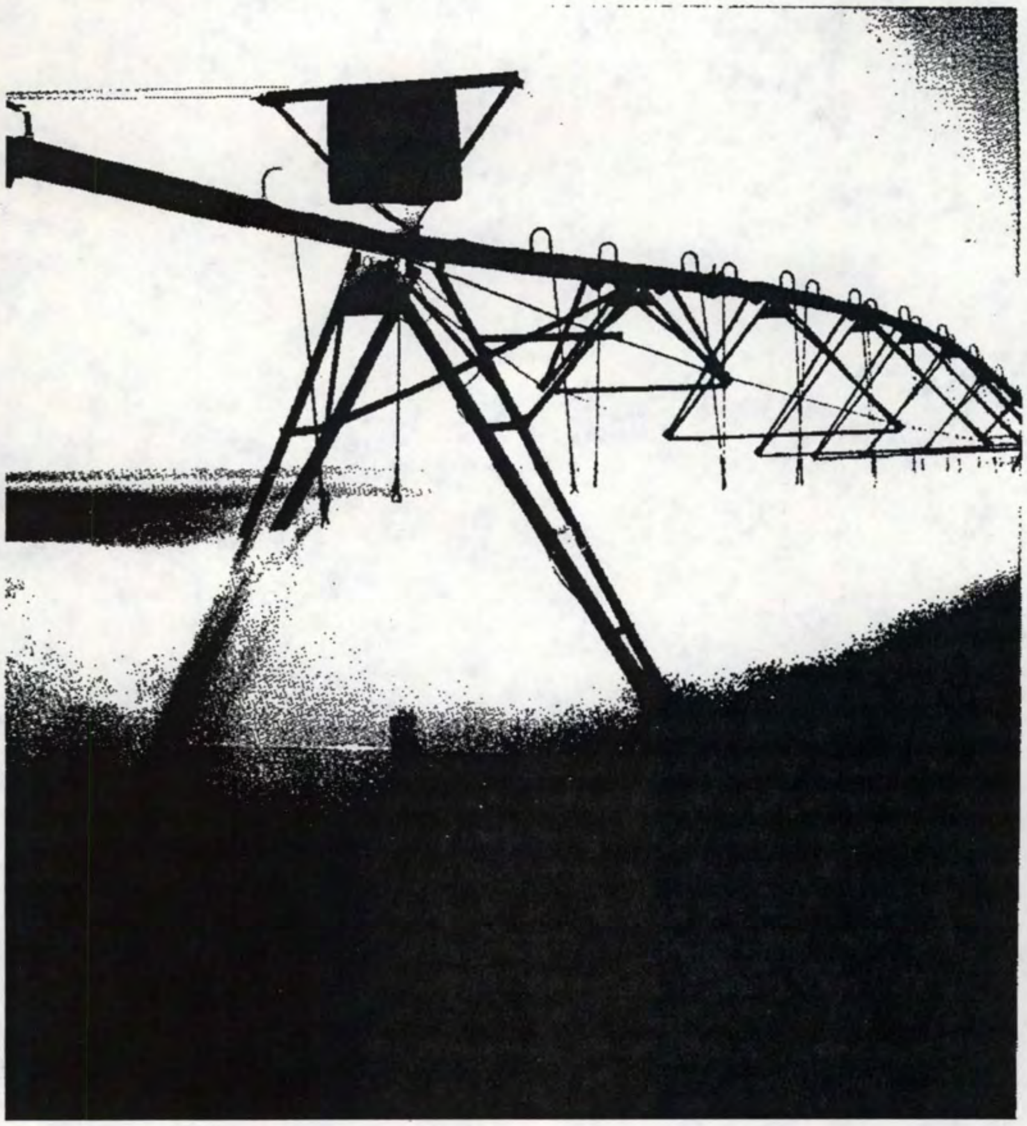
Southern Idaho/Eastern Oregon
Ag Lenders' Seminar



Idaho Water & Irrigation

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University of Idaho
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December 1, 1993

Dear Agricultural Lender :

Irrigation is critical to the economy of Idaho and the Northwest. Without it, our agricultural base would shrivel like plants in a drought. In order to remain competitive, conserve soil and water, and return clean water to the streams and rivers we all enjoy in this area, new technologies and practices must be considered. In some presentations references to specific brand name products are made. The University of Idaho does not recommend any brands nor does it promote one product over another.

The time and effort of the speakers, Twin Falls R & E Center staff, and support of the Idaho Ag Lenders is appreciated and gratefully acknowledged. Much effort has gone into making this material available. We hope you find these proceedings a useful reference as you work with clients in making irrigation system decisions.

Sincerely,

C. Wilson Gray

C. Wilson Gray
Extension Livestock Economist

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FINANCIAL INSTITUTIONS

The Missing Link in Water Quality?

Warren T. McFall, P.E.
Chief, Idaho Water Programs
US EPA, Boise, Idaho

The Clean Water Act is currently up for Re-authorization in Congress. Several versions have been proposed, but at this point it's anyone's crystal ball. One scene that seems to recur in various versions involves controlling runoff from agriculture and other non-point sources. This change could replace the current voluntary approach of controlling sediment and other types of runoff pollutants. Congress is responding to the perception that the voluntary approach is not getting the kinds of results that are necessary to clean up the nations waters.

EPA currently has no authority to regulate non-point sources of pollution and control of such pollution is primarily through voluntary programs in Idaho. Although there have been cases in the state of Idaho where there have been significant improvements in water quality from this approach, non-point sources of pollution remain the major water quality problem in Idaho.

The mechanism of non-point source control typically revolves around what is referred to as Best Management Practices (BMPs). Ideally the application of BMPs will prevent run-off of sediment, nutrients and pesticides from reaching surface water or the groundwater. Although non-point sources include runoff from forest lands, inactive mining sites, and urban areas, the major contributor of non-point source pollution in the Snake River Basin is from agriculture.

Agricultural experts assure us that technology exists such that contaminants can be kept out of our waters. Applying BMPs can be expensive, however recent information from the Agriculture Research Station in Kimberly indicates that application of current BMPs is not only effective in keeping our soils in the fields and in keeping our waters clean but using such methods is also said to be a profitable venture.

So, why is it then that we have problems with agriculture non-point source pollution, if in fact the technology exists to eliminate the discharge of pollutants profitably? The answer is simple: farmers are just not putting the new technology into practice. They have difficulty leaving the traditional methods behind and going to the new state-of-the-art technology.

Congress, in their infinite wisdom, is receiving messages that voluntary non-point source controls are not successful in cleaning up our nation's waters. They are being pressured to put into place tighter controls over non-point sources. If this is accomplished in the rewrite of the Clean Water Act, another layer of regulation and oversight is likely to be the result. This will increase the cost of production and reduce the profitability of operations to a great extent.

Agricultural experts tell us that the majority of the farmers are using BMPs and that the problems of water quality are resulting from a relatively few farmers that are not willing to part with the traditional methods. If this is true, then we have a relatively few farmers to thank for a trend that may well result in increased regulations for all operations.

Assuming that it is not too late, financial institutions may be able to provide the "missing link" in making the voluntary non-point source approach more successful. If a program were created which would foster incorporation of BMPs into all of our farms (without regulatory controls), then we may be able to convince Congress that we can take care of our own problems.

Financial institutions are concerned with the ability of the farmer to repay loans. Part of the farmers ability to repay hinge on his long term programs. The ability of the farmer to retain his soil should be a critical factor in determining long range sustainability of the farm. If a farmer is not practicing good farming techniques then he may not be the best financial risk (in the long term).

A program that would screen loan applicants for their farming practices may help lenders identify the long term risks associated with a farmer-applicant. In addition, this approach could result in a major improvement in water quality. Agricultural agencies could be requested to assist in the development of appropriate screening information and data forms that the farmers could submit to the lender much as any other application requirement.

If such an approach is workable on a local or statewide level, then it may be the kind of approach that could be used to demonstrate to Congress an alternative to more regulations. In the scenario that I have presented, the financial institutions are obviously a key. EPA will be pleased to work with a group of lenders to help develop a possible demonstration or pilot program.

WATER ISSUES FOR IDAHO
Presented Dec 7,8,9, 1993
C.E. Brockway PhD, P.E.

Federal -State Water Rights Conflicts
- Reserved Water Rights Expansion
  - Dept of Interior
  - Reclamation Law
- FERC- Authority over hydro projects"Rock Creek"
- ESA- Endangered Species Act
  - NMFS-Salmon
    - USBR Upper Snake River water search
  - USFWS-Snake River and Bruneau Snails

WaterSupply
- Drought
- Expansion of Use for irrigation et al
- Demands on supply
- Changes in irrigation methods

Water Rights
- Stream-Aquifer relationships
- Conjunctive use
- Appropriation Doctrine
  - First in Time-first in right
  - Futile call- aquifer time lag
  - Public Interest Doctrine
- Snake River Basin Ajudication

Water Quality
- Mid Snake Water Quality Problems
  - Aquaculture
  - Irrigation
  - Municipalities
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- Nutrient Management Planning
- EPA Total Maximum Daily Load

CURRENT IRRIGATION SYSTEMS

Howard Neibling, Extension Water Management Engineer
University of Idaho Cooperative Extension System

Idaho has approximately 4.1 million acres of irrigated land. Estimated acreage of major crops is shown in Table 1. Estimated acreage irrigated by various methods is shown in Table 2. The majority of irrigation application systems in Idaho are either surface (gravity) or sprinkler, with a small acreage of micro-irrigation (trickle or drip).

Selection of irrigation system or the decision to continue with a gravity system rather than convert to a sprinkler system is a matter of tradeoffs among the following factors: initial investment costs, operating costs, site factors and management skills. A relative comparison of these factors is given in Table 3. In general, the higher investment, higher water application efficiency systems are found in areas where large fields of high-value water-sensitive crops are grown, or where water supply may be limited or pumping lift is high. In short growing season areas or areas where soil depth or texture limit production, lower initial investment surface systems are generally used. Lack of available three phase electric power and specialty crop production requirements may also dictate continued surface irrigation use.

In a ideal irrigation system on a field with uniform soil properties, water is supplied uniformly over the entire area of a field at a rate not to exceed the rate at which water will enter the soil (infiltration rate) and with a frequency and amount to meet the crop need. Since crop water use varies during the year, water application should also vary to just meet this need. Water in excess of crop need should be applied only on fields where soil or water supply quality requires over-irrigation for salinity control.

Application Efficiency: Application efficiency is the percent of water delivered to the head of a field that is actually stored in the crop root zone. Application efficiencies for a number of surface and sprinkler irrigation systems is given in Table 4.

Water applied by surface irrigation systems may be stored in the root zone, lost to surface runoff, or lost to deep percolation below the root zone because of excess application. Evaporation losses are minimal compared to sprinkler irrigation. Surface irrigation methods have relatively low application efficiencies because runoff from the field may be up to 30-40% of water applied and deep percolation may be up to 30-40%. Application efficiencies for traditional furrow irrigated systems supplies by siphon tubes or gated pipe is 30-40%. Land grading to eliminate low spots reduces local over irrigation and raises efficiency. Improved systems that give better control over water application rates, or improved management to reduce runoff or deep percolation will increase the fraction of applied water that is usefully store and raise application efficiency.

Water applied by sprinkler systems may be stored in the root zone, lost to evaporation or wind drift during application, or lost to deep percolation if more water is applied than the root zone can hold. If application rate exceeds the rate at which water can enter the soil, water can also be lost to surface runoff if the land is sloping. Equipment that applies water closer to the ground with very good areal uniformity will reduce losses by evaporation and wind drift and losses to localized areas of excess application and resulting deep percolation or runoff.

Nearly all water applied by micro-irrigation (trickle) systems should be stored in the crop root zone if water is not over-applied. Since application is at or below the soil surface, evaporation is minimal, runoff should be zero, and deep percolation losses due to non-uniformity of application should be minimal. Therefore, application efficiencies are quite high.

SURFACE IRRIGATION SYSTEMS

Furrow or Corrugate Irrigation: Before advances in sprinkler design and aluminum pipe production in the 1950's, almost all irrigated land was surface irrigated. Water is supplied to rowcrops as water flows down furrows spaced from 22 to 36 inches apart, depending on crop grown. Water is supplied to close-growing crops such as alfalfa or small grains by corrugates spaced 24-30 inches apart. Furrows are deeper and wider than corrugates. Water supply to the furrows or corrugates is by feed ditches and cutouts, earthen or concrete head ditches with siphon tubes, or by gated pipe. Siphon tubes or gated pipe allow closer, more repeatable control of water discharged into each furrow or corrugate. This allows better water management and improved application efficiencies with little additional labor. It should be emphasized that concrete ditches with siphon tubes or gated pipe do not by themselves improve irrigation efficiency - they are just a tool to help improve water management which does improve efficiencies.

Border or Graded Border Irrigation: Irrigation of alfalfa, pastures or small grain may also be accomplished by graded or level border irrigation. In border irrigation, water is supplied at the head of 40-100 foot wide borders separated by earthen ridges. Border width is designed so that the entire border width is flooded and the flood wave moves downslope. Fields with very little sideslope and low infiltration rates will allow wider borders than will fields with more pronounced slope across the border and higher infiltration rates. Water supply may be by large siphon tubes, riser outlets from surface or buried mainline, or by gates in a supply ditch.

Wild Flooding: When water is plentiful, crop value per acre is relatively low, and improved irrigation management will not yield a significantly higher financial return, wild flooding may be the irrigation method of choice. Wild flooding involves diverting water from cross slope ditches at intervals to assure adequate coverage of a slope. The water flows downslope and may concentrate in low areas or skip high areas. The spacing between diversion points on the supply ditch and spacing between successive downslope ditches must be reduced as topography becomes more undulating, soils become more sandy or gravelly (higher infiltration rates), or resistance to water flow increases (plant density at the soil surface becomes higher)

IMPROVED SURFACE SYSTEMS

Surge irrigation is a relatively new technique that reduces tailwater runoff and deep percolation. Initial testing suggests that it can reduce water losses by 30-50%. Water is applied to each furrow in a series of pulses rather than as a continuous stream. A valve controlled by a clock or microprocessor allows flow to be alternated between sets of furrows. This surging action in a furrow allows faster advance to the lower end, resulting in less deep percolation at the head of the furrow. Changing cycle time within an irrigation can reduce tailwater runoff, saving additional water. This system works best on light loose soils and is less effective on heavier soils or on soils where compaction occurs during the growing season. Cost is about $1500-2000 per surge valve. Typically, one or at most two valves are used per run of gated pipe.

Cablegation is an automated surface irrigation system that uses a travelling plug inside a gated pipe delivery system. The plug restricts water application to only those gates nearest the plug. Flows nearest the plug are the greatest and advance fastest down the furrows. Flow in any furrow gradually decreases as the plug moves on downstream. This nearly matches the natural decrease in infiltration rate with time and thus reduces tailwater runoff. Because the system encourages rapid initial advance and later cutback of flow, water application is more uniform, and runoff and deep percolation are reduced. Cost is approximately $100-200 per acre.

Tailwater recovery systems are typically used in surface systems where water supply is short or where sediment discharge in runoff must be eliminated. A pond installed at the base of the field catches all runoff where it is stored until pumped back to the head of the field to be used to irrigate another set of furrows. Tailwater recovery systems can improve application efficiencies to values near 70% and are compatible with cablegation and traditional gated pipe or head ditch systems. Cost is about $100 to $200/ acre, depending on distance from the nearest power line to the pond.

SPRINKLER IRRIGATION SYSTEMS

Sprinkler systems may be divided into set-move, solid set, and continuous move systems. Set-move systems are operated for a given set time, usually 5, 11 or 23 hours and then moved to a new location for operation again. If about one hour is allowed for moving 4, 2 or one sets can be irrigated per day. Examples most used in Idaho are wheel lines (shown in Figure 1a) and hand lines. Initial system cost is about $250-300/acre for hand lines and $300-350/acre for wheel lines. Required operating pressure is about 45-55 psi. Labor is required for moving but the entire field may be irrigated. Since impact sprinklers mounted 3-4 feet above the ground, these systems are good for low-growing crops but not for corn. Spacing between nozzles on a lateral is 40 feet and spacing between moves is 50 or 60 feet.

Solid set systems are typically used for center pivot corners and for potato production. They are like hand lines but with enough equipment to cover the entire area to be irrigated without moving pipe. Equipment costs are higher but labor costs are lower since sets may be started or stopped by adjusting valves and no pipe must be moved. Spacing is usually 40 x 40 or 40 x 50 feet.

