities such as timber harvesting, mining activity, etc., as well as existing hydro projects), to bring about significant cumulative effects. Thus, while the application of CEA methodologies such as that proposed here at the programme level facilitates the assessment of the additive cumulative effects of undertakings that are similar in nature and spatially and temporally extensive in scope, there is also a need to address cumulative effects which may result from two or more independent and unrelated actions on a regional scale - an even more complex and difficult process. The following section presents a framework for a CEA approach which facilitates the consideration of various potential sources and types of cumulative effects in the impact assessment, management and planning processes.

6.4 A FRAMEWORK FOR THE IMPLEMENTATION OF CEA

Several authors propose that effective CEA requires that cumulative effects be considered at the proper stages in the decision-making hierarchy, and that different types of impacts may best be assessed at different tiers within this process (McCold, 1991; Wood and Dejeddour, 1992). Figure 6.2 presents a Cumulative Effects Framework which represents such an approach. The following section discusses the various steps involved in this proposed framework using the example of small-scale hydro development in Newfoundland.

FIGURE 6.2: CUMULATIVE EFFECTS FRAMEWORK



i) POLICY/PLAN: Policy and plan development consisted of Hydro's policy change regarding small-scale hydro development on the Island and subsequent RFP. Von Mirbach (1996: 9) contends that:

> Currently there are a number of small-scale hydro development proposals going through convoluted, expensive and divisive environmental assessment processes. Surely a better - and certainly more cost-effective - approach would have been to put Newfoundland Hydro's long-term energy supply plan through an environmental assessment, at which time it would have been possible to explore alternatives to small-scale hydro...

Environmental impacts are, however, inherently difficult to predict, even at the project level. As noted by Sadler (1996: 161), "Impact relationships are much more attenuated and uncertain at the strategic level", and this is especially true at the policy and plan levels. Also, in most cases, specific project proposals are often not yet developed or finalized at these stages, and thus, a detailed and comprehensive assessment of potential cumulative effects is unlikely to be possible. At the very least, however, a qualitative analysis and preliminary identification of potential cumulative effects can and should be made at this stage (Sadler, 1996), and this albeit cursory analysis can be used in the development of policies and plans. For example, if it is initially determined that the probability of significant and unacceptable cumulative effects from small hydro development is great, energy policies can be devised or altered to ensure that small hydro is not considered to be the preferred energy option.

In addition, the CEA methodology developed and utilized in this assessment does not explicitly consider the impacts and cumulative effects of past and present projects on a provincial scale (e.g. those resulting from the 35 hydroelectric facilities already in operation on the Island). This is necessary to ensure that the scope of the CEA remains focused and manageable. The impacts of these developments must, however, also be considered within the "sectoral CEA", but are perhaps best dealt with at the policy and plan stages. For example, if it is determined that the cumulative effects of past and present hydroelectric developments in the province are already of such significance that no further hydro sites should be developed, then policies and associated plans should be designed or adjusted to proactively prevent further cumulative environmental change.

ii) CEA/PLANNING (PROGRAMME DEVELOPMENT): Hydro's policy change and RFP led to a series of project screenings to determine which proposed projects should form the small hydro programme (based primarily upon technical and economic criteria). This resulted in four projects eventually being selected for development, subject to the findings of project-level EIAs. However, this framework facilitates the consideration of potential cumulative effects in programme planning and design.

Through the application of, for example, the CEA methodology developed and used in this study, projects could be selected on the basis of potential project-specific and cumulative effects (in addition to technical and economic considerations). As discussed earlier, the technique allows for the assessment of potential project-specific impacts; accordingly, individual projects which are initially identified as having the potential for unacceptable levels of environmental impact could subsequently be removed from further consideration. Those specific projects that will comprise the programme could be selected so as to minimize the overall cumulative effect of the set of projects, or at least, preferred configurations of projects selected on the basis of technical or economic feasibility could be screened to ensure that the programme does not result in significant or unacceptable levels of cumulative effect. As such, the consideration of potential cumulative effects could be integrated into the selection of those specific projects that would constitute the programme, thereby facilitating a planning approach to CEA.

As illustrated in Section 5.5.2, the proposed technique allows for the assessment of the potential cumulative effects of various temporal configurations of projects, and thus, the degree to which these effects change in significance with the adding of further developments. If additional developments were required in the future, the data could subsequently be used to introduce CEA into the selection of these projects by considering not only their potential impacts, but also the degree to which they would contribute to the cumulative effects of those developed previously. In short, the proposed CEA technique results in the compilation of a *Cumulative Effects Baseline* with regard to the particular sector under consideration, and this can subsequently be used to plan for further developments on the basis of potential cumulative effects. Also, in the context of this study, it is anticipated that additional projects over and above those being considered in this assessment will be proposed in the future. These projects could be assessed in the same manner, and information regarding them added to the existing data set. (It should be noted, however, that impact scores compiled for each project represented existing environmental conditions at a specific point in time. Also, in calculating project-specific impact indices, VECImp1 scores reflected the relative importance of the VEC as compared to the same VEC in only those project areas initially being considered. As a result, some of the data for several of the initial projects may also have to be recollected/adjusted when adding additional projects to the cumulative effects baseline).

iii) PROJECTS (EIA/CEA): Selected developments should then be subject to individual environmental assessments at the project-level. These EIAs should address, not only the potential impacts of the individual project (including those on other VECs not considered in the sectoral CEA), but also explicitly consider potential cumulative effects on a regional scale. This should include any potential indirect, secondary and spatially and temporally extensive impacts, as well as potential cumulative effects resulting from the incremental or interactive accumulation of the effects of the project with those of other past, present or reasonably foreseeable activities (including related and unrelated developments). Potential impact accumulations at the regional scale were, to a certain degree, considered through the CEA technique developed and used in this assessment (i.e. by having panellists rate the Current/Pre-project State of the

VEC). However, in some cases there was considerable uncertainty regarding the type and extent of past and existing disturbances in an area, and no direct consideration could be given to the potential interactive accumulation of their impacts. Also, ratings for this evaluation criteria considered only past and existing sources of stress, without regard to reasonably foreseeable developments. This was, of course, unavoidable because most panellists would obviously not be aware of, or able to confidently predict, an area's future development. The impacts of past, present and potential developments in an area should, however, be identified and explicitly considered in subsequent project-specific EIAs.

At the project level, CEA techniques which are designed for use at the regional scale and, if necessary, can assess interactive impact accumulation should be used. A benefit of SEA is that in some cases it may reduce or eliminate the need for EIA at the project level, limit the scope of project-specific EIAs to those issues not previously addressed at the strategic level, or at very least, highlight specific areas which require consideration and further study in these assessments. Indeed, as previously suggested, the CEA technique used here allowed for the identification of particular areas requiring further study (i.e. baseline conditions or impact processes), as well as areas where interactive impact accumulation is possible. In short, the consideration of cumulative effects at higher-order stages of the decision-making hierarchy also serves as a preliminary scoping exercise for project-specific EIAs, and thus, ensures that their focus is more clearly defined.

iv) IMPLEMENTATION: Pending their release from the EIA process, selected projects could be implemented as required. In cases where a project(s) is not permitted to proceed on the basis of the findings of its EIA, a replacement project should be selected by considering its potential contribution to the cumulative effects of the set of remaining projects. The selected project should then subject to a project-level EIA.

