Inquiry on Federal Water Policy
Research Paper # 18

WATER AND CANADIAN AGRICULTURE: SELECTED ISSUES

by

Gary Bowden and Marv Anderson

Gary Bowden is with Clayton Consulting Services, Vancouver
Marv Anderson is with Marv Anderson & Associates, Sherwood Park, Alberta

April 1985

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn
Director of Research

Abstract

This paper reviews selected issues in water use in Canadian agriculture. Agriculture is a major consumptive user of water in Canada, and as production grows, water consumption may increase significantly - particularly for irrigated agriculture in the Prairie provinces. Associated with the expansion of agriculture across Canada are concerns about resource degradation-soil erosion and salinity, flow depletion, water quality deterioration, and adverse impacts from drainage.

Implicit in the recognition of these concerns is that water is no longer freely available for use in agriculture. This requires in turn a re-thinking of past approaches where governments have been almost universally willing to underwrite the majority of costs associated with supplying water for agriculture.

Recognizing that using water in agriculture may impose costs elsewhere in the economy does not necessarily mean that use in agriculture should be curtailed, however. There needs to be consideration of whether the gains from use in agriculture exceed the costs imposed elsewhere. As far as federal participation is concerned, it is not clear that this question is being consistently asked.

It should be, and the report recommends application of the federal benefit-cost guidelines to projects in which there is federal participation. It is also recommended that consistent standards and procedures for federal participation in water resources development in Canada be established.

Résumé

Ce rapport passe en revue quelques-unes des questions reliées à l'utilisation de l'eau pour l'agriculture au Canada. L'agriculture est une importante consommatrice d'eau au Canada et, la quantité d'eau consommée pourrait augmenter de façon importante à mesure que la production croîtra; ceci est particulièrement vrai dans le cas de la culture à partir de terres irriguées dans les Prairies. Certaines préoccupations peuvent être associées à une expansion de l'agriculture à travers le Canada: dégradation des ressources - érosion et augmentation de la salinité des sols, diminution de la quantité d'eau disponible, détérioration de la qualité de l'eau et impacts négatifs du drainage des terres.

Le fait que l'eau n'est dorénavant plus disponible gratuitement pour l'utilisation en agriculture est sous-jacent à ces préoccupations. Cette situation exige que l'attitude antérieure des gouvernements qui consistait à accepter d'absorber la majorité des coûts associés aux projets d'approvisionnement en eau pour l'agriculture soit repensée.

La reconnaissance du fait que l'utilisation de l'eau en agriculture puisse résulter en des coûts suplémentaires quelques part ailleurs dans l'économie ne signifie pas nécessairement que les quantités utilisées devraient être réduites. On se doit de vérifier si les bénéfices engendrés par l'utilisation de l'eau en agriculture sont supérieurs aux coûts imposés ailleurs. Il n'apparaît pas clairement que cette question soit posée de façon constante au niveau de la participation fédérale.

Ceci devrait pourtant être le cas et le rapport recommande la mise en application des lignes directrices fédérales de bénéfices-coûts pour les projets auxquels le gouvernement fédéral participe. Il est aussi recommandé que des normes et procédures consistantes appliquables à la participation du gouvernement fédéral dans le développement des ressources hydriques soient établies.

CONTENTS

LIST OF TABLES

INTRODUCTION

This report is written in response to the Terms of Reference issued by the Inquiry on Federal Water Policy for a report on Water and Canadian Agriculture.

The Terms of Reference ask for a number of specific topics to be addressed, including: projections of future agricultural use of water; the capability of agricultural water users to pay for water-related services; adverse impacts of agricultural expansion on other water uses; documentation and critique of federal policies and programs; and recommended changes in federal policies and programs. These tasks follow a logical sequence, and the report is organized into five sections which correspond to them.

It has not been possible to respond to the call for projections of trends in agriculture with more than very broad estimates. This reflects the nature of projections dealing with agriculture, which, because of the fragmented nature of the industry, are necessarily imprecise.

There is a concentration on federal water-related policies and programs in the Prairie provinces. The authors confess, unabashedly, to this "bias". It reflects both the geographic focus of federal programs themselves, and the fact that it is in the Prairie provinces that the continued availability of water for agriculture is an emerging issue.

The report does not find a clearly defined federal policy which focusses on water in agriculture. There is, in Environment Canada, a broad policy with respect to water, and, in Agriculture Canada, policies dealing directly with agriculture. Within each of these are components which deal with water in agriculture. In broad terms the policies are consistent. Insofar as they endorse the efficient use of resources so that Canadians can derive the "greatest social and economic benefit" therefrom, there is little to criticize.

What is identified, however, is a lack of scrutiny to ensure that federal actions do serve the broad policy objectives. The scope of this study does not extend to the evaluation or assessment of specific programs or proposals, nor to a retrospective evaluation of various projects. We are limited, therefore, to the observation that without a commitment to consistent, rigorous, program and project evaluation there can be no assurance that federal activities dealing with water in agriculture will in fact contribute to the "greatest social and economic benefit" for Canadians. Application of principles that have already been enunciated in the federal benefit-cost guidelines to programs and projects dealing with water in agriculture would do much to ensure both efficiency and consistency - which are presently lacking.

1. AREA AND YIELD PROJECTIONS AND IMPLICATIONS FOR USE OF WATER

Agriculture is a major water user in Canada. Daily withdrawals from surface or ground water reservoirs are estimated at 8 billion litres. This is far less than the 37 billion litres withdrawn for use in manufacturing or the 54 billion withdrawn for thermal power generation. But, unlike these other major water users, over 50 percent of the water withdrawn for agriculture is consumed, primarily for irrigation and stock watering. The result is that in terms of actual consumption of water, agriculture ranks higher than any other industry (17).

Significant changes in the nature or magnitude of the agriculture industry could have important implications for water resources. In the same context the availability and cost of water may have a strong bearing on the future direction of agriculture in many areas of Canada. Of particular interest in this paper is how anticipated changes in agricultural acreage and yields will impact on the water resource, in both a quantitative and qualitative context.

Land Base

The process of change in Canada's agricultural land base is markedly different between what have been described as the "agricultural heartlands" of the east and west. In the western heartlands, west of the Manitoba-Ontario border, the years 1961 to 1976 saw an increase of 2.5 million hectares in total farmland, and, significantly, a greater increase of 3.7 million hectares in improved farmland. During the same period the eastern heartlands, primarily in Ontario, recorded a decrease of 3.9 million hectares in total farmland, and 1.3 million hectares in improved farmland (32).

These trends are expected to continue, with significant expansion of the agricultural land base limited largely to the Prairie provinces. Projections of changes in the improved area in western Canada indicate that it will continue to increase at least until 1990, and probably well beyond (1, 8, 14, 23). While there are differences of opinion regarding the projections, an estimate of approximately 120,000 additional hectares per year is probably a reasonable rate of increase to expect to 1990 (8).

In the Prairie provinces these projected increases do not appear to be conditional upon strong market prices. Rather the phenomenon has been on-going since at least 1951 and reflects the structure of agriculture in those provinces (45). Data for Alberta, for example, indicate that relatively strong agricultural prices during the early 1970s were correlated with a decline in the rate of growth in cultivated area while relatively soft prices in the late 1970s were correlated with an increase in

the rate of growth in cultivated area.

The annual increase in improved area in the Prairie provinces will continue to come largely from three sources, conversion of improved pasture to cropland, drainage of wetlands and reduction of summerfallow.

Converting 10 percent of the improved pasture to crop land could increase the cropped area on the Prairies by roughly 300,000 hectares (about 1 percent), based on 1981 Census data. The on-going drainage of wetlands, however, is the most likely source of additional cultivated area. If one assumes that the wetland areas on the Prairies are approximately equivalent to 10 percent of the total cropped area in size, and that half of this area could be economically drained, this would add about 5 percent, or 1.2 million hectares, to the 1981 cropped land base. Increasingly, the agricultural policy thrust across Canada is being directed towards getting these wetlands into production (2,13,15).

The current trend towards summerfallow reduction across the Prairies will further increase the cropped area. One study suggests that summerfallow acreage may decline by 20 percent in Alberta, 24 percent in Saskatchewan and 33 percent in Manitoba, over the decade 1981 to 1990 (8).

Elsewhere in Canada the prospects for significant increases in the improved or cultivated area are not as strong. In British Columbia opportunities to expand the agricultural land base are limited, and any major new expansions will require withdrawals from competing uses (forestry, recreation). Government policy has in recent years favored the release of Crown land to agriculture, and has included low interest loans for land clearing. The efficacy of these policies is currently being questioned, however, and in the next decade expansion of the cultivated land base is expected to be far below the 16,000 hectares per year average of the 1961 to 1976 period.

Ontario experienced a decline of 390,000 hectares of improved farmland, 1961 to 1976. On balance this decline is expected to continue, although it is expected that some new land will be added to the improved category, partially offsetting other land that is withdrawn. Drainage of wetlands is likely to be the greatest source of new improved farmland in Ontario. Some 1,200,000 hectares are presently serviced by subsurface drains, and one estimate indicates that there are an additonal 1,500,000 hectares which would benefit from installation of such drains (38).

In Quebec and the Atlantic provinces there was a collective reduction of 2.6 million hectares of total farmland, 1961 to 1976, and a reduction of 955,000 hectares of improved farmland. Some abatement in the rate of decline is expected, and drainage programs may bring some additional land into production, particularly in Nova Scotia (36). Overall, however, expansion in the agricultural land base is not forecast for Quebec and the

Atlantic provinces (with the exception of some small areas in Newfoundland).

Yield Changes

Yield projections for both western and eastern Canada are optimistic with regard to growth potential (1, 8, 23). Overall, the expected average annual yield increase for Western Canada is expected to be about 1 percent. This estimate gives considerable weight to the yield depressing impacts of expanding onto inferior lands, and continued soil degradation (31). Yield increases in eastern Canada can be expected to be of the same magnitude.

Yield increases typically arise from several sources, the most important being:

a) Dryland Cultural Practices

Greater use of fertilizers and agricultural chemicals and the adoption of water management strategies (snow trapping, shelterbelts) are on-going changes which improve crop yields. The management aspect in farming is becoming more critical to obtaining top yields (through variety selection, timing of operations, and related matters).

b) Genetic Improvements

Research scientists are involved in developing varieties which are more drought resistant, respond better to fertilizer and mature more quickly than those currently in use. While the importance of genetic improvements to overall yield increases is uncertain, recent estimates suggest that they may account for 20 percent of total yield increases (31).

c) Irrigation

A profile of the present extent of irrigation in Canada is provided in Table 1.1. Perhaps 5 percent of the farmers in Canada have some irrigation; about 1 percent of the improved farmland in Canada is irrigated.

Irrigation in Canada is concentrated in the west, and within the west primarily in Alberta. In 1980, nearly 400,000 hectares were irrigated in Alberta, approximately 100,000 in British Columbia, 56,000 in Saskatchewan and 7,000 in Manitoba. Elsewhere in Canada there are about 40,000 hectares under irrigation in each of Ontario and Quebec. In the Atlantic provinces irrigation is much more limited, less than 3,000 hectares, and frequently resorted to only in very dry years.

Irrigated yields for any given crop are much higher than under dryland conditions, although yields obtained in production still remain far below the potential achieved under experimental conditions (29, 39). There is a significant potential to increase the irrigated area in Canada, which would lead to both increased yields for some crops, and in some areas shifts to new crops to take advantage of water availability.

In British Columbia irrigated area is expected to continue to grow by some 1,000 hectares per year through to about 1995. In the Prairie provinces there are an estimated 2.8 million hectares in the South Saskatchewan River basin which are suitable for irrigation, .5 million hectares of which might be irrigable with conventional irrigation practices and existing water supplies in that basin (5). In Alberta in the next two decades an increase of 150,000 hectares over 1982 levels is a realistic growth projection. The Alberta Minister of Agriculture has recently announced a $150 million, five year, program for rehabilitation and expansion of irrigation systems. The long term goal of the program is to increase irrigable area by 160,000 hectares by 1995.