Continuous move systems typically used in Idaho are center-pivot systems (shown in Figure 1b) and linear move systems. Initial center-pivot system cost is $350-400/acre. Since center pivot systems irrigate a full or part circle pattern, not all of a square or rectangular field may be irrigated by the system. For example, a typical pivot on 160 acres will irrigate about 134 acres. About 10-12 additional acres can be irrigated with a folding attachment that swings out to irrigate more of the corners. The corners must be irrigated by hand lines or solid set. Because of the system geometry, more water must be applied per foot of pivot as one moves outward from the pivot point. This is usually accomplished by closer nozzle spacing and larger nozzles. Typical water application packages for pivots are either high pressure impact sprinkler (50-60 psi) mounted on the top of the pivot lateral pipe or low pressure (20-35 psi) mounted about 6 feet off the ground on drop pipes mounted under the pivot lateral pipe. Average system cost is about $350-400/acre.

If the pump is properly sized and designed for the low pressure system, considerable energy cost savings may be achieved. However, in the conversion from high to low pressure, many pumps remain unchanged either to reduce capital costs or to support the high pressure end gun and lines necessary to water the corners. In this case, no energy is saved although system uniformity is improved. In many cases, a smaller high pressure pump can be installed to serve the corners and a booster pump added for the end gun. The larger pivot pump may then be re-worked to really save energy and reduce energy costs.

Almost all new pivots are equipped with the low pressure package and about half of existing pivots have been converted to low pressure. Because nozzle spacing is closer, application uniformity is better for low pressure pivots. With the discharge point closer to the ground, water droplets reach the ground sooner and thus have less evaporation on low pressure systems. High pressure impact sprinklers typically covered about a 100 foot wetted diameter, while low pressure spray nozzles cover about a 20-foot diameter. Since the same amount of water is applied over a 20-foot circle instead of a 100-foot circle, runoff was a problem in low infiltration rate soils.

One option to avoid surface runoff under low infiltration conditions are mounting a number of spray nozzles along a boom running parallel to direction of pivot travel (thus spreading water over about 50-60 feet instead of 20 feet). Another widely used option is the use of "rotators" or "wobblers" to apply water at low pressure but over a 40-55 foot wetted diameter. The wetted area may be further increased (to avoid surface runoff) by mounting these devices on offset booms about 5-10 feet in front of and behind the pivot lateral pipe on the outer one third to one half of the pivot lateral.

Linear move systems are continuous move systems with water supplied by a dragging hose that must be periodically re-attached to another riser, by automated mechanical attachment to special risers on a buried mainline, or by pumping from a concrete ditch. The first two supply methods are used in Idaho. Linear move systems have the advantage of irrigating an entire rectangular field, and of excellent uniformity of water application. They may be configured as either high or low pressure systems, with nearly all new installations being low pressure systems. Initial system cost is $600-750/acre.

From: Irrigation Journal Annual Irrigation Survey. 43 (1): 19-34

TABLE 1. ACREAGE IRRIGATED BY CROP (1990 DATA)

Alfalfa	1,030,000
Barley	469,000
Beans	143,000
Corn	123,000
Hops	4,118
Mint	18,300
Oats	45,000
Onions	8,000
Pasture/Hay Crops	992,982*
Potatoes	393,000
Small Fruits/Nuts	600
Sugar Beets	195,000
Sweet Corn	21,600
Tree Fruits	15,000
Wheat	646,000

TABLE 2. ACREAGE IRRIGATED BY METHOD:

Sprinkler - 2,340,000	
Center Pivot/Lateral	721,000
Side Roll/Wheel Line	686,000
Hand Move	865,000
Solid Set	66,000
Traveller	1,500
Gun	500
Low-Flow	**5,000**
Drip/Trackle	5,000
Gravity	**1,754,600**
Gated Pipe direct from source	95,000
Open Ditch, Siphon Tube	890,000
Lay-Flat Pipe	2,500
Underground with Valves	10,000
Flooding from Ditches	756,000
Cablegation	600
Surge	500

TABLE 3. COMPARISON OF IRRIGATION SYSTEMS IN RELATION TO SITE AND SITUATION FACTORS

	Improved Surface Systems		Sprinkler Systems			Trickle Systems
Site and Situation Factors	Redesigned Surface Systems	Level Basins	Intermittent Mechanical Move	Continuous Mechanical Move	Solid Set and Permanent	Emitters and Porous Tubes
Infiltration rate	Moderate to low	Moderate	All	Medium to high	All	All
Topography	Moderate slopes	Small slopes	Level to rolling	Level to rolling	Level to rolling	All
Crops	All	All	Generally shorter crops	All but trees and vineyards	All	High value required
Water supply	Large streams	Very large streams	Small streams nearly continuous	Small streams nearly continuous	Small streams	Small streams, continuous and clean
Water quality	All but very high salts	All	Salty water may harm plants	Salty water may harm plants	Salty water may harm plants	All-can potentially use high salt water
Efficiency	Average 60-70%	Average 80%	Average 70-80%	Average 80%	Average 70-70%	Average 80-80%
Labor requirement	High, training required	Low, some training	Moderate, some training	Low some training	Low to seasonal high, little training	Low to High, some training
Capital requirement	Low to moderate	Moderate	Moderate	Moderate	High	High
Energy requirement	Low	Low	Moderate to high	Moderate to high	Moderate	Low to moderate
Management skill	Moderate	Moderate	Moderate	Moderate to high	Moderate	High
Machinery operations	Medium to long fields	Short field	Medium field length, small interference	Some interference circular fields	Some interference	May have considerable interference
Duration of use	Short to long	Long	Short to medium	Short to medium	Long term	Long term, but durability unknown
Weather	All	All	Poor in windy conditions	Better in windy conditions than other sprinklers	Windy conditions reduce performance: good for cooling	All
Chemical Application	Fair	Good	Good	Good	Good	Very Good

TABLE 4. IRRIGATION SYSTEM APPLICATION EFFICIENCIES

Irrigation System	Application Efficiency
Surface Systems	
Furrow	35 -65%
Corrugate	30 - 55%
Border, Level	60 - 75%
Border, Graded	55 - 75%
Flood, Wild	15 - 35%
Surge	50 - 55%
Cablegation	50 - 55%
Sprinkler System	
Stationary Lateral (wheel of hand move)	60 - 75%
Solid Set Lateral	60 - 85%
Traveling Big Gun	55 - 67%
Stationary Big Gun	50 - 60%
Center Pivot Lateral	75 - 85%
Moving Lateral (linear)	80 - 87%
Trickle System	
Drip	90 - 95%
Subsurface	90 - 95%
Bubbler	90 - 95%
Spray or Mist	85 - 90%

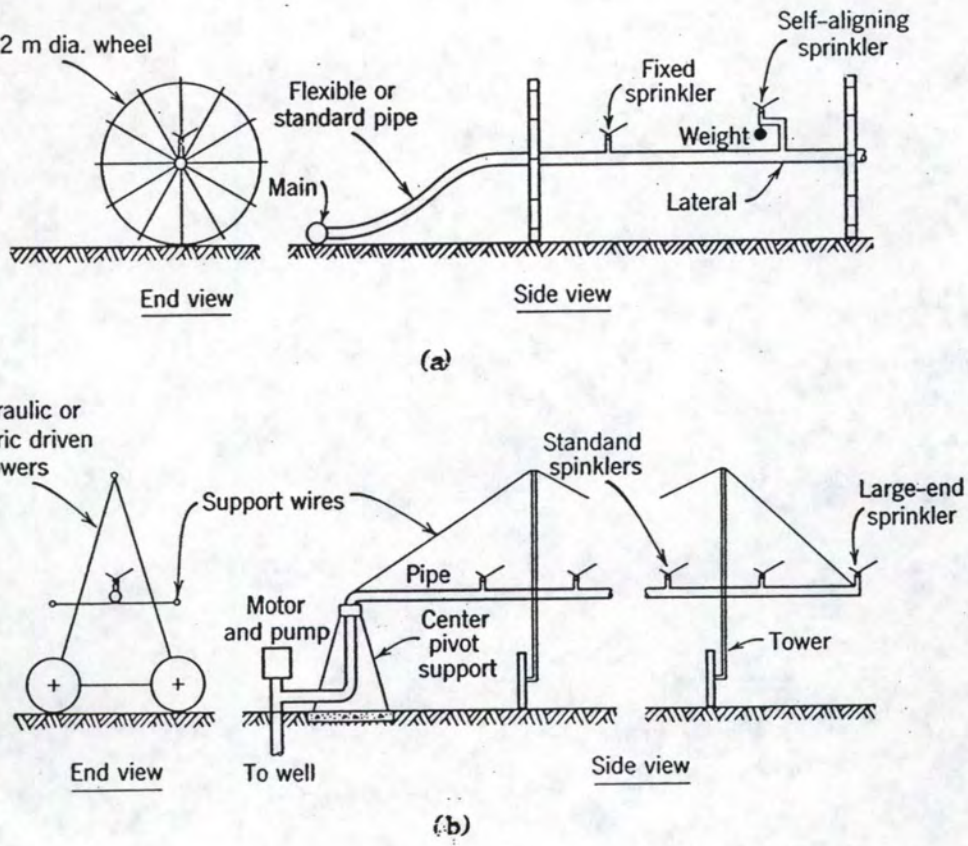

Figure 1. Mechanical-move sprinkler systems. (a) Side-roll lateral (hand or mechanical move). (b) Self -propelled (center pivot) lateral.

SPRINKLER PACKAGE SELECTION FOR CENTER-PIVOT IRRIGATION

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For presentation at Ag. Lenders Seminar-Southern Idaho/Eastern Oregon
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General characteristics of center-pivot irrigation

Sprinkler irrigation now comprises nearly fifty percent of the 59 million irrigated acres in the U. S. Over half of the sprinkler irrigated acreage is under center pivot irrigation, and the percentage under center pivot is increasing. In Idaho, Oregon, Montana and Washington there are about 1.6 million acres under center pivot at the present time. Center pivots are popular with farmers because of ease of operation and management, and low labor cost per acre. Because of common field sizes, they are usually 1/4 mile in length and irrigate approximately 125 acres.

Pivots have some inherent advantages and disadvantages. The main advantage is that with continuous rotation, the system is always irrigating the portion of the field that needs water the most. Also, since the lateral is moving continuously, water application is normally more uniform than with stationary sprinkler laterals. Irrigation efficiencies of approximately 90 percent are possible with a well designed sprinkler package. The main disadvantage is the circular irrigated area which leaves about 20 percent of a square field unirrigated. While corners can be irrigated by some other means, or with special extensions of the pivot system, many farmers find it economically advantageous to leave the corners unirrigated. Of course, this will depend on land values, water supplies, labor costs, etc.

Traveling-lateral irrigation systems, including center-pivots, have one thing in common, a relatively high cost per unit length of lateral. Therefore, they must irrigate a large area per unit length of lateral. This leads to the crux of the problem when it comes to selecting a sprinkler package to distribute water. On a center pivot the area irrigated per unit length and thus the discharge per unit length increases with distance from the pivot. High discharge rates lead to high application rates and potential runoff. A typical pivot discharges about 1.2 gallons per minute per foot of lateral near the outer end. The pivot lateral is usually about 12-14 feet above ground, and the supporting truss provides a minimum of 8 feet clearance for growing corn.

Types of sprinkler packages

Table 1 lists the most common types of sprinkler packages available today. The recommended range of nozzle pressures and the approximate pattern width are given for each type. The sprinkler spacing usually starts at about 15-20 feet on the inner portion of the lateral, and decreases to about 8-10 feet toward the outer end. Computer programs are used to determine the proper nozzle size for each head. Selection of the best sprinkler package for a particular situation involves balancing the tradeoffs between application rate, application uniformity, energy requirement, and evaporation and drift losses. In general, as energy requirement decreases, potential runoff increases, because the pattern width decreases with reduced nozzle pressure. The application rate is inversely proportional to the pattern width of the sprinkler package. Another important consideration is to control droplet sizes to minimize droplet impact on the soil, and resulting reduction of infiltration capacity, while minimizing spray drift losses.

The impact sprinkler with standard straight bore nozzles, operated at high pressure, was the most common package for many years because it produces the widest pattern. With rising energy costs, several types of reduced pressure devices have been developed and have become popular. Reducing nozzle pressure usually requires flow control nozzles or pressure regulators on each head, if elevation differences within a field exceed about 20 feet. Low pressure nozzles for impact sprinklers and low pressure spray heads are becoming widely used, and these offer good control of drop size ranges. Various types of spray plates are available, ranging from flat plates which produce the smallest drops, to rotating grooved plates which produce larger drops while producing larger spray patterns.

The Wobbler is a type of spray head which utilizes a rapidly rotating deflector to distribute water. LEPA (Low Energy Precision Application) utilizes drop tubes with emitters placed close to the soil surface to eliminate spray drift losses. The application pattern is very small, resulting in high potential runoff. Special tillage is needed to control runoff. The LEPA system is not recommended for the erosive soils and slopes predominant in the Pacific Northwest.

Booms and drops are rigid pipes which offset the spray heads horizontally and/or vertically from the pivot lateral, thus increasing the effective pattern width, or placing the spray closer to the soil. Booms are recommended on the outer 1/3 to 1/2 of center pivot laterals when using flat plate spray heads or the rotating spray heads at the lowest pressures, to reduce application rates. Most of the potential spray drift loss can be eliminated without seriously reducing the water application uniformity, by mounting the spray heads at an elevation of about six feet above the soil (8 feet for corn).

Tillage practices which maximize the soil surface roughness and infiltration capacity should be used, to reduce the tendency for runoff. The detrimental effects of droplet impact on bare soil occur early in the season, but can carry through the season unless tillage is used to counteract these effects. Crop residues on the surface will reduce the effects of droplet impact early in the growing season before full crop cover.

Cost considerations

The cost of a 1/4 mile center-pivot lateral installed complete with sprinklers is approximately $35,000, or about $280 per acre for 125 acres. The cost of the sprinkler package is less than 10 percent of the total cost, as shown in Table 1. Costs of each package will vary depending on the sprinker spacing and pressure level chosen. Generally, the lower pressure packages will cost more because more heads, nozzles, pressure regulators, etc. are needed. Drops can add about $500 to the cost of the package and booms added to the outer half of the system would add about $1000. With booms, the system pressure can usually be reduced by 10-15 psi. A reduction of 10 psi translates to about $200 savings per year in energy costs (assuming 125 acres, 25 inches of water applied, at $.03/kwh).

Table 1. Characteristics of sprinkler packages for center pivots.

Type	Pressure range psi	Pattern width feet[1]	Approximate cost $[2]
Impact sprinkler			
High pressure	50-80	80-100	1200-1600
Low pressure	25-40	70-80	1500-2000
Rotating spray head	15-30	50-70	1000-1800
Flat plat spray head	10-20	20-40	900-1500
Wobbler	15-30	50-60	1800-2200
LEPA	6-10	2-10	2000-4000

[1]Booms can add 20-30 feet to the pattern width.
[2]System length 1/4 mile, sprinkler spacing 10-20 feet.

Chemigation in the Pacific Northwest

W.L. Trimmer, T.W. Ley, G. Clough, and D. Larsen

Presented by Brad King at the Ag Lenders' Seminar

Injecting agricultural chemicals such as fertilizers, herbicides, and insecticides into an irrigation system is commonly called *chemigation*. The use of chemigation has increased rapidly during the past few years; an estimated 12.8 million acres (5.2 million hectares) in the United States were chemigated during 1985.

Other names such as *fertigation, herbigation, insectigation, fungigation,* and *nemagation* (see "Glossary," page 21), are used to describe injection of specific chemicals. Chemigation can be an effective application method if the chemical is suited for this method of application and if the irrigation system is properly designed and operated.

This publication describes the specialized equipment, specific application conditions, accurate calibration, proper management, and safety precautions required for chemigation. Some legal aspects of chemigation such as pesticide registration are covered as well.

This publication covers only chemigation systems not connected to public drinking water supplies. All recommendations in this publication are advisory—be sure to follow *your* State's regulations. Some states require certification of chemigation operators.

Reasons for chemigation include:

- relatively uniform chemical distribution,
- flexible timing of chemical applications,
- possible economic advantage compared to other application methods,
- potential to use fewer chemicals, and
- less crop damage than with ground-applied chemicals.

The primary concern about using chemigation has been the possibility of contaminating groundwater and surface water if:

- injected chemicals flow back into the water source because of mechanical failure or power loss in the irrigation system;
- water backflows through the chemical injection system and overflows the chemical supply tank;
- there's back flow in the irrigation system after the pumping plant shuts down, creating a vacuum in the pipeline that might cause siphoning of the chemical from the chemical supply tank; and
- the chemical injection system continues to operate after a shutdown of the irrigation pumping plant, pumping the remaining chemical solution into the irrigation pipeline, where it can flow back into the water supply.