In summary, the framework discussed above, although relatively simple, allows for the incorporation of CEA into various stages of the decision-making process. It facilitates the consideration of potential cumulative effects from both a sectoral and a regional perspective, and therefore ensures that all potential sources and types of cumulative effects are addressed in the decision-making process. As a result, the proposed framework facilitates an anticipatory and comprehensive planning approach to cumulative effects analysis and management.

6.5 REMAINING ISSUES AND RECOMMENDATIONS

As indicated throughout, this study is, in the context of small hydro development in insular Newfoundland, an attempt to overcome two of the most prevalent and significant analytical and administrative impediments to CEA. Various other issues must also be resolved, however, in order for CEAs and SEAs to be carried out effectively. This section presents an overview of these additional analytical and administrative constraints (some of which are evident in the context of this study), and where possible, provides recommendations which will assist in resolving them.

6.5.1 Legislation and Mandate

The lack of a legislative requirement for CEA has, as discussed in Chapter Three, also contributed to the apparent failure of most existing EIA processes to incorporate the consideration of cumulative environmental change. As indicated, the Newfoundland EA Act contains no requirement for CEA, and although the process is currently under review, even recently proposed reforms (NDOE, 1995) do not include any consideration of cumulative effects. Consequently, comprehensive attempts at CEA in this province have been limited. While this study could obviously do little to rectify this situation, it is recommended that the requirement for CEA be explicitly included in EIA legislation.

Partidario (1996a: 39) contends that "insufficient political will and commitment" are also among the most common barriers to the implementation of SEA. With very few exceptions (e.g. New Zealand, the Netherlands and the United States) most jurisdictions do not yet have a legislated SEA process (Partidario, 1996b). In Canada, a cabinet directive issued in June 1990 requires that all federal departments and agencies apply a mandatory, yet non-legislative, environmental process to policy and programme proposals submitted for cabinet consideration that may have environmental impacts (Doyle and Sadler, 1996; Partidario, 1996b). At the provincial level, only Newfoundland and Nova Scotia have provisions for policy-level EIAs (Doyle and Sadler, 1996). In Newfoundland, policies, plans and programmes are included in the definition of the term "undertaking", and thus, require registration under the province's EA Act. For example, five-year management plans for each of the province's 24 Forest Management Districts require registration, although these plans are rarely subject to formal EIAs (Cleary, 1995 pers comm). The recently proposed reforms to the province's EIA process (NDOE, 1995) take a profound "step-backward" in the context of SEA, however. It is proposed that policies, plans and programmes no longer be subject to the EA Act because "It is neither reasonable nor practical to apply the environmental assessment process to such matters." (p. 18). However, given the fact that effective and timely CEA very often requires assessments at the strategic level, there is an overwhelming need for the introduction of formalized provisions and requirements for SEA within existing and proposed EIA legislation in all jurisdictions.

Even in cases where CEA and SEA are required by law, there is often considerable uncertainty regarding when these assessments are required, and if so, often considerable disagreement regarding who is responsible for carrying them out. In the case of the CEA for the Alberta Express Pipeline project discussed earlier, for example, the proponent argued that under the CEAA it was not compelled to conduct a separate cumulative effects *assessment*, but merely to consider cumulative effects within the project's EIA (Dupuis and Hegmann, 1997). It was also argued that CEA "is not the responsibility of a single proponent and requires input from regional resource planners and managers, other interested stakeholders and landowners" (Priddle et al., 1996: 97).

Conacher (1994: 349) contends that "CEA means that, pragmatically, EIA cannot be undertaken by project proponents. They lack the necessary information and it is not their problem." Indeed, an assessment such as that described in this thesis would clearly be beyond the responsibility of individual project proponents, and would presumably be conducted by a higher-level authority (i.e. Hydro). Accordingly, EIA legislation should not only include requirements for CEA and SEA, but also explicitly outline the situations where these types of assessments are required (or, at least, whose mandate it is to order such assessments) and who is responsible for conducting them. In Newfoundland, for example, a CEA Committee consisting of scientists, managers, planners and stakeholders should be established by the Environmental Assessment Division to identify those particular regions or sectors where significant cumulative effects are likely, and thus, which require the consideration of potential cumulative effects within SEAs or project-specific assessments.

6.5.2 Boundaries

Cumulative effects and their sources are often characterised by extensive spatial and temporal dimensions, and CEAs must therefore consider the spatial and temporal attributes of both the stressor(s) and their effects (Shoemaker, 1994).

From an analytical perspective, the necessity of expanding the spatial and temporal bounds of CEA poses difficulties with regard to the identification of the boundaries appropriate to the assessment, and the challenges of working at such extensive scales. Defining the boundaries appropriate to a CEA has proven to be quite a difficult practice, due in part to an incomplete understanding of the structure and dynamics of environmental systems, and their responses to multiple perturbations. It is also often difficult to discern the spatial extent of the potential sources of impact which may contribute to cumulative effects, and thus, which require consideration in the CEA. In general, attempts at CEA have been more successful with clearly bounded systems (such as lakes or watersheds) than with more open systems (e.g. estuaries, terrestrial systems, etc.) (CEARC, 1988b). There is also often considerable uncertainty regarding how, or to what extent, past and present projects (e.g. McCold and Saulsbury, 1996) and future actions (e.g. Rumrill and Canter, 1997) and their impacts should be considered in CEAs. The perceived significance of cumulative effects is also influenced by the scales at which they are evaluated (Kalff, 1995).

No universally accepted guidelines for the delineation of CEA boundaries have been proposed in the literature. This is due, in part, to the fact that the spatial and temporal boundaries appropriate to CEA are quite variable, as they are determined by the nature of the assessment, the type and extent of the source(s) of cumulative effects in question, the nature of the affected environmental system, and consequently, the types of cumulative effects likely to result. Bedford and Preston (1988: 767), therefore, speak of the need to let "the problem define the spatial and temporal scales and the variables to be studied". Indeed, most researchers agree that CEA requires the extension of spatial and temporal boundaries to entirely contain the environmental components of concern and the human actions that influence them (Shoemaker, 1994).

In the case of this study, the spatial bounds appropriate to the assessment were quite evident. It took a "top-down approach", assessing the potential cumulative effects of proposed small hydro developments on a provincial scale. However, as indicated, it was extremely difficult to identify the temporal dimensions of the assessment because of considerable uncertainty regarding which specific small hydro projects which would be developed in the future, and thus, required consideration in the assessment. Assigning appropriate spatial and temporal boundaries is likely an even more difficult exercise when adopting a "bottom-up" approach to CEA (i.e. focusing upon a particular VEC or environmental system), especially where interactive impact accumulation is likely.

