PRAIRIE FARM REHABILITATION ADMINISTRATION SERVING THE PRAIRIE PROVINCES

Soil and Water Conservation Service

Backflood Irrigation

Canada

Spring backflood irrigation is not a new technology. For years farmers have used a variety of methods to increase the amount of water stored in the soil from the spring snowmelt.

The types of spring backflood projects that are constructed depend on the topography, the amount and the source of water and the type of farming that's being carried out. Simple systems consist of no more than a dike across a small coulee, while large schemes backflood several hundred hectares and can involve leveling fields, constructing ditches or even pumping water onto fields.

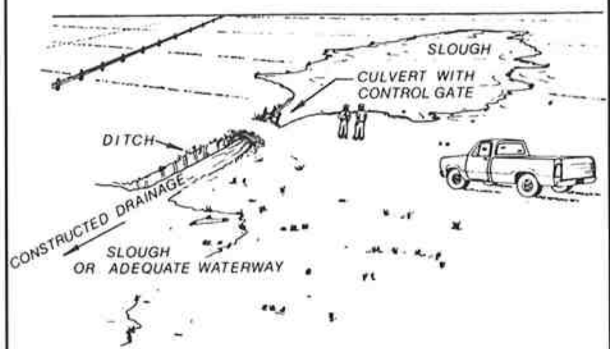
Many farmers are attracted to backflooding because its low development and operating cost make it an inexpensive way to increase crop and forage production. As well, most of the systems are simple to operate and require a small output of labor during the spring of the year.

This brochure looks at some basic backflood projects and presents some comparisons between dryland and backflood irrigation farming.

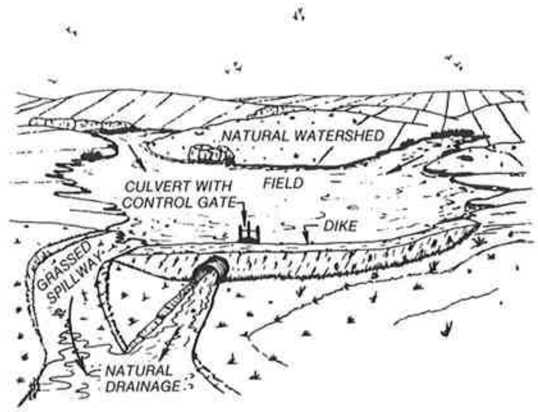
Cover photograph: Backflood irrigation project on the Moose Jaw River in the Rouleau area of Saskatchewan.

About Backflood Projects

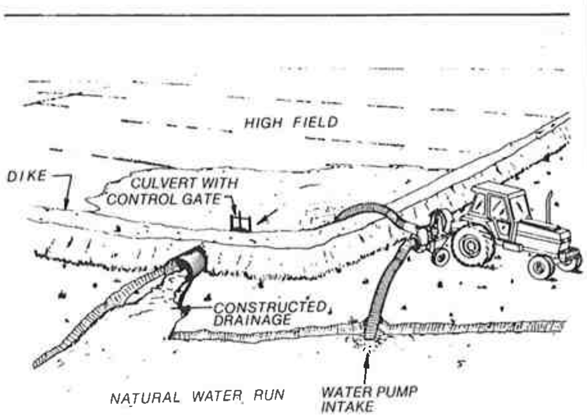
Although backflooding projects vary from farm to farm, there are only four basic designs: controlled drainage, diversion, pumped diversion and pumped drainage.



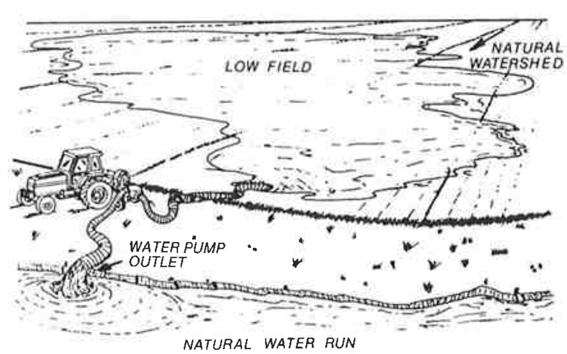
Controlled drainage systems use ditches and other structures to control and divert water from sloughs.