Additional pollution potential exists when the water-chemical mixture drifts and/or runs off onto nontargeted areas or when the water-chemical mixture is applied to open surface water areas within the field. Some states require that you report to the authorities any accidental chemical spillage.

The relative cost of chemigation compared with the cost of aerial or ground application depends on your answers to these questions:

1. Is the irrigation system is already in place?
2. Do you need to apply water anyway?
3. How many times will you chemigate each year?

Past analyses indicate that for just one application a year, chemigation is likely to be cost-effective only for chemicals that require incorporation. With two or more applications a year, however, chemigation is cost-effective.

Costs range from only a third to a half as much as aircraft or tractor applications and decrease significantly as the number of annual applications increases.

With the increased flexibility and lower costs, irrigators can change management practices and apply lighter applications of fertilizers more often.

Because of this, applying nitrogen fertilizer with the irrigation water, while using proper water management practices, is sometimes considered the best management practice to reduce the potential for nitrate leaching into ground water.

Without correct timing and amounts of irrigation, nitrogen application with the irrigation water may result in considerable leaching of nitrates into the groundwater.

Chemicals

Many different chemicals can be injected into irrigation systems, and each must be handled according to its intended use, physical properties, and the legal requirements associated with it. The three broad classes of chemicals we'll discuss are fertilizers, pesticides, and chemicals to disinfect irrigation systems.

Walter L. Trimmer, Extension irrigation specialist, Oregon State University; *Thomas W. Ley*, Extension irrigation engineer, Washington State University; *George Clough*, horticulturist, Hermiston Agricultural Research and Extension Center, Oregon State University; and *Dorrell Larsen*, Extension professor emeritus, University of Idaho.

Chemicals have physical characteristics that dictate the chemigation methods required. Chemicals can be soluble, wettable powders, oil-soluble, or gaseous. (The solubility of a few common chemicals is shown in appendix 1.)

Soluble chemicals

Soluble chemicals, those that can dissolve in water, are the easiest to handle and use. (See appendix 1.)

Whether a chemical is soluble depends on its physical properties, water temperature, and the irrigation water quality. For example, 9.8 lb of ammonium nitrate will dissolve in a gallon of water at 0C, but 72.6 lb will dissolve in a gallon at 100C.

The irrigation water's ability to dissolve a chemical can be limited by the acidity or alkalinity (pH) and dissolved solids such as sodium, calcium, magnesium, nitrates, and carbonates.

Injecting a chemical can change the pH of the water. Raising the pH (making it more alkaline) with such chemicals as anhydrous and aqueous ammonia and phosphorus can precipitate calcium and magnesium salts, plugging irrigation systems.

Changes in pH can be countered by injecting acid or caustics. If 300 lb of ammonium nitrate are dissolved in water, 185 lb of calcium carbonate must be added to neutralize the acidity. Water with a pH lower than 6.5 can cause corrosion. Injecting more than one chemical can produce chemical reactions that form nonsoluble products.

Wettable powders

These are insoluble, but they can stay in suspension with agitation in the chemical supply tank and maintain a relatively uniform concentration when you inject them.

Oil-soluble chemicals

Oil-soluble chemicals require special handling because of their flammability. In addition, you must carefully inject oil-chemical mixtures to ensure the mixture is well dispersed. Even when properly injected, oil-chemical mixtures tend to separate in the irrigation system.

Past research has found that this separation means the chemical isn't evenly divided as it travels past the first outlets in the system.

Applying nitrogen

Applying nitrogen through irrigation systems, especially drip systems, promotes the growth of microorganisms, including algae and bacterial slimes. This growth can foul pipelines and clog sprinklers and emitters. Disinfectants, such as chlorine, can be used to keep systems clean.

Gases

Gases such as chlorine or anhydrous ammonia can be effectively injected, but the main problem is volatilization of the gas into the atmosphere, once it's discharged from the irrigation system. We don't cover chemigating with gases in this publication.

A major difference

A major difference between chemicals is whether a given chemical:

- must be incorporated in the soil to be effective;
- must be applied only on the foliage; or
- (in the case of disinfectants) remains resident in the irrigation system.

How a chemical is applied affects the timing of application and the volume of water that must be applied with the chemical.

The pesticide label

While some irrigators have applied nitrogen fertilizer with irrigation water since the late 1950's, the injection of pesticides into irrigation systems in the early 1980's triggered concern about potentially polluting water sources.

Because of this concern, the U.S. Environmental Protection Agency (EPA) began regulating pesticides under the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA). More recently, the EPA Label Improvement Program (LIP) changes were made so that the statement "the label is the law" can be applied to EPA regulations concerning pesticide injection.

In 1987, the EPA issued Pesticide Registration (PR) Notice 87-1 on a label improvement program for pesticides applied through irrigation systems.

This notice required registrants of pesticide products to state on each product label whether it was intended to be applied by chemigation. If it may be applied through irrigation systems, the label must include directions for use when applied by chemigation as well as statements concerning backflow prevention and other safety requirements.

PR Notice 87-1 states that no pesticide products labeled for agricultural, nursery, turf farm, golf course, or greenhouse use may be released for shipment after April 30, 1988 unless the product bears an amended label that complies with the Label Improvement Program.

If a specific pesticide product isn't intended for chemigation, EPA PR Notice 87-1 requires that fact to be stated on the pesticide label with the statement: "Do not apply this product through any type of irrigation system."

If a pesticide is intended to be applied by chemigation, all of the following general statements will be included on the product label:

1. "Apply this product only through [a specific type (or types) of irrigation system]. Do not apply this product through any other type of irrigation system."
2. "Crop injury, lack of effectiveness, or illegal pesticide residues in the crop can result from nonuniform distribution of treated water."
3. "If you have questions about calibration, you should contact State Extension Service specialists, equipment manufacturers, or other experts."

4. "Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place."
5. "A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise."

Safety equipment

A properly engineered chemigation system has several components: an irrigation pumping plant, a chemical injection device, a storage tank for the chemical, calibration devices, a backflow-prevention system, and related safety equipment.

Table 1 lists the chemigation safety equipment required by the EPA Label Improvement Program. We'll explain these in more detail as well as some EPA-approved alternative equipment.

The backflow prevention system and other safety equipment are the antipollution devices installed to minimize the potential of groundwater and surface water pollution when:

1. water backflows through the chemical injection system and overflows the chemical supply tank, and
2. the irrigation pumping plant shuts down because of mechanical or electrical failure and allows a portion of the water and chemical mixture to flow directly into the irrigation water supply.

The latter situation is especially serious if the chemical injection equipment continues to operate after the irrigation pumping plant shuts off. This could pump the remaining chemical solution into the irrigation pipeline—and possibly allow it to flow directly into the water source.

Alternative equipment

The EPA has approved some alternative safety equipment to substitute for the devices required by the Label Improvement Program. Under certain conditions, these include alternative backflow prevention devices; substitutes for normally closed, solenoid-operated valves on the injection pump suction line; and the positive displacement injection pump.

These devices are listed in table 1. In some cases, these alternative devices may be less expensive, more reliable, or more readily available than some of those devices originally required. We've highlighted each alternative (boxes, A, B, and C) as we discuss the safety device it substitutes for.

Table 1.—Minimum required chemigation safety equipment for protecting water sources[a]

Devices required by EPA Label Improvement Program	EPA-approved alternative devices
Backflow prevention assembly Irrigation main line check valve, air/vacuum relief valve, low pressure drain and inspection port	Gooseneck pipe loop
Interlock between irrigation pumping plant chemical injection device	Interlock between low pressure switch and chemical injection device.
Chemical injection line check valve	Chemical injection line check valve with minimum of 10 psi cracking pressure
Normally-closed solenoid operated valve on chemical suction line	Chemical injection line check valve valve on with minimum of 10 psi cracking pressure
	Normally closed, hydraulically actuated valve
	Air/vacuum relief valve on chemical injection line between injection pump and injection line check valve (only on chemigation systems using a positive- displacement injection pump)
Irrigation main line pressure switch connected to irrigation pump power source to shut irrigation system down under low pressure conditions	None

[a]Your State chemigation laws may further limit specific devices acceptable within the State.

Backflow-prevention devices

Combination backflow prevention assembly. The backflow-prevention assembly specified in the EPA Label Improvement Program combines an irrigation pipeline check valve, an air/vacuum relief valve, an inspection port, and a low-pressure drain.

(Box A shows the gooseneck pipe loop, the alternative that EPA allows under certain conditions.)

The combination assembly's purposes are:

- to prevent water from flowing back into the water source;
- to drain minor leakage past the check valve, away from the water source;
- to break siphoning action; and
- to allow easy inspection for proper operation of the check valve.

Irrigation pipeline check valve. Check and vacuum relief valves (antisiphon devices) are needed in the irrigation pipeline to keep water and/or a mixture of water and chemical from draining or siphoning back into the irrigation well or water supply and polluting the water.

Both of these valves are located between the irrigation pump discharge and the point where you inject chemicals into the irrigation pipeline (figures 1 and 2). Note that the check valve:

- must have positive closing action (spring-loaded);
- must have a watertight seal;
- must be easy to repair and maintain (see figure 3);
- shouldn't have metal-to-metal seals; and
- should be installed with fittings that allow for easy removal for maintenance and repair.

If you're using a centrifugal pump in the irrigation system and you must keep the pump primed for automatic operation, you must use a second check valve upstream of the backflow prevention assembly. Don't inject chemicals into the suction side of a centrifugal pump.

Existing backflow valves in irrigation systems may not be suitable for chemigation. If the irrigation system pumps water at high pressure, the backflow valve may be a slow-closing type, designed to protect the pumps and pipelines from pressure surges during startup and showdown.

This is especially true for large irrigation-pumping installations. In large irrigation systems, smaller chemigation valves located near the fields where chemicals will be applied will be more suitable than a single backflow valve.

Air/vacuum relief valve. The air/vacuum relief valve allows air into the pipeline when the water flow stops. This prevents the creation of a vacuum that could lead to siphoning. The air/vacuum relief valve allows the back side of the check valve to drain so minor leakage from a malfunctioning check valve can be intercepted and drained away.

Inspection port. An inspection port should be located between the pump discharge and the mainline check valve. This port must be at least 4 inches (200 mm) in diameter to allow visual inspection to determine if the check valve leaks. Inspect these ports at least once a year. In many cases, the vacuum relief valve connection can serve as the inspection port (see figure 4).

Low-pressure drain. Place an automatic low-pressure drain on the bottom side of the irrigation pipeline directly under the inspection port. If the mainline check valve should leak slowly, the water and chemical solution will drain away from—rather than flow into—the well. The drain valve must incorporate some type of cup or dam to intercept minor leakage from the check valve.

The drain should discharge at least 20 feet (6.5 m) from the well or water source, and the flow should be directed away from the well or water source. You may need a hose or pipe to conduct the discharge from the drain to the minimum distance of 20 feet (6.5 m).

Some manufacturers produce backflow-prevention assemblies with all these features in one well-designed package. An example is shown in figure 4.

Interlock

The irrigation pumping plant and the chemical injection device must be interlocked or connected so that if the irrigation pumping plant stops, the chemical injection device will also stop. This will prevent injection of the chemical mixture from the supply tank into the irrigation pipeline after the irrigation pumping plant stops.

Examples of this feature are shown in figure 1 for internal combustion engines and in figure 2 for electric motors.

When a separate, small electric motor provides the power on electric motor-driven irrigation pumping systems, you must interlock the electric controls for the two electric motors, so both motors will stop when either the electric motor on the irrigation pump stops or the irrigation system stops (figure 2).

All wiring must conform to the National Electric Code. Some agricultural chemicals are flammable and require the use of explosion-proof motors and wiring. If you're injecting a pesticide, consult the label for specific information before you use it.

For internal combustion engines, the chemical injection device can be powered by belting to the drive shaft or an accessory pulley of the engine (figure 1). Other alternatives include operating the injection equipment off of the engine electrical system (12 VDC), or using the power source (oil or electric) of the sprinkler system drive.

In all cases, it's essential that if the irrigation water supply stops, the chemical injection also stops.

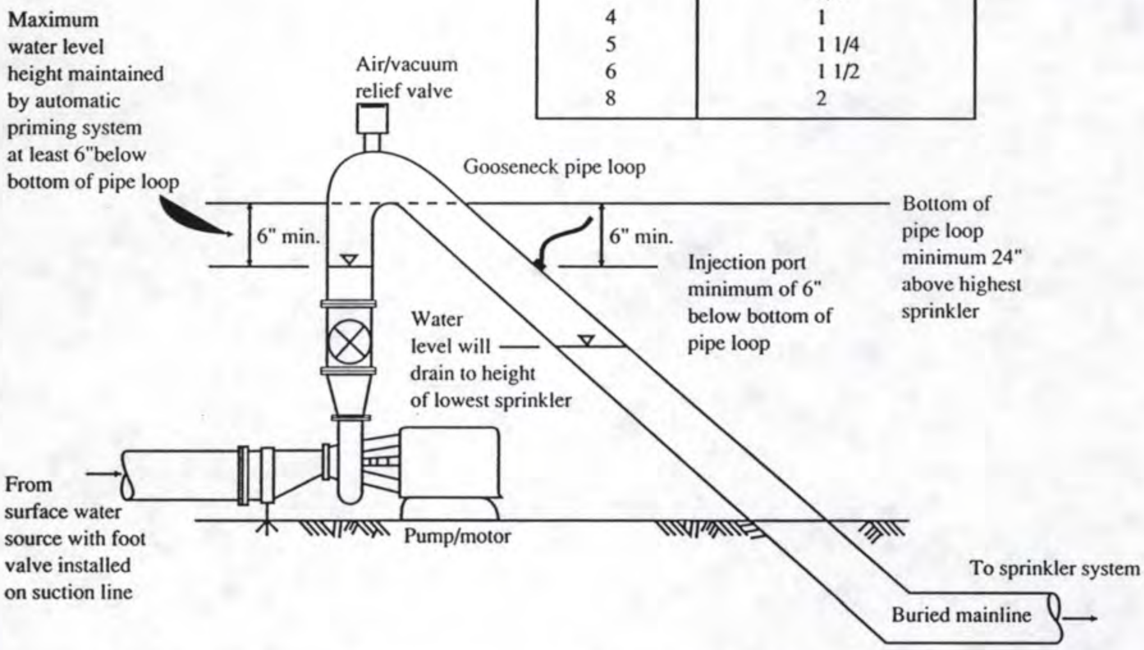
Chemical injection line check valve

A check valve in the chemical injection line is needed to stop water flowing from the irrigation system into the chemical supply tank, and to prevent gravity flow from the chemical supply tank into the irrigation pipeline after an unexpected shutdown.

Box A.—EPA alternative backflow prevention: Gooseneck pipe loop

Under certain conditions, you can replace the main line backflow prevention and antisiphon device with a gooseneck pipe loop located in the main water line, immediately downstream of the irrigation water pump, as shown here:

Mainline size (in.)	Minimum air/vacuum relief valve size (in.)
2	1/2
3	3/4
4	1
5	1 1/4
6	1 1/2
8	2



The bottom side of the pipe at the loop apex must be at least 24 inches (0.6 m) above the highest sprinkler or other type of water-emitting device. The loop must have a combination air and vacuum relief valve at the apex of the pipe loop to break any siphoning action.

Locate the pesticide injection port downstream of the apex of the pipe loop and at least 6 inches (15 cm) below the bottom side of the pipe at the loop apex.

If you omit this check valve and the injection pump stops, irrigation water could possibly flow back through the chemical line into the chemical supply tank, overflowing the tank and causing a spill around the irrigation well. The chemical then may eventually move down through the soil to the ground water.

It's recommended—and possibly required by State law—that this check valve have a minimum opening (cracking) pressure of 10 pounds per square inch (psi; 70 kPa) to prevent gravity flow from the chemical tank, through the injection pump, and into the irrigation pipeline. It should be constructed of chemically resistant materials.

Chemical suction line valve

You can install a normally closed solenoid valve between the chemical supply tank outlet and the intake side of the injection device. This provides positive shutoff on the chemical injection line. This valve should be electrically interlocked with the engine or motor driving the injection device. Then, neither the chemical nor the water could flow in either direction if the injection device is stopped.

Normally closed, solenoid-operated valves (to be located on the intake side of the injection pump) may not be readily available, and they don't always operate reliably in a vacuum.

(Box B shows suction line valves that EPA allows as alternatives.)

Figure 3.—Cutaway of check valve

Figure 4.—Check valve assembly

Extra protection

While they're not required for protection, some other fittings can contribute to safely operating the chemigation system:

- A strainer on the chemical suction line prevents clogging or fouling of the injection pump, check valve, or other equipment.
- A valve installed upstream of the backflow prevention assembly will provide a clean water source.
- The proper fittings and the means for checking injection rates, such as a clear calibration tube, installed on the outlet side of the injection device.

