# The Peace-Athabasca Delta: A Description of the Resources and an Evaluation of Management Alternatives

by

© James Y. Sparling

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## ABSTRACT

The Peace-Athabasca Delta is a unique delta environment located in the northeastern corner of Alberta. Largely controlled by Environment Canada-Parks, the fertile Delta is dependent on the natural regime of inflowing rivers to maintain natural conditions. When flows are altered, as in the Peace River when the W.A.C. Bennett Dam was built, vegetation patterns on the Delta begin to change. Remedial weirs have partially restored natural conditions. A number of major projects have been proposed which could cause further changes to flow regimes and water conditions on the Delta. In order to maintain the Delta in as natural a condition as possible, Environment Canada-Parks can pursue physical management or regulatory management approaches. Sites exist where physical control structures could be located to provide improved regulation of water levels. Regulatory management involves the institutional, jurisdictional, and legal aspects of water resource allocation. It is difficult for Environment Canada-Parks to influence events beyond Park boundaries. Overall management of the Delta is coordinated at present by the Peace-Athabasca Delta Implementation Committee. Beyond the Delta, there are no institutional arrangements to coordinate planning. Although river basin planning would provide Environment Canada-Parks with a formal water commitment, negotiation approaches may prove as effective.

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# INTRODUCTION

The Peace-Athabasca Delta is one of the largest freshwater deltas in the world. Operation of the W.A.C. Bennett Dam, upstream on the Peace River, has altered the natural water regime on the Delta. Future developments along the Peace, Athabasca, and Slave rivers could further alter the water regime. Maintaining the Peace-Athabasca Delta in as natural a state as possible requires a thorough understanding of the Delta system and considerable management effort to ensure required water regimes are maintained.

The Peace-Athabasca Delta is located in northeastern Alberta (Figures 1 & 2) at the western end of Lake Athabasca. A major portion (approx. 80%) of the Delta falls within Wood Buffalo National Park, and is administered by Environment Canada-Parks (formerly Parks Canada). The Park Management Plan (Parks Canada, 1984) identifies the Delta as one of the most significant features within the Park. It is the only boreal delta preserved in a


Figure 1: Location of Study Area

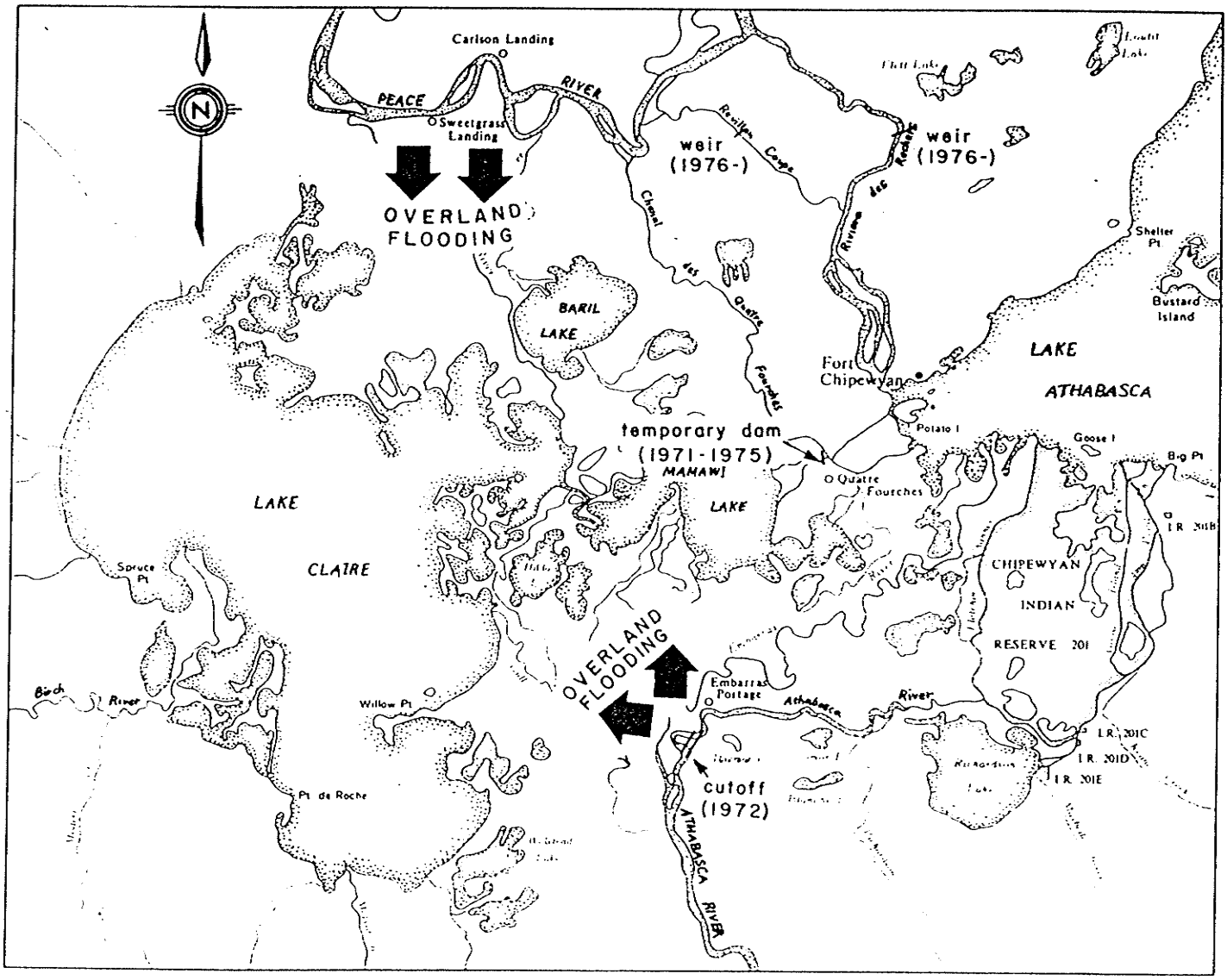


Figure 2: Details of Drainage in the Study Area. (Peace-Athabasca Delta Project 1973).

national park in North America. The international significance of the resources preserved within Wood Buffalo National Park have led to its designation as a World Heritage Site by the International Union for Conservation of Nature and Natural Resources (IUCN).

Active fluvial and deltaic processes in the Delta support a vigorous and diverse ecosystem. The complex hydrologic regime created by the inflowing rivers results in annual and seasonal fluctuations in water levels. The historic water regime is characterized by extensive flooding in late spring when distant mountain snowpack meltwaters enter the Peace and Athabasca rivers. Flooding is followed by rapid drawdown in the Delta and low water levels by late fall. Seasonal fluctuations maintain the largest undisturbed grass and sedge meadows left in North America. These fluctuations renew stands of emergent vegetation, preventing more advanced and less productive successive vegetation stages from dominating. The diverse vegetation provides habitat for bison, waterfowl, muskrat, fish, and many other animals. An ecologically complete balance of all components is present, ultimately controlled by the water regime.

The water regime in the Peace-Athabasca Delta remained unaltered until 1968. In the fall of 1967 the W.A.C. Bennett Dam on the Peace River was completed, and filling of the Williston Reservoir, which lasted four years, began. Severely reduced flows in the Peace River prevented annual

spring flooding from occurring. Resulting low water levels on the Delta raised concern and, in 1971, the governments of Canada, Alberta and Saskatchewan formed the interdisciplinary Peace-Athabasca Delta Project Group to investigate and report on the cause of low water levels in Lake Athabasca and their effects on the Delta. The Project Group was also directed to find an immediate solution to restore water levels. Its 1973 report stated that low water levels were a result of operation of the W.A.C. Bennett Dam, and that they were causing changes in vegetation within the Delta (Peace-Athabasca Delta Project Group 1973). A number of management alternatives were suggested to restore historic hydrologic conditions within the Delta. After further study, the Peace-Athabasca Delta Implementation Committee constructed rockfill weirs in 1976 on the Riviere des Rochers and the Revillon Coupe.

The weirs have not proven to be entirely effective in restoring water conditions within the Delta (Townsend, 1982a). Although annual average water levels are similar to the long term values, seasonal fluctuations have not been recreated. Water levels remain fairly constant throughout the year. Spring flooding is restricted, preventing recharge all of the Delta, particularly perched basins. Summer water levels are similar to long term averages. Fall and winter water levels remain high. The reduced amplitude in seasonal extremes is allowing vegetation succession to

proceed from sedge and grass meadows towards willow and ultimately spruce bog (Cordes and Pearce, 1978).

Environment Canada-Parks administers 80% of the Peace-Athabasca Delta. Chipewyan Indian Reserve No. 201 and the Province of Alberta control the rest. Overall management of the Delta requires cooperation among these three proprietors. To ensure the quantity and timing of water supply needed to maintain the Delta is available in the future, agreement with other water users along the Peace, Athabasca, and Slave rivers is required. Therefore, it is necessary for Environment Canada-Parks to define specific management objectives for the portion of the Delta they control, and to seek long term agreement with other Delta managers, as well as upstream and downstream water users.

## 1.1 STATEMENT OF PROBLEM

Environment Canada-Parks policy (Parks Canada 1979) directs management of national parks towards preservation of representative natural areas. This is difficult to achieve in the Peace-Athabasca Delta because important hydrologic inputs are controlled outside Wood Buffalo National Park. The problem is that if the water regime is not similar to historic conditions, ecological conditions will change. Environment Canada-Parks must meet clearly stated policy directives and protect natural processes within the Peace-Athabasca Delta. The Wood Buffalo National Park Management

Plan (Parks Canada 1984) states that "the highest degree of protection and consideration" (p.48) possible will be provided. Achieving this requires the cooperation of other users of shared riparian resources. Some of these users, over whom Environment Canada-Parks has little control, are proposing future developments, such as a hydroelectric development on the Slave River, or diversion of water from the Peace River to southern Alberta.

## 1.2 RESEARCH OBJECTIVES

This study provides a description of resources and an evaluation of management alternatives within the Peace-Athabasca Delta. Specific objectives are:

1. to

   define natural processes within the Peace-Athabasca Delta and describe the interrelationships among the various components of this complex ecosystem, including natural fluctuations.

2. to

   identify objectives of other user groups and determine the degree of conflict of their objectives with those of Environment Canada-Parks.

3. to

define alternative physical management scenarios which have been developed to return the Delta to pre-Bennett Dam conditions.