With the development of the Gardiner Dam in Saskatchewan irrigation potential was estimated to be approximately 160,000 hectares. Although only some 55,000 hectares are currently irrigated, projected growth to 1990 is approximately 2,500 hectares per year (23). In Manitoba the expansion of irrigated agriculture is not expected to exceed 250 hectares per year over the next decade, from a current base of some 7,000 hectares.

In Ontario, where 40,000 hectares are presently under irrigation, any future increase in irrigated area for major crops (corn, soybeans, white beans) is expected to be constrained by the availability of water, as well as labor and capital costs (38). Prospects for increased irrigation area in Ontario are, therefore, modest, and the situation in Quebec is similar. In the Atlantic provinces the expectations regarding irrigated area are also modest. Irrigation is expected to continue to be relied on during very dry years, and there may be some growth in connection with the expansion of horticultural production.

Overall Output Changes

There are several projections of increased production for the Prairie provinces. One, summarized in Table 1.2, indicates an increase of approximately 9 million tonnes (21%) over 1981 production to just over 50 million tonnes by 1990 (8). The major contributors to this increase are expected to be new land, 21.3%, reduced fallow, 48.5%, and improved yields, 30.2%. Other projections (23) call for production in the three Prairie provinces to be between 43 and 49 million tonnes by 1990. Both projections suggest that crop production approaching 50 million tonnes may be possible on the Prairies by 1990.

Longer term, 1975 - 2000, supply response projections for the west by Agriculture Canada for two levels of price increases are even more optimistic - an increase of 77% for the low price scenario and 100% for the high price scenario (1). Similarly, grain production (to 2000) for eastern Canada has been calculated to increase by 117% for the low price scenario, and 131% for the high price scenario over 1975 levels (1). The source of the production increase in the east would be largely yield improvements, as opposed to increases in the land base which are expected to contribute significantly in the west.

Implications for Use of Water

The major implication of the projected changes in agricultural output for use of water arises from direct withdrawal for irrigation. Other implications include water quality, as affected by erosion and siltation, and use of water by others which will be affected both by irrigation withdrawals and wetland drainage. These latter implications are addressed in Section 3 of this report and are touched on only briefly here.

The impact on regional water use of increasing the area under irrigation will depend on factors such as the kind of crops grown and average consumptive use (gross diversion less return flow). Unit consumptive use, in turn, depends on precipitation levels, irrigation operating practices and irrigation efficiencies. During the period 1973 to 1978 water use per acre in five Alberta irrigation districts ranged from 3,700 to 5,800 cubic metres per hectare (1.2 to 1.9 acre feet per acre) (4).

If irrigation efficiencies remain similar in future it implies a requirement of about 4,000 cubic metres of water for each additional irrigated hectare (1.5 acre feet per acre). With some 200,000 hectares of additional irrigation expected on the Prairie provinces, this implies a requirement for an additional 800 million cubic metres (750,000 acre feet) of water annually by about 1995. This is the most concentrated requirement seen across the country. The additional irrigation in British Columbia will require in the order of 4 million cubic metres per year, from diverse sources scattered throughout the province.

In Ontario and Quebec combined the expansion can be expected to require roughly 3 to 4 million cubic metres per year. Additional requirements in the Atlantic provinces will be far less, probably not even 5 percent of the forecast for Ontario and Quebec.

These requirements are predicated on maintaining present water use efficiencies. Between 1961 and 1978 effective irrigation water use efficiencies in the Alberta portion of the Saskatchewan- Nelson River basin were estimated to be between 47 and 63 percent in every year except 1966. Any improvement that can be achieved in irrigation efficiencies implies lower water losses and more area irrigated per unit of water delivered. To the extent that water management can be improved, irrigated areas can actually increase with no increase in the volume of water

diverted for irrigation purposes. Because of the potential for such increases, the above estimates should be regarded as upper limit water requirements for expanded irrigated area.

Projections of increased agricultural production through expansion of the land base have focussed concern on the resource degradation issue. New lands tend to be more marginal, for one reason or another, and subject to greater risk even with the application of modern farming techniques. Greater on-farm water erosion will in all likelihood be associated with expansion of the land base, with consequent adverse impacts on water quality. Offsetting or dampening this impact, the current direction of dryland cultural technologies will improve on-farm water management, and the anticipated reduction in summer fallow will reduce water erosion problems (as well as secondary soil salinity).

The availability of water to be used by others will be directly affected by irrigation withdrawals, and also by draining and consolidation of wetlands. Increased agricultural use of wetlands will impact directly on water use through:

- drainage, which will reduce the number and area of surface water bodies, thereby augmenting streamflows and decreasing groundwater levels,

- intensifying the conflicts over the use of remaining water resources.

Composite projections for agricultural water use to the year 2011, by drainage basin, in terms of both withdrawals and consumption, are provided in Table 1.3. These projections suggest "more of the same". Already regionally concentrated water demands for agriculture are generally expected to become even more concentrated.

Finally, it should be noted that the implications traced above assume that the future will reflect the past. In particular, it is generally assumed in making agricultural projections that the market price for water (to agricultural producers) will continue to be near-zero. In contrast, implicit real price changes for land, fertilizer, and other inputs are considered in these projections. This effectively means that the technological evolution envisaged has a strong bias in favor of irrigation-intensive options.

Under different price or policy assumptions regarding the supply of water for use in agriculture, it is reasonable to expect that output can be increased with a much less than proportional increase in the use of water. Indeed it is conceivable that the output projections could be realized with little or no change in water demand - through better use and managment of available precipitation, crop expansion and intensification excluding irrigation expansion.

Table 1.1

IRRIGATION IN CANADA, 1971 and 1981

Province/Region	No. of Farms*			Irrigation Farms as % of Total Farms	Irrigated Area (ha.)			Irrigated Area as % of Total Improved Land
	1971	1981	% Change		1971	1981	% Change	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Newfoundland	8	n.a.	-	1.2	50	n.a.	-	0.5
P.E.I.	17	n.a.	-	0.5	219	n.a.	-	0.1
Nova Scotia	160	n.a.	-	3.2	755	n.a.	-	0.4
New Brunswick	138	n.a.	-	3.4	1,267	n.a.	-	0.2
MARITIMES	323	-	-	2.5	2,291	-	-	0.4
QUEBEC	2,418	n.a.	-	5.0	37,609	n.a.	-	1.6
ONTARIO	3,880	n.a.	-	4.7	40,272	n.a.	-	0.9
Manitoba	151	283	87%	1.0**	2,968	6,935	134%	0.1**
Saskatchewan	918	1,277	39%	1.9**	31,372	55,913	78%	0.3**
Alberta	3,678	4,159	13%	7.2**	217,539	393,969	81%	3.1**
PRAIRIES	4,747	5,919	25%	3.8**	251,879	456,817	81%	1.2**
B. C.	5,794	6,706	16%	33.5**	89,468	100,475	12%	10.6**
C A N A D A	17,162	n.a.	-	5.4***	421,519	n.a.	-	0.9***

* Number of farms with at least some irrigation.
** In 1981. All based on farm numbers and farmland areas in 1981.
*** In 1971. Based on farm numbers and farmland areas in 1981.

Source: Statistics Canada, Census of Agriculture, 1971 and 1981.

Table 1.2

TOTAL POTENTIAL PRODUCTION INCREASE
IN THE PRAIRIE PROVINCES TO 1990

Crop	Production 1981 (,000 tonnes)	Increase ,000 Tonnes	Increase Percent
Crop:			
Wheat	23,835	3,874.5	16.2
Oats	2,529	785.8	31.1
Barley	12,628	3,467.7	27.5
Flaxseed	468	131.6	28.1
Canola	1,814	548.0	30.2
TOTAL	41,274	8,807.6	21.3

Basic Source: (8)

TABLE 1.3

AGRICULTURAL* WATER USE, 1981 and 2011 PROJECTIONS
(millions of cubic metres)

Drainage Basin	Withdrawals			Consumption		
	1981	2011 low	2011 high	1981	2011 low	2011 high
1.Pacific Coastal	--	--	--	--	--	--
2.Fraser-Lower Mnld.	258	214	543	144	120	304
3.Okanagan-Similk.	254	300	681	142	122	307
4.Columbia	33	27	70	18	15	39
5.Yukon	--	--	--	--	--	--
6.Peace-Athabasca	--	--	--	--	--	--
7.Mackenzie	--	--	--	--	--	--
8.Arctic Coastal	--	--	--	--	--	--
9.Milk	46	43	108	38	34	88
10.N. Saskatchewan	94	86	220	76	70	178
11.S. Saskatchewan	1963	1804	4586	1586	1457	3704
12.Assiniboine-Red	188	172	440	152	139	355
13.Winnipeg	1	1	2	1	1	2
14.Lower Sask.-Nelson	28	26	65	22	21	53
15.Churchill	--	--	--	--	--	--
16.Keewatin	--	--	--	--	--	--
17.Northern Ontario	--	--	--	--	--	--
18.Northern Québec	--	--	--	--	--	--
19.Great Lakes	129	110	273	107	90	230
20.Ottawa	28	23	57	24	20	51
21.St. Lawrence	65	52	132	64	51	130
22.North Shore & Gaspé	8	6	16	8	6	15
23.St. John-St. Croix	2	1	4	2	1	4
24.Maritime Coastal	8	6	17	8	6	17
25.Newfoundland	1	1	2	1	1	2

* Includes irrigation and stockwatering

Source: Adapted from D. Tate, Alternative Forecasts of Canadian Water Use, 1981-2011, forthcoming Research Paper for Inquiry on Federal Water Policy, Ottawa 1985.

2. CAPABILITY OF AGRICULTURAL PRODUCERS TO PAY FOR WATER-RELATED SERVICES [ON-FARM ECONOMIC BENEFITS]

This section of the report addresses the component of the Terms of Reference which calls for analysis of ".... the capability of agricultural producers to pay for water-related services (e.g. irrigation, drainage projects) in relation to other water users." In so doing it deals first with the capability of agricultural producers to pay for water-related services, a capability which is defined to derive from, or be equated with, the net on-farm economic benefits from those services. Following that there is a brief review of how that capability relates to other users of the water resource, and finally a discussion of the prevailing practices in charging for water-related services.

Capability to Pay [On-Farm Economic Benefits]

The phrase "capability to pay" is customarily used in discussions of public finance to refer to the wealth or income of taxpayers. In this report, however, a more stringent definition has been adopted. We are not interested in the absolute wealth or income of farmers, but in the net economic gains (or income) which they derive from water-related services. This provides what we believe to be a more relevant measure for the purposes of the Inquiry, and for addressing the balance of this component of the terms of reference "... in relation to other water users."

Irrigation and drainage services will contribute to on-farm economic gains in a variety of ways. In the case of irrigation, gains may arise from intensification, diversification and enhanced income stability. Crop intensification can be dramatic, and in areas where supplemental moisture has a relatively high payoff yields can be increased by factors of from 2 to 10, depending on the crop. Diversification opportunities are also important. With irrigation farmers can, by growing a wider variety of crops and in some cases by integrating livestock production and feed production, reduce the variability of their incomes. Finally, because moisture levels can be managed through irrigation, production levels are less volatile and incomes are further stabilized.

> "The drought of 1980 is a prime example of the value of irrigation when livestock operations in Saskatchewan had to rely to a large degree on Alberta produced forage to maintain dairy and breeding herds. The benefit of irrigation during periods of drought is but one factor that has been neglected in determining the viability of Canadian irrigation projects." (17)

Through often complex interactions, forces such as those identified above increase the net income or economic gains which farmers may realize from the use of their land. In the case of irrigation it is generally anticipated that there will be an increase in gross annual incomes, from greater yields or from a shift to new and more valuable crops. When all of the costs incurred in order to generate the increases in gross income are deducted, the balance or incremental net economic gain represents the contribution of the irrigation water to income. If the full costs of labor and all other inputs are deducted in calculating this residual, it also represents the amount that could be paid for the irrigation water - the farmer's "capability to pay" as defined for this paper.