Diversion is the least complicated of spring backflood irrigation systems. A dike across a natural water run or a coulee holds water on the land.



Pumped diversion systems use water from creeks or rivers to irrigate fields.



Pumped drainage systems are used in areas where the topography does not allow for adequate natural drainage. Water is pumped off from a sump at the lowest end of the field and into a natural watercourse.

Before Constructing a Project

Unless topography, water supply and soil type are right, backflooding won't work.

- Field Slope — Backflood irrigation requires a well-drained, fairly level field that has a very gradual slope. Generally, the slope should be no more than 0.5 metres (1.5 feet) in 100 metres (100 yards). A field with a gradual slope lets water drain off the land quickly without causing erosion. If the field slope is too steep or the land too hilly, the costs of building dikes high enough to flood a significant number of hectares may be prohibitive.
- Water Quality and Quantity — The quality of water that is used for backflooding is generally good, since it comes from the spring snowmelt. A problem can occur, however, if runoff comes from an area that is affected by salinity.

  The amount of runoff an area receives depends, of course, on the drainage basin for the region. Hydrologists can be assisted by a farmer's knowledge of past runoff to estimate how much water is available for back flooding. In years of low runoff, the number of hectares that can be flooded will drop. Projects that receive water from local runoff are more seriously affected than are projects that receive water from rivers or creeks, but in either case, productivity will be lowered.
- Soil Suitability — Any type of soil can benefit from backflooding, but generally, soils should have good moisture holding capacity and have a low percentage of soluble salts and sodium. As might be expected, backflooding works best with heavy clay soils, which hold moisture very well. However, even sandy soils can produce significantly more tonnes per hectare when they are backflooded.

Moisture Holding Capacities of Soils

	Available Moisture Per Rooting Depth*	
Soil Texture	**mm of Water Per m of Soil**	**Inches of Water Per ft. of Soil**
Loamy Sand	110	1.32
Loamy Fine Sand	125	1.50
Sandy Loam	140	1.68
Fine Sandy Loam	170	2.04
Silt Loam	225	2.70
Silty Clay Loam	208	2.50
Clay Loam	182	2.19
Silty Clay	167	2.00
Clay	167	2.00

* North Dakota Irrigation Guide, U.S.D.A. and S.C.S., 1977.

Legal Requirements

For any backflooding project, regardless of size or location, getting permission to use the water from a provincial water licencing authority is the first step. Water licences may not be granted if all the available water is allocated.

Provincial authorities may also grant approval to use a natural watercourse — a river, creek or stream — as a drainage outlet.

A project may also require approval by municipal governments and other agencies before a water license is granted.

Easements may be required for some projects when a neighbor's land is affected by flooding or drainage.

Constructing a Project

Construction costs vary according to topography and water supply. Pumping equipment can push up the per hectare capital cost considerably, but the most expensive part of any backflooding project is the earthwork.

When dikes and field ditches are being constructed, there are certain minimum design standards that should be kept in mind.

Design Standards

Dikes

Freeboard (vertical space between the water level and the top of the dike)
— 0.6 metres (2 feet) minimum

Top Width
— 3 metres (10 feet)
— 2 metres (6.6 feet) for dikes less than 2 metres high

Side Slope
— 3:1 on side facing water
— 2:1 on side not facing water

NOTE: Dikes should be seeded to grass to prevent water erosion. Spillways should also be seeded to grass.