4. to

evaluate alternative scenarios for Delta management in relation to their predicted outcomes and assess strategies which could lead to conflict resolution.

## 1.3 METHODS

Evaluation of the management alternatives for the Peace-Athabasca Delta required a multi-disciplinary approach. Biological, geomorphological, hydrological, and ecological conditions in the Delta must be understood to determine the possible effect often distant actions can have on the Delta. These actions include human activities ranging from traditional hunting and trapping to modern energy production. Preserving the Delta in as natural a state as possible involves consideration of both physical and regulatory strategies. These strategies were critically evaluated to determine their merit as management alternatives.

The description of the Delta was derived from numerous sources. Much of the background information came from the Peace-Athabasca Delta Project Group (1973). This information was supplemented by more recent reports by

Environment Canada-Parks (Fransden 1983; Thorpe 1986), Canadian Wildlife Service (Carbyn and Anions In prep.; Poll 1980),Inland Waters Directorate (1984), and Alberta Environment (DeBoer and Card 1981). A theoretical background to interpret underlying processes and trends was developed (Holling 1973; Sousa 1984 ; Wright 1978). Field reconnaissance and discussions in the Delta conducted between August 20-31, 1984 provided a first hand appreciation of conditions on the Delta.

Determining the variety of resource use pressures placed on the Delta, and the potential for conflict required a variety of sources. Park literature, such as the Wood Buffalo National Park Management Plan (Parks Canada 1984; see also 1979) provided Park objectives. The objectives of other users were determined from government documents (E.R.C.B. 1981), scientific journals (Primus 1981), published project plans (Anon. 1982), environmental impact assessments (Stanley Associates Engineering Ltd. 1982), and others (Anon. 1985).

Physical management alternatives were discussed by the Peace-Athabasca Delta Project Group (1973). A number of reports published since construction evaluate the performance of the weirs (Deboer and Card 1981; Townsend 1982a), which, along with the improved hydrologic modelling (Peace-Athabasca Delta Implementation Committee 1985) allowed a more critical evaluation of both the existing weirs and the other alternatives.

Through a review of the literature a number of alternative approaches to conflict resolution were examined (Dorcey 1983; Gusman and Huser 1984; Pearse et al. 1985) and adapted to the situation under consideration.

# Chapter II

# NATURAL PROCESSES WITHIN THE DELTA

The Peace-Athabasca Delta began forming about 10,000 years ago at the end of the last ice-age. Fluvial sediments deposited where the Peace and Athabasca rivers debouched into Lake Athabasca formed the delta complex. The resulting fertile and productive wetland system supports a diverse community of plants and animals. This chapter describes the major physical and biological systems active in the Delta and the interactions among them.

## 2.1 WATER REGIME

The Peace-Athabasca Delta is located along the edge of the Precambrian Shield which outcrops into the northeastern part of the Delta near Fort Chipewyan. Other than these outcrops the Delta is covered with thick deposits of fluvial sediments. The sediments are very flat with the land lying no more than 30-60 cm above the major lakes. Natural raised levees along active and abandoned river channels provide limited relief (Bayrock and Root 1972).

The deltas formed by the Peace and Athabasca rivers were described by Bayrock and Root (1972) as typical bird's foot deltas. Much of the west end of Lake Athabasca is now filled by deltaic sediments. Lake Claire, Mamawi Lake, and

smaller lakes formed between the individual deltas. Numerous small oxbow lakes also formed along the Peace and Athabasca rivers. Many small lakes have no inlet or outlet; these 'perched basins' depend on overland flooding for recharge.

Water levels on the Peace-Athabasca Delta historically showed seasonal fluctuations (average annual range was 1.7 meters) with high water in summer and low water in winter (Peace-Athabasca Delta Project Group 1973). In late spring, inflowing rivers would reach flood stage and flood the Delta. Although the Peace River bypasses the Delta, flowing directly into the Slave River, it played a major role in controlling Delta water levels. At flood stage, flows in the Peace and Slave rivers created a hydrologic dam preventing outflow from Lake Athabasca. In some years, this effect caused reverse flows in Lake Athabasca outlets, and Peace River water flowed into Lake Athabasca and the Delta. Overland flooding from the Peace River into Lake Claire, Baril Lake, and adjacent perched basins occurred when the Peace River reached flood stage (Fig.2). Floods on the Athabasca River caused overland flooding in the southern part of the Delta. In years when timing of floods on both the Peace and Athabasca rivers coincided, extensive flooding of the Delta occurred.

The Fond du Lac River drains into the eastern end of Lake Athabasca (Fig.1). Flows in this river are relatively

constant because it arises from small lakes in the Precambrian Shield which retain spring floodwaters, releasing water slowly during the year.

The Birch River is a small river which drains into Lake Claire from the Birch Mountains south of the Delta. This river frequently flooded, building a small delta in the south end of Lake Claire where it debouches (Fig.2).

Following floods in late spring, water recedes until, by fall, openly drained basins reach low water levels which are influenced by Lake Athabasca levels. Perched basins do not drain so water levels remain high and are reduced by evaporation. Many of these basins are recharged only in very high water years so they undergo a flooding and drying regime on a long term basis, measured in years.

## 2.2 BIOLOGICAL RESOURCES

Fluctuations in water levels play a major role in controlling vegetation on the Peace-Athabasca Delta. Dirschl et al. (1974) found that short term fluctuations in water levels maintained vegetation. Aquatic emergent vegetation begins to thin out after growing for a few years in standing water. Thick, productive stands are reestablished from seeds, which require mudflats exposed to open air for germination. Moisture gradients caused mainly by seasonal flooding affected species distribution on low

lying meadows. Longer term vegetation successional trends were first outlined by Raup (1935) who studied vegetation on newly forming, active delta areas progressing towards old, inactive delta areas. Aquatic vegetation communities grade to exposed mudflats, to meadows, to willow shrubs and finally to a climax forest of spruce. This progression is restrained by short and long term fluctuations in water level.

The Peace-Athabasca Delta Project Group (1973) found 215 species of birds, 44 species of mammals, and 18 species of fish inhabiting the Delta area. Presence and number of these species is dependent on availability of habitat, especially vegetation, thus, they are ultimately dependent on water regimes.

Muskrats in the Delta were studied by Poll (1980) who found that water level played a key role in maintaining their habitat requirements. Water must be of sufficient depth that the water body does not freeze to the bottom in winter, which can lead to high mortality among muskrats. Poll also found that muskrats could adapt their feeding habits when water conditions induced changes in food species availability, but that fluctuations are needed to maintain preferred food species. The highest muskrat numbers are found in perched basins; flooding of these areas is crucial to maintain muskrat habitat. Poll concluded that a three to five year cycle of flooding and drawdown provides optimal

water levels and food availability for muskrats. Frandsen (1983) suggested that while water levels play an important role in controlling muskrat populations, there are other factors (including trapping, predation, and intrinsic population regulating factors) which also control population levels. Frandsen suggested that water levels alone do not determine muskrat numbers but rather establish a range within which the population can fluctuate.

Carbyn and Anions (In prep.) reviewed the status of bison in Wood Buffalo National Park. Up to 75% of park bison use the Delta as winter habitat. Delta land is also important to a lesser degree as summer habitat and for spring calving. Bison graze on low lying sedge meadows surrounding open delta areas and perched basins. Optimum habitat conditions for bison occur with annual flooding of meadows surrounding open delta areas, and slightly higher floods every three years to recharge perched basins (Carbyn and Anions In prep.). Also important for bison is a decrease in water levels by fall. During winters when low lying sedge meadows remain flooded, otherwise available bison food remains trapped under ice. Extreme flooding can cause significant bison mortality through drowning.

Hennan and Ambrock (1977) found a definite relationship between waterfowl utilization and water levels. Perched basins are important breeding grounds, and open Delta waters are used for spring and fall staging. Perched basins

require flooding every three to five years to provide optimum habitat for breeding pairs. Floods in late spring can destroy unhatched eggs, reducing productivity. Optimum conditions for fall staging occur when receding water levels expose mudflats.

The Peace-Athabasca Delta is important to the continental migratory waterfowl populations of North America. Thousands of ducks, geese, swans, shorebirds, and other waterfowl congregate in the Delta each spring and fall during their migrations. All four North American flyways converge on the Delta. Many waterfowl nest on the Delta, mainly on the sheltered perched basins. In years of low water levels in other areas, the Delta serves as alternate habitat for ducks. Waterfowl use of the Peace-Athabasca Delta is influenced by continental habitat and population conditions as well as local water levels.

Although the Peace-Athabasca Delta does not support a local, overwintering fish population due to anoxic conditions in shallow lakes during winter, it is important for spawning and rearing. Donald and Kooyman (1977) found that adult goldeye migrate from the Peace and Athabasca rivers into the Delta to spawn in spring. Young of the year goldeye hatch and feed in large Delta lakes during summer and return to the rivers in fall. Kristensen and Summers (1978) found that walleye spawn in the Delta, especially in Richardson Lake. Low water levels do not appear to affect

spawning, but high discharge associated with high water levels can inhibit upstream migration.

Many other animals, such as beaver, mink, wolves, bears, moose, bald eagles, and invertebrates inhabit the Delta area, but have not received extensive study.

## 2.3 INDIVIDUAL DELTAS

Over time the Peace, Athabasca, and Birch river deltas have commingled to form the present system. Physical evolution of the overall system is a result of ongoing processes of the individual deltas and the interactions between them. Although each delta is unique because of the specific characteristics of their respective headwaters, the general principles guiding their development are identical.

Actively growing deltas are very dynamic. They form when a higher energy stream enters a lower energy body of water (lake), and the stream's sediment load is deposited. All deltas in the world, whether freshwater or marine, are formed according to the same general principles but vary considerably according to the relative intensity of various formative processes (Wright 1978). In order for a delta to form, a river carrying appreciable amounts of sediment is required. Formation is controlled by drainage basin climate, geology, relief, and catchment area. Waves, currents, and tides can mold sediments at the point of deposition.

Depending on climate, biological and chemical factors can also play a role in delta formation.

