

Natural Resources Conservation Service National Engineering Handbook

Irrigation Guide

	Part 652 Irrigation Guide
Issued September 1997	

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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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Resource Planning and Evaluation Tools and Worksheets

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652.1505 Estimating Soil Moisture by Feel and Appearance

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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.

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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.

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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

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Chapter 15	Resource Planning and Evaluation Tools and Worksheets	Part 652 Irrigation Guide

652.1504 Blank worksheets

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Irrigation Planning Worksheet

OWNER/OPERATOR FIELD OFFICE													
JOB DESCRIPTION													
LOCATION													
ASSISTED BY						DATE	Ε						
Soil—Data for limiting	soil												
Soil series	Percent of area	1 ft	2	C ft	I	ve AWC	4 f	t	5 ft		Depth to restrictive	Intal	
	(%)	(in)		n)		in)	(in)	(in)		layer ¹	max.	ate
¹ Actual observed depth in	the field												
Maximum time betwee	n irrigatioi	ns for any m		em base	d on p			roploor	mont			Maxim	num
Crop		Management root zone	Total AWC		MAD		Maximum net replacement				ak daily op ET	irrigat	tion
		(ft)	(in)	perce (in		(in/d)) (da		days)		(in/d)	freque (day	-
Minimum system flow	requireme		f irrigation app			<u> </u>				Minim	um system	flow require	ment
System description		Net	Efficiency	Gro	ss	Peak d	· ·		. irrig. uency		total		
		(F _n) (in)	(%)	(F _g)		(in/d)		(da		(9	gpm)	(ft ³ /s)
Minimum dependable fl	low availah	le to system				gpm	ı, ft ³ /s. i	nches. e	etc.				
Total irrigated area						•							
Total illigated alea		aues.	i otal opei	aung 110	ura pel	uay			·				

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.

	Acres	Monthly crop evapotranspiration - ET _C							
Crop	(ac)	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	d monthly	crop	ET,	inches.
-------------------------	-----------	------	-----	---------

² Calculated volume of water needed monthly crop ET = ac x ET _C =	acre-inches
---	-------------

$$ET_d = 0.034 ET_m^{1.09} F_n^{-0.09}$$

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

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:

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Irrigation System Inventory Worksheet

OWNER/OPERATOR _					FIELD OF	FICE		
JOB DESCRIPTION _								
LOCATION								
ASSISTED BY					DATE _			
		(Collect and fill	out onl	y portions of thi	s form that	t apply and are r	oodod)	
A constitution to the			out on	y portions of thi	S IOIIII LIIA	t apply and are i	ieeueu)	
Area irrigated		acres						
Crops								
Crops now grown								
Typical planting da	ate							
Typical harvest da	te							
Typical yield (unit)		()	()		()	()
Age of planting								
Cultivation and oth	ner cultural pra	ctices						
Water								
Water source(s)								
irrigation organiza	tion							
Water available (ft		iners inches, mg	/da)					
Seasonal total wat								
Water availability	<u> </u>	continuous		demand		rotatio	on	fixed schedule
Typical water avai	lability times (s	chedule and ord	dering pr	ocedure)				
	<u> </u>			·				
Method of determ	ining when and	d how much to iri	rigate:					
Is flow measuring	device mainta	ined and used?						
Method of measur	ing water flow	rate						
Water quality:	Sediment				Debris, m	OSS		
	Electrical cond	luctivity		mmhos/cm	SAR			
Comments		•						

Example Irrigation System Inventory Worksheet—Continued

NAME		DATE	PREP#	ARED BY	
Soils (principal soil in	field)				
Soil # 1					
Map symbol		Soil series & surface to	exture		
Percentage of field (%	s)	Area (acres)			
Depth	Texture		AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table of	or restrictive layer 1				
Intake family/intake g		n rate			
Comments	тоць/плах аррпсацої	- I late			
Soil # 2					
Map symbol		Soil series & surface to	exture		
Percentage of field (%		Area (acres)		AWC (in)	Cum ANC (in)
Depth	Texture		AWC (in/in)	AVVC (III)	Cum AWC (in)
Depth to water table of	r restrictive laver 1				
Intake family/intake g		n rate			
Comments					
Soil # 3					
Map symbol	1	Soil series & surface to			
Percentage of field	(%)	Area (acres)	<u> </u>		
Depth	(%) Texture	Alea (acres)	AWC (in/in)	AWC (in)	Cum AWC (in)
2 optii	Toxicio				,
Depth to water table of	or restrictive layer 1			1	'
Intake family/intake g	roup/max application	n rate			
Comments					

¹ If restrictive for root development or water movement

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	Irrigation Systen	n Inventory Wo	orksheet— <i>Continued</i>	
NAME	DA	ATE	PREPARED BY	
Water supply and distributed Supply system to field (earth distributed)		pipeline, etc.):		
Туре				
Size				
Capacity (ft ³ /sec, gpm, mine	rs inches, mgal/day)			
Pressure/Elevation at head o	f field or turnout	(lb/in ²)	(ft)	
System condition				
Estimated conveyance efficie	ency of supply system (%)		
In-field distribution system (ear	th or lined ditch, buried	pipe, surface portal	ole pipe, lay flat tubing):	
Туре				
Size				
Capacity				
Total available static head (g	gravity) (ft)			
System condition				
Estimated efflciency of delive	ery system (%)			
Comments				
Water application system Existing sprinkler system (at		tem evaluation. if av	ailable):	
Type system (center pivot, si	dewheel-roll, hand mov	ve, traveler, big gun		
Manufacturer name and mod	lel			
Tower spacing (pivot or linea	ır) (ft)		End gun (pivot)?	
Wheel size (sidewheel-roll) d	liameter			
Type of drive				
Pressure at lateral entrance	(first head) (lb/in ²)			
Mainline diameter/length				

