United States Department of Agriculture

Natural Resources Conservation Service

National Engineering Handbook

Irrigation Guide

Issued September 1997

Preface

Irrigation is vital to produce acceptable quality and yield of crops on arid climate croplands. Supplemental irrigation is also vital to produce acceptable quality and yield of crops on croplands in semi-arid and subhumid climates during seasonal droughty periods. The complete management of irrigation water by the user is a necessary activity in our existence as a society. Competition for a limited water supply for other uses by the public require the irrigation water user to provide much closer control than ever before. The importance of irrigated crops is extremely vital to the public's subsistence.

Today's management of irrigation water requires using the best information and techniques that current technology can provide in the planning, design, evaluation, and management of irrigation systems. Support for many of the values included in this chapter come from field research, established design processes, and many system designs and evaluations over many years. Field evaluations must always be used to further refine the planning, design, evaluation, and management process. This design guide in the Natural Resources Conservation Service (NRCS), National Engineering Handbook series provides that current technology.

Irrigation Guide, Part 652, is a guide. It describes the basics and process for planning, designing, evaluating, and managing irrigation systems. It provides the process for states to supplement the guide with local soils, crops, and irrigation water requirement information needed to plan, design, evaluate, and manage irrigation systems.

Irrigation Guide, Part 652, is a new handbook to the family of references in the NRCS, National Engineering Handbook series. It is written for NRCS employees who provide technical assistance to the water user with concerns for both water quantity and quality. Other technical personnel for Federal, State, private, and local agencies will also find the guide useful as a basic reference when providing technical assistance relating to planning, designing, evaluating, and managing irrigation systems. College and university instructors will also find the guide useful as a classroom reference.

In addition to the irrigation Guide (part 652), chapters in the National Engineering Handbook irrigation section (now part 623) describe:

- Soil-plant relationships and soil water properties that affect movement, retention, and release of water in soil
- Irrigation water requirements
- Planning farm irrigation systems
- Measurement of irrigation water
- Design of pumping plants
- Design criteria and design procedures for surface, sprinkler, and micro irrigation methods and the variety of systems for each method that can be adaptable to meet local crop, water, and site conditions and irrigation concerns

Acknowledgments

Part 652, Irrigation Guide, is an addition to the National Engineering Handbook series. The document was initially prepared by **Elwin A. Ross**, irrigation engineer, NRCS, Engineering Division, Washington, DC, (retired) with primary input and review from **Leland A. Hardy**, irrigation engineer, Midwest National Technical Center, NRCS, Lincoln, Nebraska, (retired).

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State conservation engineers coordinated a multidiscipline (representing soils, agronomy, water quality, and water management) review in all states.

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Irrigation Guide

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Chapter 15 Resource Planning and Evaluation Tools and Worksheets

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Chapter 15 Resource Planning and Evaluation Tools and Worksheets

652.1500 General

Chapter 15 lists and describes resource planning and evaluation tools and worksheets commonly used by the Natural Resources Conservation Service (NRCS). These tools and worksheets can assist the irrigation planner in:

- Addressing irrigation related environmental concerns relating to soil, water, air, plants, and animals.
- Providing technical assistance to the farmer and irrigation decisionmaker in irrigation system— planning, design, cost analysis, evaluation, and management.
- Providing technical assistance for evaluating and planning river basin, watershed, and project activities.

652.1501 Water quality, water management, and irrigation evaluation tools

Computer software programs and models include:

NRCS (SCS) Scheduler—NRCS Scheduler is a computer assisted method to predict up to 10 days ahead when irrigation will be needed. Predictions are based on daily climatic data from a weather station and calculated plant water use. Periodic calibration to actual soil moisture is used to maintain accuracy. Developed by Michigan State University with support from NRCS.

FIRI—Farm Irrigation Rating Index is used to evaluate effects of existing irrigation systems and management, and to evaluate changes. Changes can be improvements or reversals in management techniques and system condition. Developed by NRCS West National Technical Center.

SIDESIGN—Subsurface Irrigation Design program involves an analysis of providing water table control for irrigation through buried conduits. Developed by Michigan State University with support from NRCS.

NLEAP—Nitrate Leaching and Economic Analysis Package. The model provides site specific estimates of nitrate leaching potential under agricultural crops and impacts on associated aquifers. Irrigations are included as precipitation events. This model is generally used as a planning tool. Developed by the Agricultural Research Service (ARS), Water Management Research Laboratory, Fort Collins, Colorado.

CREAMS—A field scale model for Chemical, Runoff, and Erosion from Agricultural Management Systems. This mathematical model evaluates nonpoint source pollution from field-size areas. Developed by ARS laboratories in Chickasha, OK, West Lafayette, IN, and Athens, Georgia.

GLEAMS—Groundwater Loading Effects of Agricultural Management Systems. GLEAMS uses CREAMS technology to evaluate surface chemical response, hydrology, and erosion. It provides a water budget of precipitation, crop evapotranspiration, runoff, deep percolation, soil moisture, and irrigation applications. Crop evapotranspiration is checked and adjusted for localized conditions. Developed by University of Georgia in cooperation with ARS, Southeast Watershed Laboratory, Tifton, Georgia.

WEPP—Water Erosion Prediction Program is proposed to provide an analysis of precipitation and irrigation related erosion and sediment deposition. When complete, WEPP will include furrow and border surface irrigation and periodic move, fixed, and continuous move sprinkle irrigation systems. The FUSED, RUSLE, and SPER programs are available for field use until WEPP is validated and available. Being developed by ARS, National Erosion Laboratory, (Purdue University), West Lafayette, Indiana; and (University of Nebraska), Lincoln, Nebraska.

SWRRB—This basin scale water quality model process considers surface runoff, return flow percolation, evapotranspiration, transmission losses, pond storage, sedimentation, and crop growth. Crop evapotranspiration must be checked and may need to be localized. Developed by ARS, Temple, Texas.

EPIC—Process considers climate factors, hydrology, soil temperature, erosion, sedimentation, nutrient cycling, tillage, management, crop growth, pesticide and nutrient movement with water and sediment, and field scale costs and returns. Crop evapotranspiration is checked and adjusted for local conditions. Developed by ARS, Temple, Texas.

DRAINMOD—An evaluation tool for analysis of water table control for subsurface drainage systems. Included is an estimated value for upward water movement (upflux) based upon specific soil series. Developed by North Carolina State University with support from NRCS.

Instream Water Temperature Model—The model provides a process to predict instream water temperature based on either historical or synthetic hydrological, meteorological parameters, streamside vegetation, and stream channel geometry.

652.1502 Irrigation system selection, design, costs, and evaluation tools

Many programs are available from commercial sources and Universities. Most need to be purchased, but some are available as *cooperative agency programs*. A few require site licenses to use multiple program copies at several locations at one time. Several irrigation programs are available from ARS, universities, and the U.S. Bureau of Reclamation. Some of the more common programs available include:

- REF-ET—Reference crop Evapotranspiration model, from Utah State University.
- SIRMOD—Surface Irrigation Model includes surge and conventional analysis for furrow irrigation, from Utah State University.
- CPNOZZLE—Center Pivot Nozzling and surface storage program, from University of Nebraska.
- SPACE—Sprinkler Profile And Coverage Evaluation program evaluates all sprinkler heads manufactured and currently available, from California Agricultural Technology Institute, California State University.
- SRFR—Surface irrigation simulation program uses zero inertia and kinematic wave relationships to model surface irrigation, from ARS, Phoenix, Arizona.
- AGWATER—Surface irrigation system (furrow, border) model using measured advance time and field specific information for management improvements (inflow, time of set, length of run), from California Polytechnic State University.
- PUMP—Centrifugal pump selection program, from Cornell Pump Company, Portland, Oregon.
- CATCH3D—Sprinkler pattern overlap evaluation and 3D plot program, from Utah State University.
- Water Management Utilities, Interactive Simulation of One-Dimensional Water Movement in Soils, IRRIGATE—An irrigation decision aid, potential evapotranspiration, citrus irrigation scheduling.
- CMLS—Chemical Movement in Layered Soils, from University of Florida.
- Flowmaster—Open channel flow and pressure pipeline design program, from Haestad Methods, Inc., Waterbury, Connecticut.
- KYPIPE2—Pipe network flow analysis program, from Haestad Methods, Inc., Waterbury, Connecticut.

652.1503 Irrigation system planning, design, and evaluation worksheets

Example evaluations and blank worksheets are included at the back of this chapter. They may be copied and used as needed. They include:

Irrigation Planning
- Irrigation Planning
- Irrigation System Inventory

Irrigation System Design
- Sprinkler Irrigation System Planning/Design

Irrigation System Evaluation
- Walk Through Sprinkler Irrigation System Analysis
- Sprinkler Irrigation Systems Evaluation
  - Periodic Move Sprinkler—Side Wheel-roll, Lateral Tow, Hand Move and Fixed (Solid) Set Systems
  - Continuous/Self Move Sprinkler—Pivot System
- Pumping Plant Evaluation
  - Electric Motor Powered
  - Natural Gas Engine Powered
- Micro Irrigation Systems Evaluation
- Surface Irrigation Systems Evaluation
  - Graded Borders
  - Basins, Level Border
  - Graded Furrows
  - Level furrows

Irrigation Water Management
- Irrigation Water Management Plan
- Soil Moisture—Feel and Appearance Method, Speedy Moisture Meter and Eley Volumeter
- Crop and Soil Data for Irrigation Water Management
- Checkbook Method of Irrigation Scheduling
- Pan Evaporation Method of Irrigation Scheduling

652.1504 Blank worksheets

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Natural Resources Conservation Service

Irrigation Planning Worksheet

OWNER/OPERATOR ______________________________ FIELD OFFICE ______________________________

JOB DESCRIPTION ____

LOCATION ____

ASSISTED BY ______________________________ DATE ______________________________

Soil—Data for limiting soil

Soil series	Percent of area (%)	Cumulative AWC					Depth to restrictive layer [1]	Intake fam., grp. max. rate
		1 ft (in)	2 ft (in)	3 ft (in)	4 ft (in)	5 ft (in)		

[1] Actual observed depth in the field

Maximum time between irrigations for any method/system based on peak crop ET

Crop	Management root zone (ft)	Total AWC (in)	MAD percent (in)	Maximum net replacement		Peak daily crop ET (in/d)	Maximum irrigation frequency (days)
				(in/d)	(days)		

Minimum system flow requirement for irrigation system

System description	Depth of irrigation application			Peak daily crop ET (in/d)	Max. irrig. frequency (days)	Minimum system flow requirement total flow	
	Net (F_n) (in)	Efficiency (%)	Gross (F_g) (in)			(gpm)	(ft^3/s)

Minimum dependable flow available to system ________________ gpm, ft^3/s, inches, etc.

Total irrigated area ____________ acres. Total operating hours per day ____________ .

Irrigation Planning Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Weighted monthly crop evapotranspiration

The following process is used where more than one one crop is grown under the same irrigation system; i.e., several fields, farm group, district.

Crop	Acres (ac)	Monthly crop evapotranspiration - ET_c							
		Depth[1] (in)	Volume [2] (ac-in)	Depth[1] (in)	Volume [2] (ac-in)	Depth[1] (in)	Volume [2] (ac-in)	Depth[1] (in)	Volume [2] (ac-in)
Total									
Weighted average crop ET[3]									

Computed peak daily crop evapotranspiration [4]

Net irrigation depth applied (f_n) (in)	Highest weighted monthly average crop ET (in)	Peak period average daily crop ET (in)

[1] Calculated monthly crop ET, inches.

[2] Calculated volume of water needed monthly crop ET = ac x ET_c = ________________ acre-inches.

[3] Calculated weighted monthly crop ET = Total Volume/ Total Area = _____________ inches.

[4] Determined from table 2-55, Part 623, Chapter 2, Irrigation Water Requirements, or from formula:

$ET_d = 0.034\ ET_m^{1.09}\ F_n^{-0.09}$, Where: ET_d = average daily peak crop ET

ET_m = average crop ET for peak month

F_n = net depth of water application per irrigation

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Irrigation System Inventory Worksheet

OWNER/OPERATOR ____________________ FIELD OFFICE ____________________

JOB DESCRIPTION ____

LOCATION ____

ASSISTED BY ____________________ DATE ____________________

(Collect and fill out only portions of this form that apply and are needed)

Area irrigated ______________ acres

Crops

Crops now grown				
Typical planting date				
Typical harvest date				
Typical yield (unit)	( )	( )	( )	( )
Age of planting				
Cultivation and other cultural practices				

Water

Water source(s)				
irrigation organization				
Water available (ft^3/sec, gpm, miners inches, mg/da)				
Seasonal total water available (ac-ft, million gal)				
Water availability	continuous	demand	rotation	fixed schedule
Typical water availability times (schedule and ordering procedure)				
Method of determining when and how much to irrigate:				
Is flow measuring device maintained and used?				
Method of measuring water flow rate				
Water quality: Sediment		Debris, moss		
Electrical conductivity mmhos/cm		SAR		
Comments				

Example Irrigation System Inventory Worksheet—*Continued*

NAME ____________________ DATE ____________ PREPARED BY ____________________

Soils (principal soil in field)

Soil # 1

Map symbol	Soil series & surface texture			
Percentage of field (%)	Area (acres)			
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer [1]				
Intake family/intake group/max application rate				
Comments				

Soil # 2

Map symbol	Soil series & surface texture			
Percentage of field (%)	Area (acres)			
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer [1]				
Intake family/intake group/max application rate				
Comments				

Soil # 3

Map symbol	Soil series & surface texture			
Percentage of field (%)	Area (acres)			
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer [1]				
Intake family/intake group/max application rate				
Comments				

[1] If restrictive for root development or water movement

Irrigation System Inventory Worksheet—*Continued*

NAME ____________________ DATE ______________ PREPARED BY ____________________

Water supply and distribution system

Supply system to field (earth ditch, lined ditch, plastic pipeline, etc.):

Type		
Size		
Capacity (ft^3/sec, gpm, miners inches, mgal/day)		
Pressure/Elevation at head of field or turnout	(lb/in^2)	(ft)
System condition		
Estimated conveyance efficiency of supply system (%)		

In-field distribution system (earth or lined ditch, buried pipe, surface portable pipe, lay flat tubing):

Type
Size
Capacity
Total available static head (gravity) (ft)
System condition
Estimated effIciency of delivery system (%)
Comments

Water application system

Existing sprinkler system (attach design and/or system evaluation. if available):

Type system (center pivot, sidewheel-roll, hand move, traveler, big gun)			
Manufacturer name and model			
Tower spacing (pivot or linear) (ft)		End gun (pivot)?	
Wheel size (sidewheel-roll) diameter			
Type of drive			
Pressure at lateral entrance (first head) (lb/in^2)			
Mainline diameter/length			
Lateral diameter/length			
Lateral spacing (S_1)		Sprinkler head spacing (S_m)	
Sprinkler make/model			
Nozzle size(s)	by	type	
Design nozzle pressure	(lb/in^2)	Wetted diameter (ft)	
(Attach sprinkler head data for pivot)			
Maximum elevation difference:	Along lateral		
	Between sets		
Application efficiency low 1/4 (E_q) (%)		(Estimated or attach evaluation)	
Wind - Prevailing direction and velocity			
Comments			

Irrigation System Inventory Worksheet—*Continued*

NAME ____________ DATE ____________ PREPARED BY ____________

Existing surface system (attach system evaluation if available)

Type of system (graded border, level border, graded furrow, level furrow, contour levee, contour ditch, wild flooding)				
Leveled fields: Field slope: In direction of irrigation ft/ft				
Cross slope ft/ft				
Smoothness: ☐ Rough ☐ Smooth ☐ Very smooth		Laser equipment used ☐ yes ☐ no		
Border or levee width ft	Furrow/corrugation/rill spacing in			
Length of run:	Minimum ft	Maximum ft	Average ft	
Number of furrows or borders per set				
Border or levee dike heights				
Application efficiency, low 1/4 (E_q) % (Estimated or attach evaluation)				
General maintenance of system				

Drainage, tail water reuse facilitv

Method for collection and disposal of field runoff (tailwater, precipitation)
Final destination of runoff water
Surface/subsurface drainage system
Environmental impacts of existing drainage system

Existing micro irrigation system (Attach design or system evaluation if available)

Type of system: Drip emitters	Mini spray/sprinklers	Line source
Spacing between discharge devices along distribution laterals (ft, in)		
Laterals - diameter, length		
Main lines and submains - diameter, length, etc.		
Spacing between distribution laterals (ft, in)		
Average application device discharge pressure (lbs/in^2)		
Are pressure compensating devices required?	☐ yes	☐ no
Are pressure compensating devices used?	☐ yes	☐ no
Average application device discharge (gph, gpm)		
Area irrigated by one irrigation set (acres)		
Typical irrigation set time (hr, min)		
Maximum elevation difference with one irrigation set (ft)		
Type and number of filters used		
Irrigation is initiated by: ☐ manual control ☐ programmed timer ☐ clock timer ☐ soil moisture sensing device		
Comments:		

Irrigation System Inventory Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Existing subsurface irrigation system

Water table control type and number of system or segments
Water table control devices ☐ flashboard ☐ float
Buried laterals ☐ diameter ☐ spacing ☐ depths
Water table elevation(s): Existing Planned

Month	Elevation	Depth below surface

Pumping plant
Pump

(Attach pump characteristic curves and/or pump system analysis if available)		
Pump elevation above mean sea level (approx) (ft)		
Pump type: ☐ centrifulgal ☐ turbine ☐ submersible ☐ Propeller ☐ axial flow		
Make	Model	
Electric motor RPM	Engine operating RPM	
Pump design discharge gpm @	ft or lb/in^2	
Impeller size	Impeller diameter	Number of impellers
Pressure at outlet of pump or inlet to pipeline lb/in^2	date	
Discharge gpm	How measured	date
Valves, fittings		

Power unit

Rated HP at RPM

Gear or belt drive mechanism

Type (direct, gear, belt)	
RPM at driver	RPM at pump
Energy (A pump evaluation is required to get this data)	
Energy input (from evaluation) (KW) (gal/hr) (mcf)	
Pumping plant efficiency (from evaluation) (%)	
Energy cost per acre foot (from evaluation)	
General condition of equipment, problems	

Irrigation System Inventory Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Irrigation management

Irrigation scheduling method(s)
Typical number of irrigations per season
Typical time between irrigations
Set times or time per revolution
Method of determining soil moisture
Typical water application per (set, revolution, pass)
Source, availability and skill of irrigation labor

Comments about management of the existing system and reasons for improvement. What are the objectives of the irrigation decisionmaker?

What management level is planned?

Other observations and comments

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Sprinkler Irrigation System Planning/Design Worksheet

NAME ______________________ DATE ______________ PREPARED BY ______________________

DISTRICT ______________________ COUNTY ______________________ ENGR JOB CLASS __________

Inventory

Water source __________ Amount available __________ ft^3/sec __________ gpm __________ acre-ft Seasonal variation ______________

Power source: Electric __________ volts, __________ phase; Internal combustion engine __________ fuel type; Other ______________

Soils Data

Design Soil Series	Available water capacity, AWC (in/ft depth)					Depth to [1]		Sprinkler intake rate (in/hr)
	0-1	1-2	2-3	3-4	4-5	Inhibiting layer (ft)	Water table (ft)	

[1] Actual observed depth in the field.

Crop Evapotranspiration (Monthly)

Crops	Acres	Month		Month		Month	
		Depth (in)	Volume (ac-in)	Depth (in)	Volume (ac-in)	Depth (in)	Volume (ac-in)
Totals (1)		(2)		(3)		(4)	

Crop Weighted Evaportranspiration (Monthly) (Note: Maximum Monthly Total ET is greatest of nos. 2, 3, or 4 above)

ET, depth = $\frac{\text{Maximum Total Monthly ET, ac-in/mo}}{\text{Total Acres, A (1)}}$ = ______________ = ______________ in /mo

Irrigation Requirements

Crops	Root zone depth [2] (ft)	Total AWC (in)	Management allowed depletion (%)	Max Net replacement (in)	Peak daily ET (in)	Max freq @ peak E T @ max net (days)

[2] Use weighted peak monthly ET and net irrigation to determine weighted peak daily E T.