Classically, deltas are described as being composed of bottom-, fore-, and top-set beds. Bottom-set beds extend farthest from the river mouth and contain fine clay sediments which settle out last. These are covered by fore-set beds composed of the coarser suspended sediments. Top-set beds are composed of the coarsest sediments such as sands and gravels carried as bed load by the contributing stream. As the growing delta extends into the receiving waters it builds subaerial and subaqueous levees, forming a delta lobe which defines a channel (Wright 1978). Eventually, the channel may become overextended and hydraulically inefficient, causing the channel to switch to a new position. The new channel then constructs a new lobe. Deltas consist of active zones where deposition is occurring, and abandoned zones on the upper deltaic plain. In abandoned zones, subsidence of poorly compacted fine sediments is common.

The deltas of the Peace-Athabasca Delta, formed by the Peace, Athabasca, and Birch rivers were all formed by these processes. Climatic and geologic factors for these rivers are similar. The water regime is that of maximum flow in late spring due to snowmelt, followed by minimum flow in winter. Delta building is concentrated during spring and summer when flooding rivers carry maximum sediment load.

Overland flooding not only recharges water levels, it also maintains the chemical balance of the Delta by flushing out accumulated salts and the products of plant decomposition.

### 2.3.1 Peace Delta

The Peace River drains an area of 295,000 $km^2$ and formed a now abandoned delta of 1680 $km^2$ in area. The Peace River flows directly into the Slave River, and has done so at least since Europeans first reached the region. Bayrock and Root (1972) considered the abandoned Peace Delta to be semi-active because floodwaters from the Peace River overtopped the bank at Sweetgrass Landing every three to five years. Regulated Peace River flows do not reach the level required for overland flooding except when ice-jaming occurs downstream from Sweetgrass Landing during spring runoff. Ice-jamming alone never caused overland flooding as frequently as floodwaters did prior to operation of the W.A.C. Bennett Dam. Thus, floodwaters and sediments do not presently reach the abandoned Peace Delta as frequently as in the past. The numerous perched basins in this area depend on Peace River floodwaters for recharge, otherwise they dry up and vegetation succession proceeds. Compaction of sediments is causing subsidence of the abandoned Peace Delta.

### 2.3.2 Athabasca Delta

The Athabasca River drains an area of 155,000 km², creating a delta of 1970 km² in area. Unlike the Peace Delta the Athabasca Delta is actively growing at a rate of 0.8 km² per year (Neill, Evans, and Lipsett 1981). Bayrock and Root (1972) calculated that the average growth-rate of this delta over the last 10,000 years had been 0.2 km² per year. Neill, Evans, and Lipsett (1981) found that over 90% of the annual sediment inflow occurs during the summer, with about 50% occurring in one month (usually June, July or August) and that roughly 10% of the annual load can occur in one day.

Bayrock and Root (1972) reported that the Athabasca Delta was overextended and that lobe migration would occur in the near future, likely towards Lake Claire or Mamawi Lake. Since the Athabasca River is used by barge traffic, a diversion channel was constructed in 1972 to prevent the Athabasca River from joining the Embarras River (Figure 3). This action may have postponed lobe migration but it is unlikely to prevent it. The powerful Athabasca River has altered course numerous times in the past, events which are recorded in the abundant meander scars observed along it.

A new channel began to develop in 1982 when a breakthrough from the Embarras River to Mamawi Creek occurred. A channel at this location carrying high flows as

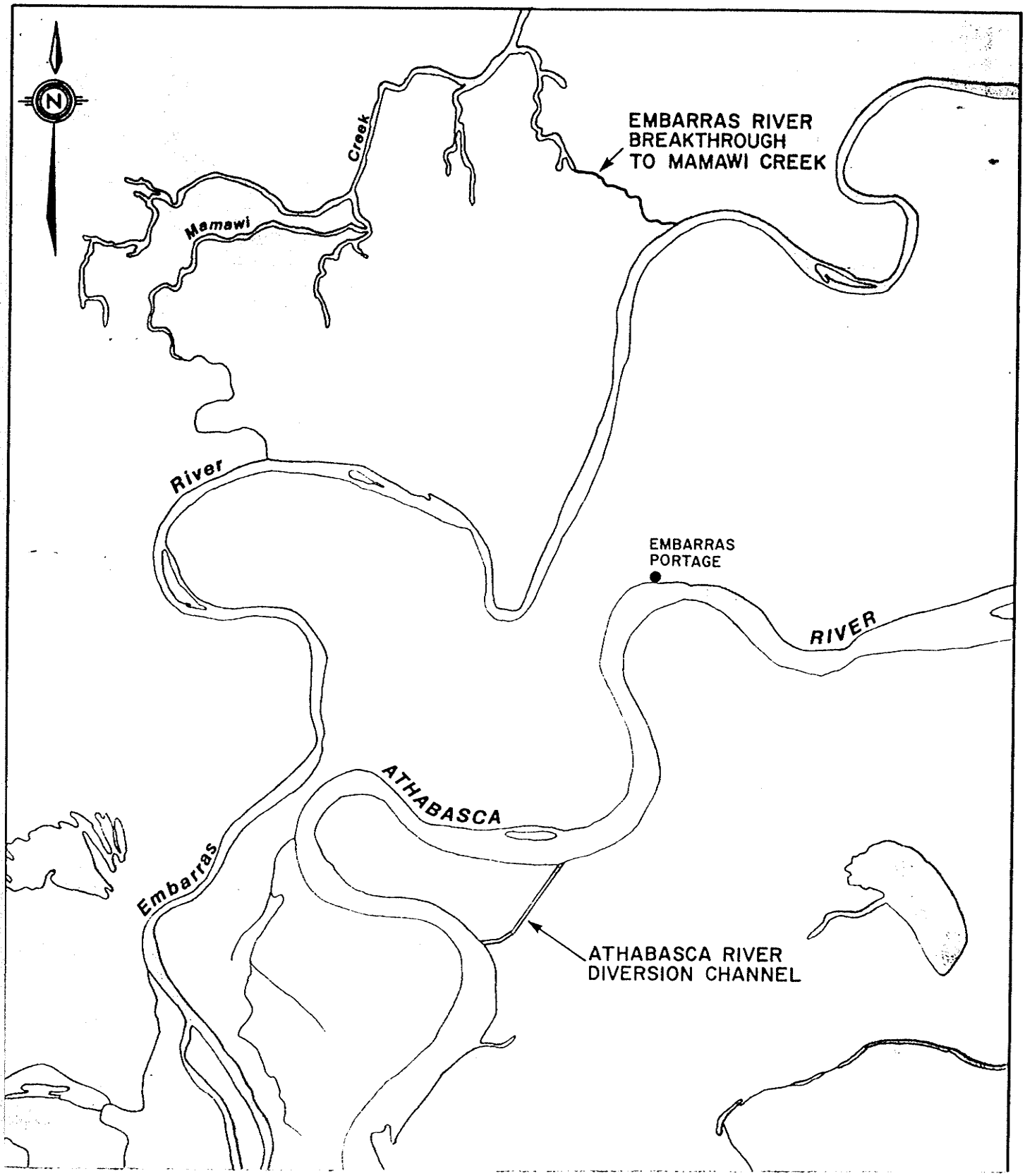


Figure 3: Athabasca River Diversion Channel

early as 1950 was identified by Flett (1983) who examined old photographs. The breakthrough channel appeared to be active and growing when I observed it in August, 1984. I observed fresh undercutting of banks and fallen trees along the channel, and the development of natural levees where the breakthrough cuts across older drainage channels. The channel continues to grow, and by August, 1985 flow rates were approximatly double the rates of the previous year (M. Falk, pers. comm.).

The Peace-Athabasca Delta Project Group (1973) suggested that when the Athabasca River eventually begins flowing into Lake Claire or Mamawi, it would reach Lake Athabasca through the Chenal des Quatre Fourches. Eventually, Athabasca River water may drain into the Peace River through a channel such as the Claire River. The Athabasca River would then entirely bypass Lake Athabasca, leading to a drop in water levels in both the lake and the Delta. This scenario suggests the Peace-Athabasca Delta would cease to be an active fluvial environment. However, the effect of Peace River flows on these suggested developments has not been considered.

It is my opinion that if the Athabasca River bypassed Lake Athabasca and flowed directly into an unregulated Peace River, hydrologic damming could be expected to occur. The Peace River at flood stage would inhibit outflow of the Athabasca River and possibly cause flow reversal. The

consequent flow of both rivers into the lake would force the Athabasca River to maintain a channel to Lake Athabasca. In addition, probable low water levels in the lake would enhance continued direct flow of the Athabasca River into Lake Athabasca. Direct flow of the Athabasca River into the Peace River would be a short lived feature. The extent to which the Athabasca Delta has extended into Lake Athabasca suggests this control mechanism has maintained the present flow configuration over time.

Flow regulation on the Peace River reduces the frequency of hydrologic damming. Water level control on Lake Athabasca, through operation of the weirs, prevents low water levels. In the absence of hydrologic damming and low lake levels it may be possible for the Athabasca River to establish a permanent channel which bypasses Lake Athabasca.

### 2.3.3 Birch and McIvor Deltas

The Birch River drains an area of 12,700 $km^2$ and has a delta of 168 $km^2$. This small delta has a growth-rate of 0.01 $km^2$ per year. The Birch Delta appears to be over-extended and lobe migration may occur. Located at the south end of Lake Claire, the delta is often exposed to high waves. Regulation of the Birch River is unlikely since the headwaters are too remote for any form of economic activity in the foreseeable future.

The McIvor River has a watershed of 1550 km$^2$. It forms a very small delta at the south end of Lake Claire.

## 2.4 ECOSYSTEM RELATIONSHIPS

The relationships between water, vegetation, and animals yields a complex, dynamic ecosystem. The interface between land and water, combined with a regular influx of nutrients carried by floodwaters, creates a highly productive community. Early descriptions of the Delta by explorers and fur traders suggest the Delta's appearance has not changed in 300 years (Dirschl et al. 1974). This apparent stability is contradicted by frequent disturbance caused by both annual fluctuations in water levels and longer term variation between high water and drought periods (Inland Waters Directorate 1984; Thorpe 1986). Using dendrochronology to reconstruct the hydrologic record back to 1810, Stockton and Fritts (1971) determined that water levels had been more variable before 1935 than since. Bayrock and Reimchem (1976) discovered erosion features on the bed of Mamawi Lake that indicated very severe droughts in the past.

Cyclical fluctuations of water levels prevent establishment of a climax ecosystem. Sedimentation and flushing of the Delta maintains the fertile soils, inhibiting development of acidic, water-logged organic soils characteristic of bogs. Many species in the Delta depend on

fluctuations to create conditions necessary for propagation and persistance. The role of disturbance in maintaining the Delta ecosystem is similar to the role of fire in boreal forest ecosystems (Sousa 1984).