Along lateral Between sets

by

(lb/in²)

Lateral diameter/length Lateral spacing (S₁)

Sprinkler make/model Nozzle size(s)

Design nozzle pressure

(Attach sprinkler head data for pivot) Maximum elevation difference:

Sprinkler head spacing (S_m)

type

Wetted diameter (ft)

Irrigation System Inventory Worksheet—Continued

NAME		D/	ATE	P	PREPARED BY		
Existing surface	e system (attach	n system evaluatio	n if availabl	e)			
Type of system	(graded border, le	evel border, grade	d furrow, lev	vel furrow, contour leve	ee, contour ditch, wi	ld flooding)	
Leveled fields:	Field slope: I	n direction of irrigation	ation	ft/ft			
	Cross slope		ft/ft				
Smoothness:	Rough	Smooth	☐ Ve	ery smooth	Laser equipmen	nt used yes	no
Border or levee v	width	ft	Furrow/co	rrugation/rill spacing		in	
Length of run:	Minimum		ft	Maximum	ft	Average	ft
Number of furrov	vs or borders per	set		1		-	
Border or levee of	dike heights						
Application efficient	ency, low 1/4 (Eq)		% (Estimated or	attach evaluation)		
General mainten	ance of system						
Drainage, tail wa	ater reuse faci	litv					
		of field runoff (ta	ilwater pred	cinitation)			
Wichied for collect	and diopoodi	or nota ration (ta	mator, proc	ipitation)			
Final destination	of rupoff water						
		.m					
Surface/subsurface	ce diamage syste	;					
Environmental im	anacta of existing	drainaga avatam					
Environmental im	ipacts of existing	drainage system					
xisting micro ir	rigation syste	m (Attach design	or system e	valuation if available)			
Type of system:	Drip emitters		Mini s	pray/sprinklers	Line so	urce	
Spacing between	n discharge device	es along distribution	on laterals	(ft, in)			
Laterals - diamete	er, length						
Main lines and su	ubmains - diamete	er, length, etc.					
Spacing between	distribution later	als (ft, in)					
Average applicat	ion device discha	rge pressure (lbs	/in ²)				
Are pressure con	npensating device	es required?		yes	no		
Are pressure con	npensating device	es used?		yes	no		
Average applicati	ion device discha	irge (gph, gpm)					
		(acres)					
Area irrigated by	one irrigation set	(40.00)					
Area irrigated by Typical irrigation		(hr, min)					
Typical irrigation	set time	· ,	t	(ft)			
Typical irrigation	set time on difference with	(hr, min)	t	(ft)			
Typical irrigation Maximum elevation	set time on difference with	(hr, min)	t programn		timer soil mo	oisture sensing devic	ce

Irrigation System Inventory Worksheet—Continued

NAME	DATE	PREPARED BY
Existing subsurface irrigation sys	tem	_
Water table control type and number of	system or segments	
Water table control devices flash	board float	
water table control devices hash	board IIoat	
Buried laterals	pacing depths	
Water table elevation(s): Existing	Planned	
Month	Elevation	Depth below surface
Pumping plant Pump		
(Attach pump characteristic curves and	d/or pump system analysis if avail	lable)
Pump elevation above mean sea level	(approx) (ft)	
Pump type: centrifulgal turbin	e 🗌 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 p	1	Ib/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 a	t pump
Energy (A pump evaluation is required		
	(gal/hr) (mcf)	
Pumping plant efficiency (from evaluation		
Energy cost per acre foot (from evaluat		
General condition of equipment, proble	ms	

Irrigation System Inventory Worksheet—Continued

NAME	DATE	PREPARED BY
Irrigation management		
Irrigation scheduling method(s)		
Typical number of irrigations per seaso	n	
Typical time between irrigations		
Set times or time per revolution		
Method of determining soil moisture		
Typical water application per (set, revo	lution, pass)	
Source, availability and skill of irrigation	n labor	
Comments about management of the e	xisting system and reasons f	or improvement. What are the objectives of the irrigation decisionmaker?
What management level is plann	ed?	
Other observations and comments		

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Sprinkler Irrigation System Planning/Design Worksheet

эргіпкі	erining	ation	Syster	II Piaili	iiiig/De	esign wor	KSHEEt			
NAME	DATE COUNTY					PREPARED BY				
DISTRICT							ENGR JOB CLA	.SS		
nventory			. 2.							
Vater source Amoun										
ower source: Electric	volts,	pha	ise; Internal c	ombustion en	igine	fuel type;	Other			
oils Data										
Design		Available	e water capa (in/ft depth)	•		Depth	to ¹	Sprink	ler intake rate (in/hr)	
Soil Series	0-1	1-2	2-3	3-4	4-5	Inhibiting layer (ft)	Water table (ft)			
Crops	Acres		Mon Depth (in)	Volume (ac-in)		1.		Mo epth n)	Volume (ac-in)	
Totals (1)			(2)			(3)		(4)		
Crop Weighted Evaportranspir ET, depth = <u>Maximum Total Month</u> Total Acres,	ly ET, ac-in/m	• • • • • • • • • • • • • • • • • • • •		•			,			
rrigation Requirements										
	Root			Manag	gement		Peak		Max freq	