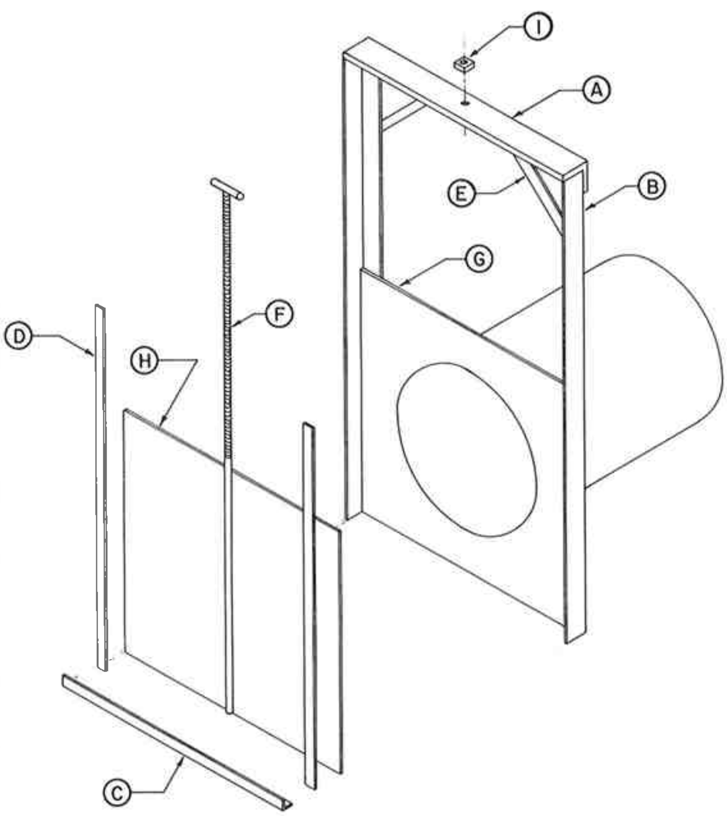
Field Ditches

Side Slope
— standard 2:1
— ditches that experience low flows and a minimum amount of erosion may have flatter slopes (6:1) to allow farming of the ditches

Control Gates and Culverts

— The flow of water determines the size of control gates and culverts

Culvert Control Gate



Culvert Size Chart

	SYM	MATERIAL	NO.	SIZE	WT.	
400 mm CULVERT	A	75 x 75 x 13 ∠	1	630 mm	8.82	600 mm of Head*
	B	55 x 55 x 6 ∠	2	1150 mm	11.3	
	C	25 x 25 x 5 ∠	1	630 mm	1.10	
	D	25 x 6 BAR	2	900 mm	2.10	
	E	25 x 6 BAR	2	300 mm	0.71	
	F	19 mm Ø ROD	1	1300 mm	2.90	
	G	4.8 mm PLATE	1	600 mm x 600 mm	13.6	
	H	4.8 mm PLATE	1	600 mm x 600 mm	13.6	
	I	NUT	1	19 mm		
		TOTAL WT kg			54.13	
600 mm CULVERT	A	75 x 75 x 13 ∠	1	830 mm	11.6	800 mm of Head*
	B	55 x 55 x 6 ∠	2	1550 mm	15.2	
	C	25 x 25 x 5 ∠	1	830 mm	1.50	
	D	25 x 6 BAR	2	1100 mm	2.60	
	E	25 x 6 BAR	2	300 mm	0.71	
	F	19 mm Ø ROD	1	1700 mm	3.80	
	G	4.8 mm PLATE	1	800 mm x 800 mm	24.1	
	H	4.8 mm PLATE	1	800 mm x 800 mm	24.1	
	I	NUT	1	19 mm		
		TOTAL WT. kg			83.61	
800 mm CULVERT	A	75 x 75 x 13 ∠	1	1030 mm	14.4	1000 mm of Head*
	B	55 x 55 x 6 ∠	2	1950 mm	19.1	
	C	25 x 25 x 5 ∠	1	1030 mm	1.80	
	D	25 x 6 BAR	2	1300 mm	3.10	
	E	25 x 6 BAR	2	300 mm	0.71	
	F	19 mm Ø ROD	1	2100 mm	4.70	
	G	4.8 mm PLATE	1	1000 mm x 1000 mm	37.7	
	H	4.8 mm PLATE	1	1000 mm x 1000 mm	37.7	
	I	NUT	1	19 mm		
		TOTAL WT. kg			119.21	

NOTE: 1) B and F to be increased in length to match top of structure.
2) Weld steel plate G to culvert, then cut out opening.
3) C and D to be welded to support frame.
* Head - (hydraulics)- the height of fluid above any plane or reference.