The issue of boundaries is also a constraining factor in CEA and SEA from an administrative perspective. Even if the boundaries appropriate to a particular CEA could be easily and accurately defined, the tendency for "administrative fragmentation" has traditionally impeded the effective assessment and management of cumulative effects. This concept is evident with regard to both the environmental systems or VECs under consideration, and the sources of impact as well. A landscape unit is typically subdivided into a myriad of administrative units; the Island of Newfoundland (111,590 km^2), for example, is divided into 19 Economic Zones, 18 Forest Management Districts, 47 Moose Management Areas, 17 Caribou Management Zones, 23 Black Bear Areas, 14 Salmon-Angling Zones, three Trout-Angling Zones and numerous other often overlapping administrative divisions. The result is a spatially segregated management framework, in which numerous agencies can usually claim direct or indirect responsibility for any particular resource or area.

In most cases these jurisdictional boundaries artificially transect environmental systems, and thus, seldom have any pertinence to the spatial characteristics of environmental effects. These discrepancies can therefore impede the assessment, and particularly the management, of cumulative effects. "Many times there is a mismatch between the scales at which environmental impacts occur and the scales at which decisions are made" (Clark, 1994: 321). However, by their very nature it is at extended spatial and temporal scales that cumulative effects originate and become evident. Accordingly, the assessment and management of cumulative environmental change requires a management framework which is more integrative and spatially and temporally extensive than that which has traditionally been achieved through existing administrative systems.

More in keeping with this assessment, however, such fragmentation is also evident with regard to potential sources of cumulative effects. As indicated, small-scale hydro developments in Newfoundland are being proposed by numerous private-sector proponents, and this has lead to a rather fragmented management framework. This assessment attempted to overcome the limitations of the province's predominantly project-driven EIA process by conducting a CEA at the programme level. The nature of the province's hydroelectric management system, however, is such that the selection of individual sites for development is not within the mandate of a single regulatory authority. As indicated previously, Newfoundland Power, although primarily a distributor of electricity, generates approximately 15 percent of the power it sells, and indeed, is the proponent for the proposed Rose Blanche Brook project considered in this study. As a result, the consideration of potential cumulative effects in programme planning by Hydro would not necessarily include the potential impacts of all such projects because Newfoundland Power is able to proceed with the development of hydro sites for which it holds water rights, independently of Hydro's review and selection process. This issue is even further compounded by the fact that, as a result of the amendments made to the Newfoundland and Labrador Hydro Act (1975) and other relevant legislation in early 1996, Hydro no longer has the exclusive right to undeveloped sites on the Island. Thus, with regard to the approximately 180 MW required for the proposed Voisey's Bay smelter and refinery, for example, although a decision has yet to be made regarding which specific sites will be developed, the Voisey's Bay Nickel Company Ltd. may chose to purchase its power from Hydro, construct its own generator at the site, or even select a proposal directly from the private sector. In short, while conducting an assessment at the programme level can theoretically serve to alleviate the limitations of the project-specific nature of the EIA process in the context of cumulative effects, the effectiveness of such an assessment (and subsequent planning) is clearly dependent upon the existence of a single, comprehensive and integrated management system and planning process.

6.5.3 Thresholds and Goals

While each of the concepts discussed above have inhibited the effective assessment and management of cumulative effects, several factors have also constrained their evaluation. The necessity of determining the significance of environmental impacts has also long been recognized in EIA. Two related concepts are relevant to, and pose difficulties in, the evaluation of cumulative effects - from a scientific perspective, the concept of carrying capacity or system thresholds, and from a societal perspective, the concept of values or goals.

A threshold is defined as:

> [A] maximum or minimum number, or some other value, for an environmental impact or resource use which, if exceeded, causes that impact or use to take on new importance (Haug et al., 1984: 18).

In theory, cumulative effects become evident only when the accumulation of individually insignificant effects cross some threshold (Dickert and Tuttle, 1985). In short, although the impact of a single action may be considered negligible (due to ability of the environmental system in question to assimilate it), it is when cumulative effects resulting from multiple sources of perturbation exceed some threshold that they become evident or significant.

The overall resilience or sensitivity of a resource or environmental system is the product of its natural state, its condition as a result of the impacts of past or present anthropogenic disturbances, or a combination of these factors. For example, a Black Bear population may be in an unhealthy state despite a lack of adjacent anthropogenic activity due to a particularly harsh winter and subsequent lack of spring forage. Similarly, a Caribou herd may be very near a threshold situation at a particular point in time as a result of the overall impact of multiple human developments within its range. In both cases, even a slight increase in the amount of stress (due to the addition of another anthropogenic disturbance) may cause a threshold to be exceeded, and thus, bring about potentially significant cumulative effects.

Thresholds, therefore, provide the "yardstick" against which the significance of cumulative effects can be determined. Accordingly, an understanding of them is vital to the evaluation and management of cumulative effects. When threshold levels are known in advance, measures can be taken to ensure that the carrying capacity of a system is not exceeded through the proactive management of cumulative effects. Predicting and defining system thresholds in CEA has, however, proven to be an extremely difficult exercise (USNRC, 1986; Mains, 1987; Peterson et al., 1987; Preston and Bedford, 1988; Damman et al., 1995; Keith, 1995). This is due, at least in part, to an incomplete knowledge regarding the ability of environmental systems to assimilate multiple perturbations. As such, there is often widespread debate and controversy among members of the scientific community when an attempt is made to set a numerical threshold limit (Dickert and Tuttle, 1985). Set values for some environmental parameters do exist (e.g. air or water quality standards), but the more intangible thresholds for most other environmental components (such as wildlife resources or fish populations) have thus far eluded quantification. Without an understanding of these thresholds, however, it is difficult to scientifically evaluate the significance of cumulative effects.

While the carrying capacities of environmental systems provide the basis for the scientific evaluation of cumulative effects, it is also necessary to appraise them in relation to social values and subsequent management objectives. For example, to what extent can a forest ecosystem be degraded by timber harvesting, road construction, silvicultural activities, etc. before the cumulative effects of these actions is deemed socially unacceptable? Numerous authors have noted the importance of goals in the evaluation of cumulative effects (e.g. Salwasser and Samson, 1985; Munroe, 1986; Proett, 1987; Preston and Bedford, 1988). For example, Horak et al. (1983: 15) state that "the ultimate significance and meaning of cumulative impacts rests against some 'ideal' environment or state..." Lee and Gosselink (1988: 592) contend that the "identification and development of commonly held social and political landscape management values or goals is central to the problem of cumulative impact assessment." Similarly, Gosselink et al. (1990: 590) state that "If cumulative impacts are to be managed, the decision at an individual site will have to be governed by earlier decisions made about the allowable extent of modification of the whole landscape unit". In short, effective CEA requires explicitly defined goals and objectives; an indication of the "limits of acceptable change" against which the acceptability of potential cumulative effects can be judged, and upon which subsequent planning can be based.