Sprinkler Irrigation System Planning/Design Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Design Data — (Based on weighted crop ET, ________ % irrigation efficiency)

	Application		Weighted [2] peak daily crop ET (in)	Frequency, F (days)	System requirements	
	Net, D (in)	Gross F_g (in)			Total gpm, Q	gpm/ac

[2] Use weighted peak monthly ET and net irrigation to determine weighted peak daily E T.

$$Q = \frac{453\ A\ D}{F\ H\ \ Eff/100} = \_\_\_\_\_\_\_\_\_\_\ gpm = \_\_\_\_\_\_\_\_\_\_\ gpm$$

Q = system requirements–gpm
H = Total operating hours/day
(suggest using 23 hours for one move per day)
(suggest using 22 hours for two moves per day)

Sprinkler head spacing, (S_L) ____________ ft, Lateral spacing on mainline (S_M) ____________ ft, Minimum Required wetted diameter = __________ft

Sprinkler head: make __________; model __________; nozzle size _________; lb/in^2 ________ gpm _________; wetted dia ____________ ft

Application rate _______ in/hr, Application time _________ hr/set. Net application = (_______ in/hr) (_______ eff) (_______ hr/set) = ________ in

Maximum irrigation cycle = Net applcation ________ in/peak ET in/d = ________ days

Minimum number of laterals = $\dfrac{\text{number of lateral sites \_\_\_\_\_\_\_\_}}{\text{(irrigation frequency, \_\_\_\_\_\_\_ days) (moves/day, \_\_\_\_\_\_\_\_\_)}}$

Designed laterals: Number ____________, Diameter __________ in, Type ____________ , Moves/day __________

Total number of sprinkler heads = (number of laterals) (number of heads/lateral) = __________

System capacity = (Total number of sprinkler heads _________) (gpm/head ____________) = ____________ gpm

Lateral design

Allowable pressure difference along lateral = 0.2 (sprinkler head operating pressure in lb/in^2) = _______________ lb/in^2

Actual head loss (worst condition) __________ lb/in^2

Pressure required at mainline: P = (sprinkler head lb/in^2 _________) + (0.75) (Lateral friction lb/in^2 ________) +/- (ft elev) / (2) (2.31) = ________ lb/in^2

(plus for uphill flow in lateral, minus for downhill flow). Use sprinkler head lb/in^2 only if elevation difference along lateral is = or > 0.75 (lateral friction loss lb/in^2)

(2.31). Under this condition, flow regulation may be required at some sprinkler heads to maintain proper sprinkler head operating near the mainline.

Sprinkler Irrigation System Planning/Design Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Mainline Design

Mainline material ________________ (IPS, PIP, SDR, CLASS) lb/in^2 rating ______________, other description, ____________

Friction factor used ________. Formula (check one) ☐ Hazen-Williams ☐ Manning's ☐ Darcy-Weibach ☐ Other (name) ______________

Station		Diameter pipe (in)	Flow (gpm)	Velocity (fps)	Distance (ft)	Friction loss (ft/100 ft)	Friction loss this section (ft)	Accumulated friction loss (ft)	Remarks
From	To								

NOTE: desirable velocities–5 ft/sec or less in mainlines, 7 ft/sec or less in sprinkler laterals.

Determination of Total Dynamic Head (TDH)

Pressure required at main ____________ lb/in^2 ____________ft

Friction loss in main ____________ lb/in^2 ____________ft

Elevation raise/fall in main ____________ lb/in^2 ____________ft (2.31 feet = 1 psi pressure)

Lift (water surface to pump) ____________ lb/in^2 ____________ft

Column friction loss ____________ lb/in^2 ____________ft

Miscellaneous loss ____________ lb/in^2 ____________ft

Total (TDH) ____________ lb/in^2 ____________ft (NOTE; TDH must be in feet for horsepower equation)

$$\text{Approximate brake horsepower} = \frac{\text{TDH (ft) X Q (gpm)}}{\text{3960 X Eff / 100}} = \frac{\text{\_\_\_\_\_\_\_\_ ft X \_\_\_\_\_\_\_\_ gpm}}{\text{3960 X \_\_\_\_\_\_\_\_ \% / 100}} = \text{\_\_\_\_\_\_\_\_ HP}$$

Mean sea level elevation of pump ____________ ft (NOTE: check required versus available NPSL for centrifugal pumps)

Pump curve data attached yes ☐ no ☐, If not, pumping plant efficiency assumed = ________% (recommended using 65-75%)

Bill of materials attached yes ☐ no ☐

Sprinkler Irrigation System Planning/Design Worksheet—*Continued*

NAME ______________ DATE ______________ PREPARED BY ______________

Other Design Considerations

Item	Evaluation performed	NOT needed	Location	Size
Measuring device				
Expansion couplers				
Reducers				
Enlargers (expanders)				
Manifolds				
Bends & elbows				
Tees				
Valved outlets				
Surge facilities (valves, chambers)				
Control valves				
Check non-return flow valves				
Pressure relief valves				
Air-vacuum valves				
Drain facilities				
Thrust blocks				
Anchors				
Pipe supports				
Other				

Remarks ______________

Special drawing(s) attached ______________

Irrigation system design by ______________ Date ______________

Reviewed and approved by ______________ Date ______________

Sprinkler Irrigation System Planning/Design Worksheet—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Irrigation System Location and Layout Map

SHOW:
- ☐ Area irrigated with sprinklers
- ☐ Direction of prevailing wind
- ☐ Elevations, contours
- ☐ High and low points
- ☐ Water source and pump location
- ☐ Mainline and submain locations
- ☐ Layout: lateral(s), travelers, guns
- ☐ Direction of move
- ☐ North arrow

Scale	Community	Section	Township	Range

U.S. Department of Agriculture
Natural Resources Conservation Service

Irrigation Water Management Plan—Sprinkler Irrigation System

NAME ____________________ DATE ____________ PREPARED BY ____________________

DISTRICT ____________________ COUNTY ____________________ ENGR JOB CLASS __________

Crop information

Field number(s)					
Crop irrigated					
Acres Irrigated (acres)					
Normal rooting depth (feet, inches)					
Management allowable depletion (MAD) (percent, inches)					
Peak daily crop requirements (ac-in/day)					
Average annual net irrigation requirements (ac-in/ year)					

Soil Information

Soils series and surface texture			
Capability class			
Allowable soil loss (T=tons per-acre per year)			
Wind Erodibility Group (WEG)			
Actual on-site (observed and measured) average root zone depth			
Total available water capacity (AWC) of soil plant root zone			
Soil intake (Maximum application rate for sprinkler system)			
Available water capacity (AWC) for crop rooting depth:	Depth	AWC	
	(inches)	(inch/inch)	(total inches)

Irrigation system management information

Irrigation system
Source of water
Delivery schedule
Estimated overall irrigation efficiency
Management allowable depletion for pasture
Irrigation set time to apply full irrigation and replace full MAD
Gross application
Net application
Actual gross sprinkler application rate
Irrigation system flow capacity requirement for full time irrigation, Q (gpm)

Irrigation Water Management Plan— Sprinkler Irrigation System—*Continued*

NAME ______________________ DATE ______________ PREPARED BY ______________________

Irrigation scheduling Information

Month	Monthly net[1] irrigation requirement (inches)	Crop evapo-transpiration use rate (in/day)	Irrigation frequency needed (days)	Average[2] number of Irrigations needed
April				
May				
June				
July				
August				
September				
October				
Total				

1 Net irrigation requirement (NIR) represents crop evapotranspiration less effective rainfall.

2 Assuming a full soil profile at start of season. Check soil moisture before irrigating. Account for rainfall that can replace soil moisture depletion. If soil moisture depletion is less than 50% wait for a few days and check it again.

Warmer than “average” months will typically require additional irrigation water; cooler than “average months will typically require less irrigation water; months with more than “average” effective rainfall will typically require less irrigation water.

Only operate the system when needed to furnish water for crop needs. The preceding irrigation schedule can be used as a guide to determine when to irrigate. It is a guide only for average month and year conditions. Optimizing use of rainfall to reduce unnecessary irrigations during the growing season is a good management practice. In semi-humid and humid areas, it is recommended to not replace 100 percent of the soil moisture depletion each irrigation. Leave room in the plant root zone for containing water infiltration from rainfall events. This will vary with location, frequency, and amount of rainfall occurring during the growing season. It should be approximately 0.5 to 1.0 inches.

Maintaining to a higher soil moisture level (MAD) typically does not require more irrigation water for the season, just more frequent smaller irrigations. This is especially true with crops such as root vegetables, potatoes, onions, garlic, mint, and sweet corn.

The attached chart for evaluating soil moisture by the feel and appearance method can be used to help determine when to irrigate. Other common methods to monitor crop water use and soil moisture include: plant signs (crop critical moisture stress periods), atmometer, evaporation pan (applying appropriate factors), tensiometers, electrical resistance blocks (moisture blocks), and crop water stress index (CWSI gm).

NRCS (SCS) - SCHEDULER computer software is available to provide calculations of daily crop evapotranspiration when used with local daily weather station values. On-site rainfall data is necessary to determine effective rainfall, whereas local weather station rainfall data is not sufficiently accurate due to spatial variability. Current rainfall and soil moisture data can be input manually or electronically to assist in predicting when irrigation is needed.

Irrigation Water Management Plan—Sprinkler Irrigation System—Continued

NAME ____________________________ DATE ________________PREPARED BY _________________________

A properly operated, maintained, and managed sprinkle irrigation system is an asset to your farm. Your system was designed and installed to apply irrigation water to meet the needs of the crop without causing erosion, runoff, and losses to deep percolation. The estimated life span of your system is 15 years. The life of the system can be assured and usually increased by developing and carrying out a good operation and maintenance program.

Pollution hazards to ground and surface water can be minimized when good irrigation water management practices are followed. Losses of irrigation water to deep percolation and runoff should be minimized. Deep percolation and runoff from irrigation can carry nutrients and pesticides into ground and surface water. Avoiding spills from agricultural chemicals, fuels, and lubricants. will also minimize potential pollution hazards to ground and surface water.

Leaching for salinity control may be required if electrical conductivity of the irrigation water or soil water exceeds plant tolerance for your yield and quality objectives. If this condition exists on your field(s), a salinity management plan should be developed.

The following are system design information and recommendations to help you develop an operation and maintenance plan (see irrigation system map for layout):

- average operating pressure =_______ lb/in^2 (use a pressure gage to check operating pressure)
- nozzle size = __________ inch (use shank end of high speed drill bit to check nozzle wear)
- average sprinkler head discharge ________ gpm
- sprinkler head rotation speed should be 1 - 2 revolutions per minute
- sprinkler head spacing on lateral = __________ ft; outlet valve spacing on main line _______ft
- lateral, number(s) ________, _________ ft, _______ inch diameter ____________________
- main line = _______________ ft _______ inch diameter, type ________, class_____________________
- pump = ________________, ____________ gpm @ _______________ ft Total Dynamic Head (TDH)

Make sure that all measuring devices, valves, sprinkler heads, surface pipeline, and other mechanical parts of the system are checked periodically and worn or damaged parts are replaced as needed. Always replace a worn or improperly functioning nozzle with design size and type. Sprinkler heads operate efficiently and provide uniform application when they are plumb, in good operating condition, and operate at planned pressure. Maintain all pumps, piping, valves, electrical and mechanical equipment in accordance with manufacturer recommendations. Check and clean screens and filters as necessary to prevent unnecessary hydraulic friction loss and to maintain water flow necessary for efficient pump operation.

Protect pumping plant and all associated electrical and mechanical controls from damage by livestock, rodents, insects, heat, water, lightning, sudden power failure, and sudden water source loss. Provide and maintain good surface drainage to prevent water pounding around pump and electrical equipment. Assure all electrical/gas fittings are secure and safe. Always replace worn or excessively weathered electric cables and wires and gas tubing and fittings when first noticed. Check periodically for undesirable stray currents and leaks. Display appropriate bilingual operating instructions and warning signs as necessary. During non-seasonal use, drain pipelines and valves, secure and protect all movable equipment (i.e. wheel lines).

If you need help developing your operation and maintenance plan, contact your local USDA Natural Resources Conservation Service office for assistance.

U.S. Department of Agriculture
Natural Resources Conservation Service

Soil Water Holding Worksheet

Field ______________________________ Location in field ___________________________________

Year _______________________ By _________________________________

Crop ____

Planting data _______________________________ Emergence data _______________________

Soil name if available ____

____

____

Factor	Season	
	1st 30 days	Remainder of season
Root zone depth or max soil depth - ft		
Available water capacity AWC - in		
Management allowed deficit MAD - %		
Management allowed deficit MAD - in		

(Note: Irrigate prior to the time that SWD is equal to or greater than MAD - in)

Estimated irrigation system application efficiency ___________________ percent

Data obtained during first field check

(1) Depth range (in)	(2) Soil layer thickness (in)	(3) Soil texture	(4) Available water capacity (AWC) (in/in)	(5) AWC in soil layer (in)

Total AWC for root zone depth of ________ ft= ______

Total AWC for root zone depth of ________ ft= ______

Data obtained each check

(6) Field check number	(7) Soil water deficit (SWD) (%)	(8) Soil water deficit (SWD) (in)
1		
2		
3		
4		
5		
6		
7		
8		
1		
2		
3		
4		
5		
6		
7		
8		
1		
2		
3		
4		
5		
6		
7		
8		

SWD summary

Check number	Check date	SWD totals
1		
2		
3		
4		
5		
6		
7		
8		

AWC(5) = layer thickness(2) x AWC(4)

$$SWD(8) = \frac{AWC(5) \times SWD(7)}{100}$$

U.S. Department of Agriculture
Natural Resources Conservation Service

Worksheet
Soil-Water Content
(Gravimetric Method)

Land user________________________________ Date ____________ Field office ________________________________

Taken by ____________________________ Field name/number ____

Soil name (if available) ________________________________ Crop __________________ Maximum effective root depth ________ ft

Depth range inches	Soil layer thickness inches d	Soil texture	Sample			Tare weight g Tw	Net dry weight g Dw	Volume of sample cc Vol	Moisture per-centage % Pd	Bulk density g/cc Dbd	Soil-water content in/in SWC	Layer water content inches TSWC
			Wet weight g WW	Dry weight g DW	Water loss g Ww							

Dry weight (Dw) of soil = DW - TW = ________g

Weight of water lost (Ww) = WW - DW = ________g

Bulk density (Dbd) = $\frac{\text{Dw(g)}}{\text{Vol (cc)}}$ = ________g/cc

Percent water content, dry weight Pd = $\frac{\text{Ww} \times 100}{\text{Dw}}$ = ________%

Soil-water content (SWC) = $\frac{\text{Dbd} \times \text{Pd}}{100 \times 1}$ = ________in/in

Total soil-water content in the layer (TSWC) = SWC x d = ________inches

U.S. Department of Agriculture
Natural Resources Conservation Service

Determination of Soil Moisture and Bulk Density (dry) Using Eley Volumeter and Carbide Moisture Tester

Farm ______________________ Location ______________________ SWCD ______________________

Crop ______________________ Soil type ______________ Date __________ Tested by ______________________

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		Volumeter										
Texture	Thickness of layer	Reading before (cc)	Reading after (cc)	Volume (cc)	% Wet wt.	% Dry wt.	% Wilting point	% Soil-water	Bulk density (g/cc)	Soil-water content (in)	Soil-water content at field capacity	Soil-water deficit (in)
	d			V	W_p	P_d	P_w	SWC_p	Db_d	SWC	AWC	SWD
									Totals			

Wet weight of all samples in grams unless otherwise shown.

$$Db_d = \frac{26}{\frac{V(1 + P_d)}{100}}$$

$$SWC = \frac{Db_d \times SWC_p \times d}{100 \times 1}$$

$$SWC_p = P_d - P_w$$

U.S. Department of Agriculture
Natural Resources Conservation Service

Typical Water Balance Irrigation Scheduling Worksheet

Grower ______________________________ Field ID ______________________ Crop ________________________

Planting date __________________________ Full cover date __________________ Harvest date ___________________

Soil water holding capacity (in/ft) ________; ________; ________; _________ Rooting depth ____________________________

Management allowable depletion ________________________ Minimum soil-water content ___________________________

Date	Daily crop ET (in)	Forecast crop ET (in)	Cum total ET (in)	Rainfall (in)	Irrigation applied (in)	Cumulative total irrigation (in)	Allowable depletion balance (in)	Soil-water content (in)	Predicted irrigation date

Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Land user ______________________ Field office ______________________
Field name/number ______________________
Observer ____________ Date ____________ Checked by ____________ Date ____________ .

Field Data Inventory:
Field area ______________ acres
Border number ______________ as counted from the ______________ side of field
Crop ______________ Root zone depth ______________ ft MAD ______________%
Stage of crop ______________________

Soil-water data for controlling soil:
Station ______________ Moisture determination method ______________________
Soil series name ______________________

Depth	Texture	AWC (in)*	SWD (%)*	SWD (in)*
	Total			

$$\text{MAD, in} = \frac{\text{MAD, \% x total AWC, in}}{100} = \_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_ \text{ in}$$

Comments about soils: ______________________
____

Typical irrigation duration ______________ hr, irrigation frequency ______________ days
Typical number of irrigation's per year ______________
Annual net irrigation requirement, NIR (from irrigation guide) ______________ in
Type of delivery system (gated pipe, turnouts, siphon tubes) ______________________
____

Delivery system size data (pipe size & gate spacing, tube size & length, turnout size) ______________

Border spacing ____________, Strip width ____________, Wetted width ____________, Length ____________

Field Observations:
Evenness of water spread across border ______________________
______________________ .
Crop uniformity ______________________
______________________ .
Other observations ______________________
______________________ .

NOTE: MAD = Management allowed deficit AWC = Available water capacity SWD = Soil water deficit

Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Data: Inflow __________ Outflow ___________

Type of measuring device ____

Clock [1] time	Elapsed time (min)	Δ T (min)	Gage H (ft)	Flow rate (gpm)	Average flow rate (gpm)	Volume [2] (ac-in)	Cum. volume (ac-in)
Turn on							
Turn off							

Total volume (ac-in) __________________

Average flow rate =

$$\frac{\text{Total irrigation volume (ac-in)} \times 60.5}{\text{Inflow time (min)}} = \underline{\qquad\qquad\qquad} = \underline{\qquad}\ ft^3/s$$

Unit flow:

$$q_u = \frac{\text{Average flow rate}}{\text{Border strip spacing}} = \underline{\qquad\qquad\qquad} = \underline{\qquad}\ ft^3/s/ft$$

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. should be recorded as 1330 hours.
2/ Flow rate to volume factors:
Find volume using ft^3/s: Volume (ac-in) = .01653 x time (min) x flow (ft^3/s)

Find volume using gpm: Volume (ac-in) = .00003683 x time (min) x flow (gpm)

Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Graded border advance recession data

	Advance time			Recession time			
Station (ft)	Clock* time	Δ T (min)	Elapsed time (min)	Clock* time	T (min)	Elapsed time 1/ (min)	Opportunity time (T_o)

Use a 24 -hour clock reading; i.e., 1:30 p.m. would be recorded as 1330 hours.

1/ Time since water was turned on.
2/ Inflow time = turn off time - turn on time.

Surface Irrigation System
Evaluation Graded Border Worksheet

Depth infiltrated

		Typical intake curve		Adjusted intake curve	
Station	Opportunity time 1/ T_Q (min)	Depth 2/ infiltrated (in)	Ave. depth infiltrated (in)	Depth 3/ infiltrated (in)	Ave. depth infiltrated (in)
		Sum of ave. depths			

1/ Difference in time between advance and recession curve.
2/ From "typical" cumulative intake curve.
3/ From "adjusted" cumulative intake curve.

Average depth infiltrated (typical)

$$= \frac{\text{Sum of depths (typical)}}{\text{Length (hundreds of feet-extended)}} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{} = \_\_\_\_\_\_\_\_ \text{ in}$$

Extended border area (acres)

$$= \frac{\text{Extended border length x wetted width}}{43{,}560} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{43{,}560} = \_\_\_\_\_\_\_\_ \text{ acres}$$

Actual average depth applied to extended border length

$$= \frac{\text{Ave inflow (ft}^3\text{/s) x duration (hr)}}{\text{Extended border area (acres)}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_ \text{ in}$$

Average depth infiltrated (adjusted)

$$= \frac{\text{Sum of depths (adjusted)}}{\text{Length (hundreds of feet - extended)}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_ \text{ in}$$

Note: Should be close to actual depth applied.