Operating a Backflood System

The object is to fill the root zone — generally accepted to be 0.9 metres to 1.2 metres (3 to 4 feet) — and then to use all of the stored moisture during the growing season.

Cropping the soil dry each season prevents the buildup of subsoil water levels and ensures that the soil will be dry enough to absorb water the following spring. (Good absorption of water solves problems with ponding after heavy rainfalls.)

Holding the water on the land too long oversaturates the soil. If the subsoil gets oversaturated, the only way it can dry is by evaporation. That can bring salts up to the surface. Oversaturating the subsoil also cuts down on yields, because it causes shallow rooting and plants will suffer during hot, dry weather.

Letting the water go too soon means water won't have a chance to soak down far enough to replenish the root zone.

A soil probe is used to check how deeply moisture has penetrated.

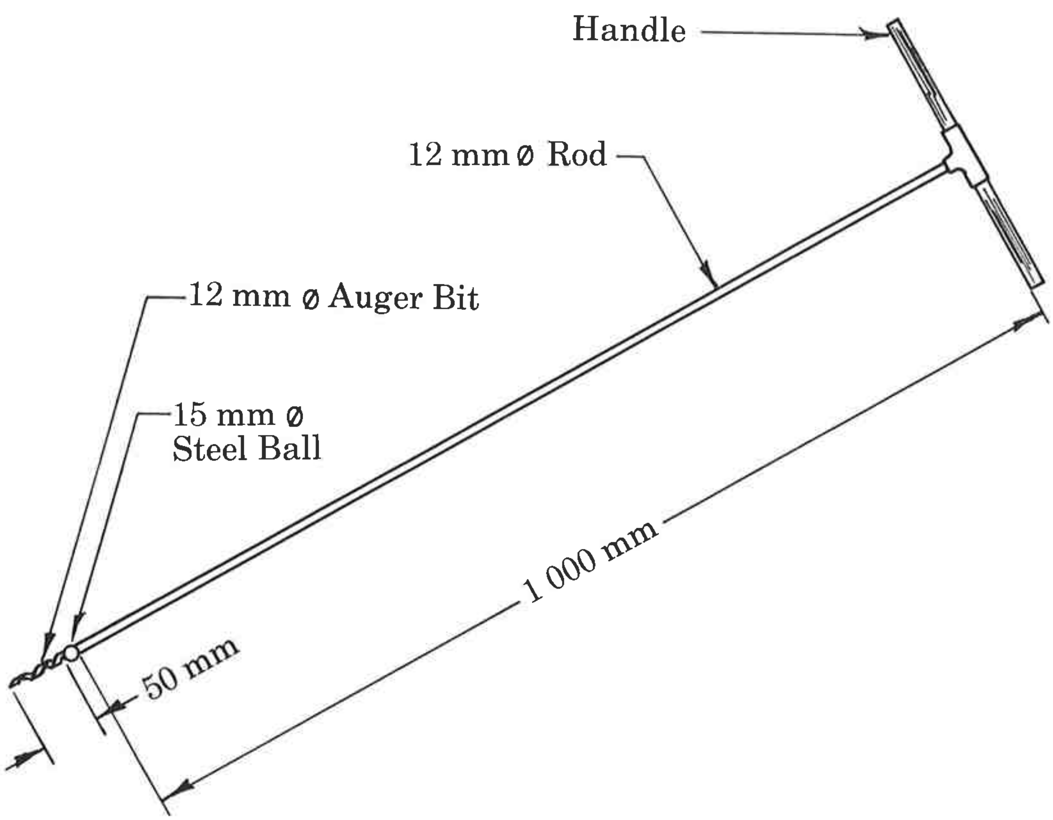
If the soil texture is uniform, probing in only two or three spots in the field will be sufficient.