However, the development and articulation of explicit goals and objectives for regional resource planning is rare. Further compounding this problem is the fact that societal goals are often somewhat ambiguous, and are often quite variable among and between groups, as well as over time and space. Roots (1986: 158) warns against the "tendency to homogenize society", and maintains that effective CEA must be capable of accounting for these variations. Several authors have commented upon the difficulty of determining and defining goals in the context of CEA (e.g. Munroe, 1986; Roots, 1986; Bardecki, 1990), and as argued by Gosselink and Lee (1987), the establishment of goals may be the most difficult process in the evaluation and management of cumulative effects.

In summary, in order for the consideration of potential cumulative environmental change to become integrated into the planning process, there is an overwhelming need for explicit environmental thresholds, societal goals, and subsequent management objectives. While this is admittedly a difficult task, without a set of criteria against which potential cumulative effects can be evaluated, the results of assessments such as this one are of limited practical utility.

6.5.4 Information Requirements

Finally, most of the factors discussed above are either the result of, or are further enhanced by, a lack of information regarding complex environmental systems and their responses to single and multiple perturbations, existing environmental conditions, and potential sources of cumulative environmental change.

The sheer complexity of environmental systems and the processes by which impacts accumulate has lead to a high degree of uncertainty in the field of CEA. In many cases the information required to predetermine system thresholds, to set appropriate spatial and temporal boundaries, and to effectively predict cumulative effects is simply not available. While the amount and type of information required is obviously determined by the nature of the particular assessment (i.e. specific projects and VECs being considered, types of impact accumulation and cumulative effects, etc.), there is a general need for further research concerning the structural and functional aspects of complex environmental systems and their responses to perturbation(s) (particularly the non-linear accumulation of the impacts of multiple sources of stress on a regional scale). This, in turn, brings about the need for the development and refinement of CEA methodologies which are able to accurately predict such impacts, while at the same time are practical and useable, and yield information which is understandable and useful in the decision-making process.

There is also often a need for more and higher quality baseline data and better inter-agency cooperation and information-sharing. In the case of this study, for example, several areas, VECs and project/VEC combinations which require a more thorough understanding of the baseline were identified (e.g. waterfowl habitat in insular Newfoundland). Also, there was often considerable uncertainty regarding the presence/absence, type and extent of past and existing anthropogenic activities in several of the project areas. There is thus also a need for more comprehensive inventories of past and existing projects and activities in order to ensure that the impacts of these developments are given adequate consideration in the assessment and management of cumulative effects.

With regard to potential impact sources, it was noted earlier that it proved very difficult to determine which particular small hydro projects were likely to be developed in insular Newfoundland in the future. One reason why programmatic EIAs are not conducted more frequently is that programme decisions and policy directions are often variable over time, making it quite difficult to identify what constitutes the programme (Ortolano and Shepherd, 1995). At the time that this study was initiated, small-scale hydro appeared to be the preferred energy alternative in insular Newfoundland. However, even before this CEA was completed, and indeed, even before projects selected for the 1992 RFP were commissioned, Hydro apparently revised this policy direction to include other generation alternatives as well (e.g. thermal and wind power, etc.).

Also, because project summaries could be obtained for only those projects which had previously been registered under the EA Act, projects that had yet to be registered at the time that this study was initiated could not be considered. Projects that were exempt from registration could also not be included, despite the fact that they may be developed in the future, and thus, may contribute to potentially significant cumulative effects. Indeed, these factors resulted in four projects having to be dropped from consideration in the assessment. The inability to obtain information regarding individual projects until such time as they are subject to project-level EIAs severely compromises the utility of the proposed CEA technique and the resulting data to a comprehensive planning approach to CEA. More specifically, CEA that can consider only those projects that have been subject to project-level EIAs is neither "all-inclusive" nor "proactive". Accordingly, specific proposals must be made available for review and assessment prior to the selection of those particular projects that will be developed. Only then can potential cumulative effects be dealt with in an anticipatory manner, and thus, more effectively considered in decision-making.

6.6 CONCLUSIONS

Recent years have indeed seen a growing awareness of, and interest in, the potential cumulative effects of multiple human developments on a regional scale. Comprehensive attempts at the assessment, evaluation and management of cumulative environmental change have, however, been limited due to various analytical and administrative factors. This study represents an attempt to overcome two of the most significant of these factors in the context of small-scale hydroelectric development in insular Newfoundland. As indicated in the preceding section, however, a series of further issues need to be addressed to ensure that cumulative environmental change is given adequate consideration in the impact assessment and overall decision-making processes.

Various comments received by expert panellists throughout the course of this study indicate that scientists, managers and stakeholders alike recognize the necessity of assessing and managing cumulative effects in Newfoundland despite the apparent lack of a means, mandate and legislative requirement to do so. Consider, for example, the following statements:

> Each individual development will generally have a relatively small impact on a localized area. However, there is a real danger that we will be *nickelled and dimed* to the point where cumulative effects become significant. An overall, provincial land-use plan is very necessary.

> The greatest issue that goes unaddressed is that of cumulative effects...Furthermore, the broad policy issue of energy alternatives (i.e. one mega project vs. numerous run-of-rivers) was never subject to an environmental or public review.

> The slow accumulation of human impact over the long-term is cumulative and greater than the sum of the effects of small projects or disruptions taken in isolation. In the past 25 years the La Poile Caribou Herd has been affected by the Burgeo Road, the Hope Brook Gold Mine, and increased cabin development and snowmobile traffic. These have all collectively reduced habitat availability and influenced migration patterns.

> Furbearers/Small Mammals are not likely to be significantly affected by a relatively small project such as this. The effect of many, however, is another issue.

> With logging activity, transmission lines, logging roads, etc. presently affecting the Buchans Plateau Caribou Herd, even a relatively small development such as Star Lake may be the straw that breaks the camel's back.

As indicated in these comments, panellists recognized that small hydro developments in insular Newfoundland may potentially result in significant cumulative effects on a provincial scale, as well as on a regional scale through the accumulation of the impacts of individual projects with those of unrelated activities. Participants also recognized that the consideration of cumulative effects is best achieved through comprehensive and anticipatory resource management and planning.

Given the current degree of interest in cumulative effects, and the recognition of the need to assess and manage such impacts in Newfoundland, the incorporation of CEA into the province's impact assessment and resource management and planning processes is clearly justified and necessary. The methodology developed in this study, and its utilization in the context of small-scale hydro development on the Island, represents a first step in the assessment of the potential cumulative effects of multiple human developments in Newfoundland.