The ability of a system to absorb change and disturbance, and still maintain relationships between components was defined as resilience by Holling (1973). According to the concept of resilient systems described by Holling, relationships between system components remain constant despite fluctuations of the forces creating and sustaining a system. There is a threshold, however, beyond which alteration of a force will lead to fundamental changes of relationships and formation of a new ecosystem. Relationships between components in the Peace-Athabasca Delta are not well enough understood to predict a threshold, but it is known that fluctuations are necessary to maintain conditions (Peace-Athabasca Delta Project Group 1973).

## 2.5 PRESENT CONDITIONS

Conditions on the Peace-Athabasca Delta are influenced by the effect of regulated Peace River flows and associated remedial measures, and by naturally occurring low water levels in the inflowing rivers. It is difficult to separate the effects of both these influences.

Reduced inflows from major rivers are listed in (Table 1).

TABLE 1

Streamflow in Major Rivers of Peace-Athabasca Delta System. (From Peace Athabasca Delta Implementation Committee 1983)

| Streamflow Station | Period of Record | Annual Mean Discharge $m^3/sec.$ |
|---|---|---|
| Athabasca River below McMurray | 1960-79 | 689 |
| | 1980-83 | 606 |
| Fond du Lac River at outlet of Black Lake | 1960-79 | 310 |
| | 1980-83 | 264 |
| Peace River at Peace Point | 1960-67 | 2270 |
| | 1972-79 | 2250 |
| | 1980-83 | 1760 |

During the period of 1980-83 annual mean discharge in each of the rivers was less than during the period of 1960-79. Annual mean discharge from the Peace River during the period of 1960-67 (unregulated) is virtually identical to discharge during the period of 1972-79 (regulated). Discharge from the Peace River was reduced during 1968-71 when water was held back to fill the Williston Reservoir.

Low inflows to the Delta from major rivers are caused by recent drought conditions across the prairie provinces.

Thus, present low water levels on the Delta, particularly along the Athabasca River, are in part caused by natural fluctuations. Flooding of the Birch River, in both 1984 and 1985, recharged perched basins in that area, otherwise the Peace-Athabasca Delta appears to be undergoing a long term dry climatic cycle (Thorpe 1986).

Fixed crest rockfill weirs were constructed in 1976 on the Rivieres des Rochers and Revillon Coupe by the Peace-Athabasca Delta Implementation Committee through a cost-sharing agreement between the governments of Canada, Alberta, and Saskatchewan. Since that time, weir effectiveness has been monitored by agencies of the three governments involved, coordinated by the Implementation Committee. Mean annual water levels on lakes Athabasca, Claire, and Mamawi have been similar to historic mean annual water levels (DeBoer and Card 1981; Townsend 1982a; Peace-Athabasca Delta Implementation Committee 1985), but the amplitudes of peak levels have not been restored. Maximum summer water levels are lower, and minimum winter levels are higher.

The fixed crest weirs act to simulate the hydrologic dam effect which occurred when the Peace River flooded, and to control mean annual water levels in lakes Athabasca, Claire, and Mamawi. Water levels in basins close to these lakes, and hydraulically connected by channels, rise and fall in coordination with water levels on the major lakes (Peace-

Athabasca Delta Implementation Committee 1985). Perched basins are not connected to major lakes and are recharged by overland flooding. Water levels required for overland flooding are not achieved by the fixed crest weirs.

Perched basins in the Peace River area are not hydraulically connected to Lake Athabasca levels, and so are not influenced by the remedial weirs. Spring flood levels on the regulated Peace River are no longer high enough to cause overland flooding in the Peace Delta area. Ice jamming on the Peace River does cause overland flooding, as it did in 1974, but not as frequently as flooding which occurred prior to regulation of Peace River flows.

The effect of the weirs on longer term fluctuations cannot be determined yet. The model prepared by the Hydrology Subcommittee (Peace-Athabasca Implementation Committee 1985) indicates Lake Athabasca water levels tend to have followed natural trends, but the period of study covers only 1960-1981. Mean annual lake levels were found to be slightly higher with the weirs in operation than under natural conditions predicted by the model.

The weirs have fixed crests, thus, the simulated hydrologic dam effect operates even in very low water years. During drought periods, including the present period, water levels on the major lakes and associated basins may be maintained at artificially high levels. Alternatively, the

existing weirs may not be able to cause very high water levels. Thorpe (1986) suggested that high water levels caused by Athabasca River flooding may drain off down the Chenal des Quatre Fourches. Under natural conditions this channel would also be dammed by Peace River floodwaters, but is now unrestricted.

The modified water regime has had an effect on vegetation communities within the Peace-Athabasca Delta. Cordes and Pearce (1979) documented changes in species composition of vegetation communities between 1970 and 1978. Stable water levels led to a reduction in sedge species which grow in wet meadows and are renewed and invigorated by water level fluctuations. These meadows are prime bison habitat, so a reduction in carrying capacity for bison can be expected. Perched basins along the Peace River have not been recharged since 1974 (Thorpe 1986), leading to a loss of muskrat and waterfowl habitat.

At present, short term fluctuations on the Peace-Athabasca Delta are reduced in amplitude. This reduction mainly affects perched basins along the Peace River, and is similar to the effect of a long term drought. Natural conditions are causing long term low water conditions on the rest of the Delta, but these areas can be expected to return to normal water conditions when the drought on the southern prairies ends. Under the existing situation normal water conditions will not return to the Peace Delta. Vegetation

succession, towards willow and spruce bog will continue unchecked, until a threshold is reached beyond which high water levels will not restore natural conditions.

# Chapter III

## RESOURCE USE, PAST, PRESENT AND FUTURE

Many demands on the resources of the Peace-Athabasca Delta have been made, or are planned for the future. These demands are for a wide variety of uses, upstream, downstream, and within the Delta itself. The uses include hunting, trapping, fishing, hydroelectric power production, transportation, industrial use (both consumptive and nonconsumptive), wildlife production, tourism and recreation, and preservation of natural environments.

Most of the future demands on water will cause changes in seasonal flow characteristics and could affect the Peace-Athabasca Delta like the Bennett Dam did. Changes in annual quantity and quality have not yet occurred to any great extent, although this could change in the future. The present and future demands or objectives of the various users other than Environment Canada-Parks are summarized in Table 2.

TABLE 2

Present and Future Uses of Peace-Athabasca Delta Resources Outside of Wood Buffalo National Park.

| User | Use |
|---|---|
| Local Level | |
| Local Native Groups | Hunting, trapping, fishing tour guiding, navigation. |
| Transport Companies | Barge navigation on major waterways. |
| Recreational Users | Sport hunting and fishing, recreational navigation, wilderness tours. |
| Regional Level | |
| Power Utilities | Hydroelectric development regulation of Lake Athabasca for water storage. |
| Industrial Development | Industrial consumption, waste disposal. |
| Communities Along Rivers | Domestic consumption, travel, recreation. |
| Alberta Farmers | Interbasin transfer of water. |
| National Level | |
| British Columbia Northwest Territories | Hydroelectric development. Mackenzie River water regime. |
| Canadian Wildlife Service | Endangered species, migratory waterfowl. |
| Private Interest Groups | Waterfowl hunting, wilderness preservation. |

## 3.1 PAST RESOURCE USE

Archaeological surveys indicate the Peace-Athabasca Delta region has been occupied by humans since at least the last glacial retreat. The first European to visit the Delta was Peter Pond in 1778 (Potyondi 1979). Recognizing the region's value as a fur producing area, he returned with trade goods. Other fur traders followed and Fort Chipewyan

was soon established as a major fur trading center, and the Athabasca, Peace, and Slave rivers became important transportation routes.

By 1890 plains bison on the southern prairies had virtually disappeared. North of the Peace-Athabasca Delta there still existed a herd of wood bison. In 1894, this herd received protection from hunting under the Unorganized Territories Game Protection Act. In 1897 Northwest Mounted Police began making regular bison patrols to enforce the Act. Wood bison responded to protection and numbers began increasing (Potyondi 1979). In 1922, to increase protection of wood bison, Wood Buffalo Park was created by a Federal Government Order-in-Council.

The new park was administered by the Northwest Territories District Agent whose primary duties were economic development of the region under his control. Thus, while in other national parks emphasis was on preservation of natural resources and public recreation, in this Park economic development became important (Potyondi 1979). Timber harvesting and trapping within the Park became a significant contribution to the economic base of Fort Chipewyan.

Starting in 1925, over 6,000 plains bison were transferred to Wood Buffalo National Park from Wainwright, Alberta. Some of these bison wandered across the Peace

River, the original southern boundary of the Park, into the Peace-Athabasca Delta. To protect these bison Park boundaries were extended south into the Delta (Potyondi 1979).

Wood Buffalo National Park was administered by the Northwest Territories District Agent until 1964 when administration was transferred to the National Parks Branch (now Environment Canada-Parks). Commercial activities continued in the Park after the transfer. Native groups have retained traditional hunting and trapping rights within the Park, except for bison which are protected.

## 3.2 LOCAL RESOURCE USE

Resource use within the Peace-Athabasca Delta and Lake Athabasca tends to concentrate on water based resources rather than direct use of water. These water bodies are dependent on upstream sources of water.

Mining operations on Lake Athabasca at Uranium City and Cluff Lake, the only industrial developments on this lake, have had no significant impact on water quality or quantity (Lane and Sykes 1982). Barge transportation was more important before railroads, roads, and airplanes were available. Currently barge transportation is limited to supplying isolated local communities, such as Fort Chipewyan and is very important for those communities. Boating is the

main form of transportation for local residents during the open water season.

Fishing , hunting, and trapping remain a major activity for many local inhabitants. Enhancement of wildlife populations, such as artificial control of water levels by Native people for muskrat production, is carried out to a limited degree. Proposals for more intensive management of water levels, such as one by Smith (1983) which involves extensive dyking and pumping to control water levels in individual perched basins on a Delta wide basis have been made. Preliminary results from experimental flooding of three perched basins by the Chipewyan band indicate muskrat populations can be increased by manipulating water levels (Thorpe 1986). Feasibility studies have been proposed to examine the potential to enhance waterfowl, fish, and wild rice (which has been successfully introduced in the area), as well as muskrat populations, through water level manipulations (Anon. 1985). Within the Park, management measures are allowed but must recognize the purpose of the Park (Parks Canada 1984). Wildlife harvesting is managed according to the Park Game Regulations.