Surface Irrigation System Detailed Evaluation
Graded Border Worksheet

Average depth infiltrated low 1/4 (LQ):

Low 1/4 strip length = $\frac{\text{Actual strip length}}{4}$ = $\frac{\rule{4cm}{0.4pt}}{4}$ = ________________ ft

LQ = $\frac{\text{(Depth infiltrated at begin of L1/4 strip) + (Depth infiltrated at the end of L1/4 strip)}}{2}$

= $\frac{\rule{4cm}{0.4pt}}{2}$ = ______________ in

Areas under depth curve:

1. Whole curve ______________sq in
2. Runoff ______________sq in
3. Deep percolation ______________sq in
4. Low quarter infiltration ______________sq in

Actual border strip area:

= $\frac{\text{(Actual border length, ft) x (Wetted width, ft)}}{43{,}560}$ = $\frac{\rule{4cm}{0.4pt}}{43{,}560}$ = ______________ acres

Distribution uniformity low 1/4 (DU):

DU = $\frac{\text{Low quarter infiltration area x 100}}{\text{(Whole curve area - runoff area)}}$ = ______________________________ = ____________%

Runoff (RO):

RO, % = $\frac{\text{Runoff area x 100}}{\text{Whole curve area}}$ = ______________________________ = ____________ %

RO = $\frac{\text{Total irrigation volume, ac-in x RO, \%}}{\text{Actual strip area, ac x 100}}$ = ______________________________ = ____________ in

Deep percolation, DP:

DP = Deep percolation area x 100 = ______________________________ = ____________ %

DP = $\frac{\text{Total irrigation volume, ac-in x DP, \%}}{\text{Actual strip area, ac x 100}}$ = ______________________________ = ____________ in

Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Evaluation computations, cont:

Gross application, F_g:

$F_g = \frac{\text{Total irrigation volume, ac-in}}{\text{Actual strip area, ac}}$ = ____ = _______________ in

Application efficiency, E_a:

(Average depth stored in root zone = Soil water deficit (SWD) if entire root zone depth will be filled to field capacity by this irrigation, otherwise use F_g, in - RO, in)

$E_a = \frac{\text{Average depth stored in root zone x 100}}{\text{Gross application, in}}$ = _________________________________ = _______________ %

Application efficiency low 1/4, E_q:

$E_q = \frac{\text{DU x } E_a\text{, \%}}{100}$ = $\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{100}$ = ________________ %

Average net application, F_n

$F_n = \frac{\text{Total irrigated volume, ac-in x } E_a\text{, \%}}{\text{Actual strip area, ac x 100}}$ = _________________________________ = ________________ %

Time factors:

Required opportunity time to infiltrate soil water deficit of ______________________ in

T_o = __________________ min (________________ hr - _____________________ min)

Estimated required irrigation inflow time from adv.-recession curves;

T_{in} = _________________ min (________________ hr - _____________________ min)

At inflow rate of:

Q = ______________________ ft^3/s per border strip

Surface Irrigation System Detailed Evaluation
Graded Border Worksheet

Present management:

Estimated present average net application per irrigation ____________________ inches

Present gross applied per year = $\dfrac{\text{Net applied per irrigation} \times \text{number of irrigations} \times 100}{\text{Application efficiency } (E_a)^{1/}}$

= _____________________________________ = _____________ in

1/ Use the best estimate of what the application efficiency of a typical irrigation during the season may be. The application efficiency from irrigation to irrigation can vary depending on the SWD, set times, etc. If the irrigator measures flow during the season, use that information.

Potential management:

Annual net irrigation requirement ________________ inches, for _____________________________ (crop)

Potential application efficiency (E_{pa}) ______________________ percent (from irrigation guide, NEH or other source)

Potential annual gross applied = $\dfrac{\text{Annual net irrigation requirement} \times 100}{\text{Potential application efficiency } (E_{pa})}$

= _____________________________________ = ____________ in

Total annual water conserved

= $\dfrac{\text{(Present gross applied - potential gross applied) x area irrigation (ac)}}{12}$

= $\dfrac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{12}$ = _______________ acre feet

Annual cost savings:

Pumping plant efficiency ________________________ Kind of fuel ________________________________

Cost per unit of fuel ____________________________ Fuel cost per acre foot $ _____________________

Cost savings = Fuel cost per acre foot x acre feet conserved per year

= ________________________________ = $ _______________

Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Potential water and cost savings, cont.

Water purchase cost

= Cost per acre foot x acre feet saved per year = ____________________________

= $ _______________________

Cost savings = pumping cost + water cost = __________________________________ = $ _______________________

Recommendations

____

____

____

____

____

____

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____

____

____

____

____

____

____

____

Profile and Cross Section

Land user ____________________
Date ________________________
Field office ___________________

Cross Section at sta. __________

Distance - feet

Profile

Distance (stations) - feet x 100

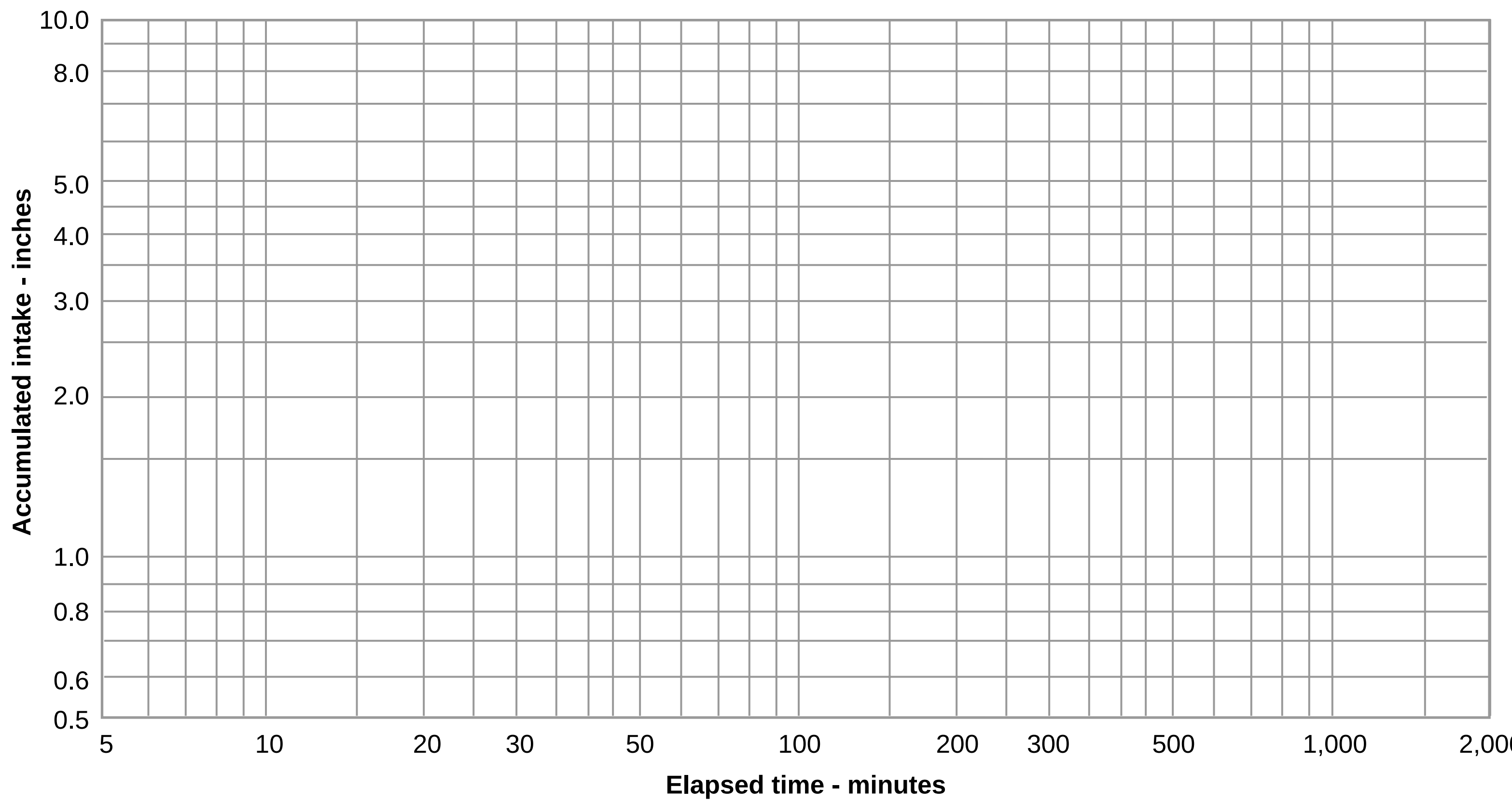
(Rod) Reading or elevation - feet

Cylinder Infiltrometer Curves

Land user ____________________

Date _________________________

Field office ____________________



U.S. Department of Agriculture
National Resources Conservation Service

Cylinder Infiltrometer Test Data

-322
02-96

FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

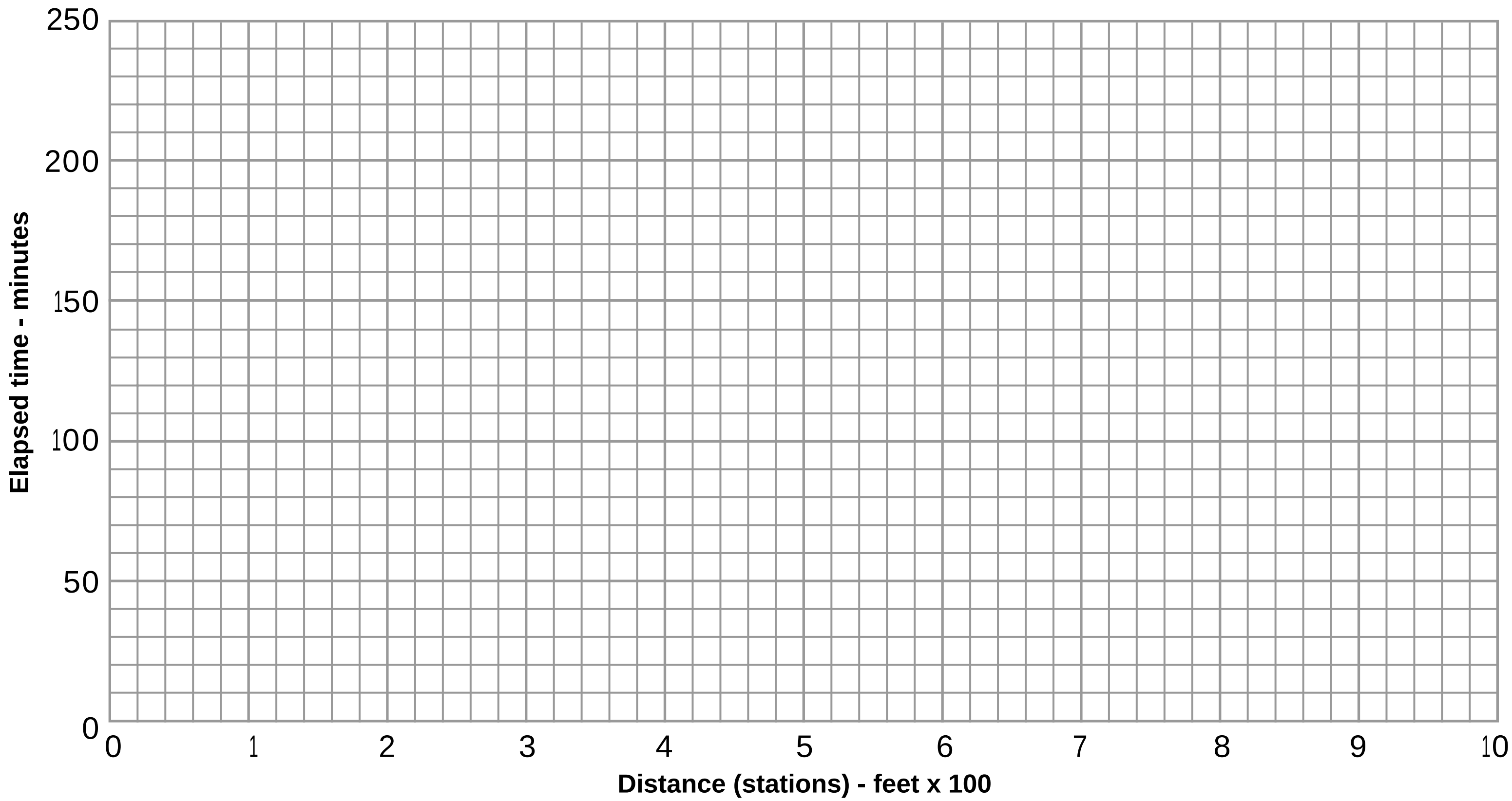
Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	
Min.		Inches			Inches			Inches			Inches			Inches		

Advance and recession curves

Land user ____________________

Date ____________________

Field office ____________________

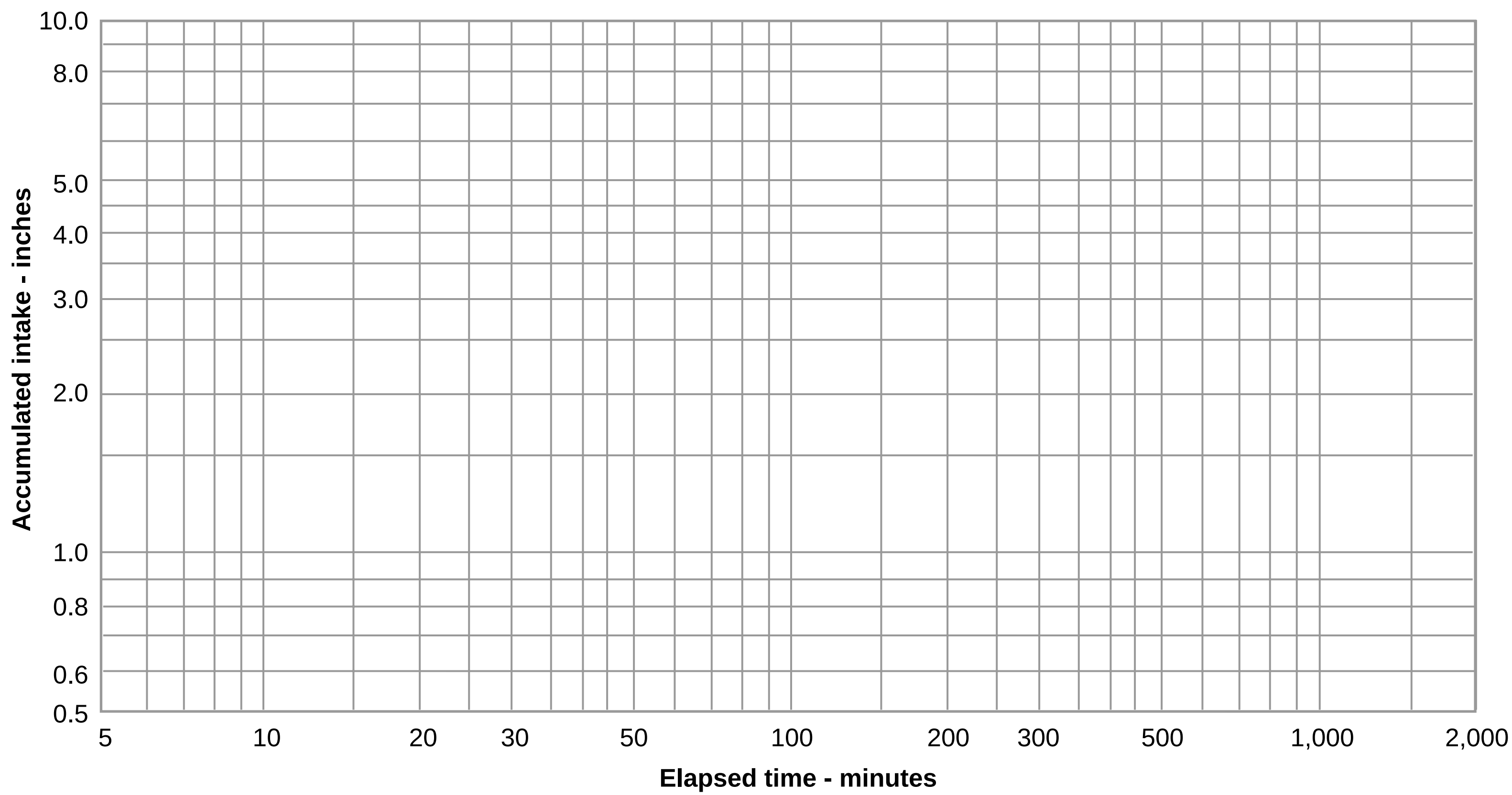


Cylinder infiltrometer Curves

Land user ____________________

Date ____________________

Field office ____________________

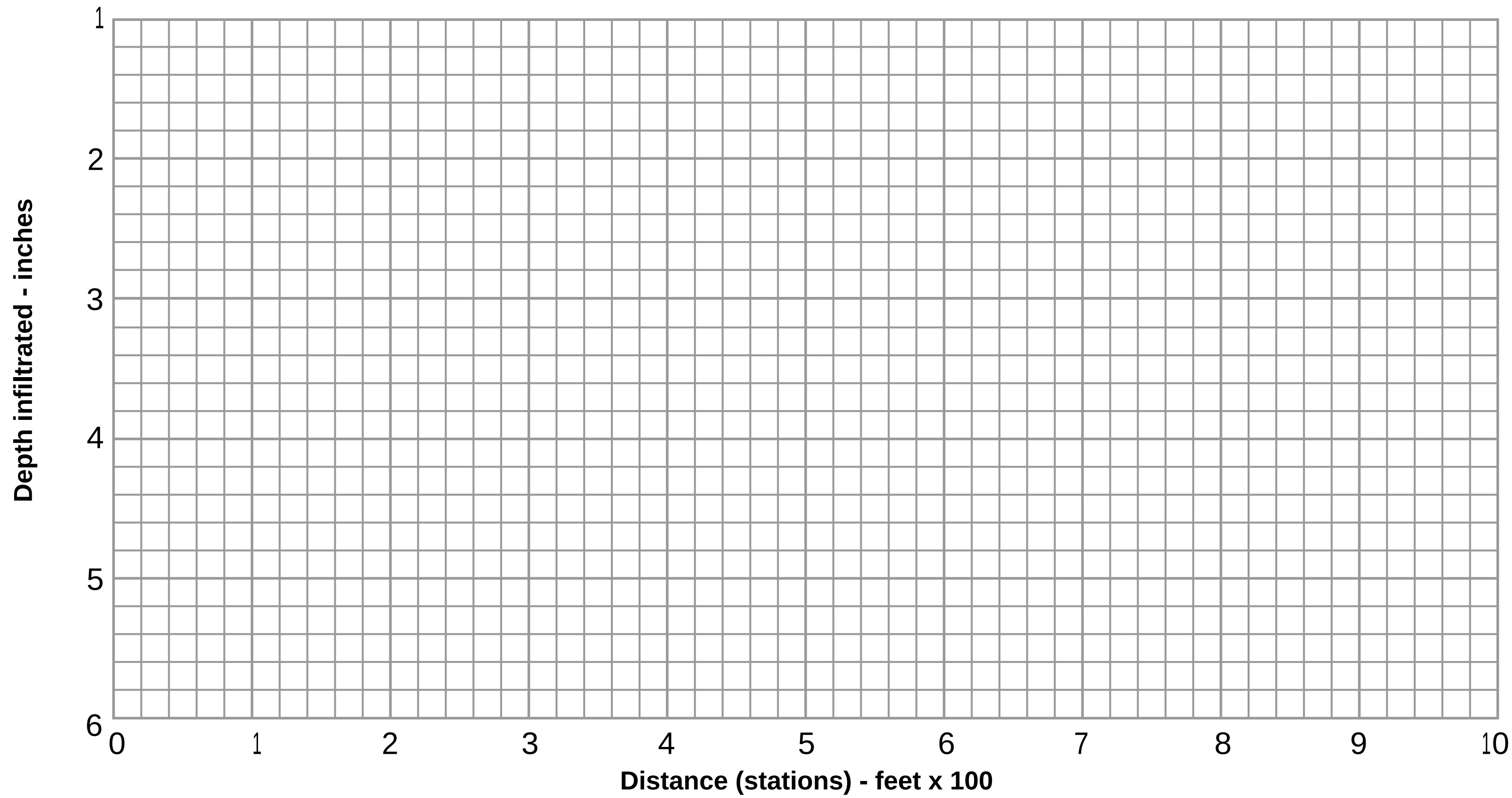


Depth infiltrated curve

Land user ____________________

Date ________________________

Field office __________________



Surface Irrigation System
Detailed Evaluation Graded Border Worksheet

Land user ______________________ Field office ______________________

Field name/number ______________________

Observer __________ Date __________ Checked by __________ Date __________ .