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 F		PREPARED BY				
Design Data — (Based on weighte	d crop ET,	% irrigation	efficiency)				
	Application		Weighted ²	Frequency, F	System requirements		
	Net, D (in)	Gross F _g	peak daily crop ET (in)	(days)	Total gpm, Q	gpm/ac	
² Use weighted peak monthly ET and $Q = \frac{453 \text{ A D}}{\text{F H Eff/100}} = {}$	Ü	Ů.	·	H = (sug			
Sprinkler head spacing, (S _L)	ft, Lateral s	spacing on mainline	(S _M)	ft, Minimum F	Required wetted diam	eter =ft	
Sprinkler head: make	; model	; nozzle size _	; lb/in ²	gpm	; wetted d	lia ft	
Application rate in/hr, App	lication time	hr/set. Net ap	oplication = (in/hr) (_ eff) (hr	/set) = in	
Maximum irrigation cycle = Net applca	tion in/pe	eak ET in/d =	days				
· ·	n frequency,	days) (moves/day	/,)				
Designed laterals: Number	, Diameter	in,	Type	, Moves/day			
Total number of sprinkler heads = (num	nber of laterals) (numb	er of heads/lateral) :	=				
System capacity = (Total number of sp	rinkler heads) (gpm/head _) =	9	pm		
Lateral design							
Allowable pressure difference along lat	eral = 0.2 (sprinkler h	ead operating pressu	ıre in lb/in ²) =	lb/	in ²		
Actual head loss (worst condition)	lb/in ²						
Pressure required at mainline: P = (spr (plus for uphill flow in lateral, minus for							
(2.31). Under this condition, flow regul				_		•	

${\bf Sprinkler\ Irrigation\ System\ Planning/Design\ Worksheet} - {\bf Continued}$

NAME			DA	ATE		PREP	PARED BY			
Mainline Design										
Mainline material			(IPS, PIP,	SDR, CLASS	i) lb/in ² rating _			, other description	,	_
Friction factor used		Formula (che	eck one)	Hazen-Willian	ns Mannin	g's Darcy-\	Weibach	Other (name)		_
Station		Diameter	Flow	Valacity		Friction	Friction loss this	Accumulated friction	Remarks	
From	То	pipe (in)	Flow (gpm)	Velocity (fps)	Distance (ft)	loss (ft/100 ft)	section (ft)	loss (ft)	, temee	
										_
										_
										_
Determination o										
Pressure required a					ft					
Friction loss in main Elevation raise/fall in					ft ft	(*	2 31 foot - 1	psi pressure)		
Lift (water surface to					rt	(4	2.51 1661 – 1	psi piessuie)		
Column friction loss					ft					
Miscellaneous loss			_ lb/in ²		ft					
Total (TDH)			_ lb/in ²		ft	(NOTE; TDH	must be in fo	eet for horsepow	ver equation)	
Approximate brake	horsepower =	TDH (ft) X	Q (gpm) =		ft 2	x	gpm =		HP	
11	_	3960 X Eff			960 X				_	
Mean sea level el Pump curve data										
Bill of materials at					·		_		- ,	

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	

${\bf Sprinkler\ Irrigation\ System\ Planning/Design\ Worksheet} - {\bf Continued}$

NAME		DATE	PREPARED BY		
Irrigation System L	ocation and Layout Map				
			☐ Dire ☐ Elev ☐ High ☐ Wat ☐ Maii ☐ Layo	a irrigated with spriction of prevailing rations, contours and low points er source and purnline and submain out: lateral(s), travection of move th arrow	wind p location locations
Scale	Community		Section	Township	Range

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Irrigation Water Management Plan—Sprinkler Irrigation System

NAME		DATE			PREPARI	ED BY				
DISTRICT		COUNTY _				ENGR JO)B CLA	SS		
Crop information										
Field number(s)										
Crop irrigated										
Acres Irrigated (acres)										
	•									
Normal rooting dep										
Management allowa	able depletion (MAD)	(percent, inches)							
Peak daily crop req	uirements (ac-in/day)									
Average annual ne	t irrigation requiremer	its (ac-in/ year)								
Soil Information										
Soils series and su	rface texture									
Capability class										
Allowable soil loss	(T=tons per-acre per	year)								
Wind Erodibility Gr	oup (WEG)									
Actual on-site (obs	erved and measured)	average root zo	ne de	pth						
Total available wat	er capacity (AWC) of	soil plant root zo	ne							
Soil intake (Maximu	um application rate fo	r sprinkler syster	m)							
Available water cap	pacity (AWC) for crop	rooting depth:		Depth		A۱	WC			
	, , ,	3 1		(inches)		(inch/inch)		(total inches)		
Irrigation system m	anagement informat	ion								
Irrigation system										
Source of water										
Delivery schedule										
Estimated overall irrigation efficiency										
_	Management allowable depletion for pasture									
	o apply full irrigation a	and replace full M	/IAD							
Gross application										
Net application										
Actual gross sprink	Actual gross sprinkler application rate									

Irrigation system flow capacity requirement for full time irrigation, Q (gpm)

Irrigation	Water	Management	Plan—	Sprinkler In	idation S	vstem—	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				

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.

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.

Irrigation Water Management Plan—Sprinkler Irrigation System—Continued

NAME	DATE		_PREPARED BY
and installed to apply in percolation. The estimate	rrigation water to meet the ne	eeds of the crop withou is 15 years. The life of	s an asset to your farm. Your system was designed t causing erosion, runoff, and losses to deep the system can be assured and usually increased m.
followed. Losses of irri irrigation can carry nut	gation water to deep percolati	tion and runoff should bund and surface water.	od irrigation water management practices are be minimized. Deep percolation and runoff from . Avoiding spills from agricultural chemicals, fuels, d surface water.
			e irrigation water or soil water exceeds plant toler- eld(s), a salinity management plan should be
The following are system (see irrigation system		commendations to help	you develop an operation and maintenance plan
average operation	ng pressure = lb/in² ((use a pressure gage t	o check operating pressure)
nozzle size =	inch (use shank e	end of high speed drill	bit to check nozzle wear)
 average sprinkle 	er head discharge g	ypm	
 sprinkler head re 	otation speed should be 1 - 2 i	revolutions per minute	
 sprinkler head s 	pacing on lateral =	ft; outlet valve spa	acing on main lineft
• lateral, number(s) ft,	inch diamet	er
 main line = 	ft i	inch diameter, type	, class
			ft Total Dynamic Head (TDH)
Make ours that all may	acuring devices valves enriel	klar baada aurfaaa nin	aline, and other machanical parts of the aveter are

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.

