MANAGING SNOW TO IRRIGATE SHELTERBELTS AND ABATE SALINITY

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ABSTRACT

Two techniques for extracting near-surface ground water were evaluated on a one-hectare (2.5-acre) salinized parcel of agricultural land situated within a barley field located in Saskatchewan. A mound of ground water formed under the parcel each spring as subsurface waters encountered impediments to downslope flow. This resulted in a near-surface watertable which subjected the parcel to salinization. The remedial technique involved extracting the excess ground water and utilizing it to irrigate shelterbelt vegetation planted for wildlife and agro-forestry benefit. Lowering the watertable reduced salinization and encouraged snow management to enhance total water supply. Upon infiltration, the additional water from melting snow could leach more of the offending salts from the parcel's root zones. Water supplies were enhanced by retaining wind-blown snow within tall wheatgrass windbreaks seeded adjacent to the parcel. Sites rich in ground water, such as the parcel studied, can be de-watered either by gravity drainage or by solar-powered pumping using one or more shallow wells and, if necessary, radial accumulation galleries. The concept of water harvesting features simple, low-cost systems that can readily be installed by land owners using a backhoe. Water harvested by these systems could be used for livestock, wildlife, waterfowl, salt-tolerant field crops, and shelterbelts.

THE CHALLENGE

Many fields and pastures located on the Northern Great Plains and Canadian Prairies naturally contain uneven distributions of subsurface water. Glacial-till parent-materials in semiarid climates typically generate large tracts of agriculturally water-deficient soils which surround smaller, wet areas in side-hill or lowland positions especially during spring seeding time. These wet areas are often water-logged, forming seeps which eventually become saline. Water-logged soils divert or stop the movement of farm equipment, delay seeding, limit root development, cause weed infestations, reduce crop yields, and add to producer stress during the busy field season. Ironically, the excess water could benefit the drier portions of the field, if the water could be redistributed to where it is needed. Such redistribution systems also offer the possibility to enhance total water supplies by better utilization of snow resources.

The challenge facing this project was to enhance snowcovers and beneficially utilize their melt waters together with the excess ground waters found under a salinized area within a test grain field. The techniques required to meet this challenge involved: confronting and accumulating wind-blown snow, infiltrating and storing snow meltwater, extracting and utilizing the stored ground water. Specifically, the extracted water was to be routed to other locations in the same field, where it could be used to irrigate woody shelterbelt plantings for wildlife and agro-forestry benefits.

STUDY SITE

A quarter-section of land located five kilometers southwest of Swift Current, Saskatchewan served as the test and demonstration field. The field slopes 3% southeastward along which major changes in the nature, texture, and hydraulic conductivity of the subsurface material slow subsurface water moving downhill causing local accumulations and water-table rises. The water forming these ground-water mounds is released naturally during the course of a the growing season and move slowly downslope through the soil, subsoil and stratigraphic contacts. Dryland salinization occurs when water from these wet areas mobilize and transfer dissolved salts into root zones in response to evapotranspiration.

A one-hectare area of water-logged land (the North Parcel) was selected for testing. The test parcel receives a mean annual precipitation of 359 mm, with up to one-third falling as snow. The growing season (May, June, July, August) precipitation and Class A pan evaporation average 210 and 883 mm, respectively. The topsoil of the field developed from a partially-eroded veneer of loess (now, no more than 15 cm thick, where it exists) overlying glacial till. The soil is mapped as a salinized Swinton silty-loam to loam merging into a Haverhill loam to clay loam. The soil bulk density and saturated subsoil hydraulic conductivity average 1.5 g/cm^3 and 2.6 (10^{-7}) m/s, respectively. Weathered Cretaceous Bearpaw shale underlies the till at depths below land surface ranging from 6 m (20 feet) along the west boundary of the saline parcel to 1.5 m (five feet) on the east side. The texture of the overlying till and subsoil changes rather abruptly from a silty loam with sand lenses on the west side to a loamy clay on the east side. This west-to-east transition occurs everywhere along a broad line trending north-south transecting the parcel. We have concluded that the higher watertables observed west of the transition along with shallower soil depths before encountering the shale in the east cause the root-zone salinity associated with the parcel.

WATER HARVEST SYSTEMS

Before any systems were designed or installed, a **preliminary subsurface site investigation** was conducted. The investigation obtained information related to: (1) the potential up-wind snow fetch; (2) the extent of the water-logged area; (3) the nature and texture of the subsurface media to a depth of 3 to 4 m (10 to 14 feet); (4) the watertable depths; (5) the salinity of the soil and associated ground waters.