Generally, water is left on the field until it has saturated the soil to 0.9 metres (3 feet). As soon as the probe can be pushed down that far, the water should be released. There will be enough water in the soil for moisture to soak down another 0.3 metres (1 foot) or so. This downward movement of water will keep salts from coming to the surface and will also allow the surface of the land to dry quickly.

Flooding frozen ground hastens thawing and results in even water penetration. A backflooded field can be ready for seeding a week after the water has been drained off.

(NOTE: If land has hardpan, it may not be advisable to soak to a depth of 0.9 to 1.2 metres (3 to 4 feet). A soil specialist can give recommendations on how to deal with this condition.)

Soil Probe



Backflood Irrigation Farming

While there are no hard and fast rules about how to get the maximum production out of backflood irrigation farming, there are some general recommendations that can be made about fertilizer application, herbicide use and cultivation practices.

- Applying fertilizers — Fertilizer requirements will be greater because of the continuous cropping that's practiced under backflood irrigation. Soil testing, especially for nitrogen — which is easily leached — should be done annually. The maximum fertilizer recommendations should be applied to get the best results. Fertilizer should be applied in the spring of the year.
- Applying herbicides — Herbicides should be applied as required.
- Cultivation practices — Straw buildup on shorelines can be a problem, so a fall cultivation to anchor the straw is required.

Crop Selection

The crops that are best suited for backflood irrigation fields are those with root systems that can go down far enough to use all the moisture that's stored in the subsoil. Because shallow rooted crops can't take advantage of all the available moisture, problems with oversaturation can occur the following year.

Durum wheat, spring wheat, and coarse grains are well suited to spring backflooding. Winter wheat can be grown, but can be damaged by extended flooding or erosion.

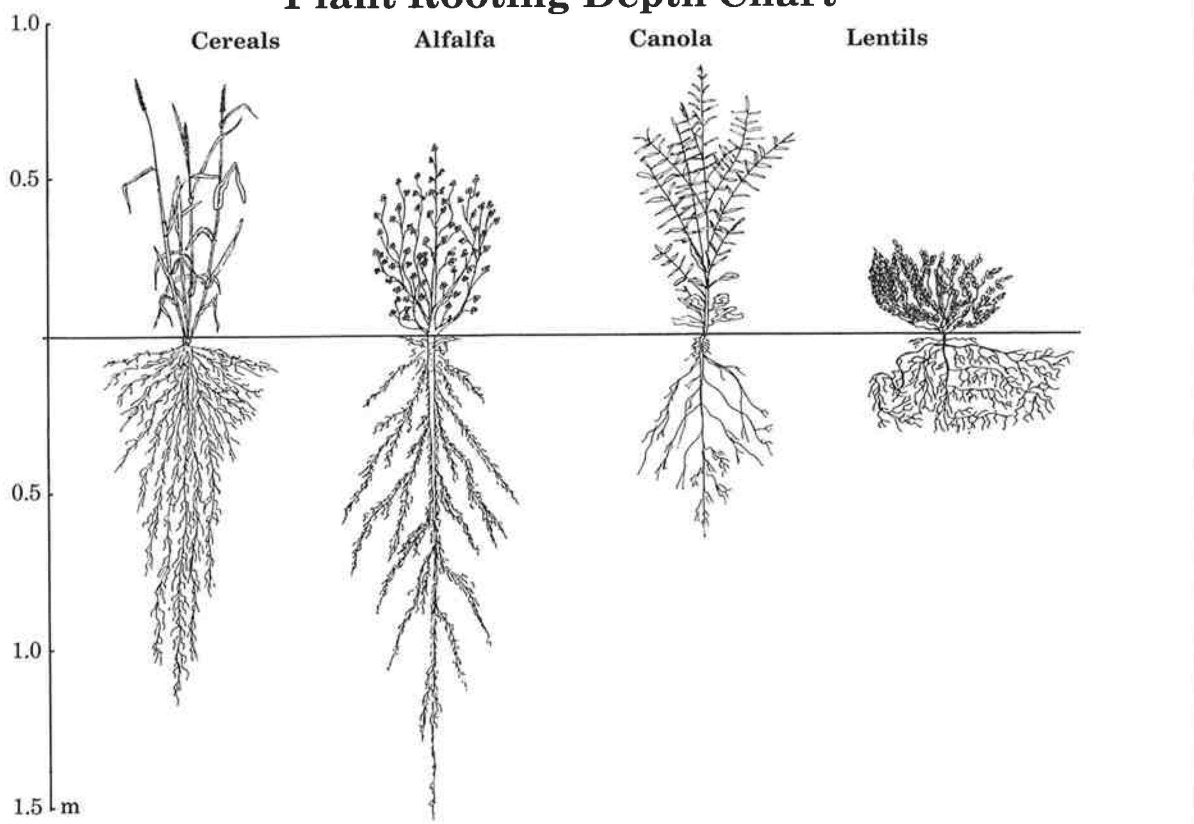
Bromegrass and timothy are well suited for growing in reclaimed slough areas that drain quickly. These grasses can tolerate flooding for three weeks without damage.