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Appendix A

PANELLIST INFORMATION FORM

Dear -------;

My name is Steve Bonnell, and I am a Graduate Student (Masters) with the Department of Geography, Memorial University of Newfoundland. My research focuses on the potential environmental effects of proposed small-scale hydroelectric developments in Newfoundland. More specifically, I am attempting to gather opinions on the potential environmental impacts of these projects through the use of an expert panel.

There has been increased interest in the development of small-scale hydro facilities in Newfoundland since 1990. In 1992, Newfoundland and Labrador Hydro called for proposals for the supply of up to 50 Mega Watts (MW) of electricity to be supplied by the private sector. While most proposed hydro facilities in Newfoundland are subject to environmental assessments, in each case projects are assessed on an individual basis, with no consideration given to the overall ***cumulative*** effects of the group of projects on the environment of the province as a whole. Accordingly, my research considers the degree to which a number of proposed small hydro projects in Newfoundland will potentially affect a set of ***Valued Environmental Components*** (VECs).

To achieve this, I am attempting to assemble an expert panel to comment upon the potential environmental impacts of these projects. (See attached document - Figure 1 shows the locations of the 12 projects which will be considered. Table 1 shows the set of VECs which will be considered). Given your expertise regarding one or more of the target VECs, I am writing to ask for your participation in the study as an expert panellist.

If you agree to participate, you are asked to indicate those "project/VEC combinations" for which you feel capable of commenting on with respect to potential environmental impacts, and to return the enclosed ***Panellist Information Form*** in the enclosed stamped, addressed envelope. Upon receipt of this information, I will forward a structured questionnaire in which you will be asked to rate the potential impact of those projects and VECs indicated on the basis of a set of specified criteria.

Once completed, the responses of the panel as a whole will be compiled, and a second round questionnaire will be formulated and distributed to you. In this round, you will be provided with a statistical summary of the group response, and in light of this, given the opportunity to reevaluate your response. You will be asked to once again return the completed questionnaire. The purpose of this procedure is to attempt to reach a consensus by panellists on the significance of potential impacts.

The procedure will require very little of your time. Please be assured that **the identity of all panellists, and their responses will, at all times, be kept in the strictest of confidence,** and only the group response will be presented in my thesis. Your cooperation and participation in this exercise would be very much appreciated. Indeed, your expertise is essential to the successful completion of this study.

I would appreciate it if you would complete and return the attached materials within one week of receiving them. **(PLEASE RETURN ALL MATERIALS EVEN IF YOU DO NOT AGREE TO PARTICIPATE IN THE STUDY)**. If you have any questions or comments concerning the study, please feel free to contact me, or my supervisor, Dr. Keith Storey. Thank you in advance for your cooperation, and I look forward to hearing from you soon.

Sincerely Yours;

Steve Bonnell
M.A. Candidate
Department of Geography
Memorial University of Newfoundland
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Fax. (709) 737-3119
Email. *sjb@europa.cs.mun.ca*

Dr. Keith Storey
Tel (709) 737-8987
Email. *kstorey@morgan.ucs.mun.ca*

SMALL HYDRO CUMULATIVE EFFECTS STUDY

Panellist Information Form

Name:

Affiliation:

Address:

Telephone:

Fax:

Email:

Please indicate below whether you would be willing to participate in this study as an expert panellist:

____ **YES** *I would be interested in participating in this study.*

____ **NO** *I am unable/unwilling to participate in this study.*

Please take a moment now to indicate any other individuals who, in your opinion, may be qualified to participate in this study.

NAME	**AFFILIATION**	**ADDRESS TELEPHONE # / EMAIL**

• **If you have agreed to participate in the study, thank you for your cooperation, and please continue.**

• **If you are unable or unwilling to participate, thank you for your time. Please return this form in the enclosed envelope.**

Thank you for agreeing to take part in this study! Please refer to Table 1. Each cell of the matrix corresponds to a particular VEC, for a specific small hydro project. To participate in this study it is not essential that you be familiar with all or any of the proposed projects, but rather that if provided with project summaries, your knowledge of particular VECs in that area would allow you to comment on potential environmental impacts.

- **For those VECs for which you have expertise:**

  - *Please mark an* **X** *in those cells corresponding to projects with which you are familiar and feel able to comment on regarding potential impacts.*

  - *Figure 1 shows the locations of each of the 12 projects. Of the projects with which you are unfamiliar, please mark an* **O** *in those cells for which you have a knowledge of the VEC in the area and thus, would be capable of commenting upon impacts if provided with project summaries.*

  - *Please mark* **N/A** *in those cells where you feel that the VEC is not present in the project area.*

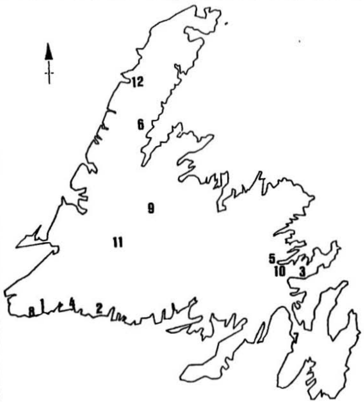
For example, if your area of expertise is caribou in Newfoundland, and you are familiar with the Garia Bay project, please place an **X** in the cell located at column 1, row 7. Also, if you are unfamiliar with the Lady Pond project, but have some knowledge of caribou in the project area, please place an **O** in the cell located at column 3, row 7. Finally, if you feel that caribou are not present in the Northwest River project area, please mark **N/A** at column 5, row 7. Please fill in any cells which correspond to project/VEC combinations which you feel capable of commenting on with respect to potential impacts.

Thank you for agreeing to participate in this study. Please return the completed form in the enclosed envelope within one week.

Sincerely Yours;

Steve Bonnell

FIGURE 1: PROPOSED SMALL HYDRO DEVELOPMENTS



1) *Garia Bay/Northwest Brook* (15 MW)
2) *Kings Harbour River* (15 MW)
3) *Lady Pond* (0.3 MW)
4) *Northwest Arm Brook/Connoire Bay* (15 MW)
5) *Northwest River* (12 MW)
6) *Rattle Brook* (4 MW)
7) *Rattling Pond Brook* (0.5 MW)
8) *Rose Blanche Brook* (5.5 MW)
9) *Sheffield Lake* (5 MW)
10) *Southwest River* (7 MW)
11) *Star Lake* (15 MW)
12) *Torrent River* (15 MW)

TABLE 1

VEC	GB	KHR	LP	NWAB	NWR	RB	RPB	RBB	SHL	SWR	SL	TR
Water Resources												
Vegetation and Soils												
Riparian Flora												
Rare or Threatened Flora												
Fish Resources												
Raptors												
Waterfowl												
Migratory Birds												
Caribou												
Moose												
Black Bear												
Furbearers												
Small Mammals												
Rare or Threatened Fauna												
Timber Harvesting												
Commercial Fisheries												
Angling												
Hunting/Trapping												
Tourism												
Aesthetics												
Historic Resources												

Appendix B

SAMPLE ROUND ONE QUESTIONNAIRE PACKAGE

Dear -------;

Thank you for agreeing to participate in my ***Small Hydro Cumulative Environmental Effects Study*** as an expert panellist. Your cooperation will help to ensure the success of this research.