In the case of drainage services provided to land the analysis would follow the same principles, with the net economic gain or "capability to pay" deriving from the net contribution of the drainage service to annual income.

The net economic gains realized by landowners, or on-farm economic benefits, from irrigation have been examined in numerous studies. Two approaches are favoured: an "accounting" approach in which costs and returns are estimated on the basis of accepted production standards; and a land value approach where inferences about the net gains realized by landowners are drawn from comparison of the market values (selling prices or annual rents) of irrigated and non-irrigated land.

The estimates derived from the "accounting" approach are sensitive to variations in assumed product prices and yields, and are both crop and site specific. Despite this, over fairly wide areas the estimates correspond reasonably well, and are actually quite consistent for individual crops. Estimates of the maximum long-term economic value of water for agricultural purposes in southern Alberta suggest an average value of from $100 per hectare ($40 per acre) to $210 per hectare ($84 per acre). For some individual crops (corn silage, sugar beets, potatoes), however, the values are estimated to be from $375 to $850 per hectare ($150 to $340 per acre) (28).

A recent United States study suggested that the absolute maximum ability to pay for water would be around $120 per acre-foot ($300 per hectare for crops requiring one acre foot of water). This is above the average for southern Alberta, but is not inconsistent with the estimates for some of the higher valued crops (22).

As discussed subsequently, it has not been the practice in Canada to base the charges for irrigation or drainage services on the contribution which they make to the primary producer's net income. To the extent that the charges for such services are less than their contribution to net income, the net gain realized by the landowner will rise. The market for farm land effectively translates this increase in the residual return into either higher annual rentals or higher land prices. By looking at land prices and rental rates, the "land value" approach draws

inferences about the value of irrigation (more specifically, about that part of the value of irrigation that is not captured in charges for the water).

Some evidence that is directly applicable to this approach can be found in the PFRA submission to this Inquiry (42) which states that dryland around Outlook, Saskatchewan may sell for $1,235 per hectare, with irrigable land selling for $1,850 per hectare ($500 and $750 per acre, respectively). Other things being equal, this difference of some $615 per hectare ($250 per acre) in the selling price of irrigated versus dryland will reflect the capitalized value of the water's net annual contribution to income - over and above what is charged for the water. These figures are reasonably comparable to those in an earlier study (28) which found a difference of $535 per hectare ($214 per acre) between the selling price of irrigated land and dryland in southern Alberta.

The Alberta study suggested that if farmers were using a discount rate of 5 per cent in capitalizing their net annual economic gains (in excess of what they pay for water fees) from irrigation, the average annual value was in the order of $27.50 per hectare ($11 per acre). Adding to this the annual per hectare water fees in the Irrigation Districts of roughly $14 ($5.50 per acre), indicates that the total contribution of irrigation water to income (the net economic gain) was in the order of $42 per hectare ($16.50 per acre). It is notable that the water fees only captured about one-third of this value, with the rest being capitalized into land values.

A similar calculation can be performed with the data for the Outlook area of Saskatchewan, referred to above. Here the difference in the selling price of irrigated versus non-irrigated land, $615 per hectare, would reflect an annual value to the farmer (in excess of water fees) of $31 per hectare ($12.50 per acre). Farmers in six PFRA projects in Saskatchewan pay $11.25 per hectare ($4.50 per acre) per year for full irrigation services (storage, conveyance and distribution). If those rates are applicable in the Outlook area, it suggests that the total contribution of irrigation water to annual incomes is, as in Alberta, about $42 per hectare ($16.50 per acre). In this case, however, it appears that only about one-quarter of the annual value is captured in the water fees, with three-quarters being capitalized into land values.

Finally, estimates of the contribution of water to incomes can also be obtained by looking at the difference in annual rents paid for irrigated versus non- irrigated land. In southern Alberta dryland is said to rent for $62 to $100 per hectare, while irrigated land rents for $148 to $200 per hectare (42). Other things being equal, the differences, $80 to $100 per hectare ($32 to $40 per acre), can be taken as a reflection of the annual net contribution of irrigation water to income - over and above what is actually paid for the water.

The estimates based on annual rentals indicate a significantly larger contribution to income than those derived from the selling price of land. These may provide a more accurate measure of the annual value of irrigation water, insofar as rental rates are directly observable and this approach requires fewer assumptions about the economic behaviour of farmers. (One factor alone, the discount rate that is assumed to be used by farmers in determining land values, can have a marked effect on the analysis which works back from differences in the selling price of land.) On the other hand, the differences between the two approaches which are noted here may simply reflect that the observations on which they are based were not derived through a rigorous selection process, and that the areas to which they refer may not be truly "comparable".

The reader is cautioned against imputing too much precision to these estimates. The more important points are that irrigation water does make a fairly substantial contribution to net annual incomes (on-farm net gains or economic benefits), and that those who supply the water capture only a fraction (one-quarter to one-third) of that value in the water fees.

The situation with respect to irrigation water is believed to be similar throughout the rest of Canada. Irrigation water will make a positive contribution to net annual income, with the magnitude of the contribution varying markedly with the type of crop being grown, location, soil, and other factors. It is also the case that, as in the examples cited above for Alberta and Saskatchewan, the charges which are levied for irrigation water generally capture only a portion of its value, as measured by its contribution to net income.

Of fundamental importance in this discussion of the value of water in irrigation is that the figures which have been examined relate only to the benefits accruing to landowners, in excess of their on-farm costs (on-farm economic benefits). It cannot be inferred from these data that there is any overall net economic gain, viewed from a province or nation-wide perspective, from irrigation. That depends on the relationship between the off-farm costs of supplying irrigation water - which are borne almost exclusively by governments - and the net gains to farmers. In subsequent discussion, which reviews pricing policy for irrigation, several references are introduced which indicate that the total gains in agricultural production fall far short of the costs of supplying irrigation water.

Circumstances are much the same for drainage services, which can greatly increase agricultural productivity and income (38). We do not have any estimates of the annual contribution of drainage to net incomes, which would in any event tend to be somewhat more site-specific than those for irrigation. As discussed subsequently, charges levied for drainage services do not appear to be based on the contribution to income.

Capability to Pay Relative to Other Users

Agricultural producers generally do not have the same capacity to pay for water as many other users, as indicated by a comparison of the value of water in alternative uses. In both agriculture and industrial uses the value of water is derived from the interaction of product prices and other input costs. In comparison with other industrial uses, the value of water in agriculture is relatively low. This in part reflects the extensive nature of water use in agriculture, as contrasted with more intensive application in many industries.

Estimates from the United States, although somewhat dated, indicate that the value of water in industrial uses will generally be twenty times, or more, higher than in agriculture (see Table 2.1). A more recent comparison indicates that in California the value added per unit of water is 65 times greater in industry than in agriculture (40). The value of water in agriculture does appear to be higher than for either waste load assimilation or hydroelectric power generation (Table 3.4), but much lower than its value in the other non-industrial uses listed.

In making these comparisons between the value of water in alternative uses it should be emphasized that the relative values do not imply that all water should be allocated to the highest valued use, e.g., industry. The actual consumption of water by industry is modest in any event, and as more water was applied to industrial uses the value of the additional water would decline rapidly. A more appropriate goal is to try to allocate water among uses so that its incremental or marginal contribution in each use is roughly equal.

In this context the data from Table 2.1 do not suggest that no water should be allocated to agriculture. They do suggest, however, that extensive agricultural application of water (irrigation) should probably be the marginal user - being supplied only after other demands have been met, and being reduced in favor of other uses in cases of shortage. The exceptions would be waste assimilation and hydroelectric power generation where the data indicate values in crop irrigation to be higher. These are of course broad generalizations, and the particular circumstances surrounding alternative water uses would have to be carefully examined in making actual allocation decisions.

One brief to the Inquiry suggests that we are now approaching the point where those kinds of allocation choices will have to be made. That brief (18) suggests that on the Prairie provinces instream uses have generally been met from the unused portions of water available, with exceptions in low flow years in some basins. This suggests that either those instream uses have been protected in decisions to licence withdrawals for other uses (primarily agricultural and municipal), or that to date there has been sufficient water to meet all demands. The

latter is probably the case in most circumstances, and the brief emphasizes that as the unused portion of available water diminishes, provision will have to be made to adjudicate between competing uses.

Pricing Policy, Water-Related Services to Agriculture

As noted in reviewing the capability of farmers to pay for water-related services, only a part of the on-farm economic benefits (or value) from the use of water is actually recovered in water fees. And while there are often substantial on-farm economic gains from irrigation, it is not clear that irrigation projects generate overall net economic benefits when the off-farm costs of water supply are set off against the on-farm gains. We review here the common approaches to pricing for water-related services, and some information on the latter question - the overall relationship between benefits and costs of irrigation projects.

There are numerous observations, as noted above, about the value of water (the on-farm economic benefits and related capacity to pay) in irrigation. The prices charged for water-related services have not been based on that criterion, however. Instead, historical water management policies in Canada have generally contained elements of three basic approaches to establish what should be paid:

1. Pricing on the basis of the financial costs of providing the service;

2. Pricing on the basis of the beneficiaries' capability to pay;

3. Pricing on the basis of social goals including income redistribution, economic stability, or regional development, and in relation to the socio-economic benefits derived from the service.

Pricing on the basis of the total financial costs involved in providing a water-related service has been almost universally rejected in agriculture, because the direct net farm benefits are almost invariably less than the total costs involved. (This is readily apparent when one considers the relatively small amount of private irrigation that takes place without government intervention.)

Pricing strictly on the capability-to-pay basis (derived, as defined above, from the on-farm net economic gains) requires judgments about the cost or value of various inputs, including the operator's labor, and the resulting estimates vary widely between various areas and for different crops. For these reasons, pricing on the capability to pay basis has not been attractive.

Given the rejection of the above two approaches to pricing, what has emerged can best be described as pricing on the basis of the distribution of economic impacts, or gross economic activity generated. The costs of providing water-related services tend to be pro-rated between direct beneficiaries (farmers) and others on the basis of the ratios between on-farm incomes and "spin-off" economic activity and associated government revenues. Governments of various levels bear directly the share of the costs which would be attributed to the non-farm sectors of the economy. This approach in effect represents a "weak" application of the first two approaches, and a heavy reliance on the third which is seen as justifying the use of water resources to attain "socio-political" goals.

These kinds of analyses are frequently looked upon as providing project justification, for which they are not appropriate, and for which they have been criticized with varying degrees of harshness:

> "Secondary (indirect) benefits can only be counted as benefits within the effeciency analysis if resources are unemployed ... and the spinoff activity truly represents a net gain in economic acitivity and ... the unemployment of resources would be chronic over the life of the project. (Thus), in general, economists remain reluctant to justify projects in terms of their secondary benefits ... Their proper role relates to the objective of regional income distribution as well as to questions of repayment and pricing...." (51).

> "... certain errors in economic reasoning have played a role (in the historical mis-allocation of water resources): among them ignorance of the marginal principle, double counting of benefits, and the use of inappropriately low discount rates. Some advocates of irrigation not only fail to understand economics but also the simplest principles of accounting, and are unable even to distinguish gross from net returns ...." (12).

Information on current practices in pricing or cost sharing for irrigation and drainage services is reviewed below.

Irrigation

A number of government cost-sharing programs are in place to promote soil and water conservation and water enhancement on the Prairies. Alberta Agriculture provides 60 percent funding of eligible costs on projects to control soil erosion, soil salinity, slough consolidation, drainage and channel improvement. It is also responsible for 86 percent cost-sharing of the capital cost of district irrigation system rehabilitation. Alberta Environment provides 75 percent cost-sharing of eligible engineering and capital costs in general water management projects. In effect, with respect to irrigation

in Alberta, this probably means that the farmers' historical contribution to total water delivery costs has not exceeded 5 to 10 percent of off-farm capital costs.

Similar cost-sharing formulae have encouraged irrigation development in Saskatchewan. And a 50-50 capital cost sharing program (for 5 or more farmers interested in irrigation) is also available through the PFRA. In addition numerous provincial and federal technical support services are also provided free of charge to the farmer.