Alfalfa can be grown on backflood land but can only tolerate flooding 7 to 10 days after the frost comes out of the ground.

Grasses such as tall wheatgrass and slender wheatgrass can tolerate saline conditions better than any other crop. These grasses can tolerate flooding for four weeks and should be used where wild barley normally thrives.

Pulse crops (such as fababeans, lentils and field peas) and oilseeds rely on moisture closer to the 0.6 metre (2 foot) zone and are not recommended as part of the crop rotation. However, canola can utilize water from a greater depth and may be suitable for backflood irrigation.

Plant Rooting Depth Chart



Backflooding: A Case in Point

Does backflooding pay? Generally, yes, because crops produce higher yields when they have adequate moisture.

Yield Increases

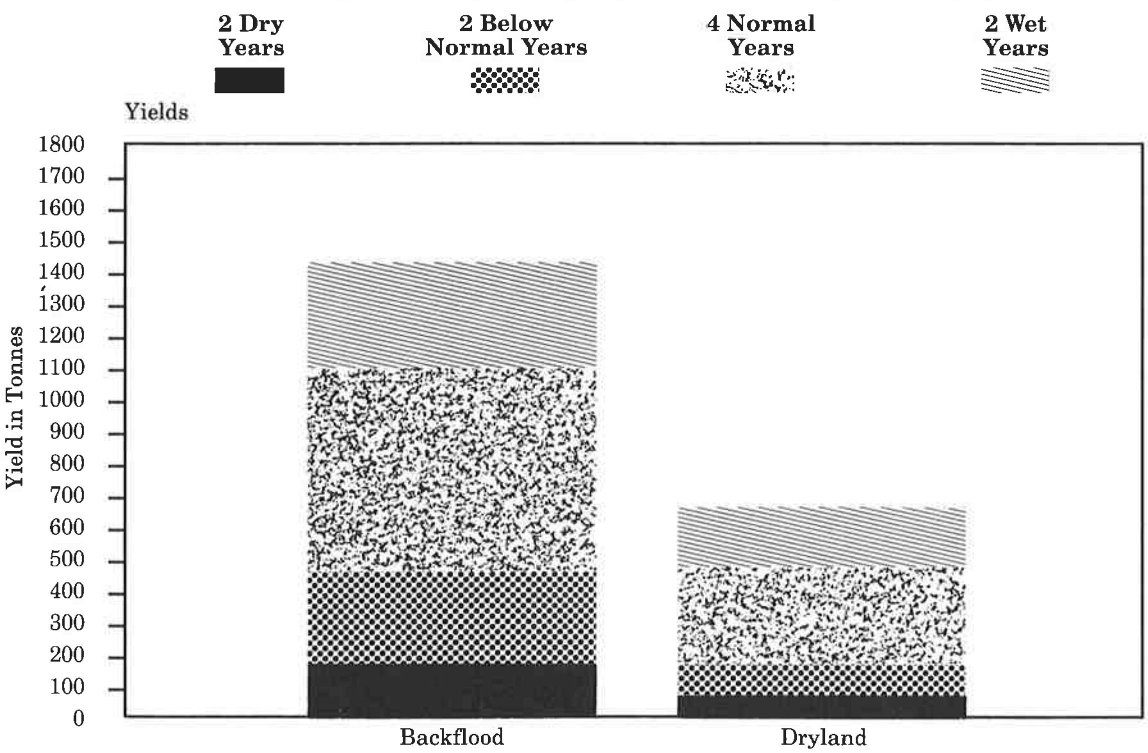
To demonstrate the potential yield increases under backflood irrigation, PFRA compared the net effect of dryland and irrigation production on a 60 hectare case farm over a 10 year period.