As indicated in my earlier correspondence, you are asked to rate the potential environmental impacts of those small hydro project/Valued Environmental Component (VEC) combinations for which you have indicated an ability to do so. Please find enclosed the following documents:

- **Document A:** *Brief project summaries for selected small hydro project(s).*
- **Document B:** *Criteria upon which you are asked to rate potential impacts.*
- **Document C:** *The questionnaire, containing a question sheet for each of those project/VEC combinations which you identified previously.*

Please note that most of the enclosed material is simply background information on project(s) identified and impact evaluation criteria to aid you in commenting upon potential impacts; the questionnaire itself (Document C) is quite short, and will require little time to complete. Please note also that the number of projects and VECs being considered have been reduced; eight projects (See Document A) and eight VECs (See Document C) remain under consideration. Thus, the number of project/VEC combinations which you are asked to comment upon may be considerably less than that which you initially identified.

Panellists are reminded that it is the objective of this study to gather the individual responses of a group of experts on the potential impacts of these projects. Accordingly, I would ask that your responses be your own, and that you do not discuss your responses with anyone. Also, the projects being considered are at various stages of the environmental assessment process; thus, to keep "*all things equal*", please give your impact ratings without regard to proposed or possible impact mitigation measures.

Again, please be assured that **the identity of all panellists and their individual responses will, at all times, be kept in the strictest of confidence.** Please retain Documents A and B for future reference. Please return the completed questionnaire (Document C) in the enclosed envelope at your earliest convenience.

If you have any questions or comments concerning the study, please feel free to contact me. Thank you for your cooperation and for your interest in my study, and I look forward to hearing from you soon.

Sincerely Yours;

Steve Bonnell
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DOCUMENT A: Small Hydro Project Summaries

Please find enclosed brief project summaries and maps for project(s) which you have indicated an ability to comment on. The following are terms used in relation to small hydro project components:

- **Dam:** *A structure built across a river to create an impoundment area for storing water.*

- **Diversion Weir:** *A weir created for diverting flow from the water course into a power conduit or canal.*

- **Headpond/Reservoir:** *An artificial lake into which water flows and is stored for future use.*

- **Intake Structure:** *A device used to convey flows from the natural channel to the penstock/power canal.*

- **Interconnection:** *The means by which power generated by the facility is connected to the utility grid system.*

- **Penstock:** *A pipeline conveying water from the water intake to the powerhouse turbines.*

- **Power Canal:** *An open canal which carries water to the powerhouse.*

- **Powerhouse:** *A structure housing the generating units and the pertaining installations.*

- **Run-of-river plant:** *A development with little or no pondage regulation, such that the power output varies with the fluctuations in stream flow.*

- **Spillway:** *A structure designed to pass flows larger than can be used for hydroelectric generation.*

- **Tailrace:** *A canal which carries water from the powerhouse back to the watercourse.*

SMALL HYDRO PROJECTS UNDER CONSIDERATION

1) Garia Bay (NW Brook)
2) NW Arm Brook (Connoire Bay)
3) NW River
4) Rattle Brook
5) Rose Blanche Brook
6) SW River
7) Star Lake
8) Torrent River

GARIA BAY/NORTHWEST BROOK (15 MW)

• **LOCATION:** South coast of Newfoundland; on the Northwest Brook - Garia Bay, approximately 13 km northeast of Rose Blanche.

• **PHYSICAL FEATURES.**

○ **Access:** Access for both construction and operation of the development would be via water from Rose Blanche to a wharf to be located near the head of Garia Bay. A 10 km long site road would extend from the wharf to access the powerhouse, construction camp and the headpond area, with a bridge spanning Northwest Brook downstream from the powerhouse.

○ **Dam:** Northwest Brook would be dammed by a roller compacted concrete structure, to be located approximately 3 km upstream from Garia Bay. The proposed dam/spillway would be approximately 500 m in length (dam: 400 m, spillway: 100 m) with a maximum height of approximately 30 m. The uncontrolled overflow spillway would discharge excess river flows directly into the existing riverbed.

○ **Headpond:** The proposed dam/spillway would form a headpond extending about 1.5 km upstream and providing approximately 14.7 million m^3 of water storage. The headpond would have a surface area of 18 ha at low supply level and 115 ha at full supply level.

○ **Intake Structure & Power Tunnel:** Water for power generation would be drawn from the headpond through a concrete intake structure extending to the power tunnel's vertical shaft through a buried 3.8 m diameter steel pipe. This pipe would also be used as a temporary river diversion during construction of the dam/spillway. The intake structure would be incorporated within the dam/spillway structure, and would be equipped with an inclined trashrack, fishscreen, bulkhead and service gates. A 2430 m long power tunnel (3 m wide by 3 m high) would extend along the east side of the valley, from the powerhouse to a 3.35 m diameter vertical shaft raising 140 m up to the intake structure.

○ **Powerhouse:** A concrete powerhouse structure (approximately 20 m long by 10 m wide and 15 m high) would be situated on the left bank of the river, approximately 700 m upstream from Garia Bay. It would incorporate one 14 MW turbine-generator unit and one 1 MW unit. A fenced substation would be located on the roof of the powerhouse to convert the generated voltage to 66 kV.

○ **Interconnection:** Power from the development would be delivered to the existing Long Lake Terminal Station via a 32 km long, double wood pole transmission line.

• **CONSTRUCTION & OPERATION:** Construction of the plant would be staged over three construction seasons. A construction camp to accommodate up to 50-75 persons would be erected near the shore of Garia Bay. Concrete aggregates required to construct the dam/spillway would be derived from a quarry to be located within the proposed headpond area. The facility would operate as a run-of-river plant during periods of low flow, with limited regulation of discharge. Energy production would be curtailed once the headpond reaches the low supply level (about 4 m below the full supply level), until the pond has recharged sufficiently.

SOURCES: Genergy Inc. (1991). **Registration Pursuant to Section 6 of the *Environmental Assessment Act* for the Proposed Garia Bay Power Development in the District of La Poile, Newfoundland.** Revised December 2, 1991.; Genergy Inc. (1996). **Garia Bay Power Development: Updated Project Description (July 19, 1996).**

GARIA BAY (NW BROOK) - PROJECT LAYOUT

DOCUMENT B: Criteria for the Evaluation of Impacts

- **For each project/VEC combination, you are asked to rate the potential impact on the basis of the following evaluation criteria:**

Impact Probability: **An estimate of the probability (in percent) that the VEC in question will be affected by the proposed small hydro development.**

Impact Magnitude: An estimate of the degree of impact.		
Score	**Magnitude**	**Definition**
1	**Negligible**	A change to the VEC that is indistinguishable from natural variation.
2	**Minor**	A reversible change to the VEC's normal or baseline condition, usually restricted to a particular facet of the environment. The fundamental integrity of the VEC is not threatened.
3	**Moderate**	A reversible change to the VEC's normal or baseline condition, with a medium probability of second order effects on other environmental components. The fundamental integrity of the VEC(s) is not threatened.
4	**Major**	An irreversible change to the VEC's normal or baseline condition, with a high probability of second order effects on other environmental components. The fundamental integrity of the affected VEC(s) is threatened.