Recreational uses include boat trips and wilderness tours into the Delta or along the major rivers. In Delta areas outside of the Park there is some sport hunting and fishing. There is no cottaging in the Park portion of the Delta although there are a few trappers cabins (Parks Canada 1984).

Land claims by The Cree Band of Fort Chipewyan, involving lands along the Embarras River and at Peace Point, are unresolved. Environment Canada-Parks is currently involved in negotiations to settle these claims. The Peace Point site is located entirely within the Park and Environment Canada-Parks is prepared to exchange Park land adjacent to the Embarras River claim for the Peace Point site (Parks Canada 1984). The settlement may result in this exchange but Environment Canada-Parks would also consider monetary compensation, firmer resource use guarantees, and economic development provisions as an alternative. Future land claims by Dene or Metis are possible (M. Falk, pers. comm.). Under the Terms of the Transfer of Resources Agreement, the Province of Alberta may also be required to surrender land or other forms of compensation when settlements are reached.

## 3.3 UPSTREAM RESOURCE USE

Upstream uses of water have critical implications for natural processes within the Peace-Athabasca Delta. Regulation of Peace River flows by the W.A.C. Bennett Dam in British Columbia led to construction of remedial works to control water levels. Further alteration of inflowing waters could make remedial works even more essential if natural processes are to continue. Reductions in annual flow, sedimentation, and flushing rates would make it

difficult to recreate historic conditions. At a minimum, sufficient flow is required to allow a rapid increase in water levels to recreate spring flooding.

Development on the Fond du Lac and Birch rivers does not at present, and will not in the foreseeable future, affect flows. The Athabasca and Peace rivers are, however, being developed and projects which affect flows are likely in the future. Primus (1981) reports that rivers forming the Mackenzie system carry 86.5% of the mean annual discharge leaving the Province of Alberta. The Peace and Athabasca rivers carry the bulk of this flow and are valuable potential sources of water to southern Alberta where 80% of the present total water demand occurs.

A general increase in municipal, industrial, and recreational use is expected along the Peace River. Two new hydroelectric developments have been proposed, one at Fort St. John, British Columbia, and the other near Dunvegan, Alberta. Further significant changes to the already altered flow characteristics are not expected (Land and Sykes 1982).

The potential for hydroelectric development along the Athabasca River has been investigated (see Energy Resources Conservation Board 1981). A number of sites were identified with the most attractive ones being located upstream of Fort McMurray.

Forestry and agricultural activity within the Athabasca River basin have altered runoff characteristics, increasing sedimentation. Lane and Sykes (1982) report that erosion mainly takes place in tributaries.

Oil sand development in the Fort McMurray area can affect the quantity and quality of water of the Athabasca River, through consumption during oil recovery or through waste disposal. The degree of impact will ultimately be related to number and size of oil sands plants which become operational and the technology which is applied. Lane and Sykes (1982) suggest water quality problems could become the most significant impact of oil sands development. The walleye fishery on Lake Athabasca was temporarily closed in 1982 due to phenol contamination attributed to oil sand development (Peace-Athabasca Delta Implementation Committee 1983).

Interbasin transfers of water from northern Alberta to the south have been proposed. The major use of water in southern Alberta is for irrigation. All available water is presently allocated but potentially irrigable land is still available (Environment Council of Alberta 1982). Alberta policy "is that the water in each major river basin must be fully and efficiently utilized before inter-basin augmentation could be considered." (Ramage 1986 p.26). The first issue to be resolved would be whether surplus water supplies existed in the north. Oil sands water requirements are high enough that a surplus may not be available in the

Athabasca River basin (Primus 1981). Recent drought conditions in southern Alberta have renewed interest in interbasin water transfer. Large scale diversion of Peace River flows has been studied, but at present this is an expensive and unlikely solution to drought conditions. Smaller scale, sequential transfer of water from the Peace River to other basins may prove to be a more likely solution in the future (Ramage 1986). A reduction of Peace River flows by any project would result in further disruption of water and ecological conditions on the Peace-Athabasca Delta.

## 3.4 DOWNSTREAM RESOURCE USE

A potential hydro-electric site lies downstream of the Delta on the Slave River near Fort Smith (see Fig. 1). A feasibility study was recently prepared for the Alberta Government Cabinet under the direction of a steering committee. This study (Anon. 1982) examined the technical feasibility and economic attractiveness of hydro-electric development on the Slave River. Detailed analyses of probable economic, environmental, community and social impacts were conducted by a variety of consulting firms. There is no provincially owned power utility in Alberta; power is supplied by a number of private power companies. There is as yet no official proponent for a potential Slave River hydro project, so the feasibility study examined a

range of alternatives rather than identifying a preferred alternative.

The effect hydro-electric development on the Slave River may have on the Peace-Athabasca Delta depends on the operating conditions selected. A major concern is the level of the forebay. Optimum economic benefits would result at about 205 to 206 m.asl. At a level of 206 m there would be a rise in annual mean water levels on the Peace-Athabasca Delta and Lake Athabasca of about 35 cm (Anon. 1982). This is a small rise, but because the land of the Delta has little relief, considerable area would be flooded. Operating conditions at this level would raise annual mean water levels. Increased flooding would result in changes to vegetation and increase open water area on the Delta. Flooding of Park lands and waters which would result are unacceptable to Environment Canada-Parks (Parks Canada 1984). At a forebay level of 204 m, there would be no increase in water levels on Lake Athabasca or the Peace-Athabasca Delta, but the project would not be as efficient in producing power.

Even at a forebay level of 204 m, Park lands along the Slave River would be flooded. Environment Canada-Parks has strongly objected to any inundation of its land and referred this issue in 1980 to the Federal Environmental Assessment Review Office (F.E.A.R.O. 1984). Impact Assessment guidelines were prepared, but in August, 1985 the project

was shelved because of lack of demand for electricity. An increased demand for electricity in the future will lead to renewed interest in the project. Winston (1986) recommends that in the interim environmental considerations be more carefully examined, and that these considerations be addressed in further engineering studies.

## 3.5 SUMMARY

Resource use patterns on the Peace-Athabasca Delta, and the Peace, Athabasca and Slave Rivers are changing. In the past, conflicts which arose between various user groups, other than problems caused by the Bennett Dam, were small scale and did not involve major changes in conditions on the Delta. Because of the changing use patterns, and the number and scale of potential projects being proposed which could affect the Delta, conflicts are becoming more serious, and more likely to be irreconcilable. Skilful management is required in the future if the Delta is to be preserved.

For Environment Canada-Parks the problem entails two aspects. First, Environment Canada-Parks must seek agreement with other Delta proprietors over what conditions to maintain on the Delta, and how these conditions will be achieved. Second, Environment Canada-Parks (and other Delta proprietors) must ensure that sufficient water is available to achieve desired conditions, and that downstream uses neither affect nor are affected by uses on the Delta.

Conflicts over direct use of the Delta that Environment Canada-Parks may become involved in arise mainly from operation of a structure which provides control over the entire Delta (i.e. a gated control structure on the Peace River, see Chapter IV). This would lead to conflict over water levels to enhance wildlife populations, to provide hydroelectric power benefits, and to recreate natural conditions. Another possible conflict is over whether to alter the Athabasca River to improve barge movements, or to allow it to establish its own natural channel. This issue is dependant on the path of the Athabasca River following lobe migration.

Conflicts over use of resources beyond the Delta involve large scale projects in various stages of development. At the present scale of operation, oil sand development presents no major problems, but could if increased activity leads to a decrease in either water quality or quantity. Potential hydroelectric projects can alter water conditions on the Delta. The Slave River hydroelectric project is in the planning stages but was recently shelved indefinitely because of reduced need for the generating capacity. Interbasin transfers of water may occur in the long term.

Both physical and regulatory management approaches are needed to overcome these problems. Chapter IV deals with physical management considerations, while Chapter V focuses on regulatory management.

# Chapter IV

# PHYSICAL MANAGEMENT

The rockfill weirs located on the Riviere des Rochers and Revillon Coupe have in general achieved the predictions of the Peace-Athabasca Delta Project Group (1973). The weirs were not expected to recreate natural seasonal fluctuations and overland flooding, but this was accepted given the cost of constructing a more sophisticated control. A control structure capable of providing a closer approximation of historical water conditions management is expensive but would become more desirable if future developments led to further alteration of inputs.

## 4.1 REQUIREMENTS

In order to maintain the Peace-Athabasca Delta in as close to natural a condition as possible, a control structure would have to meet a number of requirements (Townsend 1982b).

1. It should cause water levels to rise in the spring under conditions of less-than-natural inflow.
2. It should allow water levels to recede during the summer and early fall.

3. It should allow unimpeded exit of greater-than-natural inflow during the winter.
4. It should neither increase nor decrease the frequency of overland flooding caused by ice jamming.

The first three requirements would restore seasonal fluctuations of water levels which occurred under a pre-Bennett Dam regime. The fourth requirement requires further analysis. Under a natural regime, overland flooding occurred only every two or three years, and was caused either by ice jamming or high floodwater levels on the Peace River. The cause of flooding should make little difference as long as the overall frequency of events simulates that which would have occurred without regulation of the Peace River. Theoretically a structure on the Peace River might be operated to induce flooding by either mechanism. Townsend (1982b) points out that it is not known whether higher winter flows due to upstream regulation will increase or decrease the frequency of ice jamming on either the Peace or Athabasca rivers. He suggests that a control structure should be capable of either triggering an ice jam or having no effect through its presence.

Recreating high water levels with less-than-natural inflow can be achieved by increasing the residence time of water in the Delta. This approach would provide desired water levels, but would alter both sedimentation and flushing rates. Sediments are important for delta building

processes and fertilization of meadows. Flushing of the Delta by floodwaters maintains the chemical balance of soils and waterbodies. Although flushing and sediment deposition rates are poorly understood, they are factors to be considered in the establishment of minimum limits for inflowing waters.

## 4.2 CONTROL STRUCTURE OPTIONS

A number of control structure options were identified by the Peace-Athabasca Delta Project Group (1973). Potential sites were identified, and effectiveness of different control structures estimated using a hydrological model. Structures were designed to raise water levels on Lake Athabasca and connected Delta lakes to simulate conditions which would occur without operation of the W.A.C. Bennett Dam.