Field Data Inventory:

Field area ______________ acres

Border number ______________ as counted from the ______________ side of field

Crop ______________ Root zone depth ______________ ft MAD ______________%

Stage of crop ______________________

Soil-water data for controlling soil:

Station ______________ Moisture determination method ______________________

Soil series name ______________________

Depth	**Texture**	**AWC (in)***	**SWD (%)***	**SWD (in)***
	Total			

MAD, in = $\frac{\text{MAD, \% x total AWC, in}}{100}$ = ______________________ = __________ in

Comments about soils: ______________________

____

Typical irrigation duration __________ hr, irrigation frequency __________ days

Typical number of irrigation's per year ______________

Annual net irrigation requirement, NIR (from irrigation guide) ______________ in

Type of delivery system (gated pipe, turnouts, siphon tubes) ______________________

____

Delivery system size data (pipe size & gate spacing, tube size & length, turnout size) ______________

Border spacing __________, Strip width __________, Wetted width __________, Length __________

Field Observations:

Evenness of water spread across border ______________________

______________________ .

Crop uniformity ______________________

______________________ .

Other observations ______________________

______________________ .

NOTE: MAD = Management allowed deficit AWC = Available water capacity SWD = Soil water deficit

Surface Irrigation System
Detailed Evaluation Level Border and Basins Worksheet

1. Basin area (A):

   $A = \frac{\text{Length x Width}}{43{,}560}$ = ________________ x ________________ = ______________ acres

   46,560

2. Gross application, F_g, in inches:

   $F_g = \frac{\text{Total irrigation volume, in ac-in}}{\text{A, ac}}$ = ______________________________ = _________ in

3. Amount infiltrated during water inflow, V_i:

   V_i = Gross application - Depth infiltrated after turnoff = ________________= ____________ in

4. Deep percolation, DP, in inches:

   DP = Gross application - Soil water deficit, SWD = ___________________ = ____________ in

   DP, in % = $\frac{\text{(Soil water depletion, DP in inches) x 100}}{\text{Gross application, } F_g}$ = __________________ = ___________ %

5. Application efficiency, E_a:

   Average depth of water stored in root zone = Soil water deficit, SWD, if the entire root zone average depth will be filled to field capacity by this irrigation.

$E_a = \frac{\text{(Average depth stored in root zone, } F_n\text{) x 100}}{\text{Gross application, } F_g}$ = ___________________ = ____________ %

6. Distribution uniformity, DU:

   Depth infiltrated low 1/4 = $\frac{\text{(max intake - min intake)}}{8}$ + min intake

   = $\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{8}$ + __________ = ____________

   DU = $\frac{\text{Depth infiltrated low 1/4}}{\text{Gross application, } F_g}$ = ____________________________ = __________________

7. Application efficiency, low 1/4, E_q:

   $E_q = \frac{\text{DU x } E_a}{100}$ = ______________________ = ____________ %

Surface Irrigation System
Detailed Evaluation Level Border and Basins Worksheet

1. Present management
   Estimated present average net application per irrigation = ________________________ inches

   Present annual gross applied = $\frac{\text{(net applied per irrigation) x (number of irrigations)}}{\text{Application efficiency, low 1/4, } E_q}$ x 100

   = _______________________________ x 100 = _________ inches

2. Potential management
   Recommended overall irrigation efficiency, E_{des} ________________________

   Potential annual gross applied = $\frac{\text{Annual net irrigation requirements x 100}}{E_{des}}$

   = _______________________________ = _________ inches

3. Total annual water conserved:
   = $\frac{\text{(resent gross applied, in - potential gross applied, in) x area irrigated, acres}}{12}$

   + ____ = ______________ ac-ft

4. Annual potential cost savings
   From pumping plant evaluation:

   Pumping plant efficiency _____________________ Kind of fuel ______________________________
   Cost per unit of fuel _________________________ Fuel cost per acre-foot $ ____________________

   Cost savings = (fuel cost per acre foot) x (water conserved per year, in ac-ft)

   = _________________________ x ________________________ = $ ________________

Water purchase cost per acre-foot, per irrigation season __________________________

Water purchase cost savings = (Cost per acre-foot) x (water saved per year, in acre-feet)

= ____ = $ ________________

Potential cost savings = pumping cost + water purchase cost = __________________ = $ _____________

Surface Irrigation System
Detailed Evaluation Level Border and Basins Worksheet

Recommendations:

Surface Irrigation System
Detailed Evaluation Level Border and Basins Worksheet

Inflow Data

Type of measuring device ____

Clock 1/ time	Elapsed time (min)	Δ T (min)	Gage H (ft^3/s)	Flow rate (ft^3/s)	Average flow rate (ft^3/s)	Volume (ac-in)2/	Cum. volume (ac-in)
Turn on							

Turn off

Total volume (ac-in) _______________

Average flow:

Average flow = $\frac{\text{(Total irrigation volume, in ac-in)}}{\text{Inflow time, in minutes}}$ x 60.5 = ___________________________ = _______________ ft^3/s

Unit:

q_u = $\frac{\text{Average inflow rate, in } ft^3/s}{\text{Border spacing}}$ = ___________________ = ____________________ $ft^3/s/ft$

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is recorded as 1330 hours.
2/ Flow rate to volume factors:

To find volume using ft^3/s: volume (ac-in) = .01653 x time (min) x flow (ft^3/s)
To find volume using gpm: volume (ac-in) = .00003683 x time (min) x flow (gpm)

Surface System
Detailed Evaluation Level Border and Basins Worksheet

Advance - Recession Data

Station (ft)	Elevation (ft)	Advance time 1/ (hr: min)	Recession time 1/ (hr: min)	Opportunity time To (min)	Intake 2/ (in)	Minimum maximum intake (in)
Total						

Water surface elevation at water turnoff _________________ ft 3/

Average field elevation = $\frac{\text{elevation total}}{\text{no. of elevations}}$ = ____________________ = _______________ ft

Depth infiltrated after water turnoff
= (water surface at turnoff - average field elev) x 12

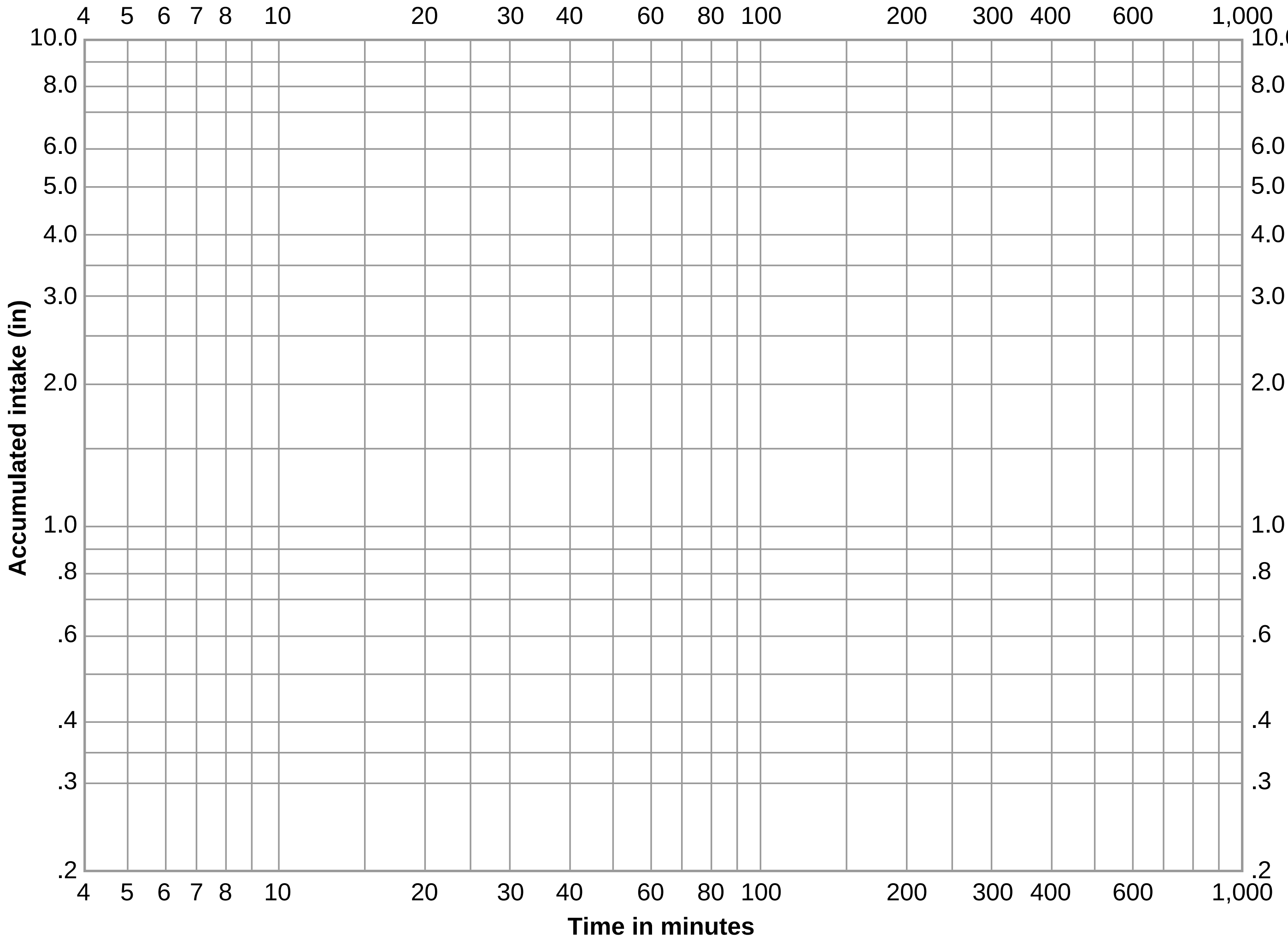
= (__________________ - _______________ x 12 = _________________ in

Average opportunity time = $\frac{\text{total opportunity time}}{\text{no. of sample locations}}$ = ___________________ = ______________ min

1/ Use 24-hour clock time. As a minimum, record times at upper end, mid point.
2/ Obtain intake from plotted intake curve.
3/ Water surface elevation should be read to nearest 0.01 ft.

Land user ____________________
Date ________________________
Field office __________________

Soil Water Intake Curves



Surface Irrigation System
Detailed Evaluation Graded Furrow Worksheet 1

Land user ____ Field office ____________________________________

Field name/number ____

Observer ____________________ Date ____________ Checked by ______________________ Date ___________

Field Data Inventory:

Show location on evaluation furrows on sketch or photo of field.

Crop ________________________ Actual root zone depth _______________ MAD [1] _______ % MAD _______ in

Stage of crop ________________________________ Planting date (or age of planting) _____________________

Field acres _______________________

Soil-water data:

(Show location of sample on soil map or sketch of field)

Soil moisture determination method ____

Soil mapping unit ____ Surface texture ________________

Depth	Texture	AWC (in)[1]	SWD (%)[1]	SWD (in)[1]
	Total			

Comments about soils: ____

____

____

____

Typical irrigation duration __________________ hours, Irrigation frequency ___________________ days

Typical number of irrigations per year ____

Crop rotation ____

____

____

Field uniformity condition (smoothed, leveled, laser leveled, etc., and when) _______________________________ _

____

____

1/ MAD = Management allowable depletion   AWC = Available water capacity   SWD = Soil water deficit

Surface Irrigation System
Detailed Evaluation Graded Furrow Worksheet 2

Cultivation no.	Date	Crop stage	Irrigate?
1	__________	__________________	__________
2	__________	__________________	__________
3	__________	__________________	__________
4	__________	__________________	__________
5	__________	__________________	__________

Delivery system size (pipe diameters, gate spacing, siphon tube size, etc.) ____________________________

____

Field observations

Evenness of advance across field ____

Crop uniformity ____

Soil condition ____

Soil compaction (surface, layers, etc.) ____

Furrow condition ____ -

Erosion and/or sedimentation: in furrows ____

head or end of field ____

Other observations (OM, cloddiness, residue, plant row spacing, problems noted, etc.) ______________________

____

____

____

Furrow spacing ___________ inches

Furrow length ____________ feet

Irrigations since last cultivation ______________________________

Furrow profile (rod readings or elevations at each 100 foot. station):

_______ _______ _______ _______ _______ _______ _______ _______ _______ _______ _______ _______

_______ _______ _______ _______ _______ _______ _______ _______ _______ _______ _______ _______

Furrow cross section:

Station: ______

Station: ______

Example - Surface Irrigation System Detailed Evaluation
Graded Furrow Worksheet 3

Furrow data summary:

Evaluation length ____________________ Slope ____________________________ Average ____________

Section through plant root zone:

Evaluation computations

Furrow area, $A = \frac{\text{(furrow evaluation length, L, ft)} \times \text{(furrow spacing, W, ft)}}{43{,}560 \text{ ft}^2\text{/acre}}$

$A = \frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{43{,}560}$ = ________ acre

Present gross depth applied, $F_g = \frac{\text{Total inflow volume, gal.} \times .0000368}{\text{Furrow area, A, in acres}}$ (Total inflow from worksheet 7)

F_g = ____ = _________ inches

Minimum opportunity time, T_{ox} = ________ min at station ___________ (from field worksheet 10)

Minimum depth infiltrated, F_{min} = ________ inches (from worksheet 10)

Average depth infiltrated, $F_{(0\text{-}1)}$ = _________ (from calculations on worksheet 10)

Distribution uniformity, $DU = \frac{\text{Minimum depth infiltrated, inches}}{\text{Average depth infiltrated, inches}} \times 100 = \frac{F\ min}{F\ ave} \times 100$

= ______________________________________ = _________________%

Example - Surface Irrigation System Detailed Evaluation
Graded Furrow Worksheet 4

Runoff, RO% = $\frac{\text{Total outflow volume, gal}}{\text{Total inflow volume, gal}}$ x 100 = ______________________ = __________ % (Total outflow, worksheet 8) (Total inflow, worksheet 7)

RO, in = $\frac{\text{Total outflow volume, gal x .0000368}}{\text{Evaluation furrow area, A, in acres}}$ = ______________ x 0.0000368 = ________ in (Furrow area, worksheet 3)

Deep percolation, DP, in = Average depth infiltrated - Soil moisture deficit, SMD (Ave. depth worksheet 10 and SMD worksheet 1)

DP = _________________________ = ____________ in

Deep percolation, DP, % = $\frac{\text{Deep percolation, DP, in x 100}}{\text{Gross depth applied, } F_g\text{, inches}}$ = ________________ = ________ %

Application efficiency, E_a

E_a = $\frac{\text{Ave depth stored in root zone* x 100}}{\text{Gross application, } F_g\text{, inches}}$ = __________________________ = ________ %

*Average depth of water stored in root zone = SWD if entire root zone depth is filled to field capacity by this irrigation. If irrigation efficiency is to be used in place of application efficiency, use average depth of water beneficially used (i.e., all infiltrated depths less than or equal to SWD) plus any other beneficial uses.

Example - Surface Irrigation System Detailed Evaluation
Graded Furrow Worksheet 5

Potential water and cost savings

Present management

Estimated present gross net application, F_g per irrigation = _______________ inches (F_g from worksheet 3)

Present gross applied per year = Gross applied per irrigation, F_g x number of irrigations

= ________________________________ = ________________ inches

Potential management

Annual net irrigation requirement _________ inches, for ____________________ (crop)

Potential application efficiency, E_{pa} = ______________%

Potential annual gross applied = $\frac{\text{Annual net irrigation req. x 100}}{\text{Potential application efficiency, } E_{pa}}$

= ______________________________ = ____________ inches

Total annual water conserved = $\frac{\text{(present gross applied - potential gross applied) x area irrigated, ac}}{12}$

= ___________________________ = ___________ acre feet

Surface Irrigation System
Detailed Evaluation Graded Furrow Worksheet 6

Annual cost savings

Water cost

= Cost per acre foot x acre feet saved per year = ______________________________

= $ ____________________________

Cost savings = Pumping cost + water cost = ________________________________ = $ ______________

Fuel cost savings = (fuel cost per ac-ft) x (ac-ft conserved per year) =_______________ = ______________

Recommendations ____

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Surface Irrigation System
Detailed Evaluation Furrow Worksheet 7-8

Data: Furrow number _________________ Inflow ________ Outflow _________

Type of measuring device ____

Clock 1/ time	Elapsed time (min)	Δ T (min)	Gage H (ft)	Flow rate (gpm)	Average flow rate (gpm)	Volume 2/ (gal)	Cum. volume (gal)
Turn on							

Total volume ________ gallon

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is recorded as 1330 hours.
2/ Volume = Δ T x average flow rate

Average flow rate = $\frac{\text{Total irrigation volume, gallon}}{\text{Elapsed time, minute}}$ = _________________ = ___________ gpm

Surface Irrigation System Detailed Evaluation
Furrow Worksheet 9

Intake Curve Plotting Data

Opportunity time at time "T"							Intake at time "T"		
Clock time		Inflow time		Outflow time		Opportunity time T_o 5/ (min)	Cumulative inflow volume 6/ V_{in} (gal)	Cumulative Outflow volume 6/ V_{out} (gal)	Intake F_{0-1} 7/ (in)
(hr-min)1/	T (hr)	Start 2/ (hr)	T1 3/ (hr)	Start 2/ (hr)	T2 4/ (hr)				

1/ Use a 24-hour clock reading for collection of field data; i.e., 1:30 p.m. is 1330 hours. Use decimal hours for inflow and outflow times.
2/ Time at which inflow or outflow starts in decimal hours (worksheet 7-8)
3/ Inflow time: T1 = "T" - inflow start time (worksheet 7)
4/ Outflow time: T2 = "T" - outflow start time (worksheet 8)
5/ Opportunity time (minutes): T_o - 30 (T1 + T2)
6/ Cumulative inflow and outflow volumes (worksheet 7-8). If data were not recorded for time T, interpolate the inflow or outflow.

Surface storage and wetted perimeter for length of furrow with water in it.

L = length of furrow with water in it, ft (worksheet 3) = ________
S = average furrow slope, ft/ft (worksheet 3) = ________
n = Mannings "n" (usually 0.04 for furrows, 0.10 for corrugations = ________
Q_{av} = average inflow rate, gpm (worksheet 7) = ________

Surface storage: $V_s = L\left[0.09731\left(\frac{Q_{av} \times n}{S^{.5}}\right)^{.7567} + 0.00574\right]$ = ________

Wetted perimeter: $P = 0.2686\left(\frac{Q_{av} \times n}{S^{.5}}\right)^{.4247} + 0.7462$ = ________

7/ Intake plotting point:

$$F_{0-1} = \frac{1.604\ (V_{in} - V_{out} - V_s)}{L \times P}$$

V_{in} = Cumulative inflow (gal) from worksheet 7
V_{out} = Cumulative outflow (gal) from worksheet 8
V_s = Surface storage (gal) in length of furrow with water in it

Surface Irrigation System Detailed Evaluation
Furrow Worksheet 10

Furrow advance/recession data

	Advance time			Recession time						
Station (ft)	Clock time 1/	Δ T (min)	Elapsed time T_t (min)	Clock time 1/	Δ T (min)	Elapsed time T_r (min)	Total elapsed time 3/	Opportunity time (T_o) 2/ (min)	Intake in wetted perimeter (in) 4/	Intake in furrow width (in)
	Turn on			Turn off	Lag			Inflow T		
							Totals			

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is 1330 hours.

2/ $T_o = T_i - T_t + T_r$

3/ Time since water was turned on.