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Soil Water Holding Worksheet

			3				
			_ Location in fie				
				Ву			
ū	l			-	e data		
Soil name if a	available						
			1		Season		
	Factor		1st	30 days		Remainder o	f season
Root zone	depth or max so	oil depth - ft	1	-			
	vater capacity A						
	ent allowed defic						
	ent allowed defic						
-			qual to or greate				
Estimated irri	gation system a	pplication efficie	ency		percent		
Data obtaine	ed during first f	ield check			Data o	btained eac	h check
(1)	(2) Soil	(3)	(4) Available	(5) AWC	(6) Field	(7) Soil	(8) Soil
Depth	layer	Soil	water	in	check	water	water
range	thickness	texture	capacity (AWC)	soil layer	number	deficit (SWD)	deficit (SWD)
(in)	(in)		(in/in)	(in)		`(%)´	`(in) ´
					2		
					3		
					4		
					5 6		
					7		
					8		
					2		
					3		
					4		
					5 6		
					7		
					8		
					2		
					3		
					4		
					5 6		
					7		
					8		
٦	Total AWC for ro	ot zone depth of	f ft=		8	SWD summa	ıry
٦	Total AWC for ro	ot zone depth of	f ft=		Check	Check	SWD
					number	date	totals
					2		
AWC(5) = lay	ver thickness(2)	x AWC(4)			3		
					5		-
SWD(8) = AV	VC(5) x SWD(7)				6		
	100				7	1	1

8

(210-vi-NEH, September 1997)

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

Worksheet Soil-Water Content (Gravimetric Method)

Land user_				[Date		Field off	ice				
Soil name	(if available)					Crop						
Depth range inches	Soil layer thickness inches d	Soil texture	Wet weight g WW	Sample Dry weight g DW	Water loss g Ww	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
, -	. ,	y - TW =g eight Pd = <u>Ww x</u> 100 =	-					Bulk den		w(g) =	g/cc	

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					_			0.11	
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
Wet weight of a	Vet weight of all samples in grams unless otherwise shown. Totals											

 $SWC_{p} = P_{d} - P_{w}$

 $SWC = Db_d \times SWC_p \times d$

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Typical Water Balance Irrigation Scheduling Worksheet

Grower				Field ID _			Crop _	Crop		
								Harvest date		
Soil water ho	olding capacit	y (in/ft)	;	;	;					
Management	t allowable de	epletion			Minimu	um 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	

NOTE: MAD = Management allowed deficit

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Land user			Field office	ce	
Field name/number					
					Date
Field Data Inventory:					
Field area		acres			
Border number		as counted from	om the	side	e of field
Crop		Root zone der	oth	ft MAD	
Stage of crop					
Soil-water data for cont	rolling soil:				
Station		Moisture dete	rmination method		
Soil series name					
Depth	Texture		AWC (in)*		
		 Total _			
		7010.			
-	tal AWC, in =				=
100					
Comments about soils:					
Typical irrigation duration	nn	hr irrigation	n frequency	days	
Typical number of irriga				aayo	
Annual net irrigation red				in	
Type of delivery system					
Delivery system size da	ata (pipe size & gate	spacing, tube siz	e & length, turnout size	e)	
Border spacing	, Strip v	vidth	, Wetted wid	Ith	, Length
Field Observations:					
Evenness of water spre	ad across border				
Crop uniformity					
Other observations					

AWC = Available water capacity

SWD = Soil water deficit

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Da	ta: Inflow		Outflow				
Type of mea	suring device	e					
Clock 1/	Elapsed	ΔΤ	Gage	Flow	Average	Volume 2/	Cum.
time	time	(min)	Н	rate	flow rate		volume
	(min)		(ft)	(gpm)	(gpm)	(ac-in)	(ac-in)
Turn on							
					-	+	
Turn off							
						Total volume (ac-in)	
Average flow	v rate =						
Total irrigation	on volume (ad	c-in) x 60.5 =	·		= ft ³ /	s Inflow time (r	nin)

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:

q_u = Average flow rate = ___ Border strip spacing

Unit flow:

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) = $.00003683 \times time (min) \times flow (gpm)$

= ft³/s/ft

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Graded border advance recession data

	Advance time				Recessi		
Station (ft)	Clock* time	ΔT (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

•	ı			1		
		Typical in	take 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 a	ave. depths				

^{3/} From "adjusted" cumulative intake curve.

Average depth infiltrated (typical) = Sum of depths (typical) Length (hundreds of feet-extended)	=	in
Extended border area (acres) = Extended border length x wetted width = 43,560 43,560	=	acres
Actual average depth applied to extended border length = Ave inflow (ft ³ /s) x duration (hr) = Extended border area (acres)	=	in
Average depth infiltrated (adjusted) = Sum of depths (adjusted) = Length (hundreds of feet - extended)	= _	in

Note: Should be close to actual depth applied.

^{2/} From "typical" cumulative intake curve.