The **design criteria** identified for the prototype water harvesting and utilization systems were:

- To accumulate wind-blown snow in an up-slope position by an appropriate snow management technique.
- To store infiltrated melt and ground water below frost depths.
- To function in level terrain.
- To supply water for a trickle-irrigation system which routed the water to a wildlife-planting of hybrid poplar and dogwood seedlings.

The water was to be accumulated as an enhanced snowcover, allowed to melt and accumulate with the near-surface ground waters, extracted from the subsurface using one of two water-removal systems, and used to irrigate a new shelterbelt planting.

The snow-management technique selected for this study has been successfully applied in Colorado (Marshall 1967), Montana (Siddoway 1970), North Dakota (Black et al. 1981, and Saskatchewan (Steppuhn et al. 1987). Paired rows of a perennial grass are seeded across the field 15 m (50 feet) apart aligned perpendicular to the site's prevailing wind direction. Tall wheatgrass (*Thinopyrum ponticum*) matures into a one-meter tall, perennial bunchgrass which tolerates salinity exceptionally well. In April of 1992, a windbreak system of tall wheatgrass was seeded into saline soil located adjacent the test parcel in order to evaluate its snow management potential. In 1999, these rows of tall wheatgrass were extended across the test parcel.

Two types of water extraction systems were installed within the parcel during the Fall of 1997: a **gravity flow system** with drainage lines totaling 145 m (475 feet) in length crossing the parcel at an average depth of 1.83 m (6 feet); and, a **pump system** consisting of a gravel-packed well (66 cm in diameter, 4 m deep) and a solar-powered, submersible pump. Installations were accomplished with local labor and a backhoe. Each system was valve-controlled, fitted with water discharge measurement instruments, and operated independently at selected times during the 1998 and 1999 water harvest periods (May-October). Each year, testing with the gravity system was completed before initiating the pump system.

A **trickle irrigation system** applied the harvested water to 125 hybrid poplar and 125 dogwood seedlings. The irrigation system operated with either gravity or solar-powered line pressure and pressure-compensating emitters that supplied two liters of water per hour to each seedling. The technique utilized the natural slope of the land to route the water downslope for reuse within the same field, similar to the natural subsurface flow but faster and under control. Using shallow, solar-pumped wells, a method also exists to harvest excess field water in level terrain. We have also pumped this water to irrigate forage crops, to leach the parcel's salinized root zones, and elsewhere, to reclaim petroleum brine-spills.

OBSERVATIONS

Observation wells in the study parcel recorded the typical peak-to-trough water-table levels during the growing seasons both before and after installation of the water extractions systems (Figure 1). Before installation, spring water levels often reached the soil surface. Since installation, the levels have remained at least 0.9 m below the surface. Operation of the extraction systems during July, August, and September in 1998 and 1999 rapidly lowered the water table utilizing any excess accumulations from spring and summer precipitation. These systems pulled the late summer ground-water levels below 2 m (6.5 feet), a safe position for salinity control. The quantity and salinity

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(EC) of the harvested water were also monitored. In 1998, these totaled 206,200 liters and averaged 4.6 dS/m in salinity. In 1999, the volume of water harvested and available for irrigation totaled 624,700 liters with a salinity averaging 4.5 dS/m.

Tall wheatgrass has been used as field windbreaks for snow control for many years and has been evaluated in a windbreak system at the study site since 1993. Snowcovers were measured yearly both within and outside the grass windbreak system except in 1998 when snowcovers were too sparse to measure (Table 1). Over the six measurement years, snowcover water equivalents averaged three times greater within the windbreaks than outside them. In every year measured, this snow management technique would have delivered additional water for a ground-water harvest had an extraction system been installed.

Table 1. Mean snowcover water equivalents surveyed within and outside of a tall wheatgrass windbreak system, Smith Brothers Farms, Swift Current, Saskatchewan.

	Mean Snowcover Water Equivalent	
Survey	Within	Outside
	mm	
Jan 1993	31	26
Feb 1994	78	29
Mar 1995	31	11
Jan 1996	95	23
Jan 1997	136	42
Jan 1999	65	23
Average	72.7	25.7

A grid of ten soil sampling points west of the textural transition was also established in the test parcel. Each fall, a 50-mm diameter soil core was extracted from the surface down to 91 cm (three feet) at locations within a 2-m (6.5-foot) radius of each sampling point. The electrical conductivities (EC_e) were determined for each 15-cm depth increment of each sample core. Only the upper layer registered a decrease in soil salinity as the result of the water harvest systems (Table 2). Nevertheless, by 1999, this decrease proved sufficient to produce a respectable barley crop from the parcel, the first in many decades (Table 3).

Table 2. Mean electrical conductivity of saturated soil paste extracts (EC_e) from ten soil cores extracted each Fall, North Parcel, Smith Brothers Site, Swift Current, Saskatchewan.