In Alberta existing irrigation farmers (through their largely self-governing Irrigation Districts) are subject to relatively low water rates. The requirement for Alberta Agriculture to pay 86 percent of the cost of system rehabilitation confirms that historical water rates have not been adequate to finance on-going operations and required maintenance. Relatively low water rates also characterize most other irrigation projects in Canada. For example, farmers in six PFRA projects in Saskatchewan pay only $11 per hectare ($4.50 per acre) per year for full irrigation services (storage, conveyance and distribution).

Drainage

There is very little research which specifically focusses on the quantitative long-term socio-economic costs and benefits of drainage. The cost-sharing arrangements for drainage, as indicated in Table 2.2, reflect a similar farmer-government split to those in irrigation.

Summary

Review of present pricing policy for water-related services to agriculture indicates that governments are almost universally willing to underwrite the majority of costs associated with the provision of those services. Thus not only is there no attempt to charge the user for the water resource consumed in irrigation, only a small proportion of the associated costs of delivery of the water to the farm are recovered.

This has probably been necessary for most projects to proceed at all, given the estimate in one recent study that farmers' ability to contribute to off-farm irrigation infrastructure costs (both capital and current) probably does not exceed one half of required operation and maintenance costs and perhaps 10 percent of total costs (30). Given that the farmer's capability to contribute to those off-farm costs derives from the value generated by the water in its on-farm application, if an overall view is taken of the relation between the benefits of such projects and their costs, it is clear that the benefits will fall far short of the costs. It is difficult to argue, therefore, that there is any net economic gain, viewed from the perspective of the national economy in particular, from most irrigation projects.

This willingness to proceed with projects where the direct beneficiaries are able to defray only a fraction of total costs can perhaps be partly explained by a belief that in many areas the availability of water is a critical constraint to growth and that without it there will be little or no development in a given area (18, 27). Thus not only is the on-farm production seen to result from the supply of water, but the associated economic activity in processing and provision of services to the agriculture sector are also attributed to it. This reflects a somewhat parochial view of economic activity, for while economic activity within any given geographic area may depend on the availability of water, if the resources required for a project were employed elsewhere in the economy they could well generate equivalent or greater levels of activity.

Finally, regardless of the analyses and supporting assumptions which justify public cost sharing, the greatest impetus for additional irrigation development on the Prairies comes from government agencies which continue to adhere to their original mandate - water supply enhancement. In this context the central issue is probably not the farmer's ability to pay but rather the general public's willingness to pay for continued water supply enhancement, irrespective of the long term social, environmental and economic consequences.

> "... these analytical errors have had much less practical significance than what might be called the non-analytical error. This is the belief, usually quite unconscious, that there are fixed "needs" or "requirements" for water rather than economic demands. No matter how conclusively it is refuted by facts -- for example the experience, which is all too common, of the inability to sell high-priced water -- the belief that demands are absolutely inelastic continues to dominate much planning in this field." (12)

Table 2.1

LONG-RUN NATIONAL DIRECT VALUE OF WATER IN THE UNITED STATES*

($U.S. 1972/Acre-Foot Gross)

Use	Value/Acre-Foot**		Comment
Crop Irrigation	$5-20	($3)	Relatively Low
Domestic	16-101	($187)	Relatively High
Industrial	100-300	($74)	Relatively High
Waste Load Assimilation	.03-7.60	($1)	Relatively Low
Recreation	0-150	(n.a.)	Relatively High
Fish and Wildlife	7-13	(n.a.)	
Hydroelectric	.14-1.00	($)	Relatively Low

* Excludes spinoff value added

**Estimate from [12] for 1974 indicated in brackets.

Source: Colorado State University, Economic Value of Water, Concepts and Empirical Estimates, National Technical Information Service, Springfield, Va., 1972

Table 2.2

EXISTING PROVINCIAL CAPITAL COST SHARING FORMULA FOR DRAINAGE - 1984

(percent)

Region	On-Farm			Off-Farm[e]		
	Farmer	Government	Total	Farmer	Government	Total
Province						
N.B.	50	50	100			
N.S.	25	75	100			
P.E.I.	50	50	100			
Newfoundland	–	–	–			
Quebec	50[a]	50[a]	100			
Ontario	(b)			67[f]	33[f]	100
Manitoba	–	–	–	0[g]	100[g]	100
Saskatchewan	33[c]	67[c]	100			
Alberta				25	75	100
B.C.	(d)			33	67	100

[a] Approximate. Assumes a 70¢/meter subsidy for tile drainage = ½ installed price.

[b] Eight percent loans.

[c] For drainage in Irrigation Districts.

[d] Four percent loans.

[e] In those provinces for which detailed information is unavailable and/or unduly complex, various subsidies generally apply.

[f] For Southern Ontario. The ratios are reversed in Eastern and Northern Ontario.

[g] Only applied to certain classes of drainage facility.

3. ADVERSE IMPACTS OF AGRICULTURAL EXPANSION ON OTHER USES OF WATER

The impacts of agricultural expansion on other uses of the water resource will vary greatly across the country. The nature and extent of impacts will depend, among other things, on the nature of the expansion, changes in agricultural practices in both established and new areas, and the extent to which other uses will be protected where expansion involves withdrawal and consumption of water in agriculture. This section of the report is concerned with adverse impacts, such as erosion, salinization, contamination and flow depletion which may follow from expected agricultural expansion. We include some discussion of the economic losses associated with agricultural impacts on water resources, and means of reducing those impacts.

Flow Depletion

As noted in Section 1, the major implication of the projected changes in agricultural output for use of water arises from direct withdrawal and consumption for irrigation. The impacts of these additional water requirements on other uses of water will be very site-specific.

In British Columbia a significant portion of new requirements is expected to come from groundwater wells. Although the amount withdrawn is not expected to have a measurable effect on groundwater supplies, relatively little is known about aquifers in that province. Other requirements will be met by surface withdrawals from streams, lakes and rivers. These are licenced, and while in early years licences were granted with little regard for other water uses, the licencing process now generally requires that adequate flows remain to meet the needs of insitu uses - such as fish and wildlife, recreation, or waste assimilation. Moreover, it can be anticipated that an increasing proportion of future surface withdrawals will be provided for by diversion or storage projects. These augment flows on a seasonal basis when they are required for irrigation, thus further ensuring the provision of water for other insitu uses.

On the Prairie provinces there will be little use of groundwater to meet additional agricultural requirements, surface withdrawals being the only practical source of providing most irrigation water. From briefs submitted to the Inquiry it appears that some major projects may be required if the water requirements implicit in the various projections are to be met (18, 27, 42, 43).

Whether the governments of the Prairie provinces will continue to be willing to commit water to agricultural uses, and to provide as well the necessary funds for construction and on-going operation of major projects, is unknown. To the extent that they do, such actions will imply either that they have, in

their views, provided adequately for other water uses, or in the event that other uses are compromised in favour of agriculture, have judged the use of water in agriculture to be of a higher value.

This of course presumes that information on the value of water in alternative uses, and consistent evaluation criteria, will be available and readily applied in making decisions on the allocation of water. There is no guarantee, of course, that this will happen, and several briefs to the Inquiry have expressed concerns that evaluation criteria and decision making frameworks have failed to adequately account for non-agricultural values in the past. (2, 10, 18)

Concerns of this nature are reinforced by the generally accepted observations, as discussed in Section 1 of this report, that the costs of most large agricultural water supply projects have outweighed the benefits. That being the case, it is frequently presumed that there should be no further allocation of water to agriculture, and there is an inherent distrust of analyses that contemplate such uses. It does not seem appropriate here, however, to prejudge future projects or analyses and reject them out of hand. There may well be circumstances in which agriculture represents the most valuable use of water, and there will undoubtedly be others in which it does not.

Therefore, while flow depletion caused by increased withdrawals for agriculture clearly poses the potential for impacts on other water uses in the Prairie provinces, it is not a simple matter to predict the magnitude of those impacts. The additional requirements for agriculture may be met by flow enhancement, through diversions and storage facilities, leaving intact the requirements of other uses; or there may be some degree of encroachment on other uses. It would be out of place to comment here on whether the provinces are likely to make "good" or "bad" decisions regarding water allocation in future. With the attention that has been drawn to non-agricultural values in the present era, however, it does seem reasonable to expect that future decisions will at least be better informed than some taken in the past.

In Ontario, irrigation requirements are presently met from surface water and to a lesser degree ground water. It is expected that additional requirements would be met from the same sources, in roughly the same proportions. The impact this will have on other water uses is not expected to be substantial. Permits are required for both surface and groundwater withdrawals for irrigation quantities in excess of 50,000 litres per day (11,000 gallons), and the permits for surface withdrawals require the protection of the natural functions of streams and provide a mechanism for allocating available flows among users (38). A means for taking account of non-agricultural values in making decisions about the future allocation of water to agriculture clearly exists in Ontario. Its success in guiding "optimal" allocation decisions will depend on the quality of information

which is made available as future decisions are taken.

In the Atlantic provinces irrigation demands are expected to be modest, as are potential impacts of flow depletion on other uses.

Soil Degradation (Salinization and Erosion)

Several briefs to the Inquiry emphasize that soil and water problems are inseparable and must be considered together (11, 15). Some soil problems directly affect the water resource (erosion), while others result from the on-farm use of water (salinization). In either case the cultural practices which may be adopted to counter erosion and salinization themselves have implications for water use, hence the logic of considering these soil degradation problems in the context of water management. This is particularly important in the context of agricultural expansion, as expansion onto marginal arable lands may exacerbate both salinization and erosion.

Salinization

The salinization of agricultural lands is one of a number of soil degradation problems threatening agricultural production in Canada. Crop yields are very responsive to soil salinity levels, with yield reductions of 50 percent not uncommon in saline areas (16,44).

"Secondary" or man-induced salinity is a result of the addition, redistribution or concentration of soluble salts by groundwater or surface water (16). A primary cause of soil salinization in western Canada appears to be the practice of summerfallowing, which permits the deep percolation of excess water. Thus, while soil salinization appears to result in part from water use practices, it does not in itself appear to impact on other uses of water resources.

The extent of the salinity problem is the subject of some debate. Some recent estimates and projections for western Canada to 2008, excluding irrigated areas and areas of unimproved pasture, are presented in Table 3.1. These indicate something in excess of 1 million hectares (2.5 million acres) presently affected by secondary salinity, with 1.25 million hectares (3.1 million acres) expected to be affected by the year 2008, an increase of 10,000 hectares (24,000 acres) per year (16).

Salinization is less extensive, although proportionally no less serious, on irrigated lands in western Canada. Estimates of approximately 100,000 hectares (250,000 acres) affected appear reasonable (19, 33). Unlike dryland salinity, the salinization of irrigated lands results principally from seepage, inefficient irrigation practices and poor surface drainage (3).

Salinity control and mitigation is very dependent upon on-going improvements in farm management practices (16):

- use of deep-rooted perennial crops to dry out the soil profile;
- more intensive cropping with the gradual elimination of summerfallowing in saline-prone areas;
- surface and sub-surface drainage;
- utilization of effective snow management practices; and
- the planting of salt-tolerant crops.

The future extent of this salinity control in the context of an expanding agriculture will, in turn, affect agricultural water use. The major considerations in this regard are:

- the additional water necessary for leaching saline soils under irrigation will increase the pressure on available water supplies;
- the trend in summerfallow acreage reductions, with the resultant increase in stubble cropping, will tend to increase the variability of crop yields and, hence, the importance of on-farm water management strategies.
- reductions in water losses from irrigation canals will serve a two-fold function of reducing irrigated saline areas, and making more water available for productive uses.

Some estimates place the annual cost of salinity to crop producers at $29 million, expected to grow to $465 by the end of the century (11), while others indicate the annual cost to be $100 million already, and growing by about 1 percent each year (16, 44). This latter estimate suggests that current losses are equal to 1.5 percent of the total value of annual Prairie crop production.