Spatial Extent: An estimate of the geographical extent to which the VEC will be affected.

Score	Extent	Definition
1	**Site**	Effect will be confined to the project development area.
2	**Local**	Effect will be confined to the project area and immediate environment.
3	**Regional**	Effect will occur within and beyond the development area and immediate environment, affecting a defined territory surrounding the proposed development.
4	**Provincial**	Effect will occur across the province.

Temporal Duration: An estimate of the time period for which the VEC will be affected.

Score	Duration	Definition
1	**Short-term**	Effect may persist less than two years from the onset of disturbance.
2	**Medium-term**	Effect may persist from two to less than five years from the onset of disturbance.
3	**Long-term**	Effect may persist from five to less than ten years from the onset of disturbance.
4	**Prolonged**	Effect may persist ten years or more from the onset of disturbance.

VEC Importance: The relative importance of the VEC (considering both its *direct* and *indirect* importance):

i) Its importance compared with other VECs in the same project area;

ii) Its importance compared with the same VEC in other project areas.

Current State of VEC: The natural condition of the VEC, or its condition due to the impacts of other past or present human activities.

Score	VEC State	Definition
1	Resilient	VEC is quite resilient to impact, due to its natural condition and/or the lack of other adjacent human activities.
2	Low Sensitivity	VEC has a low susceptibility to impact, due to its natural condition and/or the impacts of other adjacent human activities.
3	Medium Sensitivity	VEC is moderately susceptible to impact, due to its natural condition and/or the impacts of other adjacent human activities.
4	High Sensitivity	VEC is highly susceptible to impact, due to its natural condition and/or the impacts of other adjacent human activities.

Rationale/Comments: For each rating (or series of ratings), you are invited to give a brief summary of the rationale for your response(s).

DOCUMENT C: Questionnaire

Panellist's Name and Affiliation

Please find enclosed question sheets for each of those project/VEC combinations which you indicated an ability to comment upon with regard to potential environmental impacts. For each question sheet, please circle the number which corresponds to your best estimate for each of the impact evaluation criteria.

A project may affect a VEC to varying degrees over space (eg. an impact may be *major* in one part of the affected area, but only *minor* in another), over time (eg. an impact may be *moderate* in the project construction period, but *negligible* in the operation period), and/or, where applicable, within a *VEC category* (eg. one species of raptors may be more severely affected than another). Please assign impact ratings which reflect the maximum level of impact likely.

If, in your opinion, the VEC in question is not present in the project area and thus, will not be affected, please circle 0% under '*Impact Probability*' and disregard the remaining questions on that sheet.

Please complete and return only this document.

VECs UNDER CONSIDERATION

The following eight VECs potentially affected by small hydro developments in Newfoundland are being considered in this study:

- ***Water Resources***
- ***Fish Resources***
- ***Raptors***
- ***Waterfowl/Migratory Birds***
- ***Caribou***
- ***Moose***
- ***Furbearers/Small Mammals***
- ***Historic Resources***

Garia Bay/Northwest Brook - Water Resources

Criteria	Score										
Impact Probability	%										
	0	10	20	30	40	50	60	70	80	90	100

Criteria	Score				
Impact Magnitude	Negligible 1	Minor 2	Moderate 3	4	Major
Spatial Extent	Site - Specific 1	Local 2	Regional 3	4	Provincial
Temporal Duration	Short - Term 1	Medium - Term 2	Long - Term 3	4	Prolonged

Rationale/Comments:

Criteria	Score				
VEC Importance (Compared with other VECs)	Not at all Important 1	2	Somewhat Important 3	4	Very Important 5
VEC Importance (Compared with other project areas)	Not at all Important 1	2	Somewhat Important 3	4	Very Important 5

Rationale/Comments:

Criteria	Score			
Current State of VEC	Resilient 1	Low Sensitivity 2	Medium Sensitivity 3	High Sensitivity 4

Rationale/Comments:

Thank you for participating in Round 1 of this study. The following will allow me to learn more about the prior knowledge of expert panellists regarding the small hydro projects under consideration. Again, please be assured that **the identity of all panellists and their individual responses will, at all times, be held in the strictest of confidence.**

1) Please indicate your level of knowledge of each of those projects you have commented upon prior to receiving this questionnaire (circle only one response for each):

A: *Actively involved in Environmental Assessment of project*
B: *Familiar with project*
C: *Unfamiliar with project*

Garia Bay/NW Brook	**A**	**B**	**C**	**Rose Blanche Brook**	**A**	**B**	**C**
NW Arm Brook/ Connoire Bay	**A**	**B**	**C**	**Southwest River**	**A**	**B**	**C**
Northwest River	**A**	**B**	**C**	**Star Lake**	**A**	**B**	**C**
Rattle Brook	**A**	**B**	**C**	**Torrent River**	**A**	**B**	**C**

2) Any additional comments which you may have are welcome:

Again, thank you for your cooperation. I will forward a summary of the results to you (in which you will be given the opportunity to reevaluate your responses in light of the group responses) once all Round 1 questionnaires have been received.

Appendix C

SAMPLE ROUND TWO QUESTIONNAIRE PACKAGE

Dear -------;

Thank you for your participation in Round 1 of my ***Small Hydro Cumulative Environmental Effects Study***. Panellist response thus far has been exceptional, and the results are most encouraging. Your continued participation would be very much appreciated, and indeed, is essential to the successful completion of this study.

Please find enclosed your Round 2 questionnaire. In this round you are invited to reevaluate your Round 1 responses in light of the comments/rationales given by other expert panellists in relation to their responses. I have also included a brief set of assumptions and further instructions which I would also like you to consider when formulating your Round 2 impact ratings.

Please note, this round will require much less of your time to complete than did the original questionnaire. Again, please be assured that **the identity of all panellists and their individual responses will, at all times, be held in the strictest of confidence**. If you have any questions or comments concerning the study, please feel free to contact me. Please complete and return the Round 2 questionnaire in the enclosed envelope at your earliest convenience (preferably within one week of receiving it).

In anticipation of your continued participation, thank you. I look forward to hearing from you soon.

Sincerely Yours;

Steve Bonnell
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Tel. (709) 737-8998/7417
Fax. (709) 737-3119
Email. *sjb@europa.cs.mun.ca*

ASSUMPTIONS & INSTRUCTIONS FOR ROUND 2

In formulating your Round 2 ratings, you are asked to consider the following:

• **Impact Mitigation:** In Round 1 you were asked to disregard any proposed or possible impact mitigation measures. It is assumed, however, that the proponent will adhere to any applicable laws or regulations; therefore, impact ratings should be based upon this assumption. Where impact mitigation is **not** incorporated into the initial project design, or falls outside of existing regulations, you are asked to **disregard** such measures in rating potential impacts.