Chemical injection devices

Active and passive

A wide variety of approved chemical injection devices are available; they're classified as either active (an outside power source is required) or passive (no outside power is needed).

Active injection devices include positive displacement pumps such as diaphragm, piston, roller, and gear pumps. Injection pumps can typically be adjusted over a range of different injection rates to provide a continuous and relatively uniform concentration of chemical in the irrigation water. They should be mechanically rugged with internal and external components made of chemically-resistant, noncorrosive materials.

Passive. The primary passive injection device operates on the venturi principle, where, under the proper conditions, a flow constriction in the pipeline creates a vacuum because of the increased velocity of flow. Another less common passive device is the batch tank system.

Chemical injection rates

Chemigation is being used to apply a wide variety of chemicals to many different crops through varying types

Box B.—EPA alternative suction line valves

1. **A spring-loaded check valve with a minimum of 10 psi (70 kPa) cracking pressure.** This single device can substitute for both the solenoid-operated valve and the automatic, quick-closing check valve in the pesticide injection line when it has a minimum 10 psi (70 kPa) opening pressure.
2. **A normally closed, hydraulically operated check valve.** The hydraulic control line is connected to the main water line, and the valve opens only when the main water line is pressurized.
3. **A vacuum relief valve located in the pesticide injection line between the positive displacement pesticide injection pump and the injection line check valve.** This alternative is appropriate for only chemigation systems that use a positive displacement injection pump—don't use it with venturi injection systems.

   Locate this valve at least 12 inches (0.3 m) above the highest fluid level in the pesticide tank—it must be the highest point in the injection line to function properly. The valve should open at 6 inches (15 cm) water vacuum or less, and it must be spring-loaded or otherwise constructed so it doesn't leak when you close it

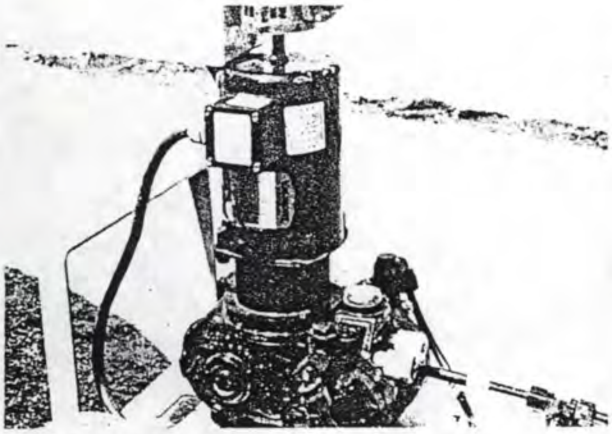


Figure 5.—Diaphragm-type injection pump

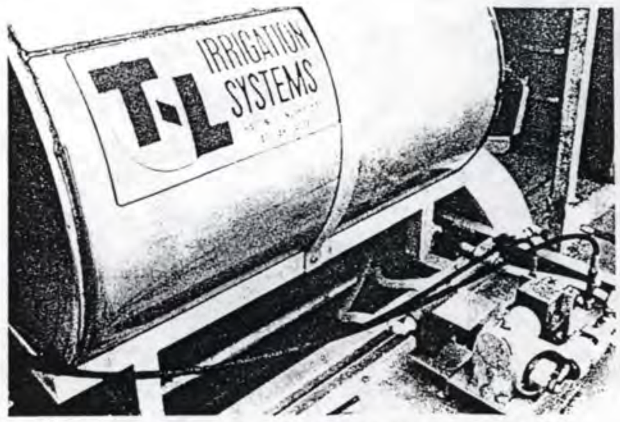


Figure 6.—Piston-type chemical injection pump and tank

of irrigation systems. The required rate of chemical injection is depends very much on each of these factors; and it ranges from 1 pint per acre (1.18 L/ha) for foliar-applied materials like insecticides to more than 30 gallons per acre (281 L/ha) for liquid fertilizer solutions like nitrogen.

No single injection device can accurately cover this entire injection range. In this case, at least two injection devices, one with a low and one with a moderate injection rate range, might be required for chemigation.

Your type of irrigation system may limit your choice of injection device. Some, such as set move sprinklers, solid set sprinklers, and drip irrigation, are batch systems. The chemicals can be mixed and applied in batches.

Moving irrigation systems such as center pivots, linears, and travelers must have chemicals injected continuously at uniform rates based upon the water application rate, rate of travel, and area covered. Injection pumps used with moving irrigation systems should be accurate to within 1% of the maximum injection rate.

Diaphragm pumps

Diaphragm pumps can be accurately calibrated to provide the continuous, uniform injection rates required with moving irrigation systems. They have two distinct advantages over other injection units. First, they have few moving parts, and only a limited area of their components is exposed to the chemical being injected. This greatly reduces the potential for corrosion, wear, and leakage. Consequently, this reduces potential maintenance costs and the potential for the human and environmental safety concerns associated with leakage.

Second, you can easily adjust the injection rate while the pump is operating. For most of these pumps, you adjust the injection rate by simply turning a micrometer type adjustment device (see figure 5).

The main disadvantage: Diaphragm pumps are more expensive than other kinds of injectors.

Piston pumps

Piston pumps have been used extensively for chemigation. Their main advantage is their ability to inject at a constant rate against fluctuating pressure in an irrigation system (see figure 6).

Piston pumps, however, have two distinct disadvantages for chemigation:

Mechanically complex. Piston pumps have complex valves, pistons, and connecting linkages and a relatively large internal area exposed to the chemical being pumped. This creates corrosion and wear on internal components, increases maintenance cost, and reduces the useful life of these pumps—in addition, the worn seals can leak chemicals onto the irrigation platform and soil around the chemigation system, creating a safety hazard.

Difficult to calibrate. It's inherently difficult to calibrate the chemical injection rate by setting the pump stroke. You must stop the pump to adjust the stroke length and restart it to check the new injection rate.

Calibration of a piston injection pump is a time-consuming and frustrating process of stopping, adjusting, starting, and checking the pump over several cycles. Many irrigators don't accurately calibrate piston pumps because of this difficulty.

Other pumps

Other types of chemical pumps such as roller or gear pumps and even chemically-resistant nonpositive displacement centrifugal pumps can be used on batch-type irrigation systems (wheel-lines, hand-lines, solid set sprinklers, drip/trickle) that don't require the high accuracy needed by moving irrigation systems.

Venturi units

Chemical injection units based upon the venturi principle inject chemicals by generating a differential pressure across a venturi device. The venturi creates a vacuum, sucking the chemical into the irrigation system.

Operating chemigation systems

The goal of operating a chemigation system is to apply the proper amount of chemical safely, and as evenly as possible.

To achieve this goal, take these precautions:

- assure both personal and environmental protection;
- calibrate chemigation equipment to inject the desired quantity of chemical;
- apply only the right amount of water at the right time, to reduce the possibility of runoff, drift, or deep percolation, all of which carry chemicals from the field; and
- use a well-designed and maintained irrigation system—you can't distribute the chemical more evenly than the water.

Calibration

To get the most value from the chemicals you apply through an irrigation system and to avoid environmental and health problems, you must properly calibrate the chemigation system.

A University of Nebraska study showed only about 40% of chemical application equipment checked was calibrated to apply the chemical within ±10% of the intended rate—and some equipment in the survey was 83% off! *Successful Farming* called this a billion dollar blunder.

Calibration of chemigation systems is relatively straightforward, but it recquires time, equipment, and accurate calculations to arrive at the correct chemical application rate.

Calibration involves six basic steps:

Step 1. Determine the area to be irrigated (treated) in acres.

Step 2. Determine the desired amount of chemical to be applied per acre by carefully reading label directions.

Step 3. Determine the total amount of chemical required: Multiply the area to be treated (step 1) by the chemical application rate (step 2).

Step 4. Determine the length of time in hours during which injection will take place. This will depend on such factors as the length of the irrigation set or the time to cover the field, irrigation water application rate, and the desired amount of water to be applied with the chemical. Take into account the transit time for the chemical to move through the irrigation system.

Step 5. Determine the proper chemical mixture.

Step 6. Set the injection device to the proper flow rate.

Two categories. Calibrating chemigation equipment must take into account the type of irrigation system. Irrigation systems can be divided into two broad categories—batch systems and moving (continuous application) systems.

Batch mode. Irrigation systems such as set move sprinklers (side rolls, hand lines), solid set sprinklers, and drip irrigation are operated in batch mode. This is because these systems irrigate a block of land at a constant rate for some period of time. A batch of chemical can be mixed and applied to this block during irrigation.

Continuous application. The second category is continuous injection of chemicals into moving irrigation systems such as center pivots, linears, and travelers. These machines cover irrigated land at a constant rate, and the rate of injecting chemicals must be matched with the rate of travel.

Setting the injection rate. In either case, you must adjust the injection device under the same conditions as those under which the system will normally operate. You can make coarse ajustments by injecting clean water; you set the device by estimating the percentage of full flow based on the manufacturer's nominal recommendations. Don't rely on flow rates labeled on the equipment's controls.

You must make the fine adjustments by calibrating the equipment *yourself*. Install a tube or tank with accurately marked increments of volume, inline on the suction side of the injection device.

Adjust the injection device after measuring the volume of the chemical pumped per unit of time while injecting against normal pressure. Use a stopwatch to time the flow rate and allow at least 5 minutes pumping time for the final check. You must make the final ajustment while you inject the properly mixed chemical solution.

Changes in viscosity and density may change the injection rate.

The injection rate accuracy for moving irrigation systems should be as high as possible. The accuracy of batch injection is only as critical as the timing requires. For example, if injection is to be over a 2-hour period in an 11-hour irrigation set, an error of 10 minutes will have little effect.

Mixing the chemical. In either batch or continuous application, mix the chemical before you start (Step 1 through Step 3). Determine the total chemical that you should mix by multiplying the rate at which you'll apply the chemical by the area of land to be covered. Use accurate scales or volumetric measuring tools to mix the chemicals.

Table 5.—Irrigation system characteristics

Method	Uniformity	Type
Set move	Fair	Batch
Solid set	Fair	Batch
Drip	Good	Batch
Surface	Poor	Batch
Center pivot	Good	Moving
Linears	Good	Moving
Travelers	Fair	Moving

Time to move through the system. Keep in mind that injected chemicals do not instantly move through the irrigation system. The chemicals can take a surprisingly long time to make it through the pipeline and be applied. The time required can be calculated using the hydraulic design of the system.

A rough estimate of travel time is to divide the pipe length (in feet) the chemical will travel by 300 to find the number of minutes.

A better way to estimate transit time is to inject a food safe dye (red is a good visible color) and time the travel both to the irrigation equipment and how long it takes to move through the irrigation system. On batch type irrigation systems you should also note if the duration of injection is affected by velocity differences in the pipeline.

For example, a 15-minute injection of a foliar applied chemical may stretch to a slightly longer time due to dispersion in the pipeline. In most irrigation systems this effect will be minor.

You'll need to consider *all* these factors when you determine how long to run the system, when you can start a new set, or the time that you must allow for irrigation lines and laterals to be flushed (table 5).

If automatic valves switch before the slug of chemical has passed, the chemical can be misdirected, doubling applications or leaving the chemical in the pipeline. It can be difficult to coordinate these time requirements, especially if foliar application is desired.

Flushing equipment. Prevent the accumulation of precipitates in the injection equipment by flushing the injection system with clean water after each use. After injection is completed, operate the irrigation pump for at least 10 minutes to flush the irrigation system of the chemical. If the irrigation system was shut down automatically, flush the system as quickly as possible after the shutdown is discovered, and extend the flushing period to 30 minutes.

Personal precautions. Because many chemicals used in chemigation are hazardous, take these personal safety precautions to protect yourself and others:

1. Always wear rubber boots, gloves, and other appropriate protective equipment at the injection site.
2. Exercise extreme caution when injecting any insecticide or nematicide into an irrigation system because they are so toxic.
3. For safety and application accuracy, use a separate system apart from that used for injecting liquid fertilizer to apply insecticides.
4. Consider identifying the field with a suitable warning sign that states *"Chemigation is in progress"* even if not required by regulation (it is required in Idaho).
5. Read the label to determine when it will be safe to reenter the field after applying insecticide. Figure 14 shows a typical curve of the safety hazard declining over time after using (as an example) the oil-soluble insecticide Lorsban.
6. Keep the injection site clean and orderly.
7. On center pivots, plug the two nozzles outward from the pivot point so sprinklers do not wet down the injection site.

Environmental precautions. Use the following precautions to protect the environment:

1. Don't leave chemigation equipment unattended. Monitor continuously.
2. Inject pesticide only when the irrigation system is running.
3. Don't apply when weather conditions favor pesticide drift from treated areas. Usually, this means shutting down when wind speeds exceed 10 mph.
4. Discontinue chemigating if significant rainfall occurs.
5. In the event of accidental well contamination, shut off the injection system and continue pumping water for several hours.
6. Avoid injecting pesticides through irrigation systems on those fields with permanent or semipermanent surface water areas, as it could harm wildlife and other nontarget plants and animals.

Summary

By following these guidelines, chemigation can be an effective means of applying agricultural chemicals. The chemicals can be applied uniformly and achieve their intended effect. This will maximize the economic benefits while minimizing the potential for pollution of our water supplies.

Glossary

Chemigation.	Injecting agricultural chemicals into an irrigation system.
Pesticide.	A chemical used to kill animal, insect, and plant pests.
Efficacy.	Degree to which a pesticide is effective in controlling the target pests.
Nemagation.	Chemigation with a pesticide to kill nematodes.
Fertigation.	Chemigation with fertilizer.
Herbigation.	Chemigation with an herbicide to kill undesirable plants.

For further reading

Hansen, Hugh J., and Walter L. Trimmer, *Irrigation Runoff Control Strategies,* Pacific Northwest Extension publication PNW 287 (Oregon State University, 1986). No charge.

Trimmer, Walter L., and Hugh J. Hansen, *Irrigation Scheduling,* Pacific Northwest Extension publication PNW 288 (Oregon State University, 1986). No charge.

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A Cost Comparison
of Alternative Irrigation Systems

Paul E. Patterson
Bradley A. King
Robert L. Smathers

Introduction

A grower should consider technical, economic, and financial factors when choosing an irrigation system or when evaluating conversion from one system to another. Technical factors include the physical characteristics of the resources available to the grower, including: climate, topography, soil texture, and the quality, quantity and source of water. Availability and quality of labor, the desire to use the system to apply chemicals or to control frost, and the crop mix alternatives available to the grower are other important considerations. The need to improve energy and water use efficiency are becoming increasingly important in this decision process.

Sprinkler irrigation systems are designed to match field specific situations, including soil texture, root zone, crop mix, seasonal water requirement, peak water requirement, peak daily water requirement, pumping plant efficiency, irrigation efficiency and shape of the field.

Systems under serious consideration by a grower should be designed to meet the technical specifications. Next, an economic analysis should be made. Two questions should be addressed in this analysis: 1) Which system will do the job at a minimum cost?, and 2) Will the least-cost system yield the desired long term profit?

Before these questions can be answered, a determination must be made as to which costs to include and on what basis. Should the evaluation focus on the total cost of the system, the ownership costs per acre, the operating costs per acre or the total per acre costs? Is the basis calculated on total acres or only on irrigated acres?

This paper will present alternative cost comparisons of four sprinkler irrigation systems: handline, wheelline, center pivot and center pivot with corner catcher. Economics should play an important role in choosing an irrigation system.

Basic Assumptions

<u>Location:</u> The Mini-Cassia area of southern Idaho was used as a reference.

<u>Soil Type:</u> A silt loam soil with a water holding capacity of 2.6 inches per foot and soil depth not a limit to crop root zone.

<u>Crop Rotation:</u> To determine crop water needs, a four crop rotation of potatoes, sugarbeets, spring barley and winter wheat was used. This rotation was applied to a 160 acre field. The land irrigated by each system was equally divided between the four crops. The gross revenue was determined from this rotation and the deficiency payments from participation in the farm program. The wheat base was equal to one-fourth of the irrigated acreage.