It was assumed that:

- major earthwork is required for diking
- the soil is silty clay loam with good moisture holding capacity
- water is pumped onto fields to backflood them
- runoff conditions are above normal 2 years, normal 4 years, below normal 2 years, and much below normal 2 years
- extra yields from rainfall are equal for irrigation and dryland production and so do not need to be taken into account
- under dryland farming, the 60 hectares are in a 1/3 summerfallow, 2/3 crop rotation, so that over a 10 year period, 200 ha are stubble cropped, 200 ha are cropped on summerfallow, and 200 ha are left fallow
- dryland yields reflect the expected production under the various snowmelt runoff conditions
- there is enough runoff 6 out of 10 years to flood all 60 ha, but that there is only enough runoff to flood 45 ha in the 2 years of below normal runoff and that no irrigation is possible in the 2 dry years; consequently, only 450 of the cumulative 600 ha are continuously cropped over the 10 year period
- wheat is the only crop grown

Backflood — Dryland

Ten Year Wheat Production Yields — 60 Hectares



NOTE: The results shown on the graph are based on conditions assumed above. The production figures are based on **stored soil moisture,** not on actual climatic conditions. Extra yields from rainfall are not taken into account because the increase for both graph quantities will be equally affected. There is a calculated increase of 769.2 tonnes on 60 ha of backflooded land over the same number of hectares under dryland farming over a 10 year period, or 76.9 tonnes annually. Greater fluctuations in conditions and yields are likely under actual farming conditions.

Fixed and Variable Costs

An economic analysis, comparing backflood irrigation and dryland farming, should be done before any project is started. This is especially true of major schemes involving a great deal of earthmoving.

Yield increases do not have to be large to cover the cost of implementing and operating a system. But any economic projection has to include commodity prices, which vary from year to year.

To give some idea of the kinds of things that should be included in an economic analysis, fixed and variable cost charts have been included. One uses data from the case farm, the other is blank, and can be used by anyone thinking about starting a backflood irrigation project. The numbers from the case farm and the ones applicable to individual farmers will, of course, vary.