4/ Interpolated from graph, furrows volume curve

Average opportunity time = $\frac{\text{total opportunity time}}{\text{number of stations}}$ = ____________________ = __________________ minutes

Average depth infiltrated in wetted perimeter, F_{wp}:

$F_{wp} = \frac{\text{total intake in wetted perimeter}}{\text{number of stations}}$ = ______________________ = _______________________ inches

Average depth infiltrated in tested length of furrow, $F_{0\text{-}1}$:

$F_{0\text{-}1} = \frac{F_{wp} \times P}{W}$ = ________________________ = _______________________ inches

U.S. Department of Agriculture
National Resources Conservation Service

Surface Irrigation System Detailed Evaluation
Furrow Worksheet 11

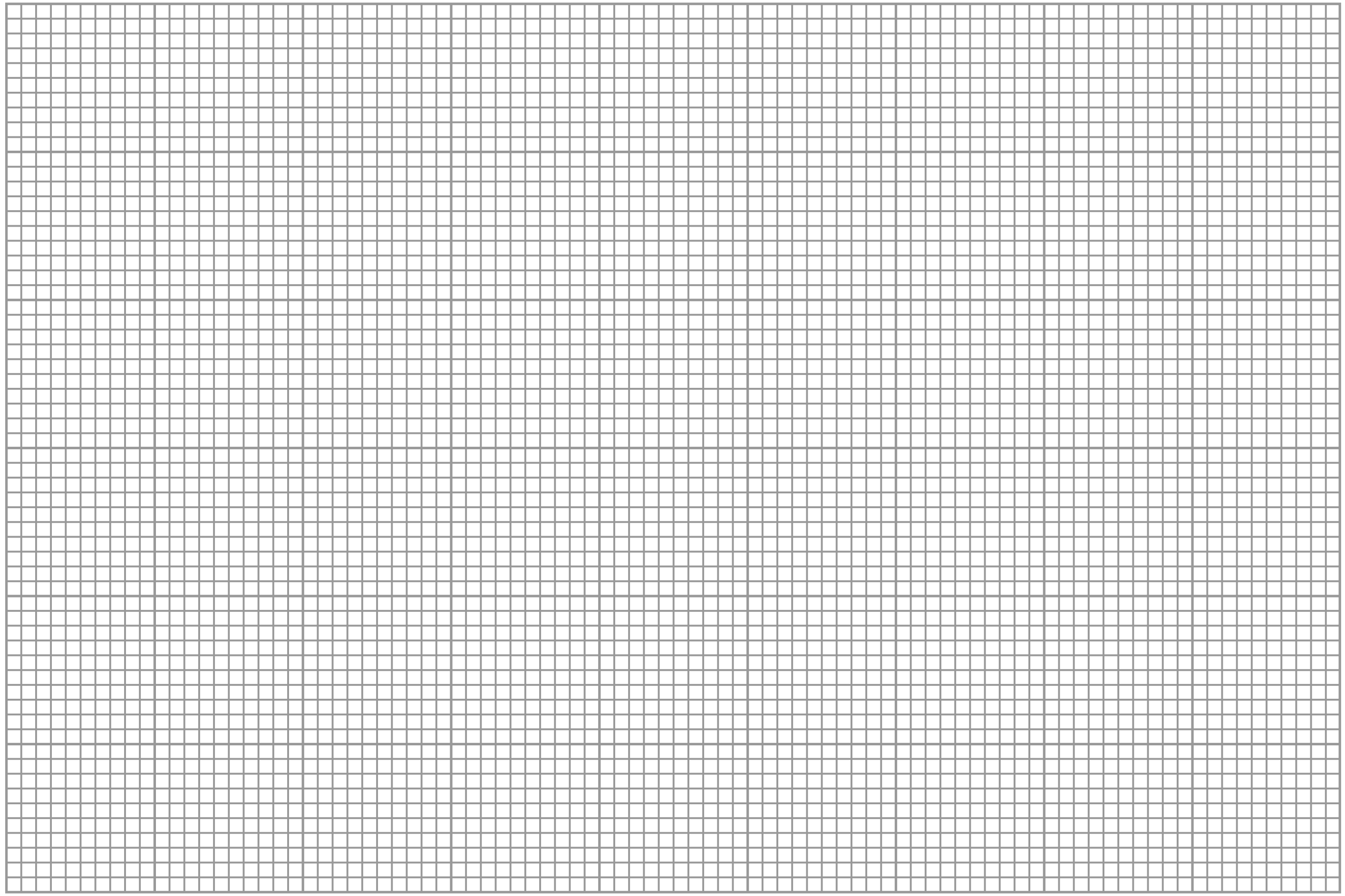
Land user ____________________

Date ________________________

Field office ___________________

Advance and recession curves

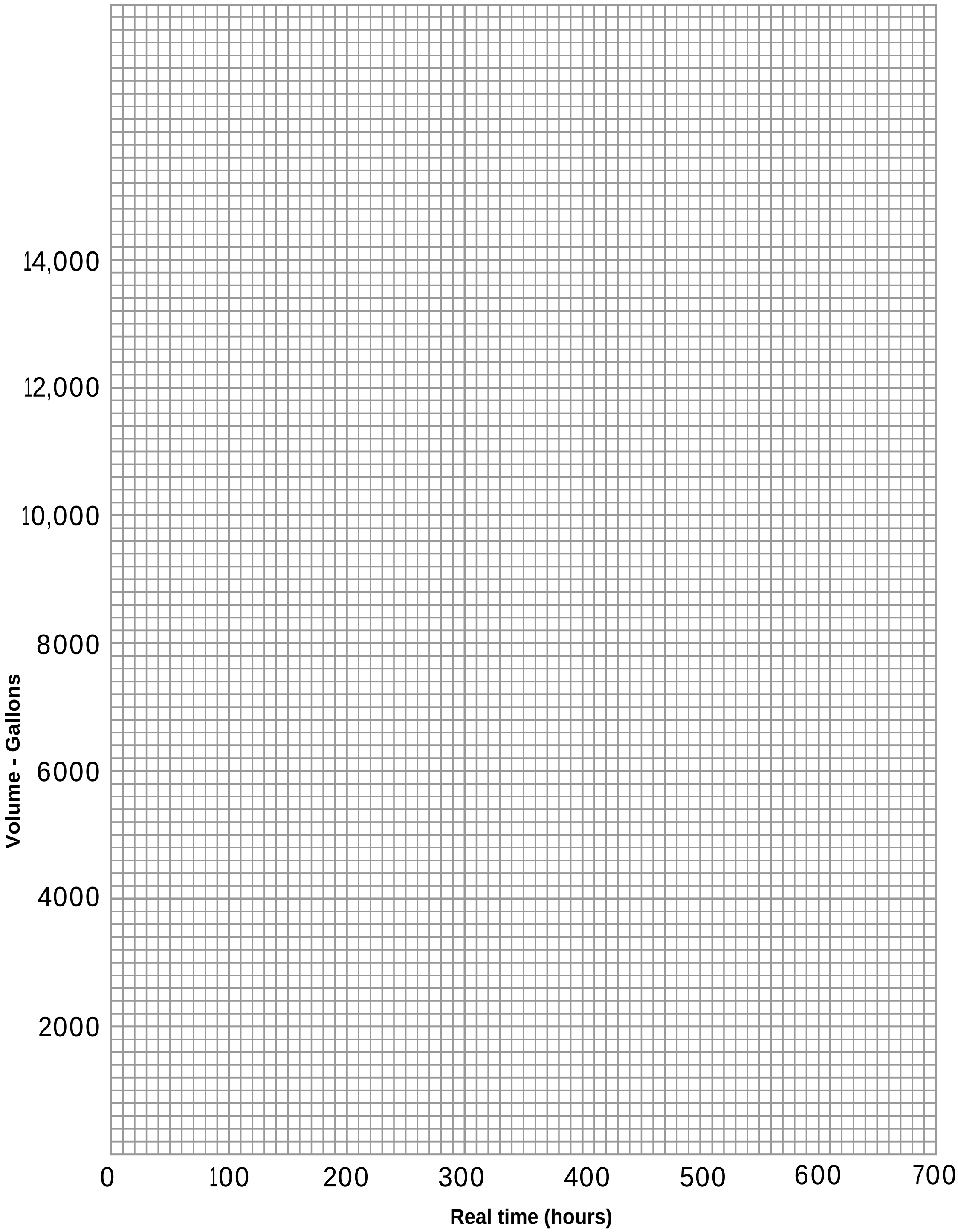
Time - minutes



Distance (stations) - feet x 100

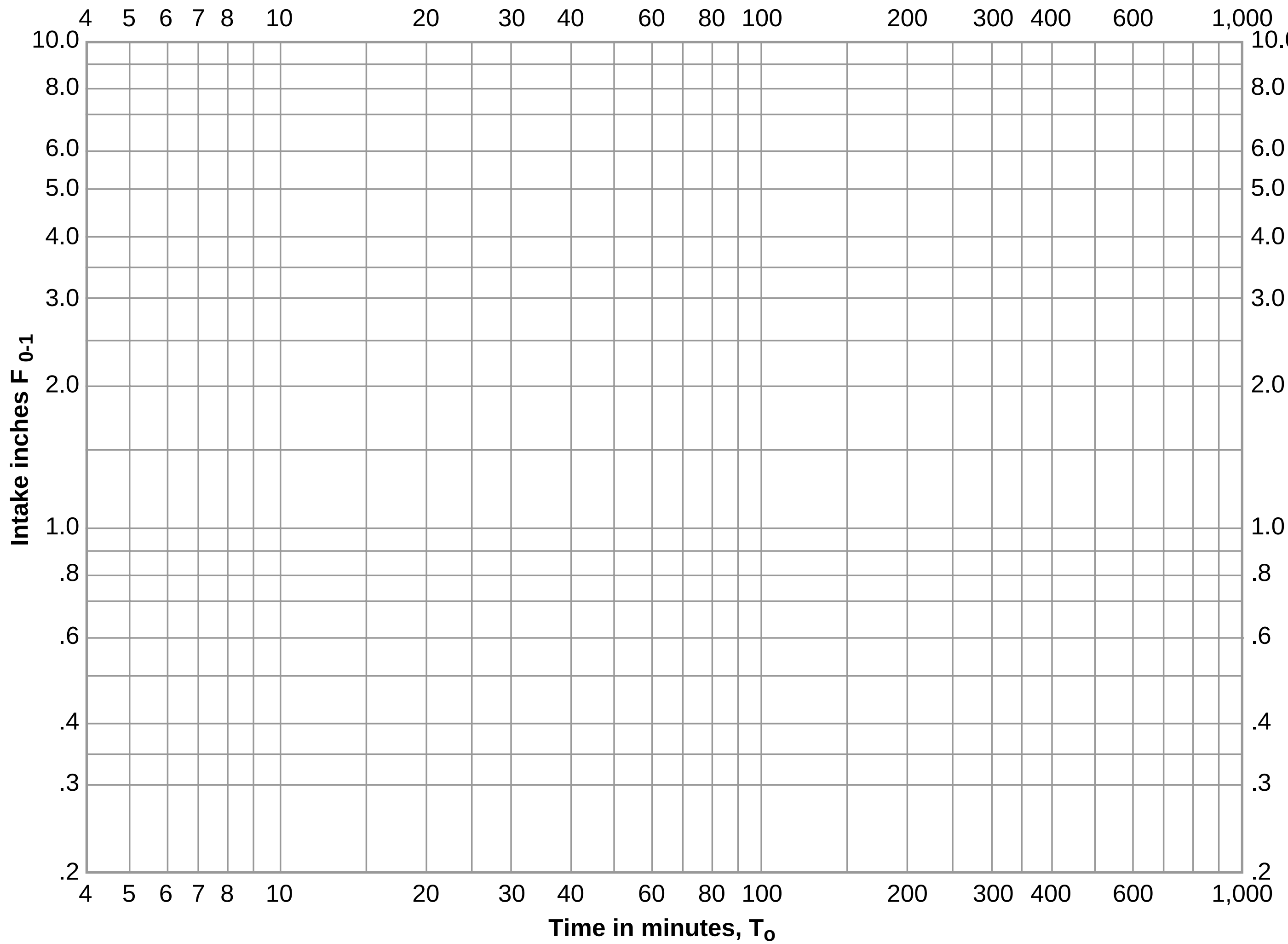
Land user ____________________
Date ________________________
Field office ___________________

Flow volume curves



Land user ______________________
Date __________________________
Field office ____________________

Soil water intake curves



Surface Irrigation System
Detailed Evaluation Contour Ditch Irrigation System Worksheet

Land user ______________________________________ Field office ___________________________________
Field name/number ____
Observer ____________________ Date ____________ Checked by ______________________ Date ___________

Field Data Inventory:
Field size __________________ acres
Crop _________________ Root zone depth ______________ ft MAD 1/ ____________ % MAD 1/ ____________ in
Stage of crop ____
____

Soil-water data:
(Show locacation of sample on grid map of irrigated area.)
Soil moisture determination method ____
Soil series name ____

Depth	Texture	AWC 2/ (in)	SWD 3/ (%)	SWD 3/ (in)
	Total			

Comments about soils: ____
____

Typical irrigation duration __________________ hr, irrigation frequency _________________ days
Typical number of irrigations per year ____

Type of delivery system, (earth ditch, concrete ditch, pipeline) ______________________________
____
____

Method used to turn water out (shoveled opening, wood box turnout, siphon tubes, portable dams, concrete checks with check boards, etc.) ____
____
____

1/ MAD = Management allowable depletion
2/ AWC = Available water capacity
3/ SWD = Soil water deficit

Contour Ditch Irrigation System
Detailed Evaluation Worksheet

Field observations

Crop uniformity ____
____

Wet and/or dry area problems ____
____

Erosion problems ____
____

Other observations ____
____

Evaluation computations

Irrigated test area (from gird map) = (___________ in^2) x (___________ in^2/ac) = ________________ac

Actual total depth infiltrated, inches:

$$\text{Depth, inches} - \frac{(\text{Irrigated volume, ac-in}) - (\text{Runoff volume, ac-in})}{(\text{Irrigated area, acres})}$$

Depth, inches = ___________________________ = ______________ in

Gross application, F_g, inches:

$$F_g = \frac{(\text{Total inflow volume, ac-in})}{(\text{Irrigated area, acres})}$$ = __________________________ = _____________ in

Distribution uniformity low 1/4 (DU):

$$DU = \frac{(\text{Average depth infiltrated (adjusted) low 1/4, inches})}{(\text{Average depth infiltrated (adjusted), inches})}$$

DU = ____ = _______________

Runoff, RO, inches:

$$\text{RO, inches} = \frac{(\text{Runoff volume, ac-in})}{(\text{Irrigated area, ac})}$$ = ________________________________ = ______________ in

$$\text{RO, \%} = \frac{(\text{Runoff depth, inches})}{(\text{Gross application, } F_g\text{, inches})} \times 100$$ = ___________________________ = ______________ %

Contour Ditch Irrigation System
Detailed Evaluation Worksheet

Deep percolation, DP, inches:

DP, inches = (Gross applic. F_g, inches) - (Runoff depth, RO, inches) - (Soil water deficit, SWD, inches)

DP, inches = ____ = __________ inches

$$\text{DP, \%} = \frac{\text{(Deep percolation, DP, inches)}}{\text{(Gross application, } F_g \text{, inches)}} \times 100 = \_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\%$$

Application efficiency (E_a):

(Average depth replaced in root zone = Soil water deficit, SWD, inches)

$$E_a\% = \frac{\text{(Average depth replaced in root zone, inches)}}{\text{(Gross application, } F_g \text{, inches)}} \times 100 = \_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\ \%$$

Potential water and cost savings

Present management:

Estimated present average net application per irrigation = __________________ inches

$$\text{Present gross applied per year} = \frac{\text{(Net applied per irrigation, inches)} \times \text{(no. of irrigations)}}{\text{(Application efficiency, } E_a \text{, percent)}} \times 100$$

Present gross applied per year = ______________________________ = __________ inches

Potential management

Annual net irrigation requirement: _________________ inches, for _______________ (crop)

Potential application efficiency, E_{pa}: ____________ % (from irrigation guide or other source)

$$\text{Potential annual gross applied} = \frac{\text{(annual net irrigation requirement, inches)}}{\text{(Potential application efficiency, } E_{pa} \text{, percent)}} \times 100$$

Potential annual gross applied = ____________________________________ = ________ inches

Total annual water conserved:

$$= \left(\frac{\text{(Present gross applied, inches)} - \text{(Potential gross applied, inches)}}{12} \times \text{Area irrigated, ac}\right)$$

$$= \left(\frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{12}\right) \times (\_\_\_\_\_\_\_\_\_\_\_\_) = \_\_\_\_\_\_\_\_\_\_\ \text{acre-feet}$$

Contour Ditch Irrigation System
Detailed Evaluation Worksheet

Cost savings:

Pumping plant efficiency _______________ percent, Kind of energy ____________________________

Cost per unit of fuel ________________________ Fuel cost per acre foot __________________________

Cost savings = (Fuel cost per acre foot) x (Acre inches conserved per year)

= ____

Water purchase cost:

= (Cost per acre foot) x (Acre feet saved per year) =

= (______________) x (______________) = ____

Cost savings = (Pumping cost) + (Water cost) = (______________) + (______________) = __________

Recommendations

____
____
____
____
____
____
____
____
____
____
____
____
____

Contour Ditch Irrigation System
Detailed Evaluation Worksheet

Inflow ________ Outflow _________

Type of measuring device ____

Clock 1/ time	Elapsed time (min)	∆ T (min)	Gauge H (ft)	Flow rate (ft^3/s)	Average flow rate (ft^3/s)	Volume 2/ (ac-in)	Cum. volume (ac-in)
Turn on							

Total volume (ac-in) _______________

Average flow = $\frac{\text{Total irrigation volume in (ac-in)}}{\text{Flow factor x elapsed time (min)}}$ = ___________________________ = _______________ ft^3/s

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is recorded as 1330 hours.
2/ Flow rate to volume factors:
To find volume using ft^3/s:
Volume (ac-in) = .01653 x time (min) x flow (ft^3/s)

To find volume using gpm:
Volume (ac-in) = .00003683 x time (min) x flow (gpm)

Surface System
Detailed Evaluation Contour Ditch Irrigation Systems Worksheet

Grid Data

Grid point	Advance time 1/ (hr:min)	Recession time 1/ (hr: min)	Opportunity time " T_o" (min)	Typical depth infil. 2/ (in)	Adjusted depth infil. 2/ (in)	Low 1/4 adjusted intake 4/ (in)
			Total			

2/ From "typical" cumulative intake curve.
3/ From "adjusted" cumulative intake curve.
4/ Adjusted intake for lowest intake 1/4 of points (total number of points divided by 4).

Average depth infiltrated (typical):

= Total depth typical / Number of grid points = ____________________ = ____________ in

Average depth infliltrated (adjusted):
(Should be close to actural depth infiltrated)

= Total depth adjusted / Number of grid points = ____________________ = ____________ in

Average depth infiltrated (adjusted), low 1/4:

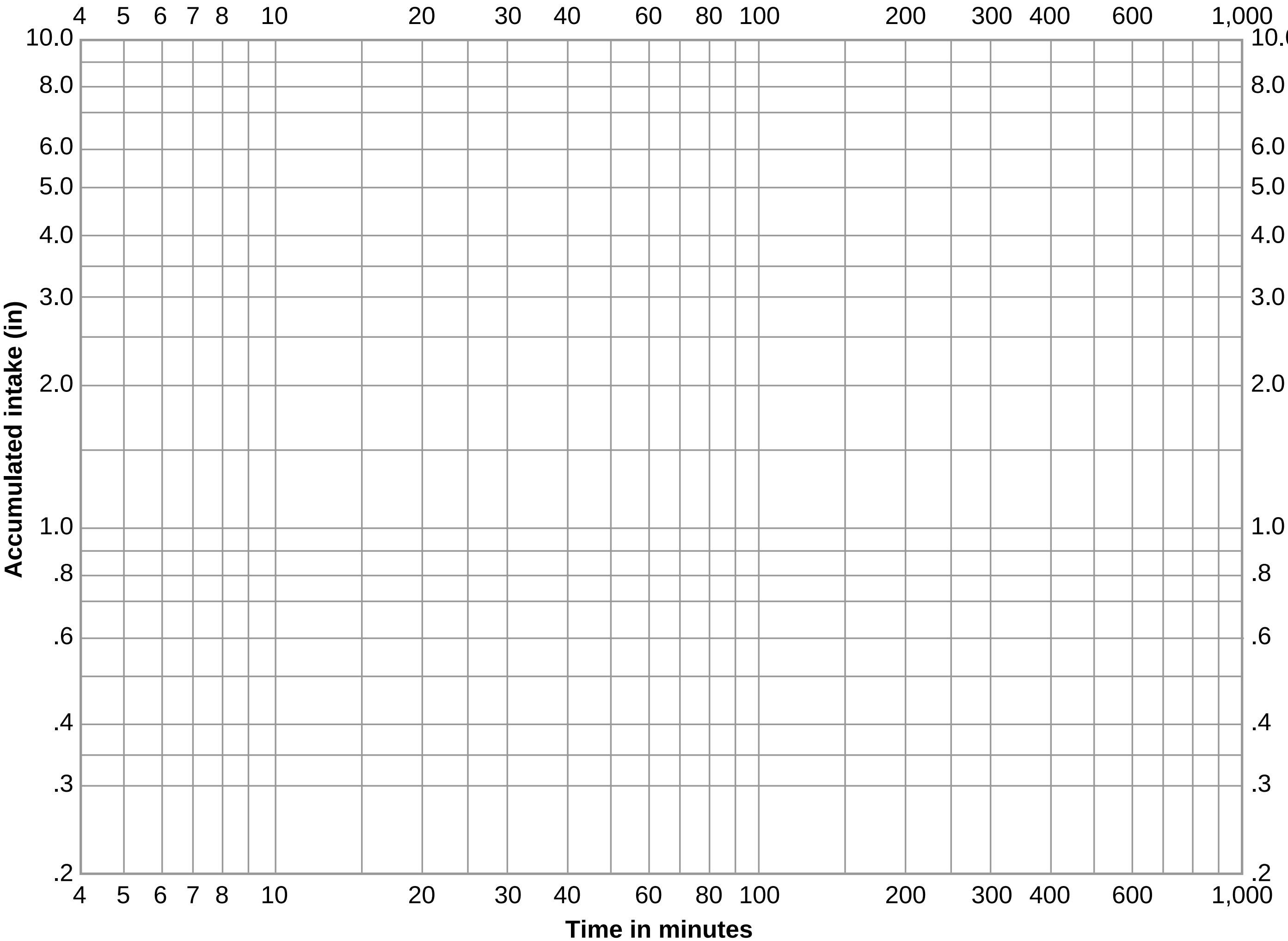
= Total depth adjusted, low 1/4 / Number grid points, low 1/4 = ____________________ = ____________ in

Land user ____________________

Date ______________________

Field office ___________________

Soil Water Intake Curves



U.S. Department of Agriculture
Natural Resources Conservation Service

Cylinder Infiltrometer Test Data

NRCS-ENG-322
02-96

FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	
Min.		Inches			Inches			Inches			Inches			Inches		

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Land user ____ Prepared by ____________________________________

District _______________________________ County ______________________ Engineer job class______________

Irrigation system hardware inventory:

Type of system (check one) : Side- roll ______ Handmove ______ Lateral tow ______ Fixed set ________

Sprinkler head: make _________, model _____________, nozzle size(s) _________ by _________ inches

Spacing of sprinkler heads on lateral, S_1 _____________ feet

Lateral spacing along mainline, S_m ________________ feet, total number of laterals ____________

Lateral lengths: max ____________ feet, minimum ______________ feet, average ______________ feet

Lateral diameter: ____________ feet of ________ inches, ___________ feet of __________ inches

Manufacturer rated sprinkler discharge, ________ gpm at ________ psi giving ________ feet wetted diameter

Total number sprinkler heads per lateral ___________, lateral diameter _________ inches

Elevation difference between first and last sprinkler on lateral (=/-) _____________ feet

Sprinkler riser height ____________ feet, mainline material ____

Spray type: _______ fine (>30psi), _________ coarse (<30psi)

Field observations:

Crop uniformity ____

Water runoff ____

Erosion ____

System leaks ____ .