### Slave River Site

Located approximatly 9 km downstream of the confluence of the Slave River and Riviere des Rochers, this site would allow control over Peace River and Lake Athabasca outflows. Overland flooding from the Peace River could be induced, maintaining sedimentation and flushing patterns.

A rockfill constriction design and a gated concrete and rock design were considered for this site. Both designs could be used to recreate peak water levels in the summer.

Control over levels achieved would be possible with the gated design. Hydrological modelling indicated both designs would cause higher winter water levels than occurred under pre-Bennett Dam conditions. If additional discharge capacity was included in the gated design, desired minimum levels could be achieved.

Both designs at this site would interfere with navigation and fish movements, so navigation locks and fishways would have to be included. A structure could either create undesired ice jams or be damaged by ice. Estimates of cost at this site (in 1973 dollars) were $13,000,000 for the rockfill constriction and $20,000,000 for the gated concrete and rock structure.

Riviere des Rochers

The Little Rapids site on this channel is where the existing weir is located. Although control over Peace River flows is not possible at this site, Lake Athabasca levels can be controlled. Control depends on inflow into Lake Athabasca from the Athabasca and Fond du Lac rivers. Sedimentation and flushing patterns associated with flooding from the Peace River are not recreated by a structure at this site.

Three designs were considered for the Little Rapids site, a rockfill constriction, a rock weir, and a gated concrete and rock structure. A dam on the Revillon Coupe would

accompany any of these designs to prevent erosion of that channel. Peak summer levels could be recreated by each of these designs, but the peak would occur later in the season than under pre-Bennett Dam conditions. Winter minimum water levels would be higher with these designs, although if greater discharge capacity was included in the gated design these minimum levels could be achieved. Interference with fish movements was considered minimal, so no fishways were proposed. Commercial navigation could utilize the Chenal des Quatre Fourches so locks would not be needed. Ice jamming problems were considered minimal at this site. Cost estimates for structures (in 1973 dollars) were: $1,500,000 for a rockfill constriction, $1,000,000 for a rock weir, and $5,500,000 for a gated concrete and rock structure.

Chenal des Quatre Fourches

A temporary dam was constructed at a site on the Chenal des Quatre Fourches in the fall of 1971 (see Fig.2). The dam provided control over water levels in 60% of the Delta, but it restricted exchange of water between Lake Athabasca and the other Delta lakes, and interfered with navigation and fish migrations. This site did not provide control over Peace River flows, and the decision was made to remove this structure in 1975. High water levels in 1974 washed out most of this dam, and the remainder was removed in the spring of 1975.

As a result of a request to the Peace-Athabasca Delta Implementation Committee by Cree trappers from Fort Chipewyan, this site was recently re-evaluated. A control structure at this site could provide improved control of water conditions on lakes Mamawi and Claire, and closely associated perched basins, but would have no effect on other parts of the Delta. Natural lobe migration on the Athabasca River will increase flow into Lake Mamawi, and this would serve to counteract any benefits of such a control structure (M.Falk, pers. comm.).

Ice Damming

Artificial creation of temporary ice dams was explored as a technique for controlling water levels. A technique using cryopiles filled with refrigerant, cooled by cold winter air, was tested and proven feasible. Ice formation can be supplemented with upstream ice blasted from the river. This technique could be applied at a number of locations on the Riviere des Rochers.

The possibility of causing ice jamming on the Slave River was suggested, but never tested. Floated steel cable anchored to massive cement blocks on opposite shorelines could be used to induce jamming of spring ice floes.

Neither of these techniques could fully restore the Delta water regime to pre-Bennett conditions. Instead, they could be used to recreate extensive flooding on an irregular

basis, or to provide localized control of parts of the Delta. Further study is required before these techniques could be applied. Cost estimates were not provided.

Compartmentalization

Control structures discussed by the Peace-Athabasca Delta Project Group (1973) were designed to provide water regime management for the entire Delta. It is only during extreme flood events that the Delta functions as a single, interconnected hydrological unit. During non-flood periods water levels on lakes Athabasca, Claire, and Mamawi are important, but inflowing rivers also have a significant effect on water conditions in their respective parts of the Delta. The Peace, Athabasca, and Birch deltas are each distinct enough that they can be considered as separate entities for management purposes.

The Birch Delta is very active, and its headwaters are unlikely to be influenced by the actions of man. This delta will remain an unaltered, natural example of deltaic processes. Because this delta is subjected to wave erosion, water levels on Lake Claire influence delta formation.

Much of the Athabasca Delta is owned by the Province of Alberta and Native people. Intensive, small scale management of water levels on individual perched basins for wildlife and wild rice production are profitably conducted in this area. If feasibility studies (Anon. 1985) are successful,

more of this type of management can be expected outside the Park.

The Athabasca Delta is very active. Lobe migration can be expected in the future, but when this will occur cannot be predicted. Lake Athabasca water levels influence delta development, although the effect is minimal in active areas and many perched basins. Changes in the Athabasca River water regime caused by upstream actions will influence developments in this delta.

The Peace Delta is largely inactive, but overland flooding has been important in maintaining the extensive meadows and perched basins. A control structure or ice jamming is required to restore natural conditions on this Delta.

If the Peace-Athabasca Delta is divided into compartments for management purposes then the most critical area is the Peace Delta. Lake Athabasca levels require regulation. The Athabasca and Birch deltas remain active, evolving delta systems without physical management. Intensive management of perched basin water levels would increase wildlife productivity.

## 4.3 DISCUSSION

A variety of alternatives are available to control water levels on the Peace-Athabasca Delta. Decisions over control structures depend on two factors: (1) the water regime of inflowing rivers may be altered in the future by upstream development,and, (2) managers must determine what water regime they want to establish.

Environment Canada-Parks policy (Parks Canada 1979) directs managers to maintain the Delta in as close to a natural condition as possible. The Peace-Athabasca Delta is a dynamic, evolving environment. Managers can never entirely know what conditions would exist without altered flows. Natural conditions can be inferred, however, because only the water regime has changed. Hydrological modelling by the Inland Waters Directorate (1984) provides a good approximation of what the water regime would be without altered inputs. If further data from snow surveys and upstream gauging systems are gathered and incorporated into this model, the natural water regime could be predicted each year. Using such a model in combination with a sophisticated control structure, natural conditions could be recreated.

Weirs are effective at maintaining annual average water levels but cannot recreate fluctuations. Providing occasional flooding by ice jamming would provide a closer

approximation to natural conditions than is achieved now. Floods created by ice jamming on Riviere des Rochers would not reach perched basins near the Peace River. Ice jamming on the Peace River could theoretically be accomplished but has not yet been done. If jamming could be induced, Peace River basins could be flooded. With the ability to create ice jamming, managers would be able to recreate high water levels, but not low ones. Lowering the weirs would allow lower water levels to occur but would lead to a dependency on ice jamming to maintain annual average levels.

Ice jamming, used in combination with the existing weirs may provide an improvement but this approach has not been evaluated. Costs, incurred on an annual basis, are not expected to be high. Because this alternative does not require expensive construction of a permanent facility, no long term financial commitment is required. Further study of inducing ice jamming on the Peace River is needed before this alternative could be pursued.

Gated concrete and rock control structures would provide the closest approximation to natural conditions. Both summer peaks and winter minima can be achieved, as well as fluctuations between years. A gated structure on the Riviere des Rochers creates fewer problems with navigation and fish movements, and costs less than one on the Peace River would, but the Rochers site provides no control over Peace River flows. Induced ice jamming on the Peace River

would still be needed to overcome this problem. Since a gated structure on the Riviere des Rochers depends entirely on Lake Athabasca inflows, it would be less capable of compensating for altered flows in the Athabasca River than a Peace River structure. A gated structure on the Peace River is the alternative which provides the greatest degree of control, although it is the most expensive.

Downstream uses on the Slave River must be coordinated with control structure management. High water levels caused by a Slave River hydroelectric dam could interfere with operation of a control structure. It has been proposed that instead of a high level hydroelectric dam, a control structure on the Slave River could be operated in conjunction with a low level dam so that Lake Athabasca and the Delta act as storage reservoirs, increasing the power benefits of the dam while providing ecological control (Anon. 1982). The water regime required to maintain the Delta is incompatible with optimum requirements for hydroelectric power production. Low water levels by late summer, and throughout the winter are the usual 'natural' conditions on the Delta. Peak load demands for power occur in winter, so it is desirable to retain high water levels until then to optimize power production.

Hydroelectric power production is not the only source of pressure to manage the Delta for reasons other than preservation of a natural environment. Both muskrat and

waterfowl populations can be enhanced by manipulating water regimes. Extensive droughts or floods can seriously affect the population levels of wildlife over the short term. If a control structure capable of creating droughts and floods is constructed, Environment Canada-Parks can expect pressure to avoid creating these extreme events.

The potential for future alteration of the water regime in inflowing rivers exists. Further changes to water regimes would affect water conditions on the Delta, and operation requirements of a control structure. Operation of a control structure to maintain conditions on the Delta would increase the use which could be made of upstream water resources without leading to a decline of Delta resources.

# Chapter V

# REGULATORY MANAGEMENT

Regulatory management in the Peace-Athabasca Delta is very complicated. The Peace-Athabasca Delta Project Group (1973) identified well over 20 agencies from the governments of Canada, Alberta, and Saskatchewan involved with Lake Athabasca and the Peace-Athabasca Delta. In addition, local residents, Native people, and various public interest groups are concerned about the Delta and use of its resources.

Legal rights over water use are not clearly defined and are a sensitive political issue since they involve Federal interference with a Province's right to enjoy its natural resources. Regulatory management of water conditions on the entire Delta, and on the Park controlled portion, entails decisions over what water conditions are desirable and what control structure(s) are needed to achieve these conditions, and requires agreements to ensure sufficient water is available to achieve desired conditions. Competition for control of the rich resources inside and outside the Delta and the complexity of jurisdictional control make regulatory management of the Delta very complicated. In this chapter the existing decision making process is examined to determine how conflict resolution can be facilitated.

Alternative regulatory management strategies for improved interagency decision making and conflict resolution are developed.

The basic requirement of regulatory management over the Peace-Athabasca Delta is to provide coordination of effort amongst the various groups involved and facilitate agreement on management goals. The Peace-Athabasca Delta Implementation Committee, composed of representatives from the Federal, Alberta, and Saskatchewan governments provides coordination but its powers are limited. The Implementation Agreement provided for construction of the present control structures and monitoring of their effects, and provides for recommendations on preservation to the three governments involved. Further action by the Implementation Committee would require review of the Agreement by the signatory parties. By agreement of the parties involved, review of the agreement, required under Article XVI, will take place on September 16, 1986, or earlier at the request of one of the parties. At that time the agreement can be renewed or terminated.