Cost Comparisons
Backflood Irrigation/Dryland Farming - Case Farm 60 Hectares

Fixed Costs

	Capital Costs	Years of Use	Annual Depreciation	Annual Investment Cost of Capital*
Earthwork	$21,783	30	$ 726	$1,307
Culverts	500	30	17	30
Control Gates	300	30	10	18
Pump	10,000	25	400	600
Hose	1,000	25	40	60
Storage	1,600	50	32	96
TOTAL	$35,183		$1,225	$2,111
Total annual fixed costs			$3,336	

Variable Costs Per Hectare

	Irrigation	Summer-fallow	Stubble
Chemicals	$ 40.77	$ 19.40	$ 40.77
Fertilizer	61.76	16.60	48.43
Fuel & Lube (Pump)	22.12	13.22	22.73
Repairs	22.73	17.67	22.73
Rentals	5.68	0	5.68
Insurance	18.53	13.59	13.69
Pumping	6.17	0	0
Cultivation	0	16.68	0
Seed	23.72	23.72	23.72
SUBTOTAL	$201.48	$120.88	$177.75
Miscellaneous (5%)	10.07	6.04	8.89
TOTAL	$211.55	$126.92	$186.64

Average Annual Variable Cost

	Area	Unit Cost	Cost
IRRIGATED			
Full Irrigation	45	$211.55	$ 9,520
Dry Area	15	186.64	2,800
TOTAL			$12,320
DRYLAND			
Summerfallow	20	$126.92	$ 2,538
Stubble Crop	20	186.64	3,733
TOTAL			$6,271
Net added cost of irrigating			$6,049

* Annual Investment Cost of Capital is the amount of money that could be earned if the capital expenses were invested. For the case study, we've assumed a rate of return of 6%.

Returns

The extra gross income from stored soil moisture, based on the case farm's annual increased production of 76.9 tonnes and a grain price of $147 per tonne, is about $11,304. (76.9 x $147 = $11,304.)

Minus the annual fixed cost of $3,336 and the annual variable cost of $6,049, the case farm shows an annual net return of $1,919. ($11,304 - $9,385 = $1,919.)

In this case, the spring backflood project provided an increase in income of $31.98 per hectare. But because every project is unique, increased revenues will vary according to capital expenditures, cropping practices, and variable input costs. Commodity prices and interest rates will also affect returns to a great degree.

Cost Comparisons Worksheet
Backflood Irrigation/Dryland Farming

Fixed Costs	Capital Costs	Years of Use	Annual Depreciation	Annual Investment Cost of Capital
Earthwork				
Culverts				
Control Gates				
Pump				
Hose				
Storage				
TOTAL				
Total annual fixed costs				

Variable Costs Per Hectare	Irrigation	Summer-fallow	Stubble
Chemicals			
Fertilizer			
Fuel & Lube (Pump)			
Repairs			
Rentals			
Insurance			
Pumping			
Cultivation			
Seed			
SUBTOTAL			
Miscellaneous (5%)			
TOTAL			

Average Annual Variable Cost	Area	Unit Cost	Cost
IRRIGATED Full Irrigation			
Dry Area			
TOTAL			
DRYLAND Summerfallow			
Stubble Crop			
TOTAL			
Net added cost of irrigating			

For more information about spring backflood irrigation, contact:

— any PFRA office in Alberta, Saskatchewan or Manitoba

— local Agricultural Representatives (Ag Reps), Extension Agrologists or District Agriculturists (DAs)

— Alberta Environment, Water Resources Administration Division, Surface Water Rights Branch

— The Saskatchewan Water Corporation

— Manitoba Agriculture or Manitoba Natural Resources, Water Resources Branch

PFRA is a federal government agency established in 1935 to deal with soil and water conservation and development in the three Prairie provinces. Before starting any on-farm water project, contact your local PFRA office for technical advice and financial assistance. PFRA policy statements and applications are available from your local district office.

PFRA Office Locations

Alberta	Saskatchewan		Manitoba
Hanna	Gravelbourg	Rosetown	Brandon
Lethbridge	Maple Creek	Shaunavon	Dauphin
Medicine Hat	Melfort	Swift Current	Morden
Peace River	Melville	Watrous	
Red Deer	Moose Jaw	Weyburn	
Vegreville	North Battleford		
Westlock			

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Administration du Rétablissement Agricole des Prairies

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