Allowable soil moisture depletion and crop rooting depth:

Crop	Allowable Depletion	Rooting Depth
potatoes	33%	2.0 ft
sugarbeets	50%	2.5 ft
winter wheat	50%	3.0 ft
spring barley	50%	3.0 ft

Seasonal water requirements:

Crop	Net	---------- Applied ------------			
		HL	WL	CP	CP/wC
potatoes	24 inches	37	34	28	28
sugarbeets	25 inches	38	36	31	31
winter wheat	17 inches	26	24	21	21
spring barley	21 inches	32	30	26	26
rotational acre	22 inches	33	31	27	27

Peak water use month and amount:

Crop	Peak Month	Water Requirement
potatoes	July	9.5 inches
sugarbeets	July	9.5 inches
winter wheat	June	9.0 inches
spring barley	June	8.5 inches

Peak Daily Water Requirements (PDWR):

PDWR = Peak Month ET / # of days/month

Crop	Application Efficiency
potatoes	0.31 in/day = 5.9 gpm/acre
sugarbeets	0.30 in/day = 5.7 gpm/acre
spring barley	0.28 in/day = 5.3 gpm/acre
winter wheat	0.30 in/day = 5.7 gpm/acre

Pumping plant efficiencies:

75%.

Irrigation efficiencies:

System Type	Application Efficiency
handline	65 percent
wheelline	70 percent
center pivot	80 percent

Irrigations per crop by irrigation system:

	HL & WL	CP & CP/wC
potatoes	14	40
sugarbeets	15	42
spring barley	7	29
winter wheat	7	29

Technical coefficients:

System	Labor	Repair
handlines	1.0 hours/irrigation	3% of purchase price
wheellines	.35 hours/irrigation	4% of purchase price
center pivots	.08 hours/irrigation	7% of purchase price

Problem Defined

The analysis compares the four sprinkler irrigation systems designed for a 160 acre field. Both the handline and wheelline systems irrigate 154 acres. The center pivot irrigates 128 acres without a corner catcher and 150 acres with a corner catcher. To simplify the analysis and to make it possible to evaluate a number of alternative irrigation systems, costs were put on a rotational acre basis. With a four crop rotation, each grown for one year, meant dividing the per acre costs by four. The analysis was done per design acre and per irrigated acre.

Preliminary 1993 crop enterprise budgets for Southcentral Idaho were used with this analysis. The irrigation electricity and repair costs, the irrigation labor costs and land costs were removed from each budget.

Cost Analysis

Table 1 summarizes the cost of the four irrigation systems, including the total cost, the cost per design acre (total cost divided by 160 acres) and the cost per irrigated acre (total cost divided by the net irrigated acres specific to each system). The cost of the irrigation systems was based on a 1993 survey of irrigation equipment dealers conducted by the authors.

The center pivot system without a corner catcher is the least expensive system. As expected, when viewed on a per acre basis the center pivot system is also the least cost alternative. However, when the cost is placed on an irrigated acre basis, the handline system is less costly. While cost per irrigated acre is certainly preferable to cost per acre, neither is appropriate to make this type of comparison because no time dimension is specified.

Ownership Cost Comparison

To account for time, or how long the systems will last, the cost should be spread over the useful life. Costs spread over the life of an asset are generally referred to as ownership or fixed costs. Ownership costs include depreciation, interest, taxes and insurance. In

Idaho, irrigation systems are exempt from property tax, so only the remaining three costs were calculated.

The ownership costs are shown in Table 2. These are shown for the whole system, as well as on a per acre and per irrigated acre basis. The ownership costs were calculated using the annualized equivalent cost method. This is a much more detailed calculation than simply using the straight line method [(purchase price - salvage value) / years of life] to calculate depreciation and the average level of investment [(purchase price + salvage value) / 2]times the appropriate interest rate and tax rate to calculate interest and taxes, respectively. The annual equivalent cost method allows comparison of systems or components of systems that have different years of useful life. Again, the center pivot system is the least expensive for the whole system and on a per acre basis. On an irrigated acre basis, however, the handline system is the least expensive.

Besides the cost of the irrigation system, land costs should also be included in the ownership cost comparison. How the land is valued will depend on whether it is new, relatively low cost ground being brought into production or if it is land already in production. The assumption used for this part of the analysis was that the land is developed and is part of an irrigation district providing water on a fixed cost of $24 per acre delivered to the field. The value of the land was the land payment, plus the water charge and taxes. The land payment was based on a per acre value of $1,200 for each of the 160 acres, or $192,000 total value. The loan was assumed to be for 30 years at 9 percent interest. The entire amount was assumed to be borrowed. The land cost information is summarized in Table 3.

The land charge per acre must be adjusted for each irrigation system based on the number of acres irrigated. The land not being irrigated must be paid for by what is being irrigated. The land cost adjustment factors used included: 1.04 for handline and wheelline (160/154), 1.25 for center pivot (160/128), and 1.07 for the center pivot with corner catcher (160/150).

When the land charge is added to the ownership charge, the ranking of the least cost alternative on an irrigated acre basis is different than when just looking at the irrigation system ownership costs. The handline system is still the least cost system. But the center pivot is now the most expensive where it was the second least costly when only the system ownership costs are compared. See Table 5 for a ranking by capital cost.

Operating Cost Comparison

Operating costs can only be generated after specifying the crop rotation. The amount of water applied and the number of irrigations varies by crop, and so, therefore, does the irrigation labor and energy cost. The labor cost for each crop acre and for a rotational acre by type of irrigation system is shown in Table 6. The amount of labor was calculated using the number of irritations per crop and the irrigation labor coefficients specified in the assumptions. All irrigation labor was valued at $6.75 per hour.

A summary of operating costs, including labor, maintenance and power costs per acre for each system is shown in Table 7. Maintenance costs were calculated using the repair coefficients specified in the assumptions, applied to the cost per irrigated acre from Table 1. The energy cost was calculated using the Irrigation Fuel Cost Calculation program from Texas A&M University. Electricity was valued at 4 cents per kilowatt hour. The discharge pressure for the wheelline and handline systems was 65 psi, while the discharge pressure for the center pivots was 40 psi. The overall plant efficiency was 75 percent for all systems. Since a surface water source delivered to the field was assumed, no lift was used in the energy cost calculations. While the net water applied was the same for each system, as specified in the basic assumptions, the water applied or pumped was calculated for each system based on the application efficiencies, also specified in the basic assumptions. The center pivot without a corner catcher has the lowest operating costs per acre.

When the operating costs from Table 7 are combined with the ownership costs from Table 2, shown in Table 8, the center pivot systems are still the low cost systems. When land is added, the center pivot with a corner catcher becomes less expensive than the center pivot, and both these are less expensive than the wheelline and handline systems. See Table 9. However, the overall difference between the high cost and low cost system is only $18 per acre. A relative ranking of these four system by the cost components is shown in Table 10.

Table 9-b shows the total land and irrigation costs per acre when the land cost has been increased by 50 percent. The center pivot without a corner catcher becomes the highest cost system because of its greater inefficiency in terms of land irrigated. The center pivot with a corner catcher is now the least cost system.

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Negri, Donald H., and John J. Hanchar. "Water Conservation Through Irrigation Technology." Agricultural Information Bulletin Number 576, Economic Research Service, USDA, November 1988.

Willet, Gayle S., Richard W. Dunford, and M. Anthony Wright. "Estimating Irrigation Pumping and Sprinkler System Costs." Extension Bulletin No. 1166, Cooperative Extension, Washington State University, Pullman, WA, September 1982.

Table 1. Sprinkler Irrigation Cost Summary.

SYSTEM	Irrig Acres	Total Cost	Cost/ Acre	Cost/ Irrig. Acre
Handline	154	$ 62,825	$393	$408*
Wheelline	154	110,050	688	715
Center Pivot	128	57,595*	360*	450
Center Pivot w/corner	150	80,895	506	539

* Indicates least cost system.
Systems are designed for a 2,640' by 2,640' 160 acre field.
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Table 2. Sprinkler Irrigation Ownership Cost Summary.

SYSTEM	Irrig Acres	Total Ownership Cost	Ownership Cost/ Acre	Ownership Cost/ Irrig. Acre
Handline	154	$ 6,865	$ 42.90	$ 44.60*
Wheelline	154	12,457	77.90	80.90
Center Pivot	128	6,652*	41.60*	52.00
Center Pivot w/corner	150	9,394	58.70	62.60

* Indicates least cost system.
Systems are designed for a 160 acre field.
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Table 3. Land Cost Per Acre.

Land Payment 1/	$117
Taxes	11
Irrig. District Fees	24
Total	$152

1/ $1,200/ac, 30 yr, 9%
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Table 4. Land and Sprinkler Irrigation Ownership Costs Summary.

SYSTEM	Land + Ownership Costs/Acre	Land + Ownership Costs/Irrig. Acre
Handline	$194.90	$202.70*
Wheelline	$229.90	$239.00
Center Pivot	$193.60*	$242.00
Center Pivot w/corner	$210.70	$225.25

* Indicates least cost.
Land cost adjustment factors: HL & WL = 1.04 (160/154), CP = 1.25 (160/128) and CP/wC = 1.07 (160/154).
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Table 5. Capital Cost Comparison: Low (1) to High (4).

	TOTAL COSTS		OWNERSHIP COSTS Without Land		OWNERSHIP COSTS With Land	
SYSTEM	Per Acre	Per Irrig. Acre	Per Acre	Per Irrig. Acre	Per Acre	Per Irrig. Acre
Handline	2	1	2	1	2	1
Wheelline	4	4	4	4	4	3
Center Pivot	1	2	1	2	1	4
Center Pivot w/corner	3	3	3	3	3	2

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Table 6. Labor Costs per Irrigated Acre.[1/]

	Handline	Wheelline	Center Pivot	Center Pivot w/corner
Potatoes	$94.50	$33.10	$21.60	$21.60
Sugarbeets	101.25	35.45	22.70	22.70
Malting Barley	47.25	16.55	15.65	15.65
Winter Wheat	47.25	16.55	15.65	15.65
Rotational	$72.55	$25.40	$18.90	$18.90

[1/] Labor valued at $6.75/hr.
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Table 7. Sprinkler Irrigation Operating Costs per Irrigated Acre.

	Labor	Maintenance	Power	Total
Handline	$72.55	$12.25	$28.75	$113.55
Wheelline	25.40	28.50	26.50	80.40
Center Pivot	18.90	31.50	18.00	68.40*
Center Pivot w/corner	18.90	37.75	19.00	75.65

* Indicates least cost.
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Table 8. Total Irrigation Costs per Irrigated Acre.

	Operating Cost	Ownership Cost	Total Cost
Handline	$113.55	$44.60*	$158.15
Wheelline	80.40	80.90	161.30
Center Pivot	68.40*	52.00	120.40*
Center Pivot w/corner	75.65	62.60	138.25

* Indicates least cost.
file:ec-tab8.doc

Table 9. Irrigation Costs and Land Cost by Irrigation System.

	Total Irrig. Cost	Land Cost	Total Cost
Handline	$158.15	$158.00	$316.15
Wheelline	161.30	158.00	319.30
Center Pivot	120.40	190.00	310.40*
Center Pivot w/corner	138.25	163.00	301.25

* Indicates least cost. Land valued at $152/acre.
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Table 9-b. Irrigation Costs and Land Cost by Irrigation System.

	Total Irrig. Cost	Land Cost	Total Cost
Handline	$158.15	$224.00	$382.15
Wheelline	161.30	224.00	385.30
Center Pivot	120.40	269.00	389.40
Center Pivot w/corner	138.25	230.00	368.25*

* Indicates least cost. Land valued at $215/acre.
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Table 10. Total Cost Comparison: Low (1) to High (4).

SYSTEM	Op. Cost	Own. Cost	Total Cost	TC + Land	TC + Land * 1.5
Handline	4	1	3	3	2
Wheelline	3	4	4	4	3
Center Pivot	1	2	1	2	4
Center Pivot w/corner	2	3	2	1	1

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WATER MANAGEMENT TOOLS

Roger Ashley
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Water management is a far better term for today's society than the term irrigation. As with all things today, different terminology in agricultural practices that relate to conservation and wise use of natural resources is needed. In the same light, we in agriculture need to concern ourselves with those practices that not only conserve our resources, but also reduce our production costs and improve our efficiency.

The tools that will be discussed today are just that, tools. They are tools that when used properly can assist the producer to be a more effective and efficient water manager (irrigator). At the same time this increased effectiveness and efficiency can lead to better water quality, an issue that is constantly before us.

As we look at these tools, let us keep in mind a few facts: water is becoming a resource that is being sought by many for uses other than agricultural; water quality issues are of high concern; the recent drought had agricultural water users concerned about their water sources; and water cost is sure to increase in the future.

We must also look at what the tools can do for the producer. They are a source of information or data which the producer must have confidence in if he is to use it effectively. To have the tool and have it in place and then not believe what it tells you does no good. Once the information or data is obtained, it is then up to the producer to fit it into his/her water management program to obtain the most effective use of the water.

One tool that can be used very effectively with most all of the "physical" tools is irrigation scheduling. Irrigation scheduling is not an exact science by any means, but it can and does provide the producer with some very valuable information regarding evapotranspiration (ET) of the various crops listed on the crop water use charts which are published in local newspapers. By using the data in these published crop water use charts a producer can use a checkbook method of determining when to schedule irrigation for his/her crops. The producer must, of course, be familiar with the soils in terms of water holding capacity and depth to make this system be effective. If the producer has a computer and a modem, he/she may desire to contact the /Bureau of Reclamation in Boise and receive the data directly rather than use the newspaper. This would allow for daily chart information or whenever the producer wanted it.

Tools:

1) Aquateer

Two different models:

a) Analog

b) Digital

A portable moisture sensing device that features the advantage of being able to check as many different sites in a field as desired.

2) Water Mark soil moisture sensor

Components include the sensors and the meter for readings. All indications from work done indicate that they are quite accurate when installed properly. Installation can be done in such a manner that the sensors can be located within the field and the contacts for the meter readings can be located on the edge of the field.

3) Tensiometers:

Individual moisture sensing devices that are set for a specific depth at a particular location for determining soil moisture content. It works on the basis of the tension between the soil particles and the water in the soil.

4) Soil Moisture blocks:

Similar to the Water Mark sensor in that "blocks" are set at sites within the field to determine the soil moisture.

5) ET Gage:

An evapotranspiration simulator that measures crop water ET. The device can be mounted on a post, etc. in or near a field where ET is to be monitored. Does require distilled water.

6) Infra-red Guns:

A gun-loke device that measures infra-red radiation from the leaf surface. Care and experience in operation of this tool is necessary to get reliable data and information.

WATER MANAGEMENT TOOLS

Roger O. Ashley and Darrell Bolz

Demands on a finite water supply by agricultural producers, resource managers, and the general public have created a need for water management. Recent drought had producers scrambling for the limited water supply. Efforts in water management in the past were concentrated almost entirely on increasing storage capacity and improving irrigation equipment. Practices related to conservation and wise use of the water resource are needed by users. Water quality issues are also of high concern and water costs are sure to increase in the future. We in agriculture need to be concerned with practices that conserve resources while maintaining or increasing yields, reducing costs per unit of production, and improving overall efficiency.

Producers have traditionally feared providing too little water to the crop and have managed irrigation water with this thought in the back of their minds. Producers know all to well the reductions of yield and quality when not enough water is supplied. However, producers are sometimes unaware of the consequences to the crop if more water is provided than what the crop can use. The incidence of certain diseases such as pythium, "take-all", and black point in cereal grains increases when an over abundance of water or poor timing of application occurs. The severity of physiological disorders in potatoes such as hollow heart, internal heat necrosis, black heart, and enlarged lenticels can be influenced by excessive or poorly timed additions of water. In instances where soil conditions are saturated over a period of time (less than 48 hours for alfalfa) root zones can be greatly reduced and have a like effect on yield. Over application of water or poor timing of an irrigation can have a deleterious effect on crop yield, quality and the producers bottom line just as supplying too little water can.

A well designed and engineered irrigation system which has the capability to supply adequate water is only half of what today's agricultural producer needs to accomplish the task of irrigating and producing a high yielding, quality crop. Efficient use of water in crop production can only be attained when the irrigation system and management to operate the system are finely tuned to the needs of the crop. Maintaining moisture levels within maximum and minimum levels required for specific crops used to be more of an art rather than science. However, developments within the past few years in devices which measure soil moisture, evapotranspiration, and crop condition in terms of water stress have provided producers the tools necessary to take a lot of the guess work out of irrigation. These tools when used properly by a knowledgeable producer or crop manager can assist the producer be more effective in scheduling irrigation and in the efficient use of water while at the same time preventing degradation of ground water through leaching of nitrate and farm chemicals or excessive runoff into ponds, lakes and rivers.

Producers must have confidence in the data provided by these water management tools if the information is to be used effectively. Use of a water management tool requires proper, timely operation of the device and a knowledgeable producer. The producer must have confidence in use of this information and then act accordingly to make it fit into the farmer's water management program. Producer time limitations may preclude the proper use of water management tools. Many of these tools require a time commitment by the producer to read the device twice or three times a week as well as interpreting the information. There are a number of crop management services which provide irrigation scheduling as well as other scouting services for a minimal cost ($4 to $25 per acre for potatoes). Information provided by the crop management service should be concise and easily understood by the producer. The management information provided by these services may be well worth the cost to the producer who has little time to devote to using these tools and considering the expense and potential income that the farmer has at risk, it may be a real bargain. Whether the producer performs the irrigation scheduling task or hires it out to a consultant, adequate time and money should be allocated to do this important management practice correctly.