The Implementation Committee has no responsibility beyond the Delta itself. Control over the Peace, Athabasca, and Slave rivers is largely under the jurisdiction of Alberta. Alberta manages water resources on a river basin system. There are no river basin plans yet for the Peace, Athabasca, or Slave rivers, although Primus (1981) reported the Athabasca River Basin plan was in preparation.

The Province of Saskatchewan has control over most of Lake Athabasca. What happens in the Delta is intimately related to levels of Lake Athabasca, so Saskatchewan must be consulted when decisions are taken to control water levels.

Actions taken on the Peace-Athabasca Delta which affect downstream flows fall under the jurisdiction of the Mackenzie River Basin Board. This intergovernmental advisory agency is involved primarily in transboundary water management issues in the Mackenzie River basin.

There are many management oriented statutes available to agencies with control over Delta resources which have not yet been exercised. Even when actions in British Columbia had negative impacts on the Delta through construction and operation of the W.A.C. Bennett Dam, and a number of Federal acts could have been used to seek restitution, court imposed decisions were not sought.

## 5.1 PRESENT SITUATION

The resources of the Peace-Athabasca Delta are presently the subject of considerable controversy. The presence of a variety of valuable resources linked together in a complicated ecosystem, combined with legislative control being divested in a number of governments, has created a conflict over allocation of resources. This conflict is between parties involved in Delta management over management

goals and desired water conditions, and between parties interested in the various river basins (Peace, Athabasca, Slave, and Mackenzie) over future allocation of water resources. The conflict is over predictions of future demands on the resources involved and has not reached a critical stage. This allows decision makers to take a proactive approach to conflict resolution if they desire. Such an approach is not being undertaken at present.

The analysis in this section is adapted from Dorcey (1983). In this approach, resource management is considered to be a bargaining process. Bargaining takes place between various interest groups leading to conflict resolution. The outcome of this process depends on a variety factors, including institutional structures, power of the actors, and their skill at negotiating. Although Dorcey uses the term 'bargaining', 'negotiation' will be used in this paper. Negotiation is similar to bargaining but implies a greater degree of agreement over the outcome. Negotiation has been successfully applied to conflict resolution in a growing number of cases (eg. Susskind and McCreary 1985; Gusman and Huser 1984).

Dorcey (1983) considered three criteria in his analysis of the decision making process on the west coast of Canada:

1. Information: adequacy of information about resource uses and their consequences.

2. Representation: opportunity for informed participation or representation of affected interests in decision making.
3. Cost-Effectiveness: cost-effectiveness of institutional arrangements for generating information and for participation and representation in decision making.

Information Criterion

A considerable amount of information about the Delta has been collected over the years. Environment Canada-Parks and the Canadian Wildlife Service have monitored wildlife populations, including bison numbers and furbearer harvest in the Park. The Peace-Athabasca Delta Project Group (1973) coordinated a variety of studies of the biological and hydrological resources. The Peace-Athabasca Delta Implementation Committee has continued to oversee monitoring on the Delta. A number of studies were conducted in relation to evaluations of the proposed Slave River hydro project (e.g. Stanley Associate Engineering Ltd. 1982). Other studies conducted in the Delta include vegetation monitoring by Environment Canada-Parks (Cordes and Pearce 1978, 1979), downstream impacts of oil sand development (Neill et al. 1981), and economic management studies (Anon. 1985).

The studies provide extensive primary information about the Delta. Water levels and some animal populations have been monitored continuously since at least 1970. Vegetation monitoring was conducted only from 1974 to 1978. Sedimentation data have been collected by Alberta Environment since 1971 (Peace-Athabasca Delta Implementation Committee 1983). Ongoing monitoring is essential so that trends can be detected and management practices evaluated.

Secondary information, or a synthesis of information to determine trends and relationships is not as complete. Hydrological modelling (Inland Waters Directorate 1984) is the most complete. The lack of vegetation monitoring in recent years makes it difficult to confirm predictions about vegetation succession. Computer modelling by Townsend (1972) to predict the effect of water level fluctuations on habitat and wildlife populations has not been updated, or confirmed (Thorpe 1986).

Improved inventories and knowledge about trends and processes allow better management. The increase in available information is dependent on the institutional arrangements for its collection. Within the Peace-Athabasca Delta information gathering is mainly coordinated through the Implementation Committee, although Environment Canada-Parks and other agencies collect their own information as well. Information about the effect of projects outside the Delta is usually gathered by the proponent agency. In these cases

information collection is coordinated between parties despite the lack of an institutional framework. Since data are shared between parties, some duplication of effort is avoided. In order for management of the Peace, Athabasca, and Slave rivers to be improved information collection needs to become better coordinated, and monitoring efforts must be focussed.

Representation Criterion

Under this criterion the opportunity for informed participation, and the institutional framework for decision making are considered. Informed participation requires both the necessary information for decision making, and that the information is available to all participants. Information about the Delta is usually accessible, but must be acquired from a number of agencies.

The Peace-Athabasca Delta Implementation Committee has jurisdiction over decisions taken for the immediate Delta area only. There is no institutionalized mechanism at present which provides overall coordination of decisions taken for water bodies associated with the Delta. Groups which control resources only within the Delta, such as Environment Canada-Parks or Native people, have little control over events which take place either upstream or downstream. Formal opportunities for public participation are limited to the National Park planning process. The lack

of formal opportunities prevents parties which are not involved in the Implementation Committee, or representing major development interests, from being fully involved in the decision making process. At present, Environment Canada-Parks runs the risk of having its public meetings become the only forum available for public opposition to be expressed on issues Environment Canada-Parks is also opposed to, but unable to prevent.

A major stumbling block for effective representation of views by the various agencies is the split between federal and provincial agencies. Agencies within a government must reach agreement among themselves, even when their mandates are contradictory, as is the situation between Environment Canada-Parks and the Department of Regional Economic Expansion. This "one window" policy allows federal and provincial representatives at a high level to enter into consultation or negotiation without fear of being contradicted by an agency within their government. However, within both levels of government there are agencies involved in environmental planning and others involved in economic planning. Environmental and economic planning are complementary processes which should be conducted in unison, but frequent disagreement can be expected. With a rigid "one window" policy both governments must first resolve the conflict from within before trying to reach agreement with each other. Minority concerns, shared by agencies from both levels of government can be supressed through this process.

The present institutional arrangement does not allow for representation by groups not members of the Implementation Committee. Native people and other local interests have at present very little input into decision making on matters affecting the Peace-Athabasca Delta.

### Cost-Effectiveness Criterion

As information gathering becomes better coordinated and focussed it becomes more cost-effective. Better information allows for more informed decision making, and more effective allocation of resources. The institutional framework under which information is gathered and decisions are made influences cost-effectiveness. Under its terms of reference the Peace-Athabasca Delta Implementation Committee is cost-effective, but many of the problems in the Delta are beyond those terms of reference. Thus information gathering beyond the Delta, representation by Native people and other local resource users, and decision making on a broader, river basin scale is cost-ineffective.

## 5.2 MANAGEMENT ALTERNATIVES

The analysis in the previous section indicates that problems exist in the decision making process for resources associated with the Peace-Athabasca Delta. Problems arise from the information, representation, and cost effectiveness criteria, primarily as a result of the institutional framework in which decision making is conducted.

Many future conflicts affecting the Delta involve resources arising beyond the jurisdiction of the Implementation Committee. The Peace-Athabasca Delta Implementation Agreement provides for management of the Delta, but the terms of reference are weak on a number of points. These include decisions regarding evaluations of the weirs and possible measures to overcome deficiencies. There is no formal provision for public participation in the existing agreement. The Wood Buffalo Management Plan (Parks Canada 1984) states that when the Agreement is reviewed, Environment Canada-Parks will seek an agreement that will allow the Committee to formulate, review, and decide upon ways to restore or replicate natural conditions on the Delta. The renewed agreement should also provide for implementation of any physical structures decided on by the Committee.

Environment Canada-Parks cannot spend money beyond its boundaries without approval of the Treasury Board, which limits the options available for seeking conflict resolution. Environment Canada-Parks can either seek conflict resolution mechanisms alone, or act as a member of a renewed Implementation Committee, or a similar formally recognized structure.

The Federal Environmental Assessment and Review Process was used to address the conflict which arose over the Slave River hydroelectric project. The Governments of Alberta and

Canada developed joint impact assessment guidelines to evaluate the project, but the assessment will not reach the hearing stage unless the project is resumed. Although there was good cooperation among affected interests, and opportunity for public participation was available, this approach to regulatory management is reactive. Considerable effort was expended to establish a data base; however it was oriented only to a single project. Evaluation of projects through an environmental impact assessment considers a project according to its individual merits, rather than placing the benefits in a regional context.

Although they have not been implemented in the past, mechanisms exist for formalized river basin planning of the rivers associated with the Peace-Athabasca Delta. This could be through the Mackenzie River Basin Board, or individual river basin planning by the Province of Alberta. Formal river basin planning involves the establishment of a planning authority which is responsible for allocation of water resources within a river basin. The authority establishes an inventory of available resources and allocates resources based on need and demand. Users are then allocated a supply of water. River basin planning can be expensive, and requires the establishment of a bureacracy to oversee management.

Alternative management involving the Mackenzie River Basin Board was considered by the Peace-Athabasca Delta

Project Group (1973). Although this approach avoids the need for formation of another government committee, this Board is an advisory body chiefly concerned with transboundary flow of water. Most of the conflicts arising from management of the Peace-Athabasca Delta involve allocation of water within Alberta.

River basin planning by the Province of Alberta would provide an opportunity for Environment Canada-Parks to represent its interests. The planning would be more effective for Environment Canada-Parks if development of plans for the Peace, Athabasca, and Slave rivers were closely coordinated. Environment Canada-Parks and the Federal government may be able to stimulate interest in such an approach by offering Alberta technical assistance and funding.