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Average depth infiltrated low 1/4 (LQ):		
Low 1/4 strip length = Actual strip length =		= ft
4	4	
LQ = (Depth infiltrated at begin of L1/4 strip) + (De	onth infiltrated at the end of L1/4 etri	n)
2	epur iriiliuated at tile elid of £1/4 stil	<u>P)</u>
-		
==	= in	
2		
Areas under depth curve:		
1. Whole curve	sq in	
2. Runoff	sq in	
Deep percolation	sq in	
Low quarter infiltration	sq in	
Actual border strip area:		
= (Actual border length, ft) x (Wetted width, ft) = _		_ = acres
43,560	43,560	
Distribution uniformity low 1/4 (DU):		
DU = Low quarter infiltration area x 100 =	=_	%
(Whole curve area - runoff area)		
Runoff (RO):		
RO, % = Runoff area x 100 =	=	%
Whole curve area		
RO = Total irrigation volume, ac-in x RO, % =	=	: in
Actual strip area, ac x 100		
Deep percolation, DP:		
DP = Deep percolation area x 100 =	=	%
DP = Total irrigation volume, ac-in x DP, % =	=	in
Actual strip area, ac x 100		

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Evaluation computations, cont:

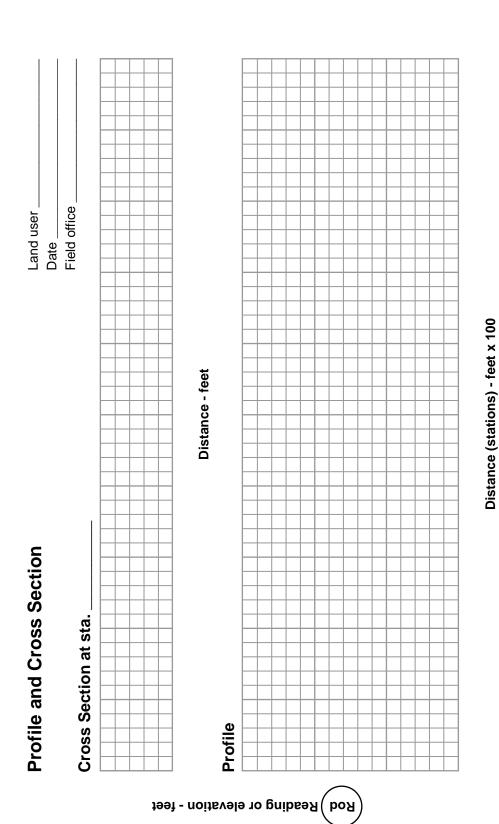
Gross application	F _g :			
$F_g = \frac{\text{Total irrigation}}{\text{Actual strip}}$			=	in
Application efficie	ncy, E _a :			
	red in root zone = Soil s irrigation, otherwise t		re root zone depth will be filled to	
E _a = Average depth	stored in root zone x	100 =	==	%
	application, in	_		
Application efficie	ncy low 1/4, E _q :			
E _q = DU x E _a , % =			=_	%
100		100		
Average net applic	cation, F _n			
F _n = Total irrigated	volume, ac-in x E _a , %) =	==	%
	area, ac x 100			
Time factors:				
Required opportuni	ty time to infiltrate soil	water deficit of	in	
T _o =	min (hr	min)	
Estimated required	irrigation inflow time fr	om advrecession curves	;	
T _{in} =	min (hr	min)	
At inflow rate of:				
Q =	ft ³ /s per l	oorder strip		

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Present management:		
Estimated present average net application	per irrigation	inches
Present gross applied per year = Net appli	ied per irrigation x num	ber of irrigations x 100
	Application efficien	ncy (E _a)1/
=	=	in
1/ Use the best estimate of what the applic	cation efficiency of a typ	ical irrigation during the season may be.
The application efficiency from irrigation to	irrigation can vary depo	ending on the SWD, set times, etc. If the
irrigator measures flow during the season,		
Potential management:		
_	inches, for	r(crop)
		· · ·
Potential application efficiency (E _{pa})		percent (from irrigation guide, NEH or
other source)		
Potential annual gross applied = Annual no	et irrigation requirement	x 100
Potenti	ial application efficiency	(E _{pa})
=	=	in
Total annual water conserved		
= (Present gross applied - potential gross	applied) x area irrigatior	ı (ac)
12		
=		= acre feet
12		
Annual cost savings:		
Pumping plant efficiency	Kind of f	uel
Cost per unit of fuel	Fuel cos	st per acre foot \$
Cost savings = Fuel cost per acre foot x ac	cre feet conserved per y	<i>r</i> ear
=	= \$	

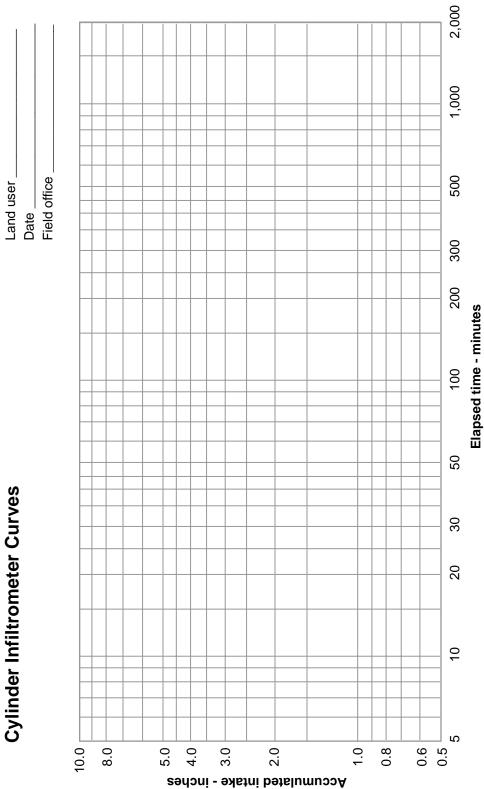
Surface Irrigation System Detailed Evaluation Graded Border Worksheet

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	



(210-vi-NEH, September 1997)