Given the magnitude of these estimated losses, it would appear that farmers have strong economic incentives to introduce cultural practices which will control salinity. The response of individual farmers can be expected to be highly varied, however. Some may recognize the problems and have adequate financial resources to take corrective measures, while others who are equally cognizant of the problems may, because of financial pressures, not alter their cultural practices. Still others may simply be slow to recognize the problems with salinity and begin to consider the various corrective actions which can be taken. Thus, while it does not seem reasonable to project that the extent of salinization will continue to grow unabated, it may be some time before there is any significant reversal in recent trends.

Erosion

As with salinity, the impact of erosion on crop yields can be dramatic. In some studies wheat yields have been shown to be only one-third as great on eroded as compared to non-eroded soil (33,44). The negative yield effects of erosion have been shown to be a function of soil type, amount of topsoil eroded and, to a lesser extent, crop grown (16).

The area of improved land in western Canada that has been affected by soil erosion is substantial, with estimates for 1984 approaching 5.2 million hectares (13 million acres) and projections for an additional 1.0 million hectares (2.5 million acres) by 2008 (Table 3.2). While soil erosion rates vary with climatic factors, topography and soil surface factors, in general bare soils are much more erodable than ones covered with plant growth (16). The various management practices which increase the susceptibility of soils in western Canada to erosion include the use of large equipment, summerfallowing, high tillage speeds, elimination of windbreaks, cultivation of submarginal soils and incorporation of pre-emergent herbicides.

In addition to the Prairie region identified in Table 3.2, serious water and wind erosion areas exist in the potato growing regions of New Brunswick and Prince Edward Island, the Annapolis Valley of Nova Scotia, the corn belt of southern Ontario, and the lower mainland of British Columbia (44).

The extent of erosion in future will depend on the soil and water management strategies adopted by farmers. Some of the management changes which are currently being made should have a positive effect. Others, in particular expansion onto marginal areas, will result in greater erosion problems.

The economic incentives to reduce soil erosion appear to be strong. One source indicates that on-farm losses on the Prairie provinces are in the order of $370 million annually and will grow to $472 million by the end of the century if unchecked (11). Others place the current annual losses at from $368 to $468 million in the western provinces, and as great as $68 million in southern Ontario alone (41,44). The response to the costs of erosion by individual farmers can be expected to vary, however, for the same reasons noted in discussing the response to salinization.

In terms of direct agricultural water use it is anticipated that on balance the impact of cultural practices introduced to deal with erosion should either be neutral or slightly positive (reducing consumption), as indicated by the assessment in Table 3.3. Erosion will continue, however, and is expected to spread to new areas with expansion onto submarginal lands. The increased silt loadings in rivers and streams may adversely affect other downstream users, with the effects ranging from increased costs to remove silt from drainage and shipping channels, to fish and wildlife and recreation losses (27).

Drainage

As noted in Section 1 of this report, there is expected to be continuing emphasis on getting wetlands into agricultural production. We have chosen to discuss the water management concerns that this gives rise to under two headings. One can perhaps be characterized as the hydrological effects - the impacts on streamflows and flood peaks within river basins. The other has to do with elimination of surface waterbodies and their withdrawal from use for other purposes.

Hydrological Effects

The use of subsurface drains to improve soil aeration and permit timely cultivation has historically been very important to agricultural production in many areas of Canada. This importance has not diminished, and in recent years increased land drainage, along with genetic advances in corn production, are credited with the establishment of feedgrain self-sufficiency in Ontario and improved self-sufficiency in Quebec (50). This has been a specific goal in Ontario, and the Ontario Ministry of Agriculture and Food estimates that in addition to the 1.2 million hectares (3 million acres) already served by subsurface drains, a further 1.5 million hectares (3.8 million acres) would benefit from the installation of such drains (38). Associated with extensive subsurface field drains, there are frequently improvements to local drainage channels, and often connecting channels which drain swamps and ponds.

There tend to be intuitive expectations that these works have led, and will continue to lead, to greater and more frequent flooding elsewhere in the affected river basins. Careful investigations have not supported such expectations, however, and in many cases refute them (26).

It is difficult to generalize, when hydrological responses will vary with different types of drainage works and differing climate and physiographic conditions. But it has been found that in most cases subsurface drainage and outlet enlargement have little effect on flood peaks, and that flood peaks are reduced when high water table areas are drained. This apparent paradox arises in large part from the fact that tile or other subsurface drainage provides storage capacity in the soil, tending to reduce surface runoff and decrease peak flows. On the other hand, the connection of swamps or enclosed areas to rivers by large arterial drains, does increase flood peaks (26). It is not uncommon to find, moreover, that whereas drainage may be blamed for increased flood peaks or frequency, encroachment of buildings and fill in river channels and on flood plains is actually the primary cause.

The extent to which increased agricultural drainage will create problems for water management through these "hydrological" effects will thus depend very much on the nature of the works. Expansion of on-farm drainage to improve soil aeration and permit effective cropping may in fact have little effect. Major channel improvement or drainage of areas that provide some surface storage may have significant effects. The latter type of projects, almost always undertaken by government agencies or with government funding, are at least easily identifiable and should be subject to review for such adverse effects before they are undertaken.

Drainage of Surface Waterbodies

The functions of a wetland are many, including the provision of habitat for a wide variety of fish and wildlife species which contribute in turn to numerous forms of recreation (10). Drainage terminates these wetland functions, a matter of concern to many who benefit from them (15, 18, 37).

Concern over the continuing loss of wetlands is serious, taken in the context of some estimates which indicate that two-thirds of the original Prairie wetlands have already been drained (15). Some evidence indicates, moreover, that wetlands are being lost at an increasing rate (6). Canadian Wildlife Service observations indicate that drainage, filling and cultivation of semipermanent and permanent wetlands is occurring at a rate of 18 percent per year in the Prairie provinces. Correspondingly, populations of mallard ducks have been declining since the early 1970s and are currently at all time lows thoughout the Prairies (6).

It is indicated in Section 1 that if half of the Prairie wetlands could be economically drained it would add 1.2 million hectares (3 million acres) to the cropped land base - an increase of about 3 percent. While that may be a speculative estimate, further loss of wetlands to this extent would be viewed with considerable alarm vis a vis the probable impacts on waterfowl.

These kinds of concerns over wetland losses are not unique to the Prairie provinces. In Ontario agricultural reclamation is pointed to as a major force in the loss of wetlands (37), and numerous interests see agricultural drainage as a major threat to that province's remaining wetlands.

Their function in providing waterfowl habitat illustrates the complexity of the wetlands drainage issue. Migratory waterfowl are a continental resource, managed jointly under Convention by Canada, the United States and Mexico. Canadian wetlands are vitally important to many species as nesting habitat (7, 21). The recreational benefits supported by the waterfowl which nest in Canada are enjoyed in all three countries, and are difficult to quantify.

The farmer who is contemplating draining a wetland is unlikely to realize any of the benefits from the waterfowl it supports, but may bear numerous costs as a result of the presence of the wetland. In his decision as to whether to drain the wetland he cannot be expected to give weight to the reduction in waterfowl productivity and recreational losses accruing to others - he will be guided by his own on-farm costs and benefits. Thus the impacts of wetland drainage on waterfowl are "external" to the farmer's decision making process and, in the absence of outside intervention, will not be taken into account.

Much of the concern over the loss of waterfowl nesting habitat is focussed on how to intervene in farmers' drainage decisions so that the full range of costs and benefits is considered (15, 21). This is in many respects a classic example of what economists would call a "market failure". There are no conventional market mechanisms through which those who benefit from the maintenance of waterfowl populations can register the benefits that they receive by paying for them, and thus influence landowners' decisions. In the absence of such mechanisms the preservation of wetlands and securing of such values must rely on intervention by government agencies and voluntary organizations.

The issue of wetlands preservation and waterfowl is particularly complex, involving as it does a large number of species with highly variable migratory patterns. The same principles affect the preservation of wetlands as habitat for non- migratory fish and wildlife species. Problems again arise because of the absence of market channels through which the consumers of the services that fish and wildlife provide can convey to landowners the values they attach to those services.

As long as this "market failure" persists, and those who make decisions regarding drainage of surface wetlands do not take account of the consequent reduction in fish and wildlife habitat, it is almost certain that the amount of drainage which takes place will be in excess of what would be considered optimal from the viewpoint of society at large. In view of the extent to which surface water bodies have already been eliminated, this is a serious concern.

Contamination

Finally, agricultural expansion may impact on other water uses via water quality degradation and contamination. Erosion and the consequent siltation of watercourses has already been discussed, the further concern here being with nutrients, chemicals and agriculturally-originated pollutants.

The agricultural sector can contribute to surface and groundwater contamination through runoff, the quality of which will reflect the type of soluble materials the water is in contact with, and the suspended materials it carries. Possible pollutants from agricultural land include sediment, nutrients, pesticides, organic matter and pathogens (38). Nutrients and

animal manure can reduce water palatability, pose health risks to people and animals and increase the eutrophication of waterbodies (2).

Opinions vary as to the significance of the various types of contaminants which originate in the agriculture sector. It has been indicated that in Prince Edward Island agricultural activities have been the largest source of groundwater contamination in the province, and there is increased concern about the impact of pesticide use on water resources (34). Similarly from Manitoba a concern singled out for early attention is the presence of agricultural chemicals in surface water and groundwater - something which is seen as a growing threat to the supply of potable water for farms and communities (27). Others (2, 36) suggest that pesticide residues do not contaminate water to any appreciable extent.

While there are divided views as to the degree to which agriculture is presently contributing to water contamination, the issue for this report is the extent to which other water uses may be affected, via water contamination, resulting from expansion of agriculture. As long as cultural practices are consistent it can be expected that there will be a pro-rata increase in contamination problems. Increasing attention is being paid to problems of this nature in some areas, however, with emphasis on management practices to control water pollution (38). If expansion in agriculture is coupled with improved cultural practices the increase in contamination problems may be less than proportional to the increase in agricultural production.

Economic Losses from Agricultural Impacts on Water

We have noted above some estimates of the on-farm losses arising from erosion and salinization. These arise from reduced soil productivity and not from changes in the quantity or quality of water. In addition to these direct on-farm losses, agriculture may impose off-farm costs on other water uses, via flow reduction, drainage, or contamination, as discussed.

Although they do not deal specifically with costs caused by agriculture, there have been some estimates of the economic costs due to water pollution in Canada. An early study for the Department of the Environment indicated annual losses across Canada of $40 to $70 million (35). Recent estimates by Environment Canada indicate the social costs of water pollution from all sources to be at least $200 million annually (2). Although these estimates are not broken down by source of pollution, it is expected that the contribution from agriculture is modest in comparison with those from industrial and municipal sources.

These estimates deal with costs arising from water pollution only, however, and do not take account of costs that may arise when other uses are "displaced" by withdrawal of water for consumptive use in agriculture, or by drainage. Several

briefs to the Inquiry have noted that the values affected by withdrawals and drainage are not well understood (2, 9, 15, 18, 37) and stressed the need for consistent criteria for taking such values into account in resource allocation decisions. As far as is known there have been no investigations of these kinds of costs in Canada, although there have been several studies of the wetlands/waterfowl issue on a continental basis (7, 21).

Means of Reducing Adverse Impacts of Agricultural Expansion

A common response to almost any identified adverse impact is to call for its reduction or control. It is not at all clear, however, that adverse impacts resulting from agricultural use of water should universally be reduced or controlled. Whether they should or should not depends very much on the relationships between the benefits realized from the agricultural use of water and the cost of the impacts. (It also depends on the relationship between the value or cost of the impacts and the costs of corrective measures). We will attempt to illustrate this with respect to the different types of adverse impacts which agricultural expansion may have on other water uses.

In the case of **flow depletion** resulting primarily from irrigation withdrawals, the licensing process almost universally provides an avenue for the protection of other uses which depend on the water. In the past little account may have been taken of other uses, in many respects reflecting oversight but in other regards probably fairly reflecting prevailing relative values. In the present era much more attention is drawn to such uses, and it is unlikely that they will suffer just from oversight.