Managers of resources outside the Delta can be expected to be reluctant to enter into any process which could limit their future activities. It is, however, in their interest to become involved in proactive management approaches to avoid serious conflict. The province of Alberta controls resources both within and outside of the Delta and can be expected to desire resolution of conflicts. The Federal government, which also desires resolution of conflicts, can initiate river basin planning under the Canada Water Act of 1970. This was done in a number of basins, but only a few of the studies resulted in implementation agreements. This

approach has not been attempted since 1981 (Pearse et al. 1985), but could still be used by the Minister of Environment to initiate planning on the Peace, Athabasca, and Slave rivers with Alberta.

Although river basin planning will eventually be required for the Peace, Athabasca, and Slave rivers when resource demand exceeds supply, such a formal approach may not be needed at present. An alternative, and more preferable, solution to river basin planning is negotiation.

Numerous examples of successful conflict resolution through negotiation exist (Susskind and McCreary 1985). Negotiation is an entirely voluntary process, and involved parties can walk away from the process at any time. Gusman and Huser (1984) found this to be a very important factor when participants were government agencies with mandates to protect. Before negotiation starts, all involved parties must be committed to reaching a solution. Solutions are entirely voluntary, and agencies are free to break the agreement at any time. A solution achieved through agreement involves tradeoffs by all sides but should ultimately be more acceptable than court imposed decisions. Mediation or facilitation of negotiations has been successful in cases of disagreement that led to an initial breakdown of negotiations. Pearse et al. (1985) suggest that the federal government institute legislation to create a body which could facilitate negotiation, and that would give the

agreement the force of law. Such a solution may prove to be inflexible, but would provide the parties with assurance the that agreement was binding. Negotiation does not become effective until all parties involved desire a solution to the conflict.

A combination of river basin planning and negotiation could be used. A similar approach was used in Manitoba by branches of the Department of Natural Resources to settle resource allocation conflicts on the east side of Lake Winnipeg in Manitoba (Thomasson et al 1982). Land use planning and negotiation were used to define and resolve a number conflicts in the region (G. Jones, Parks Branch, Province of Manitoba, pers comm.). When agreement was not reached through negotiation over a timber harvesting conflict within provincial park boundaries, senior departmental staff became involved, and established a compromise solution. Many non-government groups excluded from the planning and negotiation stages objected to this solution, which was subsequently amended at the political level. It is important that all interested parties are allowed input into decision making so that there is a consensus over negotiated settlements.

## 5.3 DISCUSSION

The Peace-Athabasca Delta and associated water bodies are valuable economic and natural resources. How these values are allocated in the future will determine how much benefit is realized. Exploitation of these resources is still at an early stage, thus, management decisions being made now will have long term consequences. At present the decision making process is inefficient at providing carefully considered allocation of resources among regional users. Because the Peace-Athabasca Delta is created and maintained by natural water regimes, it is susceptible to altered inputs caused by developments beyond the control of Environment Canada-Parks.

Decisions involving control structures are the responsibility of the Peace-Athabasca Implementation Committee, although the Implementation Agreement needs to be evaluated and renewed before such action could be taken. Desired water conditions on the Delta, a responsibility of the Implementation Committee, and the water regime of inflowing rivers, a responsibility of a variety organizations, are important considerations for control structure decisions.

A number of regulatory management approaches were identified. Reactive management through the requirement of environmental impact assessments when a project may affect Park land has been applied in the past. Proactive management

approaches were also discussed. River basin planning can be initiated by the Mackenzie River Basin Liaison Committee, the Federal Government, the Alberta Government, or by a joint effort. The establishment of a forum to facilitate negotiation could provide a less structured approach than river basin planning. A combination of river basin planning and a negotiation forum is an alternative.

Projects which could have a significant influence on the water regimes of inflowing rivers are in various phases of planning. Ultimately conflicts could be minimized through river basin planning. River basin planning can be a very expensive, unproductive exercise, but some form of planning needs to be pursued if conflicts over use of the Peace, Athabasca, and Slave are to be reduced. Low key negotiations could be used as a technique to clarify potential conflicts between any users of these rivers. Information needs and possible institutional arrangements identified through these negotiations could lead to more formal arrangements (such as a river basin planning authority) as they became necessary. Legislation exists which would allow both the Federal and Alberta Governments to establish river basin planning. Although Environment Canada-Parks would likely be required to make trade-offs under such an arrangement, Environment Canada-Parks would be better able to ensure the Delta would be preserved in as natural a condition as possible. To achieve the mandated

objective of preservation, Environment Canada-Parks should initiate negotiations leading to improved monitoring, evaluation, and decision making.

# Chapter VI

# SUMMARY AND CONCLUSIONS

The Peace-Athabasca Delta is a resource valuable to a wide variety of users. The complexity of biophysical factors and resource demands from within and outside the Delta make management a difficult task. Resource use has placed conflicting demands on the Delta system, necessitating the development of both physical and regulatory mechanisms to facilitate management. In this report the Delta system, the variety of resource uses, and alternative management strategies have been examined.

## 6.1 SUMMARY

Underlying the entire issue is water. It is the central factor maintaining the biophysical system and is the desired resource over which use conflicts are occurring. Water is the factor physical and regulatory management have focussed upon most directly.

In Chapter 2, Natural Processes Within the Delta, the biophysical system is defined. Water regulates this system through fluctuations in seasonal and long term regimes. The resulting geomorphological features and plant communities influence animal populations. The resilient Peace-Athabasca

Delta remains stable over the long term, maintained by cyclic disturbances.

In Chapter 3, Resource Use, Past, Present and Future, the demands placed on the Delta resources over time from both within and outside the Delta are identified. Demanded resources depended either directly or indirectly on water, and uses are both consumptive and nonconsumptive. Conflicts over use already exist, and an increase in water use requirements in the future potentially could create considerably more conflict.

Chapter 4, Physical Management, contains a discussion of the requirements of a physical management structure. Physical management control structure options are described. The options are evaluated, but the choice of a control structure is dependent on what water conditions managers desire, and the flow regime in inflowing rivers.

In Chapter 5, Regulatory Management, the existing jurisdictional and institutional situation is described. Regulatory management is evaluated. Changes are required in the decision making process for the Delta and associated rivers to reduce the potential for conflict over resource allocation.

## 6.2 CONCLUSIONS

The key process which has created and will continue to maintain the Peace-Athabasca Delta is the water regime. Alteration of the incoming regime by upstream activities (W.A.C.Bennett Dam) has affected natural processes within the Delta. Further alterations of incoming waters are likely to occur in the future. In order to return the Peace-Athabasca Delta to a state which would have existed without these alterations, and to protect the Delta from further alterations, Environment Canada-Parks management objectives must focus on the water regime.

The Peace-Athabasca Delta is a resilient system. Although the water regime has been altered since construction of the W.A.C.Bennett Dam in 1967, conditions which have occurred could conceivably have occurred naturally. The Delta has responded naturally to these changing conditions. Under natural conditions, periodic flooding and drought occur sporadically. Without these cyclic fluctuations relationships within the Delta system will begin to change, leading to an unnatural system. In order for Environment Canada-Parks to maintain the Delta in as natural a condition as possible, such fluctuations must be maintained.

There are a number of users involved in conflicts over resources associated with the Peace-Athabasca Delta. Most of these conflicts do not represent a threat to long term

maintainance of the Delta, such as outstanding land claims by local Native groups. Other conflicts involve large scale projects which can cause significant changes in the Delta system. These projects are located beyond Park boundaries leaving Environment Canada-Parks with little control over actions taken by proponents of these projects. Conditions on the Peace-Athabasca Delta can be maintained in as close to a natural condition as possible by pursuing both physical and regulatory management alternatives. In the absence of natural controls (i.e. altered water regime), Environment Canada-Parks mandate directs them to seek approaches which will recreate those natural controls.

Physical management primarily involves control structures on the Delta to regulate water levels. It also includes management of projects on the associated rivers, to ensure sufficient flows enter the Delta to allow operation of a control structure. Physical management of these projects lies under the jurisdiction of other agencies, and thus is a regulatory management problem for Environment Canada-Parks.

A gated concrete and rock control structure located on the Slave River provides the greatest degree of control over water conditions on the Peace-Athabasca Delta, but is the most expensive. For the short term a combination of maintaining the existing weirs, while inducing ice jamming on the Peace River as required, may provide an adequate alternative. Ice jamming techniques need to be further

developed before they can be applied. If proven feasible, ice jamming could be used while a gated control structure was designed. A gated structure would not be required until altered inflows to the Delta render ice jamming and the existing weirs ineffective, or if ice jamming is not feasible. Because a gated control structure provides sophisticated control of water levels, a greater degree of altered flow could be overcome. This would allow Environment Canada-Parks to maintain natural conditions while some development occurs in the future.

Regulatory management is critical to long term maintenance of the Peace-Athabasca Delta. Within the Delta itself, regulatory management is coordinated through the Peace-Athabasca Delta Implementation Committee. The Implementation Agreement will be reviewed in September, 1986, at which time existing inadequacies can be reviewed. Some of these problems include: the need for an evaluation of the existing weirs; the need to further develop physical management alternatives; and the need to establish an implementation mechanism through which a control structure could be constructed.

Regulatory management beyond the Delta is much more difficult for Environment Canada-Parks to influence. There is at present no formal mechanism available to coordinate management of the resources of the Peace, Athabasca, and Slave rivers. The Federal Government can initiate an

environmental impact assessment,as it did with the Slave River hydroelectric project. This approach of dealing with major projects on a reactive basis only provides short term solutions to individual conflicts.

Both Alberta and the Federal Government are free to enter into river basin planning to provide long term regulatory management of the rivers involved. Eventually such a rigid approach may become necessary. At present, a loosely structured negotiation forum could be formed through which all interested parties could meet and seek resolution of conflicts. Initially this would involve identification and clarification of present and future conflicts. Information requirements could be identified, and an agreement to provide for monitoring, analysis, and action could be negotiated. As conflicts become more serious a more structured forum must be developed to facilitate negotiation.

It is essential that negotiation be open to all interested parties throughout all stages. Through negotiation, mutual agreements are reached by making trade-offs. Parties not involved in the decisions to make trade-offs are unlikely to accept them. Thus, public participation must be part of the negotiation process.

If a more structured approach to regulatory management of the Peace, Athabasca, and Slave rivers is developed,

Environment Canada-Parks will have a better opportunity to defend its mandated interests. It is in Environment Canada-Parks interest to initiate negotiation to resolve conflicts. The resources involved will, however, become subject to conflicts between other parties, so other users of resources will benefit from establishment of a negotiation forum.

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