• **Temporal Duration:** This refers, not to the number of years over which the disturbance itself will occur, but the time it will take for the VEC, once affected, to return to its "pre-project" state.

• **VEC Importance:** Panellists are reminded that *VEC Importance* should be rated on the basis of both *direct* and *indirect importance*.

• **Current State of the VEC:** This refers to the *Pre-project state* of the VEC, which in part determines its vulnerability to increased stress. For example, a VEC which is in a naturally healthy state and is located in a pristine environment may be somewhat *resilient* to the effects of a small hydro project. Conversely, a VEC which is already in a naturally unhealthy state and/or is being affected by other human activities may be particularly vulnerable to further stress, and thus in a *sensitive state*.

• As noted in Round 1, a project may affect a VEC to varying degrees over space (eg. an impact may be major in one part of the affected area but minor in another), over time (eg. an impact may be moderate in the construction period but negligible during project operation), and/or, where applicable, within a *VEC category* (eg. one species of raptors may be more severely affected that another). Panellists are reminded that impact ratings should reflect the maximum level of impact likely.

• Finally, those panellists commenting upon potential effects on ***Water Resources*** should note that both **water quantity** and **quality** should be considered.

ROUND 2 QUESTIONNAIRE

Panellist's Name and Affiliation

Please find enclosed your Round 2 questionnaire.

- **Column 2** gives your Round 1 responses;

- **Column 3** gives a brief summary of *comments/rationales* given by panellists in relation to their impact ratings (where such comments were provided). These are intended only to give you an indication of the factors being considered by other experts in evaluating potential impacts; you <u>may</u> choose to consider them in formulating your Round 2 responses. It is recognized that:

  ○ The comments may not be a comprehensive list of all factors which should be considered in rating potential impacts;

  ○ Where several comments are given, they may in fact conflict;

  ○ You may agree or disagree with some or all of the comments given. If you question (or are unsure of) the validity and/or applicability of a particular comment, please disregard it when formulating your Round 2 response. (Please feel free to comment further on any of the *comments/rationales* provided).

- Please formulate your Round 2 response based upon the assumptions and further instructions given earlier, and the comments given in column 3. Record your Round 2 response in column 4 **<u>even if unchanged from Round 1.</u>**

Please complete and return <u>only</u> this document.

VECs UNDER CONSIDERATION

The following eight VECs are being considered in this study:

- ***Water Resources***
- ***Fish Resources***
- ***Raptors***
- ***Waterfowl/Migratory Birds***
- ***Caribou***
- ***Moose***
- ***Furbearers/Small Mammals***
- ***Historic Resources***

Garia Bay/Northwest Brook - Water Resources

Evaluation Criteria	Your Round 1 Response	Rationales/Comments given in Round 1	Your Round 2 Response (Even if Unchanged)
Impact Probability	%		% 0 10 20 30 40 50 60 70 80 90 100
Impact Magnitude			Negligible 1 · Minor 2 · Moderate 3 · Major 4
Spatial Extent			Site-specific 1 · Local 2 · Regional 3 · Provincial 4
Temporal Duration			Short-Term 1 · Medium-Term 2 · Long-Term 3 · Prolonged 4
VEC Importance (Compared with other VECs)			Not at all Important 1 · 2 · Somewhat Important 3 · 4 · Very Important 5
VEC Importance (Compared with other project areas)			Not at all Important 1 · 2 · Somewhat Important 3 · 4 · Very Important 5
Current State of VEC			Resilient 1 · Low Sensitiv. 2 · Medium Sensitiv. 3 · High Sensitiv. 4

Appendix D

SAMPLE ROUND THREE QUESTIONNAIRE PACKAGE

Dear -------;

Thank you for your participation in Rounds 1 and 2 of my ***Small Hydro Cumulative Environmental Effects Study***. Your participation in this, the third round of the study, would be very much appreciated, and indeed, is essential to the successful completion of this research.

Please find enclosed your Round 3 questionnaire. In this round you are provided with an indication of how your Round 2 impact ratings compared to the *median* responses of all panellists. Based on this feedback, you are invited to reevaluate your ratings in light of the Round 2 responses of the panel as a whole.

Please note, this round will require less of your time to complete than did the Round 1 and Round 2 questionnaires. Again, please be assured that **the identity of all panellists and their individual responses will, at all times, be held in the strictest of confidence**. If you have any questions or comments regarding the study, please feel free to contact me. Please complete and return the Round 3 questionnaire in the enclosed envelope at your earliest convenience (preferably within one week of receiving it).

In anticipation of your continued participation in my study, thank you. I look forward to hearing from you soon.

Sincerely Yours;

Steve Bonnell
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ROUND 3 QUESTIONNAIRE

Panellist's Name and Affiliation

Please find attached your ***Round 3*** questionnaire. For each question sheet:

- **Column 2** gives the *median* Round 2 response of all panellists for each of the seven impact evaluation criteria;

- **Column 3** shows *your* Round 2 responses;

- Please reconsider (if necessary) your Round 2 response in light of the median group response given in Column 2, and record your Round 3 response in **Column 4** **even if it remains unchanged from Round 2**;

- If your Round 3 response differs from the Round 2 group response, you are invited to give a brief explanation of why you feel the "correct" response should be higher or lower than the Round 2 group response. Comments can be placed in **Column 5**.

Please complete and return only this document.

VECs Under Consideration

The following eight VECs are being considered in this study:

- ***Water Resources***
- ***Fish Resources***
- ***Raptors***
- ***Waterfowl/Migratory Birds***
- ***Caribou***
- ***Moose***
- ***Furbearers/Small Mammals***
- ***Historic Resources***

Garia Bay/Northwest Brook - Water Resources				
Evaluation Criteria	**Median Round 2 Response of all Panellists**	**Your Round 2 Response**	**Your Round 3 Response (Even if Unchanged)**	**Reason(s) Why Group Response is Unacceptable (If Applicable)**
Impact Probability		%	% 0 10 20 30 40 50 60 70 80 90 100	
Impact Magnitude			Negligible 1 Minor 2 Moderate 3 Major 4	
Spatial Extent			Site-specific 1 Local 2 Regional 3 Provincial 4	
Temporal Duration			Short-Term 1 Medium-Term 2 Long-Term 3 Prolonged 4	
VEC Importance (Compared with other VECs)			Not at all Important 1 2 Somewhat Important 3 4 Very Important 5	
VEC Importance (Compared with other project areas)			Not at all Important 1 2 Somewhat Important 3 4 Very Important 5	
Current State of VEC			Resilient 1 Low Sensitiv. 2 Medium Sensitiv. 3 High Sensitiv. 4	