Cylinder Infiltrometer Curves



U.S. Department of Agriculture National Resources Conservation Service

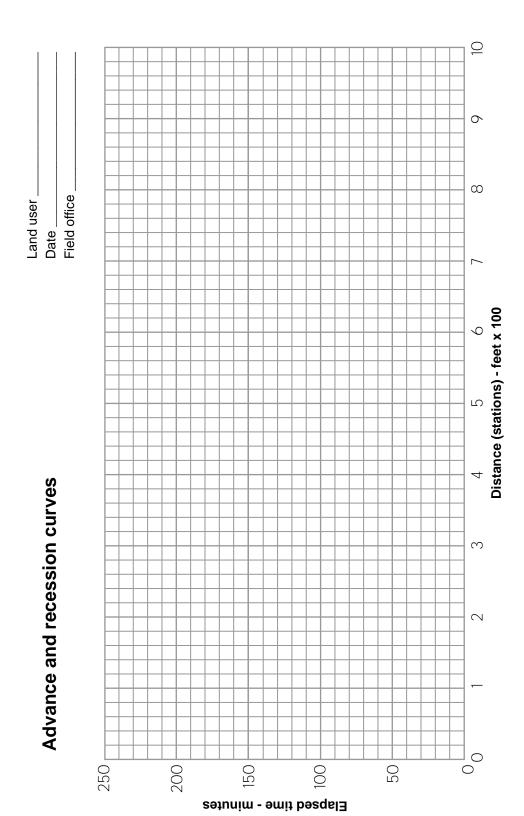
Cylinder Infiltrometer Test Data

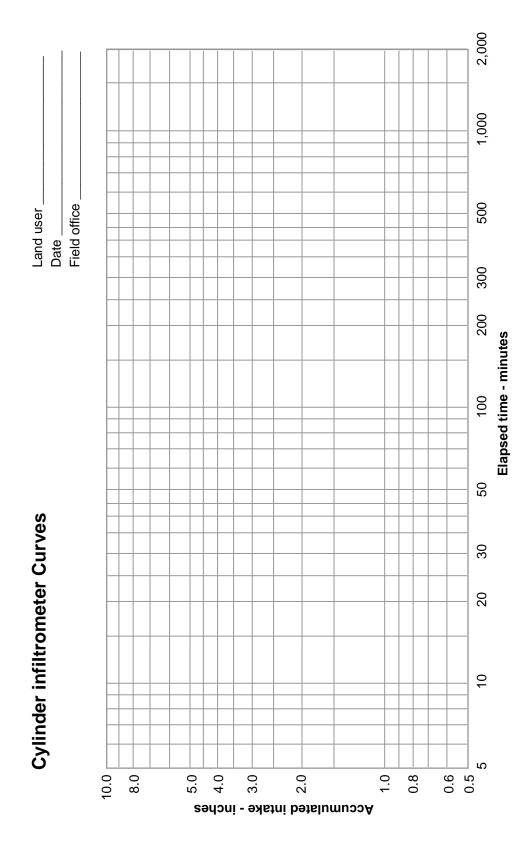
-322 02-96

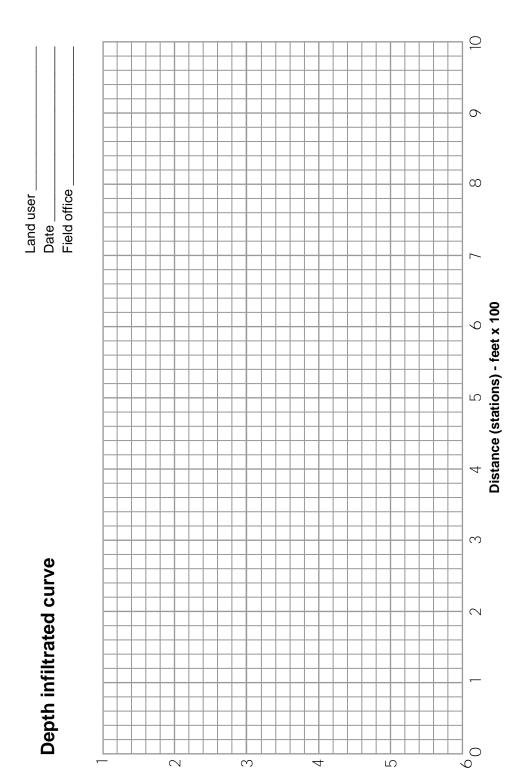
FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE	
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:		
CROP	STAGE OF GROWTH		L		

GENERAL COMMENTS

Je	Cy	/linder No.	1	(Cylinder No	o. 2	С	ylinder No.	. 3	С	ylinder No.	4	C	ylinder No.	5	نے ا
Elapsed time	Time of reading	Hook gage reading	Accum. intake	Average accum. intake												
Min.		Inc	hes	Á.												







Depth infiltrated - inches

NOTE: MAD = Management allowed deficit

Surface Irrigation System Detailed Evaluation Graded Border Worksheet

Land user Field office								
Field name/number								
		Checked by _						
Field Data Inventory:								
Field area	acr	es						
Border number	as (counted from the	side	of field				
Crop	Roc	ot zone depth	ft MAD					
Stage of crop								
Soil-water data for contro	olling soil:							
Station	Moi	sture determination method						
Soil series name								
Depth	Texture	AWC (in)*	SWD (%)*	SWD (in)*				
		Total						
MAD, in = MAD, % x tota	al AWC, in =			=				
100								
Comments about soils: _								
Typical irrigation duration	n h	r, irrigation frequency	days					
Typical number of irrigati	on's per year							
	, ,	ion guide)						
Type of delivery system	(gated pipe, turnouts, siph	non tubes)						
Delivery system size dat	a (pipe size & gate spacin	ng, tube size & length, turnout size	e)					
		, Wetted wid		_, Length				
Field Observations:								
	nd across border							
Crop uniformity								
Other observations								
OTHER ODSELVATIONS								

AWC = Available water capacity

SWD = Soil water deficit

Surface Irrigation System Detailed Evaluation Level Border and Basins Worksheet

1. Basin area (A):

2. Gross application, F_g, in inches:

3. Amount infiltrated during water inflow, Vi:

4. Deep percolation, DP, in inches:

DP = Gross application - Soil water deficit, SWD = ____ = ___ in

DP, in % =
$$(Soil water depletion, DP in inches) \times 100 = ___ = ___ %$$

Gross application, F_q

5. Application efficiency, Ea:

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.