Various methods of water management or tools are used by producers today. Some methods work better with various soil textures, crops, and moisture levels than others. Your irrigation specialist, extension agricultural agent, crop consultant, or irrigation equipment supplier should be able to help in selecting the proper water management tool for the conditions encountered in each field.

Some of the water management tools available are listed below. Advantages, disadvantages as well as approximate cost are also included.

<u>Feel and Appearance Method</u> - This method is probably most often used by producers in various degrees of application. When used correctly this low cost method can be used effectively. Several samples are drawn from the field and through the various characteristics exhibited, moisture content is estimated. When moisture content of the soil falls to a predetermined level, it is time to irrigate. Disadvantages of this particular method include time required to drawn an adequate number of samples representative of the field and experience is a must to effectively use this method. Costs associated with use of this method are the soil sampling equipment ($35 to $150) and the time involved.

<u>Gypsum Blocks</u> - These are beginning to become more popular with producers since recent improvements have been made. This method measures electrical resistance in soils. The drier the soil is the more electrical resistance is registered. Components include sensors and a meter for readings. These sensors are reasonably accurate when installed properly. Installation can be done in such a manner that the sensors are located within the field and the contact for the meter readings can be located at the edge of the field. Little experience is required to use this device and cost of sensors has become very reasonable. A disadvantage of this particular device is that salts found in some soils can cause false readings. This is less of a problem with newer sensors such as the Water Mark Soil Moisture Sensor. Also few soils in Idaho have salt problems. Another problem with this particular device is moisture within the block will not fluctuate as quickly as moisture levels do in the soil under certain field conditions. Cost associated with use of this method are the sensors, $15 to $20 per sensor, the meter to read the sensors, $150, and the time involve in reading the sensors on a regular basis.

<u>Tensiometers</u> - These devices consists of a glass tube filled with water , a gauge at one end and a ceramic plug at the other end of the tube. As soils become drier, water moves through the ceramic plug creating a suction or tension within the tube which the gauge measures in bars or atmospheres. These devices are inexpensive and work well under moist conditions as normally found in potatoes. Tensiometers work best in silt and clay (fine textured) soils. However, poor results can be expected when this particular tool is used in coarse textured soils, gravel, and at low soil moisture levels. Cost of tensiometers will range from $40 to $50 a piece. As with the previous methods discussed time is require to read the gauges, and to record and interpret the results. An example of how the results are reported can be seen in Figure 1.

Neutron Moisture Probe - When properly calibrated, these instruments are among the most accurate instruments available for measuring soil moist under variable soil moisture and texture conditions. This instrument uses a source of fast neutrons lowered through an access tube to detect moisture (Figure 2). As fast neutrons collide with hydrogen atoms (found in water (H2O)) the neutrons slow down to a speed that the gauge can detect. The ratio of fast neutrons emitted to slow neutrons detected is related to the amount of water within the zone of interest. Disadvantages of these devices have become more substantial within the past five years. Some of the disadvantages are operators of this device must be licensed, increasing licensing fees, liability insurance has become more expensive, the instrument must be stored properly away from living and work areas, and installing access tubes and calibration is time consuming. Cost of neutron moisture probes range from $4,000 to $5,000.

Capacitance Probes - These devices come in various configurations but the principle is still the same. The dielectric constant of soil and water is measured. The capacitance increases with the increase in moisture level and a meter converts the dielectric measurement to inches of water. The capacitance probe is supposed to be designed to replace the neutron moisture probe. However, variability of readings for the same soil zone of interest is greater than the neutron probe and its use may be limited. Also capacitance probes shows better sensitivity to moisture in coarse textured soils than in fine textured soils. Another disadvantage is that extreme care must be taken when installing access tubes. Loosely fitting tubes can cause half of the variability in readings. Some capacitance probes look very similar to neutron probes and cost about $4,000 while some probes such as the Aquateer which are portable cost $400 to $500. The advantage of these units is that they do not require access tubes so an individual may check as many different sites in the field as desired.

Evapotranspiration (ET) Checkbook Method - A number of variations on this method are used. Some variations use a Class A evaporation pan to determine reference ET. Others use climatic data from remote weather stations to calculate ET rates for specific crops of interest. These rates of water use are often published in newspapers and farm magazines. Producers and in fact anyone else with the desire to have this data can use their computer with a modem to retrieve this information from the Bureau of Reclamation computer in Boise or from the Idaho Agri-Net electronic bulletin board in Idaho Falls. Water use tables are updated on a daily basis by the Bureau of Rec and the Idaho Agri-Net system is updated twice a week. Contact your extension agricultural agent for information on how to become users of these systems.

The checkbook method requires an understanding of plant-soil-water relationships. Water use is recorded from one of the above sources on a soil moisture balance sheet (Figure 3) to determine the remaining amount of plant available water. When moisture levels are drawn down to a predetermined level , then it is time to irrigate the crop.

Advantages of this system are that it is relatively inexpensive to use, requires considerably less time than methods reviewed previously, and the information is readily available. Disadvantages of this system is that the method assumes that the crop is in a healthy, well watered condition without weeds, diseases or insect problems. Verification in the field by the producer or manager is still required to determine that extreme pest problems or other conditions do not exist. Cost associated with this method varies with the sophistication of how the information is collect, recorded, and analyzed.

Infrared Thermometry - Also known as infrared guns use radiant energy beyond the sensitive range of the human eye. The difference between the crop canopy and air temperature is measured and the degree of water stress determined. When a predetermined level of stress is measured, irrigation should commence. Infrared thermometry instrumentation is very portable and easy to use when calibrated correctly.

Disadvantages include high cost and the fact that the instrument can not determine the difference between stress caused by lack of water, insects, and disease. Verification of field conditions will need to be made when using infrared thermometry. Also the cost of the instrument is substantial. Current cost of one of these instruments is about $4,000.

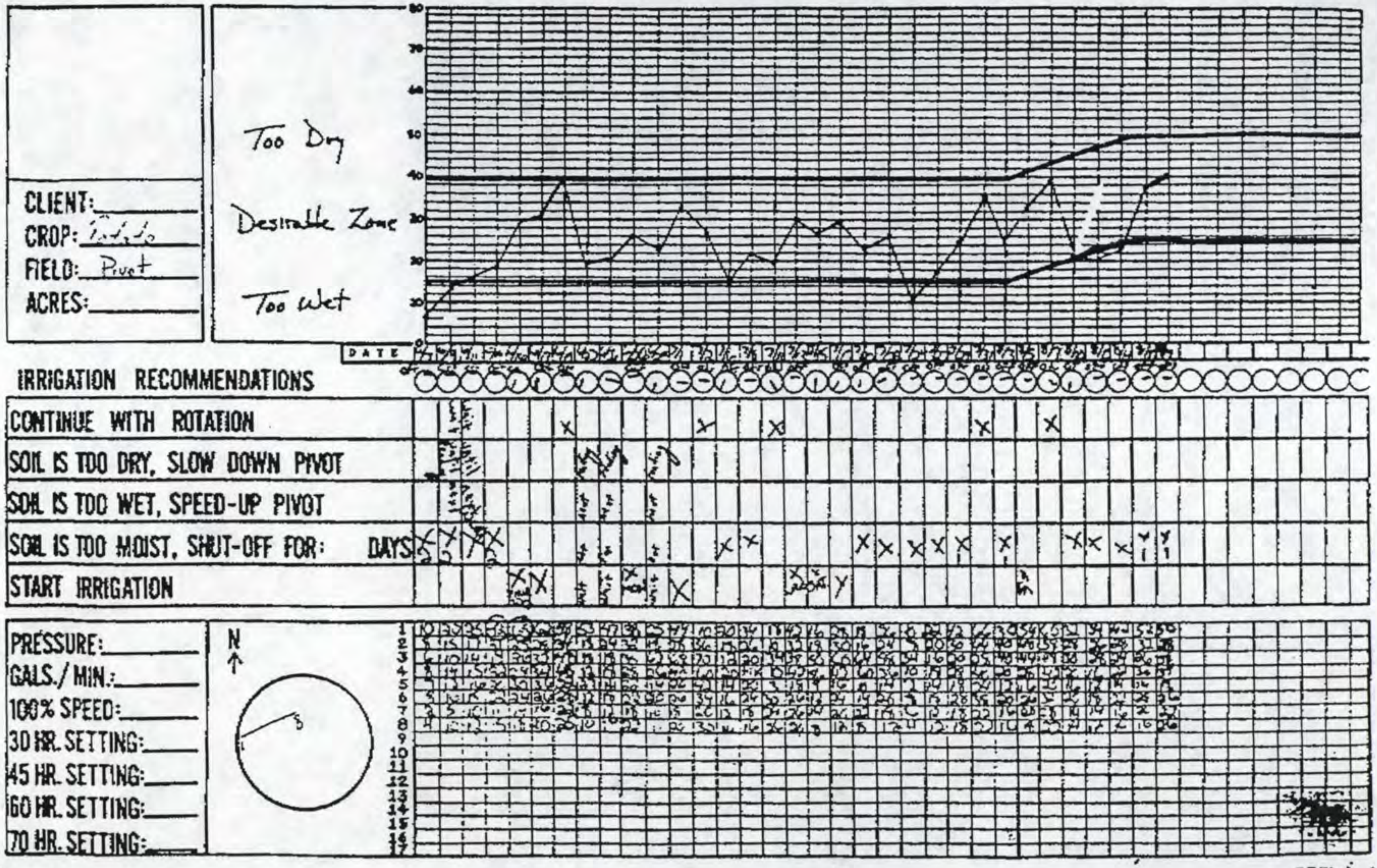

Figure 1. Plot of tensiometer readings from a pivot irrigated potato field.

Figure 2. Neutron Depth Moisture Probe.

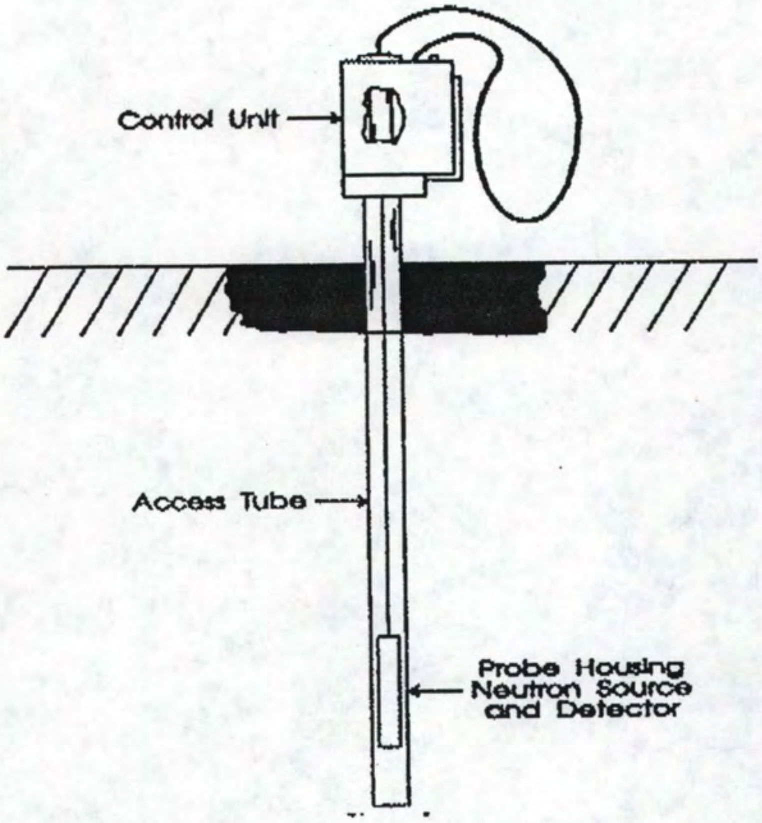

Figure 3. An example of a soil moisture balance sheet.

SOIL MOISTURE BALANCE SHEET

CROP ______________ FIELD ______________ EMERGENCE DATE ______________

PUMPING CAPACITY ____________ GPM/ACRE ____________ NET INCHES/DAY

ROOT ZONE DEPTH	MOISTURE HOLDING CAPACITY IN ROOT ZONE	50% OF MOISTURE HOLDING CAPACITY IN ROOT ZONE
__________ FEET	__________ INCHES	__________ INCHES

MAINTAIN DEFICIT LESS THAN ______ (INCHES)

			Add	Subtract		Total				Add	Subtract		Total
Week After Emergence	Date	Maximum Temperature	Crop Water Use	Rainfall	Net Irrigation	Soil Moisture Deficit	Week After Emergence	Date	Maximum Temperature	Crop Water Use	Rainfall	Net Irrigation	Soil Moisture Deficit

NEW TECHNOLOGY TO CONTROL IRRIGATION-INDUCED EROSION

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INTRODUCTION

Irrigation-induced erosion was first recognized as a problem in the 1930's. Researchers in the late 1930's and during the 1940's conducted studies on the effects of furrow stream size and slope along the furrow on the amount of sediment lost from fields. This sediment represented top soil eroded from the field. Following these studies, researchers cautioned farmers to avoid furrow stream sizes larger than necessary to accomplish the irrigation and to avoid irrigating fields with slopes that are too steep. These warnings were generally ignored by most farmers, probably because they did not know that the erosion was decreasing the productive potential of their farms, and there was little awareness of the off-site damage caused by sediment.

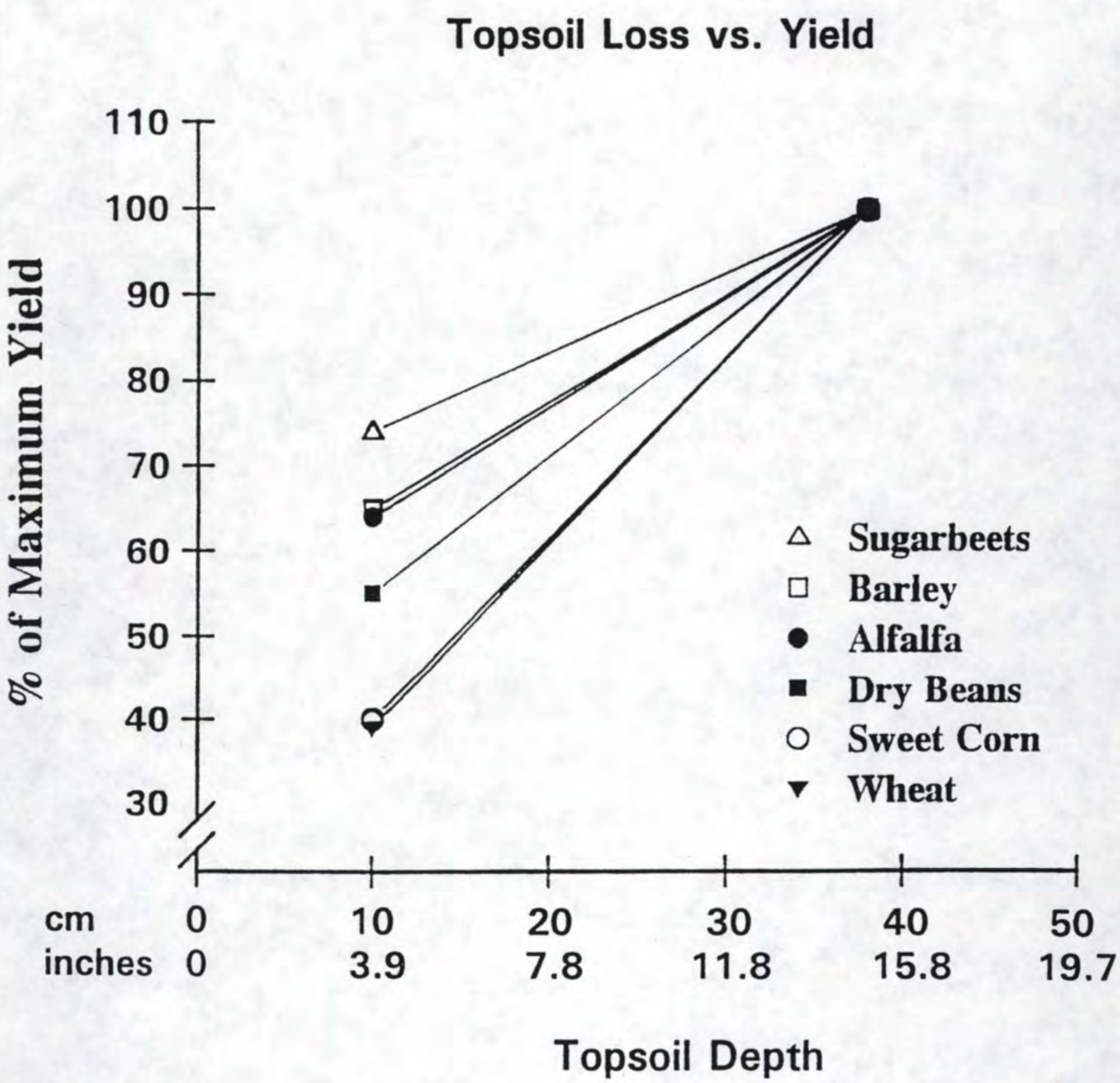
By the late 1960's off-site damage of sediment to rivers, streams, and reservoirs were recognized, and erosion on both irrigated and rainfed, cropped fields began to receive attention. Questions were raised concerning the magnitude of the off-site damage as well as questions concerning the impact of topsoil loss on the productivity of farmed fields. Environmental conscious groups pointed to erosion and loss of sediment from cropped fields as one of the primary sources of sediment that was ruining fish spawning gravels, filling reservoirs and polluting rivers and streams. As a result of this attention, the Water Quality Act of 1972 was enacted. This act not only concerned pollution from sediment, but also from nutrients, pesticides, animal wastes, sewage, and other wastes. This act focused efforts towards evaluating the impact of erosion on cropped fields and the developing of erosion control technology. Since these efforts began about 25 years ago, we have made many discoveries about erosion processes that have led to the developing of erosion and sediment control technology. We have learned that the loss of topsoil from fields reduces their crop production potential. This loss of productivity has been quantified, and it is serious.