The question of relative values remains moot, however. When there are competing demands for water, not all of which can be satisfied from available supplies, choices between uses will have to be made. These kinds of allocation decisions are a provincial responsibility, and it is expected that, at least in the case of major projects, they will result from analyses that take alternative uses and values of water into account. Whether the allocations which ultimately result represent an optimal use of resources will depend on the "quality" of the information which is used and the rigor of the analytical framework. While almost all provinces adhere to fairly conventional benefit cost approaches, there is a persistent concern that the kinds of impact analyses on which decisions about cost sharing have been based (Section 2) may be relied on to justify particular projects in the event that their costs are otherwise shown to outweigh their benefits.

It should be inherent in analyses supporting water allocation decisions that the least cost alternatives for meeting any given objective be identified. In this regard it is important to note that efficiencies in water use in irrigation

have historically been very low. This is not surprising, since the prices charged for water have hardly provided an incentive to treat it as a scarce commodity.

In southern Alberta, recent years have, however, seen increasing attention paid to improving these efficiencies, both through improvements in on-farm application methods (sprinklers versus back flooding) and improvements in delivery systems (upgrading and repair of diversion, reservoir and headworks facilities). Other areas, too, have begun to look seriously at improving the efficiency with which water is used in irrigation (46).

There appears to be considerable scope, therefore, to meet increased irrigation demands through more efficient use of water already allocated to agriculture, rather than through increased withdrawals. Such alternatives should be fully explored, and may constitute a cost-effective means of reducing impacts from agricultural withdrawals and flow depletion.

Soil salinity and **erosion** have also been discussed as problems which must be addressed in a joint approach to soil and water management. As some of the estimates of economic losses indicate, these are problems with substantial direct on-farm costs. There is little that can be done in the scope of water management to reduce those on-farm costs, the remedies to which lie almost exclusively in the hands of the farmers and their cultural practices.

To the extent that the costs of available remedies are less than the benefits to be gained through their application (ie reduction in losses) it is wasteful, from a social point of view, for those losses to continue. Thus there may be a good case to be made for special programs in soil and water conservation education - to arm farmers with the knowledge of improved cultural techniques which would reduce the losses.

Not all costs of erosion are borne on-farm, however. Erosion may cause siltation which can in turn impose a variety of costs on other water users. Reducing these off-farm costs provides a further justification for programs in soil and water conservation education. In cases where the off-farm costs of erosion remain unacceptably high, stronger remedies may have to be sought. Recourse could be had to regulating on-farm cultural practices, and incentives could also be tried, perhaps paying a per acre premium to encourage the growth of crops which do not render the soil as susceptible to erosion.

As discussed above, **the drainage of surface water bodies** is a very serious problem from the perspective of waterfowl management, and in connection with non-migratory fish and wildlife species as well. The nature of this problem is widely recognized (15) but no simple solution exists.

At least two steps are required to address this problem. The first is to provide farmers and others who are making

drainage decisions with information on the value of the wetlands as wildlife (waterfowl) habitat - something which requires considerable site-specific information that is not readily available. The second, in cases where analysis indicates that the gains to the farmer from drainage do not offset the losses to others from reduced habitat, is to develop a mechanism whereby those who gain from preservation of the wetland habitat can adequately compensate the farmer for foregoing the on-farm benefits of drainage.

To date this problem has been approached largely through "collective" action, both government and voluntary. The Canadian Wildlife Service has had a program of obtaining easements over private wetlands to preserve their role as waterfowl habitat. And Ducks Unlimited, a non-profit organization which raises funds from sportsmen in both the United States and Canada, has secured some 1.4 million hectares (3.4 million acres) of wetland habitat through agreements with private landowners and government agencies (7, 15).

To the extent that these programs have been carried out they are an effective way of "internalizing the externality" so that decisions about drainage reflect both on and off-farm costs and benefits. Should these approaches be judged to be inadequate, the further alternative would seem to lie with direct government regulation of drainage.

If provincial governments are prepared to intervene and regulate drainage, this could have the salutary effect of providing incentives for rationalization of provincial cost-sharing programs for drainage. The greatest incentive for regulation probably lies with the federal government, however, given the importance of wetlands to migratory waterfowl, which are a federal responsibility. There would be an obvious need for federal provincial coordination in any such regulation, to avoid having the two levels of government working at cross purposes with respect to drainage incentives.

Finally, the issue of **water contamination** and agricultural expansion is one which is probably best dealt with through a combination of education/research and regulation. This is largely the case at present. Education and research programs are aimed at increasing awareness of the water contamination problem and of practical means of controlling agricultural non- point source pollution. Regulations deal with the use of pesticides and chemicals (38). As with any form of regulation, however, the problems of inspection and enforcement are serious - particularly when they involve, as they do in agriculture, large numbers of different pesticides and chemicals applied at many diverse points and at highly variable times.

4. FEDERAL POLICIES AND PROGRAMS WHICH INFLUENCE AGRICULTURAL DEMANDS FOR WATER

To assess and critique all federal policies and programs which influence agricultural demands for water is a broad task, and we attempt at the outset to place some limits around it. At the most general level almost any government program which promotes economic growth will stimulate the demand for food, and in turn influence agricultural demands for water. We do not propose to consider the impacts of such general government programs on the demands for water.

Similarly, although the federal government plays a major role in a number of income, price support and supply management programs for agricultural products, which undoubtedly influence agricultural demands for water, we will not consider such programs. These programs have specific goals, and whatever the controversies about their efficacy, neither in their design nor administration should there be concern about lower level resource demands or allocation issues. Although these programs will probably stimulate the agricultural demand for water, those who are responsible for them should not be concerned with the impacts of their programs on the demand for water, for example, any more than with the demand for steel, fuel or labor.

We are restricting our considerations, therefore, to those programs and policies through which activities of the federal government directly influence the use and management of water in agriculture. These include activities through Agriculture Canada and Environment Canada and the various Acts and agencies which fall within their mandates, and other Departments which have been directly involved in agricultural projects.

Agriculture Canada

In its brief to this Inquiry (2) Agriculture Canada sets out its objective:

> "To promote the growth, stability and competitiveness of the agri-food sector, by making available policies, programs and services that are most appropriately provided by a federal government, so that the sector makes its maximum real contribution to the national economy."

Under this objective Agriculture Canada has identified the sustainability and enhancement of the agricultural industry's soil and water resources as one of the major issues needing immediate attention. A five-year departmental plan is being developed, with four areas relating to national water resource development. These are:

Surveys and Monitoring - with Agriculture Canada prepared to survey and monitor actual agri-food water use and to forecast future agri-food demands. Basic and Applied Research - the department currently has resources allocated to a number of areas affecting agricultural use of water, including water conservation under reduced tillage and through improved snow management, water erosion control, water quality control, various aspects of irrigation requirements, soil salinization and drainage.

Development Programs - Agriculture Canada has become "heavily involved" in the design and implementation of regional agricultural development strategies. These take the form of coordinated programs, under federal-provincial development agreements. Since 1982 agri-food development agreements have been signed with Nova Scotia, Prince Edward Island, New Brunswick, Manitoba and Saskatchewan, and most other provincial governments are reportedly willing to support similar programs. The majority of these programs are designed to increase the speed with which the private sector adopts improved technology and management practices.

Regulation and Registration of Pesticides - the department is responsible for regulation and registration of pesticides (under the Pest Control Products Act) and coordinates the evaluation and registration process with several other federal departments.

Prairie Farm Rehabilitation Administration

The Prairie Farm Rehabilitation Administration is an agency of the federal government which was created in 1935 by the Prairie Farm Rehabilitation Act, in response to the severe drought of the 1930's. Originally under the authority of the Minister of Agriculture, PFRA was attached to the Department of Regional Economic Expansion from 1969 to 1983, and returned to Agriculture Canada in March of 1983.

PFRA's purpose is to secure the rehabilitation of the drought and soil drifting areas of Alberta, Saskatchewan and Manitoba. Amendments to the original Act in 1937 gave the PFRA three main dimensions - water development, cultural practices, and land use. To accomplish its goals it has developed and promoted, through cooperation with the provinces and industry, new farming practices, tree culture, water supplies, land use and land settlement.

The PFRA has seen its role as a developer rather than a regulator and has provided assistance for a large number of projects. Included are more than 187,000 individual and 1,500 community water development projects. Among the individual

projects are 7,200 irrigation schemes, and the community projects include 144 group irrigation schemes.

The PFRA has assisted in the development of major water supply and irrigation projects under a variety of arrangements. This has sometimes involved cost-sharing of initial project development. In others cases Canada, through PFRA, has shared in or paid the entire cost of dams, reservoirs, main canals and headworks, with the responsibility for irrigation distribution systems and other facilities assumed by the provinces or other organizations. PFRA has generally provided engineering design and construction supervision, with operation and maintenance responsibilities accepted by provincial or local authorities.

Some special PFRA undertakings include the Bow River Irrigation District in Alberta, which was purchased by the federal government in 1950, renovated and enlarged to serve victims of the drought, and transferred to Alberta in 1974. Some 23 storage reservoirs and six irrigation projects were developed in southwestern Saskatchewan to relieve effects of the drought, and the province of Saskatchewan has developed seven irrigation projects which are served by PFRA reservoirs (42).

While PFRA continues to have a highly qualified engineering organization, since completion of the Gardiner Dam on the South Saskatchewan River in the 1960's, federal involvement in the construction of major water supply projects has declined significantly (18). A change of focus can be noted in the "drought proofing" studies and irrigation project evaluation activities that PFRA has recently been involved in, cooperatively with the provinces, under the Saskatchewan and Manitoba Agreements on Water.

Canada Water Act

The Canada Water Act of 1970 replaced the Canada Water Conservation Assistance Act of 1953, which provided for federal cost-sharing with the provinces of large-scale water conservation projects. Through this Act and other sources (Economic and Regional Development Agreements) federal funding has been made available for flood control works, and various other capital projects.

Although the federal contribution to such projects dropped off significantly following completion of major projects in the 1960's, a number of projects have been recently approved, but not yet carried out. These include further flood control structures, community and on-farm water projects and water treatment for Regina-Moose Jaw. The federal agent varies from project to project, in some being Environment Canada and in others Agriculture Canada (18).

Environment Canada

With its establishment in 1970 the Department of the Environment was given "primary responsibility for administering water resources from the national point of view" (25). A statement of water policy was issued on behalf of Canada by the Minister of Environment in 1978. The broad objectives of that policy are the conservation, development and use of water resources for the greatest social and economic benefit of Canadians - present and future.

The major points which are relevant to agricultural projects and use of water include a commitment to a joint federal-provincial approach to most issues, including cost-sharing; pursuit of water quality goals through control of nutrients and chemical contaminants; and application of the federal environmental assessment and review process where federal authority extends to water projects. Federal policy calls on users to pay the costs of using water, including pollution costs, and provides for the alleviation of flood problems.

Environment Canada has not become as directly involved in agriculture-related water resource developments as has, for instance, the PFRA. More emphasis has been placed on water resource planning and river basin management, through cooperative agreements with the provinces, and there has been considerable emphasis on flood control and damage reduction. The Canadian Wildlife Service, a division of Environment Canada, has intervened in agricultural drainage, through its program of obtaining easements over private wetlands to preserve them as waterfowl habitat.

Agricultural Rehabilitation and Development Act

Under this Act the federal government entered into numerous cost-sharing Agreements with the provinces, the focus of which included comprehensive resource inventories, research into land and water use, and development of land and water resources in low income rural areas. Throughout most of its history ARDA projects were administered by the Department of Regional Economic Expansion, and it is believed that existing Agreements will continue to be administered by the new Department of Regional Industrial Expansion.

Under the umbrella of a general ARDA Agreement, it has been common for the federal and provincial governments to enter into more specific Subsidiary Agreements, to cover particular areas, or particular kinds of projects. An example of this is the Eastern Ontario Subsidiary Agreement, which ended in 1984. Under this Agreement a two-thirds grant was paid toward the cost of outlet drains, with the grant cost being shared equally between Canada and Ontario. In other parts of the country Subsidiary Agreements have been used to develop community pastures and for land reclamation purposes.