Fouled nozzles ____

Other observations ____

Field data inventory & Computations:

Crop ____________________________, root zone depth _______ feet, MAD 1/ _______ %, MAD 1/ ________ inches

Soil-water data (typical):

(Show locations of sample on soil map or sketch of field)

Moisture determination ____

Soil series and surface texture ____

Depth	Texture	AWC 1/ (in)	SWD 1/ (%)	SWD 1/ (in)
	Totals			

1/ MAD = Management allowable depletion, AWC = Available water capacity, SWD = Soil water deficit

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Comments about soils (including restrictions to root development and water movement): ______________________
____
____
____
____
____
____

Present irrigation practices:

Typical irrigation duration _____________ hr, irrigation frequency ____________ days

Typical number irrigations per year __________________

Distance moved per set ___________ ft, Alternate sets? _____________

Measured nozzle diameters (using shank of high speed drill bit)

Sprinkler no.	___________	___________	___________	___________	___________
Diameter	___________	___________	___________	___________	___________
Size check	___________	___________	___________	___________	___________

(state whether t = tight, m = medium, l = loose)

Actual sprinkler pressure and discharge data:

Sprinkler number on test lateral

	1st				end
Initial pressure (psi)	________	________	________	________	________
Final pressure (psi)	________	________	________	________	________
Catch volume (gal)	________	________	________	________	________
Catch time (sec)	________	________	________	________	________
Discharge (gpm)	________	________	________	________	________

Test:

Start _____________ stop ____________ duration ___________ = ___________ hours

Atmospheric data:

Wind: Direction: Initial ____________ during ____________ final ______________

Speed (mph): initial ____________ during ____________ final ______________

Temperature: initial ________ final _______ Humidity: _____ low _____ med _____ high

Evaporation container: initial ___________ final ___________ loss __________ inch

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Lateral flow data:

Flow meter reading ______________________________________gpm

Average discharge of lateral based on sprinkler head discharge

= [1st gpm - .75 times (1st gpm - last gpm)] times (number of heads)

= __________________________ = ______________ gpm (ave flow per head)

= ________ heads x _________ gpm/head = ________________gpm

Calculations:

Gross application per test = (flow, gpm) x (time, hr) x 96.3 / (lateral length) x (lateral spacing)

= (gpm) x (hours) x 96.3 / (feet) x (feet) = _____________ inches

Gross application per irrigation = (gross application per test, in) x (set time, hour) / (time, hour)

= (inches) x (hour) / (5.95 hour) = _____________ inches

Catch container type ____

___________ cc (mL) or in, measuring container = __________ inches in container

Total number of containers ___________

Composite number of containers = Total number of containers / 2 = ________ = _______

Total catch, all containers = _____________ cc (mL) / cc/in = _____________ inches

Average total catch = Total catch / composite no. containers = ___________ = __________ inches

Number of composite containers in low 1/4 = composite no. containers / 4 = _______ = ______

Total catch in low 1/4 composite containers = _____________ cc(mL) / cc/in = ____________ inches

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Average catch of low 1/4 composite containers = $\frac{\text{total catch in low 1/4}}{\text{no. composite low 1/4 containers}}$

= ____________________ = ________________ inches

Average catch rate = $\frac{\text{Average total catch, inches}}{\text{Test time, hour}}$ = $\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{\text{hour}}$ = ______________inch/hour

NOTE: Average catch rate is application rate at plant canopy height.

Distribution uniformity low 1/4 (DU):

DU = $\left(\frac{\text{Average catch low 1/4 composite containers}}{\text{Average total catch}}\right)$ x 100 = $\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{\text{inches}}$ inches x 100 = ___________%

Approximate Christiansen Uniformity (CU):

CU = 100 - [0.63 x (100 - DU)] = 100 [0.63 x (100 - ______________________)] = __________________ %

Effective portion of applied water (R_e):

R_e = $\frac{\text{Average total catch, inch}}{\text{Gross applications/test, inches}}$ = $\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ inches}}{\text{inches}}$ = ________________ inches

Application efficiency of low 1/4 (E_q):

E_q = DU x (R_e) = _____________ x _____________ = _____________ %

NOTE: Use for medium to high value crops.

Approximate application efficiency low 1/2 (E_h):

E_h = CU x (R_e) = _____________ x _____________ = ______________ %

NOTE: Use for lower value field and forage crops.

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Application efficiency, (E_a):

$F_n = \frac{\text{(gross application per irrigation)} \times E_q}{100} = \frac{(\_\_\_\_\_\_\_\_ \text{ inches}) \times \_\_\_\_\_\_\_\_}{100} =$ ________ inches

$E_a = \frac{\text{(water stored in root zone)} \times 100}{\text{(gross application per irrigation)}} = \frac{(\_\_\_\_\_\_\_\_ \text{ inches}) \times 100}{(\_\_\_\_\_\_\_\_ \text{ inches})} =$ _________ %

Losses = (runoff, deep percolation) = gross application per irrigation minus SWD

= (_________________________________ = __________ inches

Potential Water and Cost Savings:

Present management:

Gross applied per year = (gross applied per irrigation) x (number of irrigations) =

= (___________ inches) x (____________) = __________ inches/year

Potential management:

Annual net irrigation requirement __________________ inches/year, for _______________________ (crop)

Potential application efficiency (E_q or E_h) ____________ % (from NEH, Part 623, Ch 11)

Potential annual gross applied = $\frac{\text{(annual net irrigation requirement)} \times 100}{\text{Potential } E_q \text{ or } E_H}$

= (____________________ inches) x 100 = ___________________ inches

Total annual water conserved

$= \frac{\text{(Present gross applied - potential gross applied)} \times \text{(area irrig. (ac))}}{12} =$ _____________________ acre/feet

$= \frac{(\_\_\_\_\_\_\_\_ \text{ inches}) - (\_\_\_\_\_\_\_\_ \text{ inches}) \times (\_\_\_\_\_\_\_\_ \text{ acres})}{12} =$ ____________acre/feet

Sprinkler Irrigation System
Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Cost savings:

Pumping plant efficiency ________________________________ Kind of fuel ___________________________

Cost per unit of fuel $ ___________________________________ Fuel cost per acre/foot $ ________________

Cost savings = (fuel cost per acre-foot) x (acre-feet conserved per year) = $ ______________

= (_______________) x (_______________) = $ ________________

Water purchase cost:

= (Cost per acre-foot) x (acre-feet saved per year) = _______________ x _______________ = $ _____________

Cost Savings:

= Pumping cost + water cost = ____________ + ____________ = $ ______________

Recommendations: ____

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Lateral move system catch can data

Land user ____________________

Date ________________________

Field office ___________________

Lateral   flow

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Land user ______________________________ Field office ______________________

Observer ______________ Date _____________ Checked by ______________ Date ________

Field name/number ____

Center pivot number _________ pivot location in field ______________________________

Acres irrigated ________________

Hardware inventory:

Manufacturer: name and model ______________________________________

Is design available? _________ (attach copy) Number of towers __________ Spacing of towers ___________

Lateral: Material _________________, Inside diameter _____________ inches

Nozzle: Manufacturer ____

Position _______________ Height above ground ______________________________

Spacing ____

Is pressure regulated at each nozzle? _______ operating pressure range ________________

Type of tower drive ____

System design capacity ____________ gpm, system operating pressure ____________ psi

Nozzle data, design:	Pivot				end
Sprinkler position number					
Manufacturer					
Model					
Type (spray, impact, etc.)					
Nozzle or orifice size					
Location					
Wetted diameter (ft)					
Nozzle discharge (gpm)					
Design pressure (psi)					
Operating pressure					

End gun make, model ____________________________________ (when continuously used in corners)

End gun capacity ___________ gpm, Pressure _____________ psi, boosted to ______________ psi

End swing lateral capacity __________________ gpm, pressure ____________________ psi

Field observations:

Crop uniformity ____

Runoff ____

Erosion ____

Tower rutting ____

System leaks ____

Elevation change between pivot and end tower _______________________________

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Wind: Speed _________________ mph Direction (from) ________________________

Line direction: From center to outer tower ______________________ moving _______________________

Time of day ______________ , Humidity: ________ low ______ med _______ high, Air temp ________________

Evaporation: start depth __________ inches, end depth ___________ inches, Evaporation ___________ inches

Crop _________________________, Root zone depth ________ foot, MAD[1/] ________ %, MAD ________ inches

Soil-water data (typical): (show location of sample site on soil map or sketch of field)

Moisture determiniation method ____

Soil series name, surface texture ____

Depth	Texture	*AWC (in)[1/]	*SWD (%)[1/]	*SWD (in)[1/]
	Totals			

Comments about soils:

____

____

____

____

Present irrigation practices:

Typical system application:

Crop	Stage of growth percent	Hours per [2/] revolution	Speed setting	Net application (in)

Hours operated per day ___________________ hours

Approximate number of pivot revolutions per season ___________________

1/ MAD = Management allowed depletion, AWC = Available water capacity, SWD = Soil water deficit

2/ To calculate the hours per revolution around the field, first calculate the average speed the end tower moves per cycle (start to start) = distance in feet divided by time in seconds.

Then: hours per revolution = $\frac{2\ (\text{distance to end tower in feet}) \times \pi}{(\text{end tower speed in ft/s}) \times 3{,}600\ \text{seconds per hour}}$

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

System data:

Distance from pivot point to : end tower ____________ ft, wetted edge ____________ ft

* End tower speed: Distance between stakes ________________

Time at first stake __________________, Time at second stake ____________________

Time to travel between stakes __________________ min

* This method is satisfactory for a continuous moving system, but need to allow for moving in start-stop cycles. Recommend using end tower move distance and from start to star. Typically, percent speed setting for end tower represents, 60% = 36 seconds of each minute, 72 seconds of each 2 minutes, etc.

Measured system flow rate ______________ gpm, method ___________________

Calculations: ____

Evaluation computations:

Circumference of end tower:

Distance to end tower x $\underset{(6.2832)}{2\pi}$ = ________________ x 6.2832 = _______________ ft

End tower speed:

$\frac{\text{Distance traveled (ft)}}{\text{Time in minutes}}$ x 60 = ______________ x 60 = _____________ ft/hr

Hours per revolution:

$\frac{\text{Circumference at end tower (ft)}}{\text{End tower speed (ft/hr)}}$ = ___________________ = __________ hr

Area irrigated:

$\frac{(\text{Distance to wetted edge})^2 \times \underset{(3.1416)}{\pi}}{43{,}560 \text{ square feet/acre}}$ = $\frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \times 3.1416}{43{,}560}$ = _______________ ac

Gross application per irrigation:

$\frac{\text{Hours per revolution x gpm}}{\text{435 x acres irrigated}}$ = $\frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{453 \text{ x } \quad \text{ac}}$ = ______________ in

Weighted system average application:

$\frac{\text{Sum of: catch x factors}}{\text{(Sum of: factors) x number of containers}}$ = _______________ = _________ cc (ml)

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Convert cc (ml) in measuring cylinder to inches depth in catch container:

_____________ cc (ml) = 1 inch in catch container

Average application = $\frac{\text{Average catch (cc)}}{\text{cc/inch}}$ = _________________ = _____________ in

Weighted low 1/4 average application:

$\frac{\text{Sum of low 1/4 catch x factors}}{\text{(Sum of low 1/4 factors) x number of low 1/4 containers}}$ = _____________ = ____________ cc (ml)

Low 1/4 average application = $\frac{\text{Average low 1/4 (cc)}}{\text{cc/inch}}$ = _______________ = _________ in

Distribution uniformity low 1/4 a (DU):

DU = $\frac{\text{Weighted low 1/4 average applic.}}{\text{Weighted system average application}}$ = _________________ = __________ %

Approximate Christiansen uniformity (CU):

CU = 100 - [0.63 x (100 - DU)] = 100 - [0.63 x (100 - _____________)] = __________%

Effective portion of water applied (R_e):

R_e = $\frac{\text{Weighted system average application (in)}}{\text{Gross applicaiton (in)}}$ = _____________ = _____________

Application efficiency of low 1/4 (E_q):

E_q = DU x R_e = ____________________________ = _____________ %

(Use for medium to high value crops)

Approximate application efficiency low 1/2 (E_h):

E_h = DU x R_e = ____________________________ = _____________ %

(Use for low value field and forage crops)

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Application:

$$\frac{\text{Gross application x hours operated per day x } (E_q \text{ or } E_h)}{\text{Hours per revolution x 100}}$$

= ____ = ________________ in/day

Maximum average application rate:

$$\frac{\text{Maximum catch inches x 60}}{\text{Time containers are uncovered in minutes}}$$ = _____________ = __________ in/hr

Pivot revolutions required t replace typical annual moisture deficit:

(Based on existing management procedures)

Annual net irrig. requirement ______________ in, for _________________________ (crop)

Pivot revolutions required:

$$\frac{\text{Annual net irrig. requirement x 100}}{(E_q \text{ or } E_h) \text{ x gross applic. per irrig.}}$$ = _______________________ = ______________

Potential water and cost savings

Present management::
Gross applied per year = gross applied per irrig x number of irrig

= ______________________________ = _______________ in/yr

Potential management:
Potential application efficiency (E_{pq} or E_{ph}) _____________ percent (from irrigation guide, NEH Sec 15, Ch 11, or other source)

Potential annual gross applied = $\frac{\text{Annual net irrig. requirement x 100}}{\text{Potential } E_{pq} \text{ or } E_{ph}}$

= _______________________________ = _____________ inches

Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Total annual water conserved:

$$= \frac{(\text{Present gross applied - potential gross applied}) \times \text{area irrig. (acre)}}{12}$$

$$= \frac{\rule{6cm}{0.4pt}}{12} = \rule{3cm}{0.4pt} \text{ acre feet}$$

Cost savings:

Pumping plant efficiency ____________ kind of fuel ___________________

Cost per unit of fuel ______________ fuel cost per acre foot $ ________________

Cost savings = fuel cost per acre foot x acre foot conserved per year

= _____________________________ = $ ____________________

Water purchase cost:

= Cost per acre foot x acre feet saved per year = ______________________

= $ ___________________

Cost savings = pumping cost + water cost = _________________ = $ ________________

Recommendations:

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Sprinkler Irrigation System
Detailed Evaluation Center Pivot Lateral Worksheet

Container spacing ____________________ feet

Container		Catch	Catch (cc)	Catch
No.	Factor	(cc)	x Factor	(in)
1	1			
2	2			
3	3			
4	4			
5	5			
6	6			
7	7			
8	8			
9	9			
10	10			
11	11			
12	12			
13	13			
14	14			
15	15			
16	16			
17	17			
18	18			
19	19			
20	20			
21	21			
22	22			
23	23			
24	24			
25	25			
26	26			
27	27			
28	28			
29	29			
30	30			
31	31			
32	32			
33	33			
34	34			
35	35			
36	36			
37	37			
38	38			
39	39			
40	40			
41	41			
42	42			
43	43			
44	44			
45	45			
46	46			
47	47			

Container		Catch	Catch (cc)	Catch
No.	Factor	(cc)	x Factor	(in)
48	48			
49	49			
50	50			
51	51			
52	52			
53	53			
54	54			
55	55			
56	56			
57	57			
58	58			
59	59			
60	60			
61	61			
62	62			
63	63			
64	64			
65	65			
66	66			
67	67			
68	68			
69	69			
70	70			

Sum ________ __________

Low 1/4 summation:

Sum ________ __________

Max application rate data (5 minute catch)

1				
2				
3				
4				
5				

Max. rate = $\frac{\text{max. catch (in) x 60}}{\text{5 minutes}}$ = __________ inches/hour

Center pivot lateral evaluation, distribution profile of catch

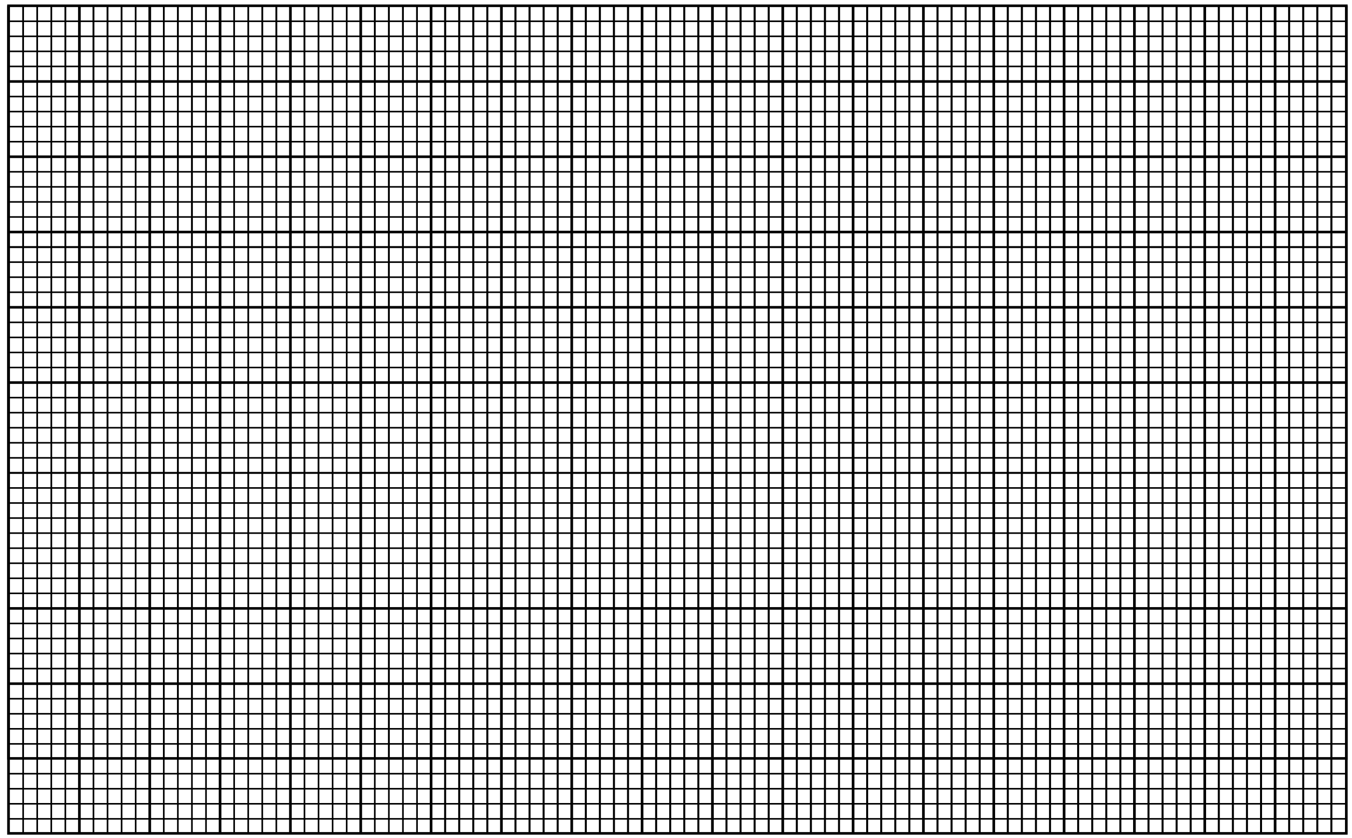
E_h = ______________

E_q = ______________

Land user ______________________

Date ___________________________

Field office ____________________



Container catch (inches)