6. Distribution uniformity, DU:

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

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

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

$$E_{q} = \frac{DU \times E_{a}}{100} = \frac{1}{100}$$

Surface Irrigation System Detailed Evaluation Level Border and Basins Worksheet

1.	Estimated present average net application per irrigation =		_ inches
	Present annual gross applied = (net applied per irrigation) x (number of irriga	tions) x 100	
	Application efficiency, low 1/4, Eq		
	=x 100 =	=	inches
2.	Potential management Recommended overall irrigation efficiency, E _{des}		
	Potential annual gross applied = $\frac{\text{Annual net irrigation requirements } \times 100}{\text{E}_{\text{des}}}$		
	=	=	_ inches
3.	Total annual water conserved: = (resent gross applied, in - potential gross applied, in) x area irrigated, acres	3	
	+=	_ 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	= \$	
Wa	ater purchase cost per acre-foot, per irrigation season		
Wa	ater purchase cost savings = (Cost per acre-foot) x (water saved per year, in a	cre-feet)	
	=	= \$	
Po	stential cost savings = pumping cost + water purchase cost =	= \$	

Surface Irrigation System Detailed Evaluation Level Border and Basins Worksheet

Recommen	dations:		

Surface Irrigation System Detailed Evaluation Level Border and Basins Worksheet

Turn on	(min)	(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 off							
						Total volume (ac-in) _	
/erage flo	ow:						
verage flo		rrigation vo		:-in) x 60.5	=	=_	
nit:							
	e inflow rate er spacing	e, in ft ³ /s =			_=	ft ³ /s/ft	
	I-hour clock e to volume		e., 1:30 p.n	n. is recorde	d as 1330 hours.		

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

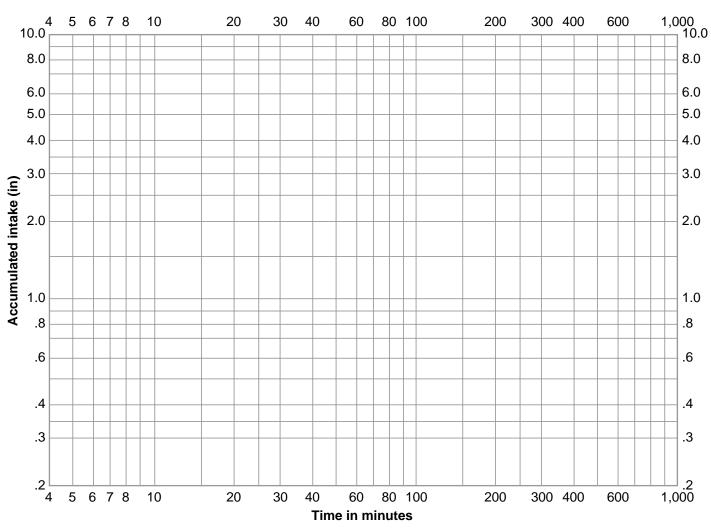
Station	Elevation	Advance	Recession	Opportunity	Intake 2/	Minimum
(ft)	(ft)	time 1/	time 1/	time	(in)	maximum
	()	(hr: min)	(hr: min)	То	,	intake
		,	,	(min)		(in)
				. ,		` '
Total						

Water surface elevation a	at water turnoff	ft 3	i/		
Average field elevation =	elevation total no. of elevations		=_		ft
Depth infiltrated after war = (water surface at turn		ev) x 12			
= (x 12 =		_ in	
Average opportunity time	$t = \frac{\text{total opportunity}}{\text{no. of sample loc}}$			=	mir

^{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.

Soil Water Intake Curves Land user ______ Date _____ Field office ______



Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 1

Land user		Field	d office		
Field name/number	er				
Observer	Date	Checke	d by	Date	
Field Data Invent	tory:				
Show location on	evaluation furrows on sketo	ch or photo of field.			
Crop	Actual ro	oot zone depth	MAD	1 ^{†/} % MAD	in
Stage of crop		Planting of	late (or age of plant	ting)	
Field acres	· · · · · · · · · · · · · · · · · · ·				
Soil-water data:					
(Show location	of sample on soil map or sl	ketch of field)			
Soil moisture d	etermination method				
Soil mapping u	nit		Surfa	ace texture	
Depth	Texture	AWC (in)¹/	SWD (%) ¹ /	SWD (in)1/	
20p				3312 ()-	
	Tota	al			
Commonto abaut	a a ila .				
Comments about	soils:				
			,		
	duration				
	firrigations per year				
Crop rotation					
Field uniformity co	ondition (smoothed, leveled	. laser leveled. etc	and when)		
		,,	<u> </u>		
1/ MAD = Manage	ement allowable depletion	AWC = Availab	le water capacity	SWD = Soil water def	icit

Date

Cultivation no.

Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 2

Crop stage

Irrigate?