Canadian Wheat Board

Although it does not directly affect the use of water, per se, there is currently much criticism of the Wheat Board policy where quotas for the delivery of grain are tied to the acreage actually cultivated. This is claimed to have the effect of encouraging or "enforcing" the practice of summerfallowing, which in turn contributes to and exacerbates soil salinity problems. In addition it encourages the drainage and cultivation of wetlands (15).

Critique of Programs and Policies

A critique of federal programs and policies which influence agricultural use of water must take as its reference point the stated policies of the federal government with respect to the water resource. In this regard it is appropriate to reiterate the objectives noted above for both Environment Canada, and Agriculture Canada.

The objectives for Environment Canada are particularly important in view of the fact that this department has been given "primary responsibility for administering water resources from the national point of view" (25). The relevant aspects of policy as it relates to agricultural use of water include the broad objective of conservation, development and use of water resources for the greatest social and economic benefit of Canadians now and in the future; the commitment to federal-provincial cost-sharing; a call for users to pay the costs of using water; and the application of the federal environmental assessment and review process where federal authority extends to water projects.

In the case of Agriculture Canada the aspect of its stated objective that is most relevant in the context of water management is the commitment to make available policies, programs and services so that the agri-food sector makes its maximum real contribution to the national economy.

The broad objectives of these two key government departments are generally consistent insofar as they relate to water use and management. The emphasis from Environment Canada is on the use of water for the greatest social and economic benefit, with the environmental assessment and review process ensuring that a broad range of uses is included in the determination of benefits. Put simply, this is a commitment to efficient use of water and related resources. In a similar sense the Agriculture Canada commitment to a maximum real contribution to the national economy can be interpreted as requiring efficient use of water resources and a respect for non-agricultural alternatives.

It is not surprising to find common elements such as these in broad statements of departmental policy. The real test lies, however, in the actual programs which are undertaken and their adherence to the stated general principles. For purposes of assessment federal programs and policies are discussed here in terms of their economic efficiency (benefits in relation to costs), and in terms of consistency.

Economic Efficiency

In discussing the economic efficiency of programs and policies they can effectively be grouped into two major areas.

The first includes various programs for research in soil and water conservation (PFRA, Agriculture Canada, Environment Canada) provision of on-farm technical assistance (PFRA), encouragement in the adoption of techonology and management practices (Agriculture Canada, PFRA), and on-farm water supply (wells, dugouts, irrigation) (PFRA).

These kinds of programs will act in two directions in influencing the demand for and use of water. They will tend to reduce the use of water to the extent that the research in soil and water conservation, provision of on-farm technical assistance, and adoption of technology and management practices all encourage more efficient use of water. They will tend to increase the demand for or use of water, to the extent that they result in an expansion of agricultural production, or introduce water intensive practices (irrigation) where they have not previously been applied.

The relationships between the costs of these particular programs and the benefits which they generate have not been clearly documented. Research has generally shown, however, that there is a high rate of return to the application of improved technology, and to the kind of basic research undertaken in many of these programs. In addition the costs of these programs are generally quite modest, and they do not involve major changes in the allocation of resources. These programs appear to be consistent with both the broad objective stated by Environment Canada - conservation, development and use of water for the greatest social and economic benefit - and the objective of Agriculture Canada - to assist the agri-food sector in making a real contribution to the national economy.

The second major policy and program area includes the large scale projects which make water available for agriculture, or directly affect agricultural use of water and related land resources. Here we identify major water supply projects for irrigation, and drainage and land reclamation projects.

Major irrigation water supply projects have served in the past to deal with water "shortages", or meet inherent demands for water, by supply augmentation. Given the climate which gave

birth to the PFRA, the major federal agent in such projects, it is not surprising that the early projects were not subject to rigorous analyses of costs and benefits. This approach persisted, and even in the 1960's the proponents of the Gardiner Dam and the South Saskatchewan River Project apparently did not feel that it was a part of their mandate to conduct such analyses. Thus when this project was approved by the newly-elected Diefenbaker government, the decision to proceed was not supported by analysis of the project's economic efficiency.

The Gardiner Dam was the last major water supply project which involved a significant federal role. Despite the emergence, since its completion, of concerns about the importance of more comprehensive analysis of such projects there is still no evidence that economic efficiency is addressed by the PFRA in project selection.

A continuing federal involvement in water supply projects on this basis seems to be inconsistent with stated policy - in particular those aspects that call for use of water for the greatest social and economic benefit of Canadians (Environment Canada), and for the agri-food sector to make a real contribution to the Canadian economy (Agriculture Canada). It is assumed that efficient resource use and allocation is an essential condition in achieving these objectives and contributing to social and economic benefits or making a "real" contribution to the economy.

Nor does there seem to be a commitment to the federal environmental assessment and review process, which might ensure that the full range of impacts would be considered in major project analyses. These kinds of tests are sorely needed, perhaps particularly for the PFRA, an agency whose original goals of rehabilitating the drought and soil drifting areas of the Prairies have surely been met, after almost fifty years.

Consistency

A frequent criticism of federal water policy is that various programs are working at cross purposes. This can be illustrated with reference to drainage and reclamation projects. While many of these are economically efficient in their own right (2), questions raised about them generally point to the fact that different federal agencies are pursuing, independently, conflicting goals.

Thus it is pointed out that while the Canadian Wildlife Service works to protect wetlands, PFRA and Agriculture Canada are involved in support of drainage and reclamation projects. And the rationale of drainage and reclamation projects is further questioned insofar as some suggest that they may accelerate runoff and peak flows, in contravention of efforts by Environment Canada in flood control and damage prevention.

While there may at first glance appear to be contradictions in these programs, closer scrutiny shows that is not always the case. In terms of the preservation of wetlands for wildlife habitat versus drainage for agriculture, it may be entirely consistent to support drainage of some wetlands and preservation of others. The appropriate use of any individual wetland will depend on the respective costs and benefits in each use, and it would hardly be expected that analyses would indicate that all wetlands should be preserved, or that all should be drained. Thus while these policies may appear inconsistent, they may very well not be. The issue, it would seem, is whether there is careful analysis of the impacts on and values from alternative land and water uses before decisions are made to support drainage, or preserve wetlands. This is something that would have to be done on a case by case basis, and we can see no evidence of this in the federal approach to these programs.

Circumstances are much the same when looking at the apparent conflict between drainage and control and prevention of damage from flooding. As noted previously, such conflicts may be more apparent than real real. Some kinds of drainage projects actually help to reduce peak runoff, while others may increase peak flows. A consistent federal policy depends again on assessment of the respective magnitude of costs and benefits associated with the program actions. The costs of realizing benefits from a particular drainage project may include the incremental costs which drainage adds to flood control in the watershed. Whether the drainage project should be undertaken, given those additional costs, depends on whether the benefits are great enough to compensate for them. If they are, it is clearly more efficient to proceed and accept the costs, rather than forego the benefits from drainage. The issue, again, is whether project analyses take the full range of costs and benefits into account - and again there is no evidence of a commitment to do this.

Finally, the objectives stated for Environment Canada call for users to pay the costs of using water. As the question of paying for water supply projects has been addressed, however, it has become obvious that agriculture cannot pay, directly, more than a small portion of total project costs. (Though the charges actually levied are generally lower than the ability to pay, even were the charges equal to the full ability to pay they would still fall far short of costs.) This has led to the evolution of cost- sharing formulae, where the majority of costs are borne by governments who are taken to represent non-farm beneficiaries of the projects. There appears to be a genuine inconsistency here, in relation to further federal participation in water supply projects.

Summary

The broad federal policy objectives relating to water use in agriculture are found to be laudable and generally consistent. The actual programs which are "delivered" under the auspices of these policies do not, however, necessarily conform. The divergences or discrepancies do not arise because what is done can be rejected out-of-hand as being inconsistent with policy objectives. (A major PFRA sponsored project, to supply water for irrigation for example, may or may not represent an efficient use of resources.) They arise because programs, and projects within those programs, are not assessed or tested in a rigorous fashion to see if they do comply.

Our major concerns, therefore, are with implementation. Programs and projects are not being tested to determine whether they represent "use of water resources for the greatest social and economic benefit of Canadians", or make a "maximum real contribution to the national economy". Nor are they being tested for internal consistency, although appropriate attention to the question of efficient resource use would implicitly address this concern.

5. RECOMMENDED CHANGES IN FEDERAL POLICIES AND PROGRAMS TO IMPROVE THE SOCIAL, ECONOMIC AND ENVIRONMENTAL CONTRIBUTION OF CANADIAN AGRICULTURE

Our critique does not fault a number of federal programs and policies affecting agriculture and the related use of water. These include research, soil and water conservation, extension and dissemination of technology and management information, and resource planning. All of these functions attempt to improve the social, economic and environmental contribution of Canadian agriculture. There may be grounds for questioning federal participation in some of these programs, but on efficiency grounds at least their goals are certainly worth pursuing.

In other areas, primarily those with a strong project orientation, we are not recommending that policies and programs be abandoned. The concerns are rather that implementation does not appear to be consistent with broad policy guidelines, and with a lack of commitment to rigorous testing and analysis of projects prior to endorsement or participation. In particular the federal role in large water supply projects and in drainage and land development programs is singled out for criticism.

It is to the implementation process involving projects of these types that we address the following recommendations for change.

Water Supply Projects

The federal government, through various agents, in particular the PFRA, has in the past made major contributions to large irrigation water supply projects. It is not clear that in doing so the federal actions have conformed to the presently stated policy regarding water resource developments. It is understood that conditions were very different when those commitments were made, however, with several important factors distinguishing them from the present. In particular, many of the projects were directed at providing relief from the drought which had ravaged the Prairies and, as the projects involved the first large commitments of river flows, the availability of adequate water for irrigation and other uses was not a concern. It is not surprising that against that background many of the projects, which have brought about dramatic changes in agriculture in many areas, are viewed as highly successful.

The purpose here is not to criticize past projects. Rather it is to note that circumstances are now markedly different from those which prevailed at the time that they were undertaken, and that the same approach to federal involvement may no longer be appropriate. Perhaps the major distinguishing feature is that at present substantial portions of available water supplies are already committed, water is no longer abundant relative to demands, and its continuing availability to potential users on a first come-first served basis is very much an issue.

Before additional water supplies are committed to agriculture there is clearly a need to examine if this will maximize the social and economic benefits from the water resource, relative to other potential uses. There is also a concern over the terms of commitments in water use - with the need to maintain a margin of flexibility in order to cope with future, unforeseen demands from alternative uses.

The provinces, with legal jurisdiction over water, have in the past been willing to allocate it for agricultural use without levying a charge for the water per se. Not only has the water been provided at no direct charge, the fees that have been levied have consistently failed to cover even the cost of the labor and capital required to deliver it. The federal government, as a cost-sharing partner in some of these undertakings, and the sole developer in others, has provided financing to recruit the labor and capital for project construction. The result has been a policy of cheap water for agriculture.

From the evidence which is available, it is not clear that past projects would have passed the tests of comprehensive benefit cost analyses. Nor is it clear that future projects will - particularly in view of the fact that most of the least expensive sources of water have already been developed. It would be unwise to recommend rejection of federal participation in future projects out of hand, however. A more appropriate response is that a clear demonstration that the projects will in fact make a net contribution to the economy should be a prerequisite to federal cost-sharing.

Recognizing that we are in an era where the availability of water can no longer be taken for granted, where alternative uses may be as or more highly valued than agriculture, and where the full range of effects on other water users should be taken into account, federal contributions to major water supply projects should be contingent on rigorous analyses. The Treasury Board's benefit cost guidelines (48) lay out the basis for evaluation of federal programs in terms of the national economic efficiency objective - and these should be applied to federal involvement in water supply projects for agriculture. These guidelines are being applied to an ever-widening range of federal investments; failing to apply them to agricultural water supply projects may result in the wasteful allocation of federal financial resources.

In making this recommendation it is noted that these guidelines have already been applied to flood control programs in which the federal government participates, and are rigorously applied to other programs, such as the Salmonid Enhancement Program on the Pacific coast. What is required is development of a consistent approach to evaluation of the various programs in which there is a federal involvement in water supply for agriculture. Such evaluations should take into account alternatives for meeting a given goal (structural and non-structural), should take full account of the effects on, and

values in, other water uses (present and future), and should attempt to fully account for "environmental" effects to the extent that they are not encompassed in the consideration of other water uses.