Container number

Sprinkler Irrigation System
Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Land user ______________________________ Date ________________ Prepared by _____________________________

District ____________________ County ___________________________Eng job class _______________________

Irrigation system hardware inventory:

Sprinkler gun make ______________________, model __________________, nozzle type ___________________________

Nozzle: size________________ inches, ________________ mm

Manufacturer rated discharge, ______________ gpm at _______________ psi giving _____________ ft wetted diameter

Hose: length, _____________________ ft, diameter ________________ inches

Towpath: spacing ____________________ ft

Elevation difference between first and last location on towpath (+/-) ________________ ft or _________________ % slope

Gun: height _____________________ ft

Mainline: material ____ diameter _________________________ inches

Field observations:

Crop uniformity ____

Water runoff ____

Erosion ____

System leaks ____

Wind drift ____

Other observations ____

____

____

Field data inventory and computations:

Crop _______________________, root zone depth ________ ft, MAD 1/ _________%, MAD 1/ ______________ inches

Soil-water data (typical):

(Show locations of sample on soil map or sketch of field)

Moisture determination method ____

Soil series and surface texture ____

Depth	Texture	AWC (in) 1/	SWD (%) 1/	SWD (in) 1/
	Totals			

Comments about soils and soil condition: ____

____

____

____

1/ MAD = Management Allowable depletion, AWC = Available water capacity, SWD = Soil water deficit

Sprinkler Irrigation System
Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Present irrigation practices:

Typical irrigation duration _____________ hr, irrigation frequency _______________ days

Typical number of irrigations per year __________________

Test:

Start ______________, Stop ______________, Duration _______________ = __________ hour

Atmospheric data;

Wind: Direction: Initial ______________, during _______________, final ______________

Speed (mph): Initial _______________, during _______________, final ______________

Temperature: initial __________ final _________, humidity: _________ low _____ med _____ high

Evaporation container: initial _____________, final _____________, loss ____________ inches

Pressure: ____________________ psi, at start of test

____________________ psi, at end of test

Measured flow into the system _______________________gpm

Sprinkler travel speed:

at beginning	________ ft	________ min =	_________ ft/min
at test site	________ ft	________ min =	_________ ft/min
at terminal end	________ ft	________ min =	_________ ft/min
average			_________ ft/min

Calculations:

Gross average depth of water applied = $\dfrac{\text{(gun discharge, gpm) x (1.605)}}{\text{(tow path spacing, ft) x (travel speed, ft/min)}}$

$= \dfrac{(\qquad \text{gpm) x (1.605)}}{(\qquad \text{ft) x (}\qquad \text{ft/min)}}$ = ___________________ in

Average overlapped catches

System = $\dfrac{\text{(sum all catch totals}\qquad\text{in)}}{\text{(number of totals \_\_\_\_\_\_\_\_\_\_\_\_\_)}}$ = ____________ in

Low 1/4 = $\dfrac{\text{(sum of low 1/4 catch totals}\qquad\text{in)}}{\text{(number of low 1/4 catches \_\_\_\_\_\_\_\_\_)}}$ = ___________ in

Average application rate = $\dfrac{\text{(Flow, gpm) x (13,624)}}{\text{(tow path spacing, ft) x (wet sector, deg.)}}$

$= \dfrac{(\qquad \text{gpm) x (13,624)}}{(\qquad \text{ft) x (}\qquad \text{deg)}}$ = ___________ in/hr

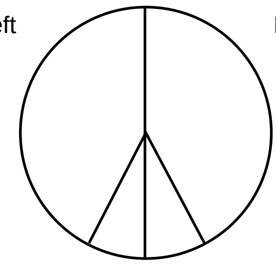
Maximum application rate = (average application rate, in/hr) x (1.5)

Sprinkler Irrigation System
Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Container test data

Catch can type ___________, ___________ cc (mL)/in

Left Right



Note part circle operation
and the dry wedge size in degrees

Towpath
and travel
direction

← 4, 3, 2, 1 Container catch row 1, 2, 3, 4 →

Path spacing (ft)	Container catch volume				Right plus left side catch totals	
	Left side of path		Right side of path			
	Catch no.	**Catch (mL)**	**Catch no.**	**Catch (mL)**	**mL**	**inches**
330	1		33			
320	2		32			
310	3		31			
300	4		30			
290	5		29			
280	6		28			
270	7		27			
260	8		26			
250	9		25			
240	10		24			
230	11		23			
220	12		22			
210	13		21			
200	14		20			
190	15		19			
180	16		18			
170	17		17			
160	18		16			
150	19		15			
140	20		14			
130	21		13			
120	22		12			
110	23		11			
100	24		10			
90	25		9			
80	26		8			
70	27		7			
60	28		6			
50	29		5			
40	30		4			
30	31		3			
20	32		2			
10	33		1			

Sum of all catch totals ___________________

Sum of low 1/4 catch totals _______________

Sprinkler Irrigation System
Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Potential water and cost savings:

Present management:

Gross applied per year = (Gross applied per irrigation) x (number of irrigation) = ____________ in/yr

+ (__________ in) x (___________) = _______________ in/yr

Potential management:

Annual net irrigation requirement ______________________ in/yr, for ________________________ (crop)

Potential application efficiency (E_q or E_h) ____________ % (estimated at 55 - 65%)

Potential annual gross applied = $\left(\dfrac{\text{annual net irrigation requirement}}{\text{Potential } E_q \text{ or } E_h}\right)$ x 100 = _____________ in

= (________in) x 100 = _________________ inches

Total annual water conserved

= $\left(\dfrac{\text{Present gross applied, inches - potential gross applied, inches}}{12}\right)$ x (area irrigated, ac) = _________ ac/ft

= $\dfrac{(\quad\quad \text{in}) - (\quad\quad \text{in}) \times (\quad\quad \text{ac})}{12}$ = _________________ ac-ft

Cost savings:

Pumping plant efficiency ____________________ kind of energy ___________________

Cost per unit of energy $ ____________________ energy cost per ac-ft $ _____________

Cost savings = (energy cost per ac-ft) x (ac-ft conserved per year) = $ __________

= (____________) x (____________) = $ ____________

Water purchase cost:

= (Cost per ac-ft) x (ac-ft saved per year) = $ ______________ x ____________ = $ _____________

Cost savings:

= Pumping cost + water cost = __________ + __________ = $ ____________

Example - Sprinkler Irrigation System
Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Recommendations:

U.S. Department of Agriculture
Natural Resources Conservation Service

Micro Irrigation System
Detailed Evaluation Worksheet

Land user ________________________________ Date __________________ Prepared by ______________________________

District ___________________________________ County ____

Crop: __________________________ age _____________ plant and row spacing ______________________________________

Soil: mapping unit _________________________________ surface texture ____

actual depth ____AWC _______________________ inches/feet

Irrigation: duration ____________ frequency ____________ MAD ___________% ____________ inches/feet

Irrigation system hardware:

Filter: pressure at: inlet ___________ psi, outlet _____________ psi, loss _____________ psi

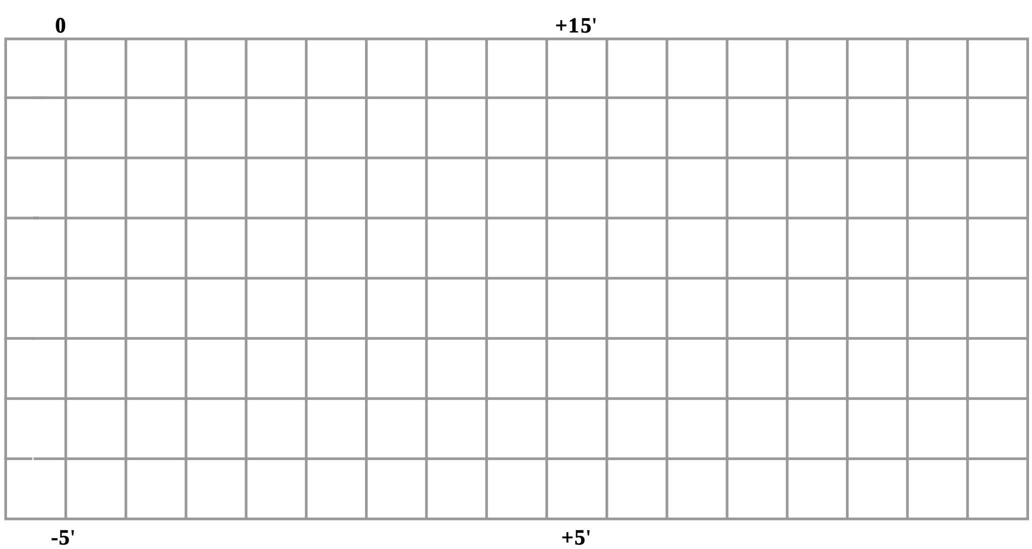
Emitter: manufacturer _______________ type _________________ spacing _________________

Rated discharge per emitter (emission point): _______________________gph at _____________________ psi

Emission points per plant ______________ giving __________________ gallons per plant per day

Later: diameter: ___________________ material ________________ length _______________ spacing _____________

Sketch of micro irrigation system layout:



Micro Irrigation System
Detailed Evaluation Worksheet

System discharge: _____________ gpm, number of manifolds ___________ and blocks ___________

Average test manifold emission point discharges at _____________________ psi

Manifold = $\frac{\text{(sum of all averages} \quad \text{gph)}}{\text{(number of averages} \quad)}$ = _________________ gph

Low 1/4 = $\frac{\text{(sum of low 1/4 averages} \quad \text{gph)}}{\text{(number of low 1/4 averages} \quad)}$ = __________________ gph

Adjusted average emission point discharges at ____________________ psi

System = (DCF _______________) x (manifold average ____________) = ____________ gph

Low 1/4 = (DCF ______________) x (manifold low 1/4 _____________) = _____________ gph

Discharge test volume collected in _____________ minutes (1.0 gph = 63 ML/min)

Outlet location on lateral		**Lateral location on the manifold**							
		inlet end		1/3 down		2/3 down		far end	
		mL	gph	mL	gph	mL	gph	mL	gph
inlet end	A								
	B								
	ave								
1/3 down	A								
	B								
	ave								
2/3 down	A								
	B								
	ave								
far end	A								
	B								
	ave								

Micro Irrigation System
Detailed Evaluation Worksheet (cont.)

Lateral: inlet pressure ______ psi ______ psi ______ psi ______ psi

far end pressure ______ psi ______ psi ______ psi ______ psi

Wetted area per plant ______ ft^2 ______ ft^2 ______ ft^2 ______ ft^2

______ % ______ % ______ % ______ %

Estimated average SMD in wetted soil volume ______________________________________

Minimum lateral inlet pressures, MLIP, on all operating, manifolds:

Manifold ID: Test _______ _______ _______ _______ _______ _______ _______ _______ Ave.

pressure, psi _______ _______ _______ _______ _______ _______ _______ _______ _______ _______

Discharge correction factor, DCF, for the system is:

DCF = 2.5 x (average MLIP psi) / (average MLIP ___________ psi + (1.5 x test MLIP ___________ psi) = ___________ psi

or if the emitter discharge exponent, x = ___________ is known,

DCF = (average MLIP psi) / (test MLIP psi) x ------- = ____________ psi

Comments: ____

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Pumping Plant Detailed Evaluation Worksheet

Land user ______________________________________ Field office ________________________________

Observer ______________________ Date ______________ Checked by ______________ Date ____________

Field name or number _______________________________________ Acres irrigated ____________________

Hardware Inventory:

Power plant:

Electric motor(s):	Main pump	Booster (if used)
Make		
Model		
Rated rpm		
Rated hp		

Internal combustion engine:

Make ____

Model ____

Continuous rated hp at output shaft ______________________ hp at ______________________ rpm

Comments about condition of power plant ____

____

Gear or belt drive mechanism:

Type: (check one) direct drive __________ gear drive ____________ belt drive _____________

______________________ rpm at driver __________________________________ rpm at pump

Pumps		
Type: (centrifugal, turbine, submers.)		
Make		
Model		
Impeller diameter		
Number of impellers		
Rated flow rate (gpm)		
at head of (ft)		
at rpm		

Pump curves: Attached _____________________ (yes or no)

Comments about conditon of equipment ____

____

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Pumping Plant Detailed Evaluation Worksheet

Land user ____ Field office ______________________________________

Existing suction or turbine column set-up (sketch showing dimensions)

Existing discharge set-up (sketch showing dimensions)

Data and computations:

Total Dynamic Head (TDH):

Elevation difference - water surface to pump outlet _________________ feet

Pressure reading at pump outlet ____________________ psi

Pressure at pump inlet (where supply is pressurized) ___________________ psi

Estimated friction loss in suction pipe or pump column ________________ feet

Miscellaneous friction loss __________________ feet

TDH = (elevation difference between water source and pump discharge) + (discharge pressure - pressure at inlet) times 2.31 + (estimated suction pipe friction loss) + miscellaneous =

____ = _________________ feet

Flow rate:

Flow meter:

Flow rate = _______________________ gpm

Velocity meter:

Pipe ID ___________________ inches

Velocity ___________________ feet/second

Flow rate, Q, in gpm = (Velocity, in feet/second) x (2.45) x (pipe ID^2) =

= _______________________________________ = __________________ gpm

Pumping Plant Detailed Evaluation Worksheet

Land user ____ Field office ____________________________________

Water horsepower:

whp = $\frac{\text{(flow rate, in gpm) x (TDH, in feet)}}{3960}$ = _______________________________ = ______________ hp

Energy input

Electric:

Disk revolutions _____________________

Time: min ___________ sec ____________ = _____________ sec

Meter constant (Kh) ___________________________________

PTR (power transformer ratio - usually 1.0)1/ _____________________

CTR (current transformer ratio - usually 1.0)1/ ___________________

KW = $\frac{\text{(3.6) x (disk rev) x (Kh) x (PTR) x (CTR)}}{\text{(time, in seconds)}}$ = ________________________________ = _________(kwh/h)

Diesel or gasoline:

Evaluation time: hours ____________ minutes____________ = ______________ hours

Fuel use _____________ gallons (a small quantity of fuel may also be weighed, at 7.05 lb/gal for diesel and 6.0 lb/gallon for gasoline)

$\frac{\text{(fuel use, in gallons)}}{\text{(time, in hours)}}$ = _____________________________________ = _______________ gallons/hour

Propane:

Evaluation time: hours ________ minutes ______________ = _______________ hours

Fuel use ________________ lb (weigh fuel used from small portable tank)

$\frac{\text{(fuel use, in lb)}}{\text{(4.25 lb/gal) x (time, in hr)}}$ = ___________________________________ = ___________ gallon/hours

Natural gas:

Evaluation time: hours ________ minutes ______________ = _______________ hours

Meter reading: End __________________ minus Start _____________________ = __________________ mcf

$\frac{\text{(fuel used, in mcf)}}{\text{(time, in hr)}}$ = ________________________________ = ___________________ mcf/hr

1/ Some power companies use a type of meter that requires a PTR or CTR correction factor. Check with local power company.

Pumping Plant Detailed Evaluation Worksheet

Land user ____ Field office ________________________________

In the next step, the efficiency of the power plant and pump, as a unit, is compared to the Nebraska Standards for irrigation pumping plants. The Nebraska standard for a good condition, properly operated plant. If the comparison comes out less than 100%, there is room for improvement.

Nebraska performance rating:

Nebraska pumping plant performance criteria ____

Pump and Power Plant

Energy source	Whp-h/unit of energy	Energy unit
Diesel	12.5	gallon
Propane	6.89	gallon
Natural gas	61.7	mcf
Electricity	0.885	kW=kwh/hr
Gasoline	8.66	gallon

The Nebraska standards assume 75% pump and 88% electric motor efficiency.

Percent of Nebraska performance rating

$$= \frac{(\text{whp}) \times (100)}{(\text{energy input}) \times (\text{Nebraska criteria, in whp-h/unit})} =$$

= ____ = _______________ %

Horsepower input:

Electric:

$$\frac{(\text{input kW})}{(0.746\ \text{kW/bhp})} =$$ ________________________ = ___________ bhp

Diesel:

(16.66) x (energy input, in gal/hr) = __________________________ = ____________ bhp

Propane:

(9.20) x (energy input, in gal/hr) = ___________________________ = ____________ bhp

Natural gas:

(82.20) x (energy input, in mcf/hr) = __________________________ = ____________ bhp

Pumping Plant Detailed Evaluation Worksheet

Land user ____ Field office ____________________________________

Pumping plant efficiency:

$$E_{pp} = \frac{(\text{water horsepower output, whp}) \times (100)}{(\text{brake horsepower input, bhp})} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_ \%$$

Energy cost per acre-foot:

Fuel cost per unit __________________ $/kW-hr, or $/gal, or $/mcf

$$\text{Cost, in \$/ac-ft} = \frac{(5431) \times (\text{fuel cost, in \$/unit}) \times (\text{energy input, in kW, gal/hr, or mcf/hr})}{(\text{flow rate, in gpm})}$$

= ____ = $ _____________/acre-foot

Recommendations:

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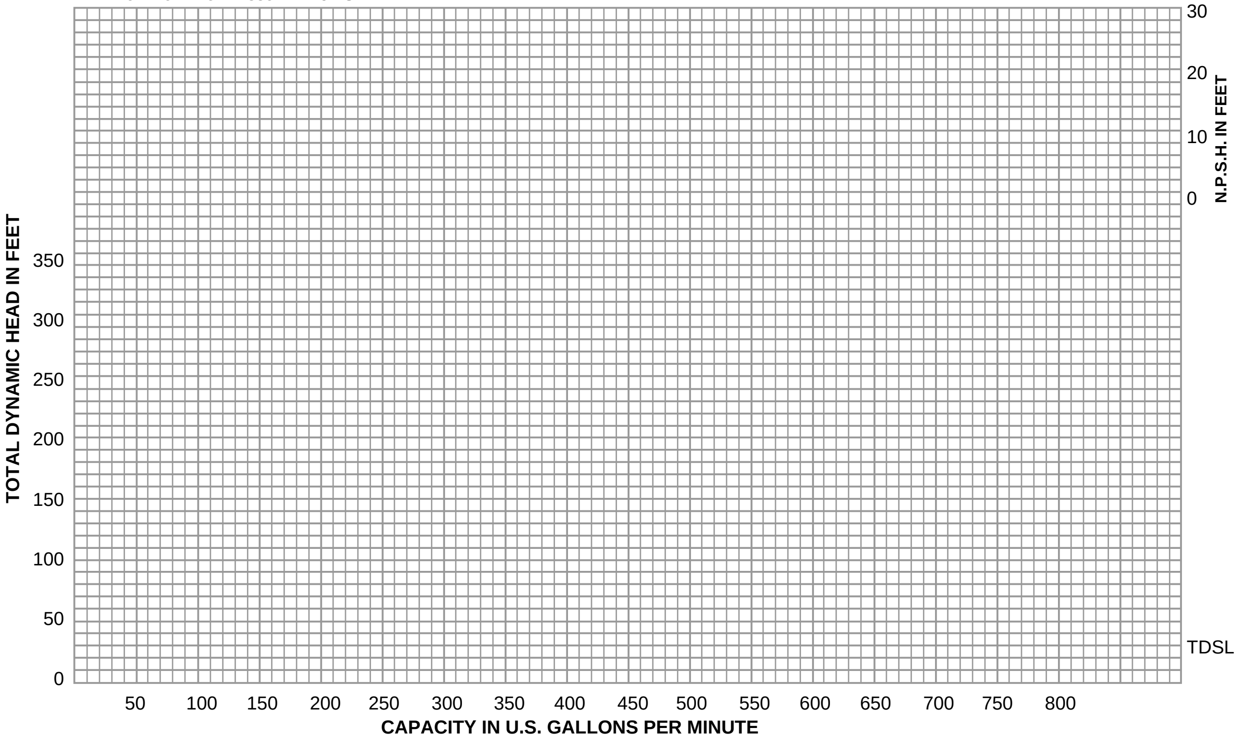
Pump performance curve