During the past decade many new technologies have been developed for controlling irrigation induced erosion. Most of these technologies have resulted from research done by the USDA-Agricultural Research Service (ARS) at Kimberly, Idaho. In the following paragraphs, I will discuss these technologies that have been developed in recent years and their potential impact when applied by farmers. The discussion will focus first on the on-site problems caused by erosion, and then on the technology available to control these problems.

THE EFFECTS OF EROSION ON CROP PRODUCING POTENTIAL

Topsoil almost always has a greater crop producing potential than does subsoil. Topsoil is a valuable resource that needs to be protected against loss to maintain the production potential of any field or farm. Research by ARS scientists has shown that the topsoil in most of the irrigated areas of Idaho is barely deep enough to provide a maximum crop producing potential under the climatic conditions of the area. Idaho irrigated soils are among the most productive in the world. These soils initially had about 12 to 16 inches of topsoil. Research has shown that about 15 inches or 38 cm of topsoil is enough to produce maximum yields of crops grown in southern Idaho. Adding to that depth does not change the production potential, but reducing that depth decreases the production potential rather dramatically. ARS scientists conducted many studies to determine how much the crop production potential is decreased per increment of topsoil loss resulting from erosion. The results are illustrated in the following figure.

The figure shows that wheat and sweet corn production decreases sharply as topsoil depth is decreased resulting from erosion. The decrease in dry bean production is a bit less, barley and alfalfa somewhat less and sugarbeets are least affected. Potato production is affected a little more severely than is dry bean production. Investigations further showed that more than 75% of the fields in a large study area representing a million acres or more have been eroded severely enough on the upslope 20 to 30% that the subsoil is exposed. This means that six inches or more of topsoil has been lost. We found some fields where nearly three feet of soil had been washed away from the upper end.



Crop Yield Response to Topsoil Loss

Data analyses and evaluation of results from many studies showed that irrigation induced erosion has reduced the average production potential of fields and farms by 25% over 85 years of irrigation. In other words, the overall production of the area is 75% of what it could be today had there been no irrigation induced erosion. Furthermore, permitting erosion to continue will further decrease the crop production potential at a more rapid rate. Therefore, it is critical that we apply all the control technology that is available to stop the loss of our valuable topsoil.

Research has also shown that the loss in crop production potential cannot be compensated for by applying fertilizers, soil amendments or other materials. The only way to restore the full crop production potential is to return topsoil to the eroded areas. Unfortunately most of the lost topsoil cannot be recovered because it has been lost into streams, rivers, reservoirs, and the ocean.

The economic impact of this loss in production potential is obvious. Undoubtedly some farmers have been forced out of business as a result of erosion and topsoil loss to the point that their management system was no longer profitable enough to pay the bills necessary to continue operating. More farmers will go out of business if they permit erosion to continue on their farms.

The upslope 10 to 20% of many fields may not be profitable except when prices for the crops grown are unusually high. Often farmers try to improve the yields on these areas by adding more fertilizer, but that approach only increases the input cost per unit of production, because these areas will not respond to extra fertilizer.

EROSION AND SEDIMENT LOSS CONTROL TECHNOLOGY DEVELOPMENT

Technology to prevent sediment from entering streams, rivers, and lakes.

The major thrust of the Water Quality Act of 1972 was to prevent sediment, nutrients, pesticides and other pollutants from entering streams, rivers, and lakes. In response to this thrust, sediment loss control technology was developed. This technology was concerned primarily with removal of sediment from runoff water from irrigation. The construction of sediment ponds or basins was the first practice to be widely implemented. Researchers developed criteria for the design and construction of many types of sediment settling ponds and basins ranging from ponds several acres in size or main drainage streams to mini-basins at the tail ends of fields. These mini basins may catch runoff from only a few furrows. This technology developed to the point that about 90% of the sediment could be removed from water before that water was discharged into a stream, river, or lake. The problem with sediment ponds and basins is that they rapidly fill with sediment that must be removed if the pond or basin is to continue to be effective. Such removal is costly.

The next step in technology development was to initiate practices to prevent sediment from leaving irrigated fields, thus the mini-basins mentioned earlier were used in combination with a buried pipe with controlled inlets to provide a way for the water to leave the mini-basins after the sediment had settled. This practice corrected a problem that had developed over many years on most irrigated fields. This problem was that the lower ends of fields had become convex shaped as a result of erosion and soil loss from the last few feet of the fields. This was caused by farmers maintaining the tailwater ditch too deep because of the fear that ponding at the lower end of a field would cause crop damage. This combination of a buried pipe system with mini-basins required relatively high initial investment, but research showed that the increased crop productivity on the lower ends of fields with these systems would pay the installation costs in 6 to 10 years. These systems should work effectively for many years. The first such systems installed in the 1970's are functioning well today.

Another practice introduced was the use of vegetative filter strips across the lower ends of row cropped fields. These strips can be wheat or other cereal, alfalfa, grass, or any other close growing plant that will slow water flow. As the flow rate decreases, sediment being transported in the stream settles out. The effectiveness of vegetative filters centered around the installation and management of them. Many problems arose because of a lack of understanding of the principles involved. Many vegetative filters filled so rapidly with sediment that a barrier to water movement was built and drainage water began to move laterally along the upper end of these filters. Vegetative filters typically removed only 40 to 50% of the sediment from drainage water.

Erosion prevention technology.

During the past decade research efforts have intensified on the development of technology to prevent soil erosion or at least reduce it to a non-damaging level. Several excellent management practices have been developed. When these are applied in combination, irrigation-induced erosion can be almost eliminated, and farmer net income can be increased substantially. However, this technology is new, and only a few farmers have adopted much of it. An extensive education program is needed to accelerate the adoption of this technology. Some cost-share or economic loss prevention guarantee programs are needed as part of demonstration projects in this education process.

During the past eight years, conservation tillage cropping systems that eliminate irrigation induced erosion most seasons and reduce it the others have been developed. These systems include no-till and reduced tillage practices and may require changes in cropping sequences. The primary concept involved is to grow crops in a sequence that permits the fewest tillage operations over a complete rotation cycle which may be 5 to 10 years. These conservation tillage cropping systems require a long term commitment, not just single season decisions. However, research has shown that if these systems are used, farmer net income can be significantly increased while conserving the important topsoil resource for future generations.

Successfully implementing of conservation tillage cropping systems requires the farmer to farm "smart" instead of "hard." It requires the exercising of good judgement rather than following traditions. It requires staying off the tractor when there is an urge, based upon tradition, to get on it and perform some tillage operation.

Research has demonstrated that corn or cereal can be grown successfully without tillage following alfalfa. Cereal can be grown following corn, and corn can be grown following cereal without tillage. Only when row crops that require the incorporation of herbicide are to be grown is extensive tillage required, and the number of tillage operations can be significantly reduced for these crops. The goal is to consecutively grow crops that require no tillage until a crop that requires tillage is the next crop. Then till as sparingly as possible.

For example, a common rotation in southern Idaho is alfalfa, alfalfa, dry beans, dry beans, cereal, corn, wheat-or peas-alfalfa. Traditionally 36 to 39 tillage operations are done over this rotation cycle, and typically 30 to 50 tons of topsoil per acre are lost from the field. Changing the rotation to alfalfa, alfalfa, no-till corn, no-till wheat, dry beans, dry beans, wheat-or peas-alfalfa required only 6 to 9 tillage operations, much less nitrogen fertilizer, produced yields as good or better than the traditional system and essentially eliminated erosion. Net income from the conservation tillage cropping system was $50 to $100 per acre greater each year than from the traditional system.

Another new technology is the use of polymers to eliminate or reduce erosion. Polymers are materials comprised of very large molecules. These large molecules somehow tend to hold soil particles together and prevent the moving water from eroding soil particles from the furrow surface and transporting them away. Polymers are added to the irrigation water in very low concentrations ranging from 1 to 10 parts per million (mg/L). The period of application generally is needed only during the advance period or until the water reaches the end of the furrow. Then the polymer application can be discontinued until the next irrigation. There are a number of different application approaches that are effective. Use of these polymers, and there are a variety of them, can essentially eliminate irrigation-induced erosion at a cost of $10 to $15 per acre. Research results indicate that the $10 to $15 per acre may be recovered from increased crop yields resulting in improved water infiltration also caused by the polymers.

The use of cheese whey alone and in combination with straw in furrows is another new technology that an almost eliminate irrigation induced erosion. Whey is not available everywhere, but in the vicinity of cheese producing plants it is often a waste product that creates a disposal problem. Usually it can be obtained for the cost of hauling.

The whey is applied by running it down furrows or by spraying it along the furrows with a conventional spray-rig. Small amounts of straw can be placed in the furrows by available machinery. The combination of whey and straw appear to be more effective than whey alone at low whey use rates. Straw alone also can provide erosion control. The whey is applied only at the beginning of the irrigation season, and it provides erosion control for the entire season. Applying 12 gallons of whey and 4 pounds of straw per 100 feet of furrow length gave almost complete erosion control for the entire season.

Combining these new erosion control technologies can almost completely prevent irrigation-induced erosion and eliminate sediment loss from fields. Applying these technologies also could eliminate the need for sediment loss prevention technologies developed earlier. Eliminating further erosion will prevent further deterioration of the production potential of soils on our farms.

The availability of these new technologies provide farmers with many options for their use. For example, a farmer can use no-till practices for some crops such as cereal and corn, and then use polymers or whey and straw when growing dry beans, sugarbeets, or corn following a tilled crop. It is important that farmers have the options to apply erosion prevention materials like polymers whenever and wherever erosive conditions occur.

Research will continue towards improving these new irrigation induced erosion control technologies and to develop additional new technologies. Efforts will be made to transfer available technologies to the farmers. Until these new practices are actually implemented, the loss of our valuable topsoil resource will continue, and the production potential of soils will continue to decrease. Everyone who can influence farmers towards accepting the new technologies for erosion control should do so.

WATERWISE IRRIGATION CONSERVATION PROGRAM

Dick Stroh
U. S. Department of Energy
Bonneville Power Administration

The Waterwise Program, sponsored by Bonneville Power Administration and local electric utilities* provides technical assistance and financial incentives to irrigators for energy improvements to their existing electric pumping systems. Financial assistance can be provided up to 50% of the cost for the improvements. Eligible equipment covered include pumps, motors, pipelines, and low pressure sprinkler nozzles.

To be eligible, the irrigator must contact their local electric utility for having an analysis of their existing irrigation system. Once the analysis is complete, recommendations are provided. An estimated incentive is calculated by multiplying the estimated annual energy savings by $0.22 per kWh saved.

Final payment is based on actual energy savings determined through a secondary analysis of the irrigation system following installation of the measures. Since the Program pays based on actual savings, a minimum guarantee is provided to the irrigator computed at $15 per existing rated motor horsepower. This only applies if little or no energy savings occurs. In no case does the Program pay more than 50% of the cost of the installed measures.

*Local Participating Utilities:

Fall River Rural Electric Coop.; Ashton, Idaho
Lower Valley Power & Light Co., Inc., Afton, Wyoming
Salmon River Electric Coop., Inc., Challis, Idaho
Lost River Electric Coop., Inc., Mackay, Idaho
Raft River Rural Electric Coop., Inc., Malta, Idaho
Rural Electric Co., Rupert, Idaho
Unity Light & Power Co., Burley, Idaho
Southside Electric Lines, Inc., Declo, Idaho
Wells Rural Electric Co., Wells, Nevada
Riverside Electric Co., Rupert, Idaho

IDAHO DEPARTMENT OF WATER RESOURCES ENERGY CONSERVATION LOAN PROGRAM

Rick Sterling
Idaho Department of Water Resources
Boise, Idaho

Program Description

This program demonstrates a financing mechanism for the purpose of energy conservation to both public and private sectors. In previous years, the Department of Water Resources has promoted innovative financing mechanisms for the performance of energy conservation measures. Unfortunately, this approach remains relatively unknown and is perceived by many institutions as too complex and risky for them to use. Since the larger portion of energy conservation yet to be undertaken in the United States will be done with private capital, demonstrations of alternative and innovative financial arrangements constitute a valuable service to the citizens of Idaho.

Statement of Demonstration

The energy conservation loan program provides a demonstration of repayment of loans for purchase of energy conservation through energy cost savings. No financing programs are available which have as their primary focus more efficient energy use and the added benefit of low interest rates. This program provides the opportunity for institutions and borrowers to install energy conservation measures and generate savings that will pay for the energy conservation measures in ten years or less. (This criteria has been used in prior programs in determining economic and technical feasibility of proposed conservation measures).

This demonstration is paving the way for private sector involvement in energy conservation and also has a direct impact on current and future energy consumption. In addition, this demonstration benefits the economic situation by getting more dollars in circulation through payments for conservation measures themselves and related installation costs.

Target Audience

The target audience encompasses all sectors of the economy. Each of the five sectors - residential, commercial, agricultural, governmental and public/institutional - initially received a specific allocation of program funds. The intent was to ensure that one sector did not monopolize the entire initial program allocation until the demand for the funds had been determined. After a period of time, if few or no applications had been received in a certain sector, funds would be reallocated to other sectors as needed. Eligibility for this program is not limited to any fuel type and has no income guidelines for applicants.

Prior Demonstration

This type of financing mechanism has not been sufficiently demonstrated in the state. This program is available to all sectors of the economy, whereas previous loan and interest buy down programs were geared toward small, distinct target audiences. This program enhances the financial institutions' understanding of energy conservation and renewable resources financing to a point that they can undertake these projects using their own funds.

Technical Assistance

IDWR has expert staff available to the target audience to provide technical assistance. When requested, staff will also help potential applicants with technical or general program information concerning the program, including decisions on appropriate energy conservation measures, if necessary.

IDWR staff have the responsibility of reviewing the energy conservation measures proposed by the applicant. IDWR also has a variety of computer programs to help calculate heat loss, energy savings and payback periods. Projects are analyzed for technical and economic feasibility based on program criteria and for potential environmental impacts. Estimated annual energy savings are calculated for each application to determine a simple payback period. Residential sector applications that meet program criteria will be referred to financial institutions for completion of the loan. Loans in all other sectors are serviced by IDWR.

Expected Benefits

All sectors and entities participating will have increased awareness of the cost benefit relationship of energy financing. Borrowers can anticipate reduced energy costs through installation of energy conservation measures. Utilities will acquire resources through conservation. We estimate an average simple payback of loan amounts of six years, resulting in energy savings of 12.8 million kWh per year.

Criteria

The more important criteria which are used to determine eligibility of agricultural projects are listed on the following pages.

AGRICULTURAL CRITERIA FOR TECHNICAL AND ECONOMIC FEASIBILITY REVIEW BY THE DEPARTMENT OF WATER RESOURCES

TO BE ELIGIBLE, PROJECTS MUST:

1. Be conducted within the state of Idaho.
2. Be consistent with the State Energy Plan.
3. Demonstrate the ability to conserve energy through efficient energy use or the utilization of renewable energy resources which results in energy savings based upon a net reduction in the use of non-renewable resources.
4. Utilize existing, reliable technologies.
5. Meet federal and state air and water quality standards.
6. Show a simple payback period of 10 years or less for the <u>total</u> cost of the project based on estimated annual energy savings. This may be subject to waiver in unusual circumstances.