It is difficult to predict what the results of individual project analyses would be if they were carried out on this comprehensive basis. (It would be particularly interesting and instructive if retrospective project evaluations could be completed, as these could shed considerable light on the reasonableness of predictions being used in prospective project evaluations.) But it would not be at all surprising if many projects did not pass the "test" with respect to national economic efficiency. This in turn would bring into question the appropriateness of federal participation in the projects.

It is recognized that there will be strong pressure for continued federal cost-sharing of projects from local and regional interests (43) who stand to benefit from the continued availability of cheap water for agriculture. And it is expected that the provinces may be willing to continue to make the water itself available for use in agriculture at little or no cost. On the other hand, it is clearly time to recognize that serious problems will emerge if policies are pursued which attempt to keep water cheap when it is not. Continuing with a cheap water policy will only encourage its continued inefficient use, thereby intensifying the eventual pressures for re-allocation and limiting the long-term role of irrigation (20).

Drainage and Land Development Projects

These types of projects do not necessarily involve the direct use of water in agriculture, but they can have significant effects on the distribution of water and its availability for non-agricultural uses. At present the effects on other resource uses, or interactions with other programs, are not consistently taken into account before projects are undertaken, and there is apparently no requirement that this be done.

The concerns identified over federal involvement in such programs lie with the apparent (though not necessarily real) inconsistencies and conflicts between various federal programs. Addressing these concerns does not require that federal participation in all such projects be suspended. What it does require, as with water supply projects, is the application of rigorous project analysis which would ensure that the full range of project impacts is taken into account. A benefit-cost analysis consistent with the Treasury Board Guidelines would appear to be appropriate, with specific attention paid to both positive and negative effects on other uses of water.

Again, as with water supply projects, it is not expected that all projects would pass the economic efficiency test implied in such analyses. The consequent prospect is that federal

participation in such programs would be reduced in future. In the case of drainage projects, in particular, the point is repeatedly made that large areas of wetlands have already been eliminated, with loss of other resource values. This increases the importance attached to remaining wetlands, and in view of that it would not be surprising if analyses indicated that it was appropriate to slow the rate of conversion of wetlands to other uses. Such a position by the federal government might well be opposed by those who would benefit from continued drainage and agricultural expansion. On the other hand it would have to be seen as recognizing the wider range of federal interests and responsibilities.

Standards for Project and Program Evaluation

Several briefs to the Inquiry have stressed the need for better techniques to evaluate projects and priorities in water use (2, 9, 10, 18). And it has been suggested that a federal strategic plan is necessary to guide federal agency programs which deal with water resources (18). Central to these recommendations, as with ours above, is the need to adopt consistent evaluation procedures.

It is instructive to note that a similar need was recognized several decades ago in the United States, where federal involvement in water resource projects was very widespread. In 1965 the Water Resources Planning Act established a U.S. Water Resources Council to coordinate the activities of the various federal agencies dealing with water resources. The Council was charged to establish principles, standards and procedures for federal participants in the preparation of comprehensive regional or river basin plans and for the formulation and evaluation of federal water and related land resources projects (24). This led eventually to the 1980 "Principles and Standards for Water and Related Land Resources Planning" (49). While the subject of some criticism, it is generally acknowledged that these standards have greatly improved the approach to federal participation in water resources projects, broadened the range of project effects which are routinely considered, and made explicit the tradeoffs between different objectives.

It may be beyond the scope of our inquiry and recommendations, but it does appear, given the wide range of federal policies and programs that impinge on agricultural development alone, that a similar approach to establishing consistent standards and procedures for federal participation in water resources development in Canada should be investigated.

REFERENCES

1. Agriculture Canada, Challenge for Growth, An Agri-Food Strategy for Canada, Ottawa, July 1981.

2. Agriculture Canada, Emerging Water Issues and Their Impact on Canada's Agriculture. Presentation to the Inquiry into Federal Water Policy, December 1984.

3. Alberta Agriculture, The Economics of Agricultural Drainage: Irrigated Saline Soils in Southern Alberta, Resource Economics Branch, Edmonton, August 1983.

4. Alberta Environment, Scenario Report, South Saskatchewan River Basin Planning Program, Calgary, 1984.

5. Alberta Environment, Summary Report, South Saskatchewan River Basin Planning Program, Calgary, July 1984.

6. Brace, R.K., and G.W. Pepper, Impact of Agricultural Drainage on Wildlife, paper presented to the Western Provincial Conference on Soil and Water Management, November, 1984.

7. Brown, G.M. Jr., and J. Hammack, "A Preliminary Investigation of the Economics of Migratory Waterfowl" in Natural Environments, Studies in Theoretical and Applied Analysis, J.V. Krutilla, ed., Resources for the Future, Inc., Washington, D.C.

8. Canada Grains Council, Prospects for the Prairie Grain Industry, 1990, Winnipeg, November 1982.

9. Canadian National Committee of the Sierra Club, Submission to the Inquiry on Federal Water Policy,(undated).

10. Canadian Nature Federation, Naturalists' Perspectives on Federal Water Policy, Submission to the Inquiry on Federal Water Policy, November 5, 1984.

11. Canadian Organic Producers Marketing Cooperative Limited, Presentation to Federal Water Policy Inquiry, (undated).

12. Carruthers, I., and Colin Clark, The Economics of Irrigation, Liverpool University Press, Liverpool, 1981.

13. Conservation and Development Association, Presentation of The Conservation and Development Association to the Inquiry on Federal Water Policy, (undated).

14. darWall Consultants, Historic Trends, Drought and Cultural Practices, Study Element #8, Saskatchewan Drought Studies, Regina, 1983.

15. Ducks Unlimited Canada, Presentation to the Inquiry into Federal Water Policy (untitled, no date).

16. Ed Braun Enterprises Ltd. et. al., Agricultural Land Degradation in Western Canada: A Physical and Economic Overview, prepared for Agriculture Canada, Edmonton, August 1984.

17. Environment Canada, Canada Water Year Book, 1981-82, Ottawa, Minister of Supply and Services.

18. _____, Inland Waters Directorate, Western and Northern Region, Water and Economic Development in the Prairie Provinces, A Submission to the Inquiry on Federal Water Policy, (undated).

19. Environment Council of Alberta, Irrigation Agriculture in Alberta, Edmonton, March, 1982.

20. Frederick, K.D., and J.C. Hanson, Water for Western Agriculture, Resources for the Future, Inc., Washington D.C., 1982.

21. Goldstein, Jon, Competition for Wetlands in the Midwest An Economic Analysis, Resources for the Future, Inc., Washington, D.C., 1971.

22. High Plains Associates, Six-State High Plains-Ogallala Aquifer Regional Resources Study. A report to the U.S. Department of Commerce and the High Plains Council, Austin Texas, March 1982.

23. Horner, W.H. et. al., Western Canadian Agriculture to 1990, Canada West Foundation, Calgary, 1980.

24. Howe, C.W., "New Procedures for the Evaluation of Federal Water Projects," in The Southwest Review, Spring 1981.

25. Inquiry on Federal Water Policy, Water is a Mainstream Issue, Ottawa, Minister of Supply and Services, 1984.

26. Irwin, R.S., and H.R. Whiteley, "Effects of Land Drainage on Stream Flow", Canadian Water Resources Journal, Vol 8, No. 2, 1983.

27. Manitoba Department of Natural Resources, Brief to the Inquiry on Federal Water Policy, October 1984.

28. Marv Anderson & Associates Ltd., Price Quantity Relationships for Irrigation Water in Southern Alberta, Prepared for Environment Council of Alberta, 1978.

29. _____, Blood Indian Irrigation Feasibility Study.

Agronomy Study Component, Edmonton, November 1981

30. _____, Historical Perspective and Assessments of Drought Programs, Study Element #1, Saskatchewan Drought Studies, Regina, September 1982.

31. _____, An Analysis of Agricultural Research and Productivity in Alberta, ECA, Edmonton, January 1983.

32. McCuaig, J.D., and E.W. Manning, Agricultural Land-Use Change in Canada: Process and Consequences, Lands Directorate, Environment Canada, Ottawa, 1982.

33. McGill, W.B., Soil Fertility and Land Productivity in Alberta, ECA, Edmonton, July 1982.

34. McMahon, G.R., A Brief Submitted by the Honourable George R. McMahon, Q.C., Minister of Community and Cultural Affairs Prince Edward Island, to the Inquiry on Federal Water Policy, Charlottetown, September 26, 1984.

35. Montreal Engineering Company Limited, Economic Damages Resulting from Water Pollution, Prepared for Inland Waters Directorate, Canada Department of the Environment, 1974.

36. Nova Scotia Federation of Agriculture, Notes for Oral Presentation: Inquiry on Federal Water Policy, Halifax, September 1984.

37. Ontario Federation of Anglers and Hunters, Presentation to the Inquiry on Federal Water Policy, November 1984.

38. Ontario Ministry of Agriculture and Food, OMAF Submission, Provincial Response to the Inquiry into Federal Water Policy, 1984.

39. Pohjakas, K., "Evaluation of Center Pivot Irrigation Practices in Alberta," presented to CSAE Pacific Northwest Regional Meeting, Edmonton, September 1981.

40. Postel, S., Water: Rethinking Management in an Age of Scarcity, Worldwatch Paper 62, December 1984.

41. Prairie Farm Rehabilitation Administration, Land Degradation and Soil Conservation Issues on the Canadian Prairies, An Overview, Regina, November 1982.

42. _____, Water and Prairie Agricultural Development, Submission to the Inquiry on Federal Water Policy, October 1984.

43. Saskatchewan Water Corporation, Brief Presented to the Pearse Inquiry on Federal Water Policy by the Saskatchewan Water Corporation, December 1984.

44. Standing Committee on Agriculture, Fisheries and Forestry,

Soil at Risk, Canada's Eroding Future, Report to the Senate of Canada, Ottawa, 1984.

45. Statistics Canada, 1981 Census of Canada, Agriculture, Alberta, Saskatchewan, Manitoba, Catalogue #96-908-96-910, Ottawa, 1982.

46. Stevenson, D.S., "Irrigation Efficiency in Orchards", Canadian Water Resources Journal, Vol. 5, No. 3, 1980.

47. Strong-Hall & Associates et. al., South Saskatchewan River Basin Planning Program: Evaluation Methodologies and Data Base, Prepared for Alberta Environment, Calgary, July 1983.

48. Treasury Board Secretariat, Benefit-Cost Analysis Guide, Ottawa, Minister of Supply and Services, 1976.

49. U.S. Water Resources Council, "Principles and Standards for Water and Related Land Resources Planning - Level C", Federal Register, vol. 45, no. 190.

50. Veeman, M., "The Regulation of Interprovincial Trade in Agricultural Products", in Transforming Western Canada's Food Industry in the 80's and 90's, The Banff Centre School of Management, 1984.

51. Veeman, T.S., "Benefit-Cost Analysis in Environmental Decision-Making: Procedures, Perils, and Promise," Symposium, Canadian Society of Environmental Biologists, Edmonton, February 1985.

STUDY TERMS OF REFERENCE

Objective:

The objective of the report is to explore the role of water in current and projected Canadian agricultural development and the impacts which agricultural demands are likely to have on the quantity and quality of waters available to other uses.

Tasks:

The contractor hereby agrees to:

1. Review agricultural acreage and yields projections and analyze their implications for the use of water nationally and regionally;

2. Analyze the capability of agricultural producers to pay for water-related services (e.g. irrigation, drainage projects) in relation to other water users;

3. Analyze various adverse impacts (erosion, salinization, contamination, flow depletion) which agricultural expansion is likely to have on other uses of the resource, and means of reducing these impacts;

4. Document and critique (federal) policies and programs which influence agricultural demands for water;

5. Recommend changes in federal policies/programs as appropriate to improve the social, economic and environmental contributions of Canadian agriculture.