Case: Material C.I. Patt. No. H-689 Mach. No. H-689 3600 NOMINAL R.P.M. 60 Cycles

Impeller: Material BRZ Patt. No. M-3380 Mach. No. M-3380 Dia. 9" FULL T.D.B.L. for fresh water at sea level 80° F max. M-1 ☐ M-2 ☐

MAXIMUM WORKING PRESSURE 215 PSI



Based on T-3184 Superaades C-5006 Dated 10-30-64 Date 5-19-71 MODEL **B3ZPL**

U.S. Department of Agriculture
Natural Resources Conservation Service

NRCS-SOILS-2328
Rev. 5-96
File Code Soils-11

Soil Description

Soil		**File No.**
Area	**Date**	**Stop No.**
Classification		
Location		
N. veg. (or crop)		**Climate**
Parent material		
Physiography		
Relief	**Drainage**	**Salt or alkali**
Elevation	**Gr. water**	**Stoniness**
Slope	**Moisture**	
Aspect	**Root distrib.**	**% Clay***
Erosion	**% Coarse fragments***	**% Coarser than V.F.S.***
Permeability		
Additional notes		

***Control section average**

Hori-zon	Depth	Color		Texture	Struc-ture	Color			Reac-tion	Boun-dary	Effer-vesc-ence	Roots	Pore	Line
		Dry	Moist			Dry	Moist	Wet						

U.S. Department of Agriculture
Natural Resources Conservation Service

Cylinder Infiltrometer Test Data

NRCS-ENG-322
05-96

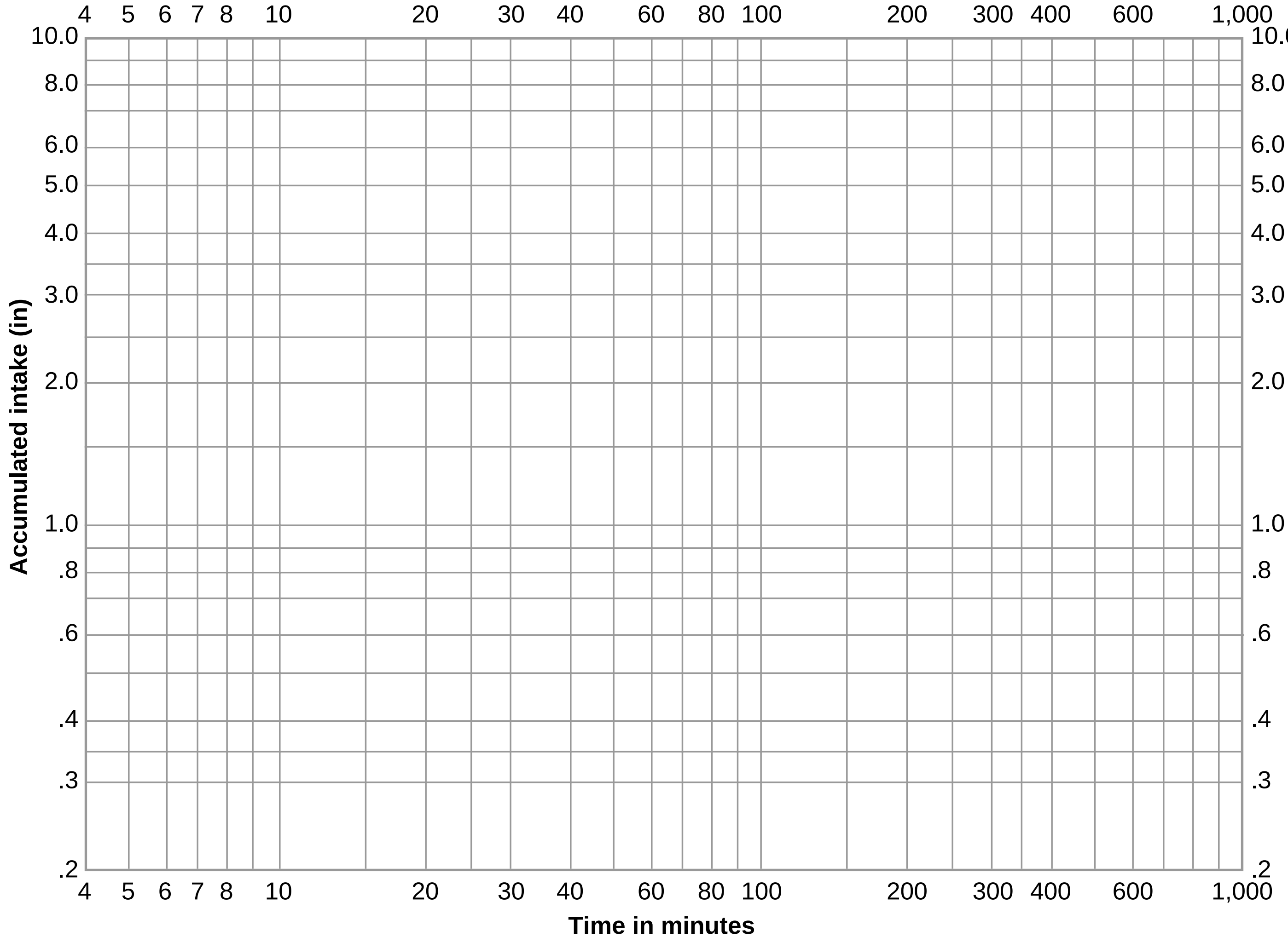
FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	
Min.		Inches			Inches			Inches			Inches			Inches		

Land user ____________________
Date ________________________
Field office __________________

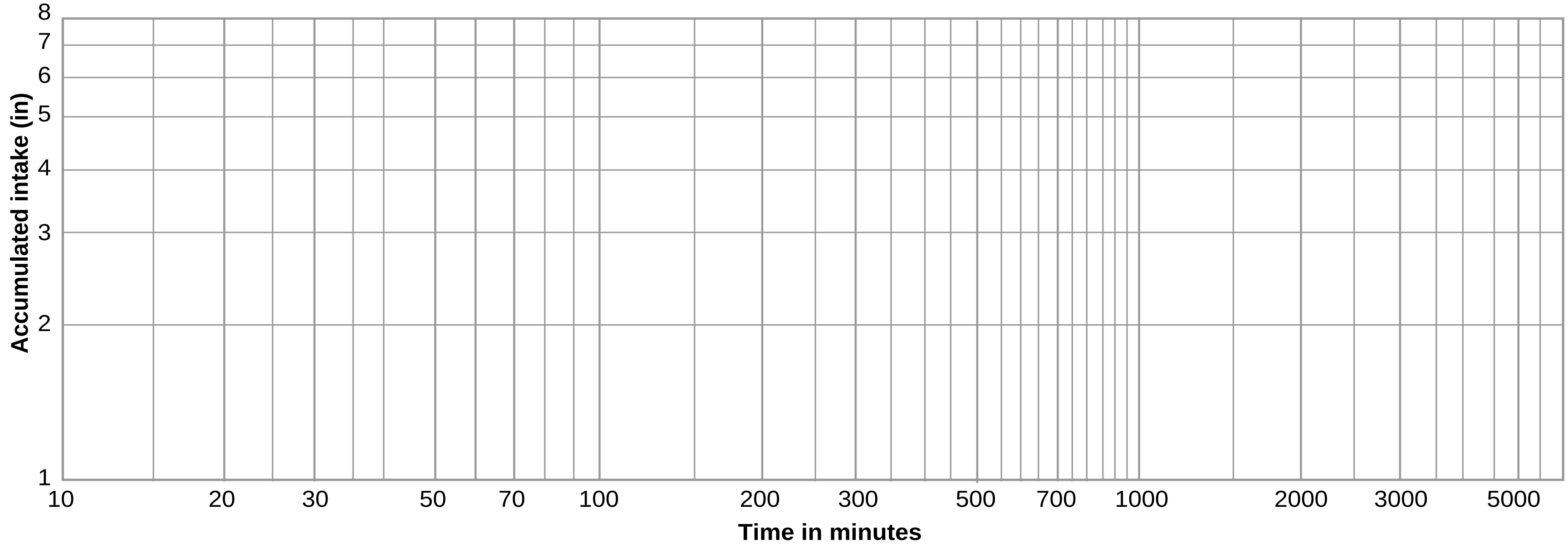
Soil water intake curves



Land user ______________________
Date ___________________________
Field office _____________________

Intake curve overlay

(Clear plastic overlay is available through NRCS State Office)



Intake Grouping for Border Irrigation Design

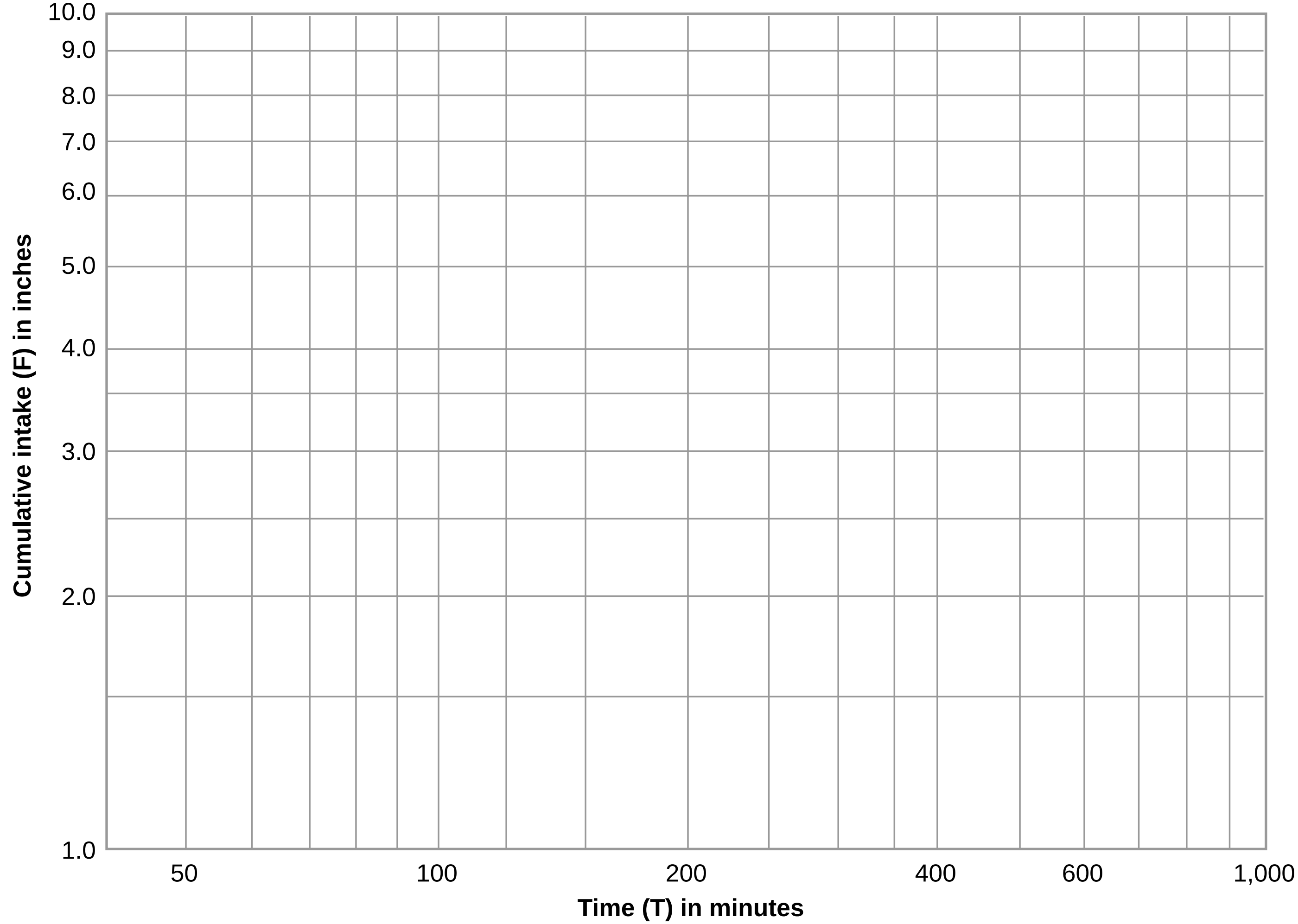
Instructions

1. Plot data from cylinder intake test on matching logarithmic paper using accumulated intake (inches) as ordinates and elapsed time (minutes) as abscissas. Draw line representing test results.

2. Place overlay over plotted curve, matching the intersection of the lines for 10 minutes time and 1 inch intake. Select the intake family that best represents the plotted curve within the normal irrigation range.

Land user ______________________
Date ___________________________
Field office _____________________

Accumulated intake vs. time

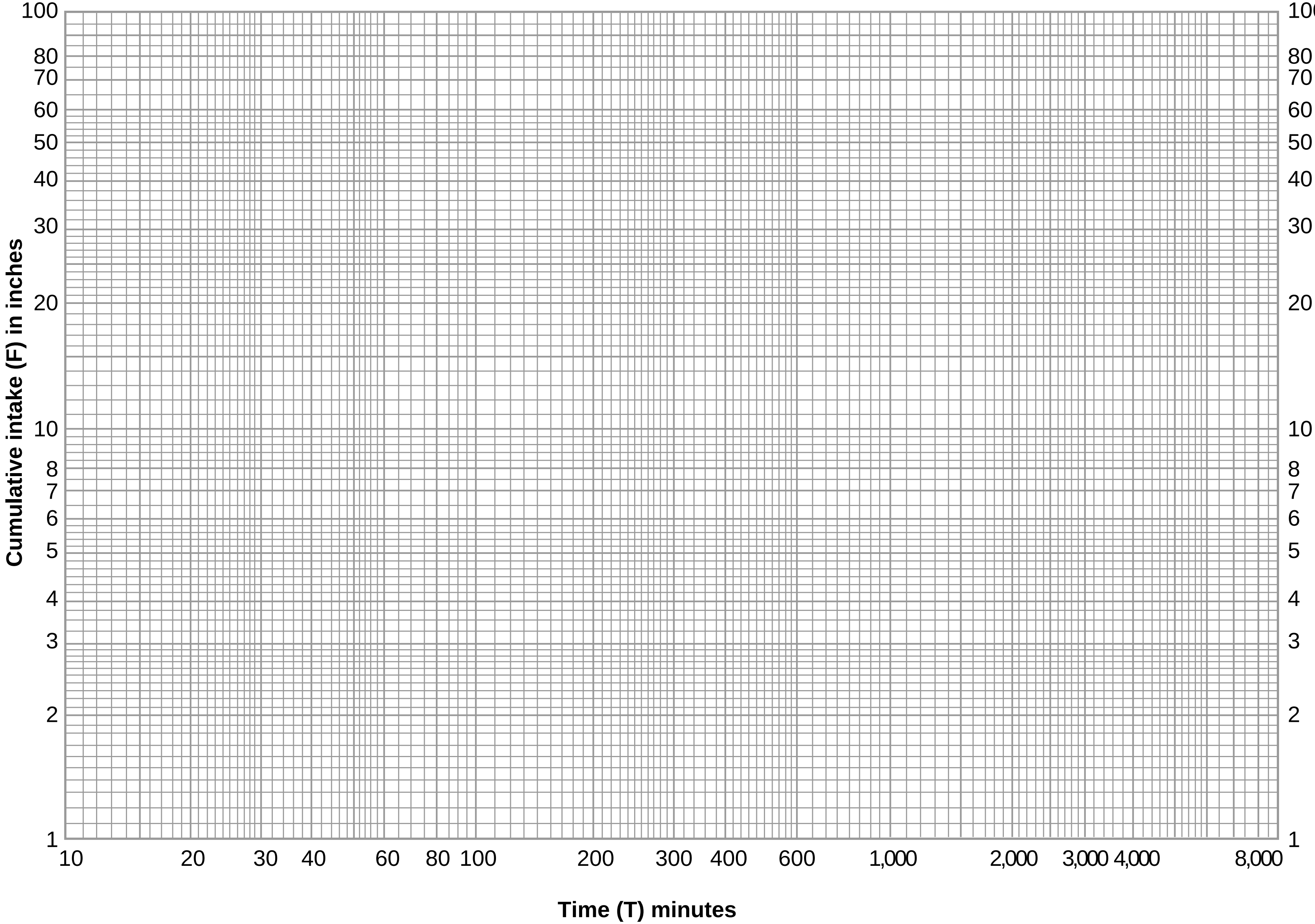


Land user ____________________

Date ________________________

Field office __________________

Intake families as used with furrow irrigation



Natural
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Estimating Soil Moisture by Feel and Appearance

Irrigation Water Management (IWM) is applying water according to crop needs in an amount that can be stored in the plant zone of the soil.

The feel and appearance method is one of several irrigation scheduling methods used in IWM. It is a way of monitoring soil moisture to determine when to irrigate and how much water to apply. Applying too much water may cause excessive runoff and/or deep percolation. As a result, nutrients and chemicals may be lost or leached into the ground water.

In applying this method, you determine the amount of irrigation water needed by subtracting water in soil storage (estimated using the feel and appearance method) from the available water capacity (AWC) of the soil. (See the example computation below.)

The feel and appearance of soil varies with texture and moisture content. Water available for plant use can be estimated, with experience, to an accuracy of about 5 percent. Soil moisture is typically sampled in 1-foot increments to the root depth of the crop at three or more sites per field. You vary the number of sample sites and depths according to: crop, field size, soil texture, and soil stratification. For each sample the feel and appearance method involves:

1. Obtaining a soil sample at the selected depth using a probe, auger, or shovel;
2. Squeezing the soil sample firmly in your hand several times to form an irregularly shaped ball;
3. Observing soil texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color;
4. Comparing observations with photographs and/or chart to estimate percent water available. (Note: A very weak ball disintegrates with one bounce of the hand. A weak ball disintegrates with 2 to 3 bounces.)

Example for a uniform soil

Sample depth (inches)	Zone (inches)	USDA texture	Field capacity* (percent)	AWC for layer (inches)	Water available (inches)	Water need (inches)
6	0-12	sandy loam	30	1.4	.42	.98
18	12-24	sandy loam	45	1.4	.63	.77
30	24-36	loam	60	2.0	1.20	.80
42	36-48	loam	75	2.0	1.50	.50
				6.8	3.75	3.05

* Determined by feel and appearance method

Summary of estimation

	(inches)
AWC in 48” root zone at 100% field capacity	6.8
Actual water available for plant use	3.7
Net irrigation requirement or need	3.1

Fine sand and loamy fine sand soils

Appearance of fine sand and loamy fine sand soils at various soil moisture conditions.
Available water capacity ....0.6–1.2 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, will hold together if not disturbed, loose sand grains on fingers.	
25-50	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers.	
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, light uneven water staining on fingers.	
75-100	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.	
100 (field capacity)	Wet, forms a weak ball, light to heavy soil/water coating on fingers, wet outline of soft ball remains on hand.	

Sandy loam and fine sandy loam soils

Appearance of sandy loam and fine sandy loam soils at various soil moisture conditions.
Available Water Capacity .... 1.3–1.7 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, forms a very weak ball, aggregated soil grains break away easily from ball.	
25-50	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers.	
50-75	Moist, forms a ball with defined finger marks, very light soil/water staining on fingers, darkened color, will not slick.	
75-100	Wet, forms a ball with wet outline left on hand, light to medium staining on fingers, makes a weak ribbon.	
100 (field capacity)	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers.	

Sandy clay loam and loam soils

Appearance of sandy clay loam and loam soils at various soil moisture conditions.
Available Water Capacity..1.5–2.1 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, soil aggregations break away easily, no staining on fingers, clods crumble with applied pressure.	
25-50	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.	
50-75	Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon.	
75-100	Wet, forms a ball with well defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.	
100 (field capacity)	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, thick soil/water coating on fingers.	

Clay, clay loam and silty clay loam soils

Appearance of clay, clay loam and silty clay loam soils at various soil moisture conditions.
Available Water Capacity...1.6–2.4 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, soil aggregations separate easily, clods are hard to crumble with applied pressure.	
25-50	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.	
50-75	Moist, forms a smooth ball with defined finger marks, light staining on fingers, ribbons between thumb and forefinger.	
75-100	Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily.	
100 (field capacity)	Wet, forms a soft ball, free water appears on soil after squeezing or shaking, thick soil/water coating on fingers, slick and sticky.	

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