PROJECTS MAY:

1. Be for existing structures or for retrofits of existing irrigation systems.
2. Include energy-efficient lighting systems (luminaires) and occupancy/daylight sensors in new construction, e.g. farm buildings. No other measures are eligible for new construction, except as defined in #3.
3. Include new irrigation systems where land has been flood irrigated or dry-farmed. Only energy-efficient components are eligible for new systems, e.g. energy-efficient motors, low-pressure nozzles, low-energy precision applications. (Lands not previously farmed are not eligible.)
4. Not utilize program funds to take advantage of an interest rate lower than one on an existing permanent loan (no refinancing) nor pay for measures already in progress or completed.

ADDITIONAL LOAN CRITERIA INCLUDE:

1. No minimum loan amount.
2. The maximum loan amount is $100,000.
3. Interest rate on loans is 4%.
4. The applicant must complete the loan application process and begin installation of energy conservation measures or renewable resource projects within 90 days following approval of project by the Department. Failure to do this will result in revocation of the loan and require submission of a new application to the Department.
5. Repayment of the loan is 5 years or less.
6. Water rights information must be provided for ascertaining legal compliance with water rights requirements, where applicable.
7. Applicants must be the direct user/benefitter of projects funded by this program. Projects which are energy-for-sale or energy-commodity-for-sale projects are not eligible.
8. Changing of fuel sources only if the change results in an increased Btu efficiency, with the exception of renewable resources, which includes solar energy, wind power, water power, geothermal energy and biomass resources. Conversion to the use of a renewable resource is excluded from the requirement of showing an increase in Btu efficiency.

LOAN APPLICATION PROCESS

1. Complete and return application form to the Department of Water Resources, Statehouse Mail, Boise, ID 83720.
2. Department staff will review the project for economic and technical feasibility. Applicants will be notified in writing of projects' approval or denial based on the analysis of economic and technical feasibility.
3. Wherever possible, and in most cases, a UCC-1 filing will be placed on the items purchased with the loan. The Department **will not** subordinate its lien position.
4. If approved, payment amount and schedule will be calculated and promissory notes and any necessary security agreements will be provided for applicants' signatures.
5. Additional collateral may be required to secure the loan.

NOTE: Request a conservation project application form for new or existing building improvements' or irrigation systems' projects. Request a renewable resource application form if proposing a renewable resource project.

OTHER CHANGES MAY OCCUR AS NECESSARY.
Revised and effective November 1, 1993.

FINANCIAL INCENTIVE PROGRAMS SUMMARY - 1993

Group	Type of Program	Incentive	Program Funds Available for Each Funding Period	Amount of Water Conserved
Idaho Dept. of Water Resources, Energy Division	Loan	For individuals , $100,000 max., 4% interest 5 year repayment	$3 million available $1.22 million loaned	Unknown - no quantifying method
Idaho Water Resource Board	Loan, Possible grants	For groups only, $500,000 max., 6% interest 10 year repayment $5,000 planning & engineering grants	Approx. $2.9 million initially Fund availability varies depending on loan repayments	Unknown - no quantifying method
Division of Environment Quality (SAWQP)	Cost-sharing	Up to 75% of project costs not to exceed $50,000	Approx. $30 million obligated on 34 projects for planning & implementation	Unknown - no quantifying method
Soil Conservation Commission	Loan, grants	For individuals, $50,000 max., 5% interest 15 year repayment Up to $10,000 grants per demonstration project		Unknown - no quantifying method
Agricultural Stabilization and Conservation Service (ACP Program)	Cost-sharing	Annual: up to 75% of cost NTE $3500 per yr. Long Term Agrmt: 50% to 75% of cost NTE $3500 per year. Pooling Agrmt: Groups up to $10,000 per individual.	$1.1 million expended FY '93 for water conservation	1.77 ac. ft./ac. saved $2.71/ac. ft. saved
Soil Conservation Service (Small Watershed Program)	Cost-sharing	Cost sharing available for watershed protection including agricultural water management and irrigation practices.		Unknown - no quantifying method
Bonneville Power Administration and BPA-serviced utilities	Cost-sharing	Waterwise program. $0.22 per kWh saved not to exceed 50% of improvement costs. Minimum guarantee for retro-fitting. Motor rebate plan.	$210,325 for FY '93 (Idaho)	9500 ac. ft./yr. increase (20.4%) based on 3 yr. ave.
Idaho Power	Cost-sharing	$200 per hp saved up to 50% of upgrade cost. Other incentives based on size of system.	$1.5 million annually	Unknown - no quantifying method
Utah Power	NA	Program being planned for future implementation.	NA	NA

IDAHO DEPARTMENT OF WATER RESOURCES
ENERGY DIVISION

Energy Conservation Loan Program

Program Objective: Energy conservation

Financing Terms:

Type of Program:	Loan
Maximum Amount:	$100,000
Interest Rate:	4%
Repayment:	5 years

Eligibility:

Projects: Any project that conserves energy.
Typical projects include replacement of pumps, motors, mainlines, and sprinklers; low pressure conversions, and conversions from diesel to electricity.

Applicants: Applicant must be owner of irrigation system.

Land: Project must be located in Idaho.

Criteria: Projects must show a simple payback of 10 years or less (e.g., a $20,000 project must save at least $2000 per year in energy costs).

How to Apply: Request application by calling the Energy Information Hotline 1-800-334-SAVE. Applications received throughout the year.

Other Information: Planning and engineering assistance may be obtained from IDWR Energy Division, local electric utility, Soil Conservation Service or private consultants.

IDAHO WATER RESOURCE BOARD

Revolving Development and Water Management Accounts

Program Objective: Reclamation, upstream storage, offstream storage, aquifer recharge, reservoir site acquisition and protection, water supply, water quality, recreation, and water resource studies, including feasibility studies for qualifying projects.

Financing Terms:

Type of Program:	Loan, possible grants
Maximum Amount:	$500,000
Interest Rate:	6%
Repayment:	10 years

Eligibility:

Projects: Any project that meets the program objectives listed above, subject to availability of funds.

Applicants: Irrigation districts, canal or irrigation companies, water user's associations, municipal or private corporations.

Land: Project must be located in Idaho and not be in conflict with any existing state water plan.

Criteria: Projects must use sound engineering and be economically feasible with a favorable benefit to cost ratio. Funding is contingent upon approval by the Idaho Water Resource Board.

Loan Security: Mortgage, deed of trust, or other security agreement upon the applicant's property, which may include, but is not limited to, the following types of property associated with the project: project facilities, equipment, easements, real property, and water rights.

How to Apply: Send a letter of intent to: Chairman, Idaho Water Resource Board, 1301 N. Orchard St. Boise, Idaho 83706.

IDAHO DEPARTMENT OF LANDS
SOIL CONSERVATION COMMISSION

Resource Conservation and Rangeland Development Program (RCRDP) Loans

Program Objective: Soil conservation improvements

Financing Terms:

Type of Program:	Loan
Maximum Amount:	$50,000
Interest Rate:	Max. of 6% annually. Currently 5%
Repayment:	15 years maximum
Loan Security:	Preferably first mortgage real estate. Can accept second mortgage or chattel, if circumstances justify.

Eligibility:

Projects: Permanent practices for:

1. Rangeland Conservation
2. Cropland Conservation
3. Pasture & Hayland Conservation
4. Woodland Conservation
5. Riparian Protection
6. Improving Water Quality

Land: Private and public land within the State of Idaho.

Other Information: Refinancing debt incurred for projects previously completed is not an eligible purpose.

How to Apply: Obtain form and file with local Soil Conservation District office.

IDAHO DEPARTMENT OF HEALTH & WELFARE
DIVISION OF ENVIRONMENTAL QUALITY

State Agricultural Water Quality Program (SAWQP)

Program Objective: Control and abatement of water pollution from agricultural lands.

Financing Terms:

Type of program:	Cost sharing
Maximum amount:	$50,000
Cost share:	75% of the total project costs, including BMP installation, technical assistance, project administration, education & information
Contract length:	5-10 years
Match requirement:	25% local match required

Eligibility:

Soil Conservation Districts which have priority stream segments in the Idaho Agricultural Pollution Abatement Plan within their boundaries apply for planning grants to study the stream and its surrounding watershed. If granted a planning project, the District coordinates an interagency, interdisciplinary planning effort to study the resource concerns and their relation to the water quality impacts in the watershed. Planning studies normally last from one to three years. If the study indicates significant water quality problems and includes a viable treatment alternative, the District may apply for funding from SAWQP to implement the plan and treat critical watershed areas. Critical areas are those areas or sources of agricultural pollution identified by the District as having the most significant impact on the quality of the receiving waters in the project area.

If selected for funding, the District signs a grant agreement with the Idaho Department of Health and Welfare to implement the plan, and thereby becomes the sponsor of the project.

Operators of critical agricultural lands within the project boundaries contract with the sponsoring District to apply agricultural water quality BMPs.

Practices: Cost-sharing is available for Best Management Practices (BMPS). BMPs are systems which have been determined to be the most effective, practicable means of preventing or reducing the amount of pollution generated by nonpoint sources. These BMPs include Irrigated and Non-irrigated Cropland, Grazing Land, Riparian/Wetland, and Animal Waste Management. BMPs are made up of component practices such as conservation tillage, filter strips, pasture and hayland planting, and planned grazing systems. BMPs and component practices used in SAWQP contracts are listed in the Idaho Agricultural Pollution Abatement Plan.

USDA AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE

Agricultural Conservation Program

Program Objective: Prevent soil erosion and water pollution, protect and improve productive farm and ranch land, conserve water used for agriculture, preserve and develop wildlife habitat, and encourage energy conservation measures.

Financing Terms:

Type of Program:	Cost-sharing
Maximum Amount:	$3,500 (lump sum payments in excess of $3500 may be authorized for long-term agreement under certain conditions)
Cost Share:	Up to 75% of the cost to install practices under annual agreements or up to 80% for certain low-income producers. Producers must agree to maintain practices for a specified number of years. Those who fail to do so are required to refund all or part of the Federal funds provided for installation of the practice.

Eligibility:

Practices: Establishment or improvement of permanent vegetative cover, contour or strip cropping systems; development of springs, seeps and wells; installation of pipelines, storage facilities, and other measures intended to provide erosion control on range or pastureland; installation of water impoundment reservoirs for erosion control, conservation, and environmental and wildlife enhancement; planting trees and shrubs and improving timber stands for protection against wind and water erosion and to protect trees for timber production; and development of new or rehabilitation of existing shallow water areas to support food, habitat and cover for wildlife.
For other practices that are or may be eligible for cost-sharing assistance, contact the local county ASCS office.

Applicants: All farmers and ranchers. Farmers and ranchers may enter into pooling agreements to cooperatively solve mutual conservation problems.

Land: No restrictions as long as other criteria are met.

Criteria: Practices must result in long-term and community-wide benefits, and must be practices that would not, or could not, be expected to be undertaken without financial and technical assistance.

How to Apply: File a request at the county ASCS office for ACP cost-sharing. An ACP practice must be approved before the practice is started.

The county ASC committee notifies the applicant by letter whether the request for cost-sharing has been approved. For long-term agreements, a conservation plan must be developed by an SCS representative and approved by the Soil and Water Conservation District before final approval by the ASC committee.

After the practice is completed, the farmer certifies to the county ASCS office that all specifications, technical standards, and any state and local regulations have been met. The farmer provides evidence of the total cost of establishing the approved practices and is then reimbursed for the goverment's share of the cost.

IDAHO DEPARTMENT OF LANDS
SOIL CONSERVATION COMMISSION

Resource Conservation and Rangeland Development Program (RCRSP) Grants

Program Objective: Improvement of rangeland and riparian areas

Financing Terms:

Type of Program:	Grant
Maximum Amount:	$10,000
Grant Match:	Must equal or exceed the grant and may include dollars, materials, labor and use of equipment and machinery.

Eligibility:

Projects: Demonstration projects for improving rangeland and riparian areas. Grants will not be approved to pay for practices and /or systems that have been applied prior to Soil Conservation Commission approval and execution of grant agreement.

Applicants: Any individual, partnership, association, trust, private corporation, or any other private legal entity which is recognized by law as the subject of rights and duties.

Land: Public and private land within the state of Idaho.

How to Apply: Obtain application form and file with the local Soil Conservation District office.

USDA SOIL CONSERVATION SERVICE

Small Watershed and Flood Prevention Program

Program Objective: To protect small watersheds by providing for a project-type approach to solving and treating land, water, and related resource problems.

Eligibility:

Applicants: The program provides for technical and financial assistance by USDA to state and local organizations representing people living in watersheds of 250,000 acres or smaller.

Purposes: Watershed protection; flood prevention; agricultural water management including irrigation and drainage; nonagricultural water management including public recreation, fish and wildlife, municipal and industrial water supply, and water quality management; energy; ground water recharge; and conservation and proper use of land, including control of agriculture-related pollution and disposal of solid waste.

The 14 projects currently in operations were not formulated specifically for water quality improvement, but rather for erosion control and sediment reduction. Future projects will be formulated for the purpose of water quality and address either the impaired or threatened beneficial uses.

Financing Terms: This program is a source for both technical and financial assistance to plan and implement projects for a number of different purposes. It can supply cost-sharing assistance for land treatment type practices as well as for structural measures.

Other Information: The competition for operations funding is nationwide and very competitive. National funding generally has been inadequate to meet the annual demand for eligible projects. Management type practices are not eligible for cost-sharing assistance.

BONNEVILLE POWER ADMINISTRATION (BPA)

WaterWise - Irrigation Conservation Program

Program Objective: To reduce irrigation energy use by conversion to lower pressure and more effficient pumping systems.

BPA plans to incorporate water management into the program in 1993.

Delivery mechanism: Bonneville provides funding through participating utilities for system analysis and design assistance (Stage I) and irrigation incentives for hardware retrofit activities (Stage II).

Stage I: Pump testing and analyses are provided to locate system components which could, through retrofit, produce energy conservation. Design assistance is provided for new and expanding systems.

Stage II: Incentive payments are made for the installation of eligible measures (e.g. low pressure, mainline, and pump modifications). For smaller systems (less than 35 acres) incentives offered are $10 per nameplate pumping plant horsepower and $2 per low-pressure sprinkler. Incentive amounts for larger systems are based on either the energy savings ($ .22 per kWh saved) or a percent of the cost of installing qualifying measures (50% for sprinkler and pumping plant equipment, 75% for mainline equipment). A minimum guarantee of $15 per pumping plant horsepower, is offered.

Once the installation is complete, a pump test is performed to verify the energy conservation acquired.

Eligibility: System must be served by a participating utility, irrigate 15 or more acres of agricultural product or turf and have operated 3 out of the past 5 years. For turf to be eligible, the pumping plant must be used solely for irrigation purposes.

IDAHO POWER COMPANY

1993 Irrigation Conservation Program
Large and Medium Size Irrigation Systems

Program Objective: To reduce demand on Idaho Power System

Financing Terms: Idaho Power will pay the lesser of $200 per horsepower for each calculated horsepower reduced on the existing system up to 50% of the upgrade cost by measure.

The program is divided into two categories:

Large customer program
1340 hp and up in a system

On projects that the kWh savings are the prevalent reason for irrigation system modifications, Idaho Power will pay:

1. An initial rebate based on 7.5 cents per projected first year annual kWh savings - up to 25% of the project cost.
2. Subsequent rebate payments would be made at the end of each year for five years based on the reduction in actual billed energy usage compared with the average actual billed kWh usage of five years prior to implementation of the modifications. (Total annual savings not to exceed 10% of estimated savings).

Medium customer program
40 hp to 1340 hp in a system

On single, multiple pump, or variable speed installations (as recommended by Idaho Power):

1. $30 per hp on a variable speed drive.
2. $20 per total multiple pump hp load.

Eligibility:

Projects: Repair and/or replacement of irrigation system components necessary to achieve projected demand savings. Eligible examples may be: conversion of sprinkler systems to low pressure, pump efficiency improvements, repair of leaking or undersized mainline, installation of drop tubes, replacement of worn nozzles, or conversion to gravity pressurized systems.

Applicants: Irrigators with at least 40 hp and larger irrigation systems in Idaho Power's service area that are on Idaho Power's irrigation rate.

Other Program Requirements:

Large: Engineering firm or consultant of customer's choice must provide report showing energy savings potential by upgrading costomer's system.

Medium: Requires system audit and report showing energy savings potential by upgrading customer's system.

How to apply: Contact Idaho Power office in Boise.