Soil Depth Layer	Year of Fall Soil Sampling			
	1996	1997	1998	1999
cm	dS/m			
0-15	19.7	20.8	17.1	14.3
15-30	15.4	13.8	21.3	18.2
30-45	11.5	9.2	13	13.7
45-60	8.4	7.1	8.7	9.4
60-75	6.6	6.1	6.8	6.2
75-90	6.2	5.8	5.7	5
0-30	17.5	17.3	19.2	16.2
0-45	15.5	14.6	17.1	15.4
0-90	11.3	10.6	12.1	11.1

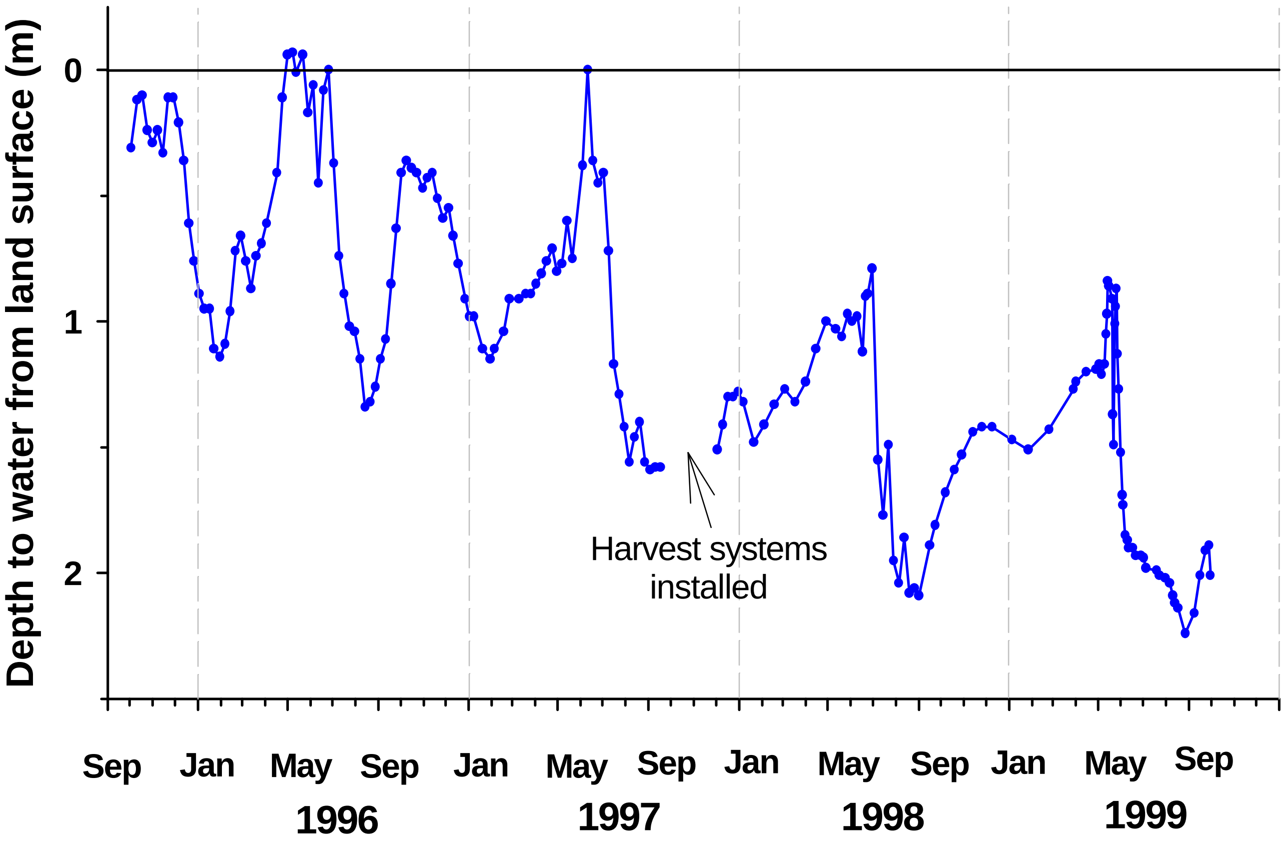

Figure 1. Observation Well 4545, Smith Brothers Site, near Swift Current, Saskatchewan.

Table 3. Mean grain yields from 36 hand-cut square metre samples obtain from ‘Harrington’ barley seedings, North Parcel, Smith Brothers Site, Swift Current, Saskatchewan.

Year	Air-dried Grain Yields	
	kg/ha	bushels/acre*
1996	0	0
1997	0	0
1998	0	0
1999	2659	47.5

* Calculated at 50 pounds per bushel

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