1	<u> </u>
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	d
	row spacing, problems noted, etc.)
, , , , , , , , , , , , , , , , , , ,	, , , , , , , , , , , , , , , , , , , ,
Furrow spacing inches	
Furrow length feet	
Irrigations since last cultivation	
Furrow profile (rod readings or elevations at each 1	
3	,
Furrow cross section:	
Station:	Station:

Example - Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 3

valuation length	Slope	Average
ection through plant root z	one:	
		
valuation computations		
urrow area, A = (furrow eva	aluation length, L, ft) x (furrow spacing, W, ft)	
, \	43,560 ft ² /acre	
	10,000 11 / 20.0	
_	=_	0000
=		acie
	43,560	
esent gross depth applied	, $F_g = \underline{\text{Total inflow volume, gal. x .0000368}}$ (Total	tal inflow from worksheet 7)
	Furrow area, A, in acres	
₁ =	==	inches
'		
inimum opportunity time, 7	ox = min at station (fr	om field worksheet 10)
-11 9	UA	· · · · · · · · · · · · · · · · · · ·
inimum donth infiltrated E	inches (from workshoot 10)	
пшпан аерин пшпасеа, г	min = inches (from worksheet 10)	
verage depth infiltrated, F _{(l}	_{O-1)} = (from calculations on worksh	eet 10)
stribution uniformity, DU =	Minimum depth infiltrated, inches $x = 100 = F$	min x 100
	Average depth infiltrated, inches F	ave

Example - Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 4

=	% (Total outflow, worksheet 8)
	(Total inflow, worksheet 7)
_ x 0.0000368 =	in (Furrow area, worksheet 3)
re deficit, SMD (Ave. de	epth worksheet 10 and SMD worksheet 1
in	
=	%
=_	_ %
	_ x 0.0000368 = re deficit, SMD (Ave. de in =

*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 a	application, F _g per irrigation =	inches (F _g from worksheet 3)
Present gross applied per yea	ar = Gross applied per irrigation, $F_g x$ nu	umber of irrigations
=	= incl	hes
Potential management		
Annual net irrigation requirem	ent inches, for	(crop)
Potential application efficienc	y, E _{pa} =%	
Potential annual gross applied	d = Annual net irrigation req. x 100	
	Potential application efficiency, E _{pa}	
=	= inches	
Total annual water conserved	= (present gross applied - potential gro	ss applied) x area irrigated, ac
	,	12
_	- acra 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 ___

Surface Irrigation System Detailed Evaluation Furrow Worksheet 7-8

Data: Furrow number			Inflow	Outflow				
Type of me	easuring dev	vice						_
Clock 1/ time	Elapsed time (min)	ΔT (min)	Gage H (ft)	Flow rate (gpm)	Average flow rate (gpm)	Volume 2/ (gal)	Cum. volume (gal)	
Turn on								
								-
						Total volume		gallon
	4-hour clock = Δ T x ave			n. is recorde	ed as 1330 hours.			
Average flo	ow rate = T_0		n volume, g time, minut		=	= gpm		

⁽²¹⁰⁻vi-NEH, September 1997)

Surface Irrigation System Detailed Evaluation Furrow Worksheet 9

Intake Curve Plotting Data

		Oppor	lr	ntake at time "T	""				
Clock time Int			v time Outflow time		w time	Opportunity	Cumulative	Cumulative	Intake
	Т	Start 2/	T1 ¾	Start 2/	T2 <u>4</u> /	time T _o 5/	inflow volume ^{6/} V _{in}	Outflow volume ^{6/} V _{out}	F ₀₋₁ <u>7</u> /
(hr-min)½/	(hr)	(hr)	(hr)	(hr)	(hr)	(min)	(gal)	(gal)	(in)
						1			

- 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:
$$V_s = L \left[0.0973 \left(\frac{Q_{av} \times n}{S^{.5}} \right)^{.7567} + 0.00574 \right] = \underline{\qquad}$$

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

$$F_{0-1} = 1.604 (V_{in} - V_{out} - V_s) V_s$$

Surface Irrigation System Detailed Evaluation Furrow Worksheet 10

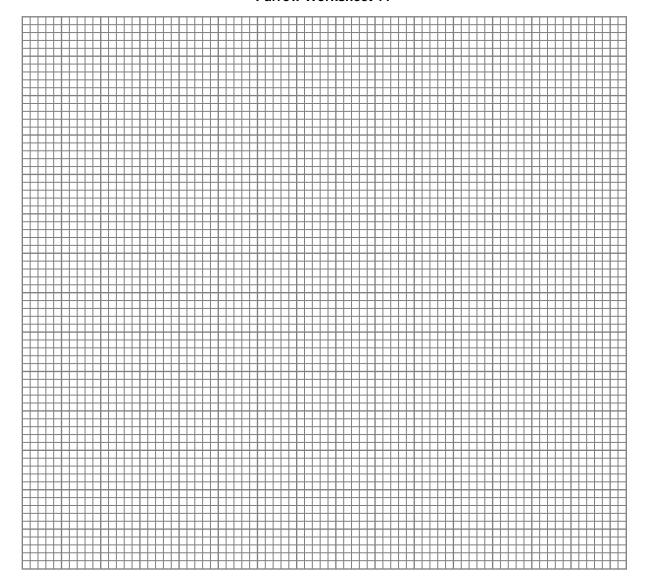
Furrow advance/recession data

W

	Advance time			Recession time						
Station (ft)	Clock time ¹ /	ΔT (min)	Elapsed time T _t (min)	Clock time ¹ /	ΔT (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 off	Lag			Inflow T		
	Turn on									
					-					
							Totals			

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is 1330 hours. 3/ Time since water was turned on.	$2/T_0 = T_i - T_t + T_r$ 4/ Interpolated from graph, fu	rrows volume curve
Average opportunity time = total opportunity time = number of stations	==	minutes
Average depth infiltrated in wetted perimeter, F _{wp} :		
F _{wp} = t <u>otal intake in wetted perimeter</u> =	_=	inches
number of stations		
Average depth infiltrated in tested length of furrow, F ₀₋₁ :		
F ₀₋₁ = F _{wp} x P = =	inches	

Surface Irrigation System Detailed Evaluation Furrow Worksheet 11

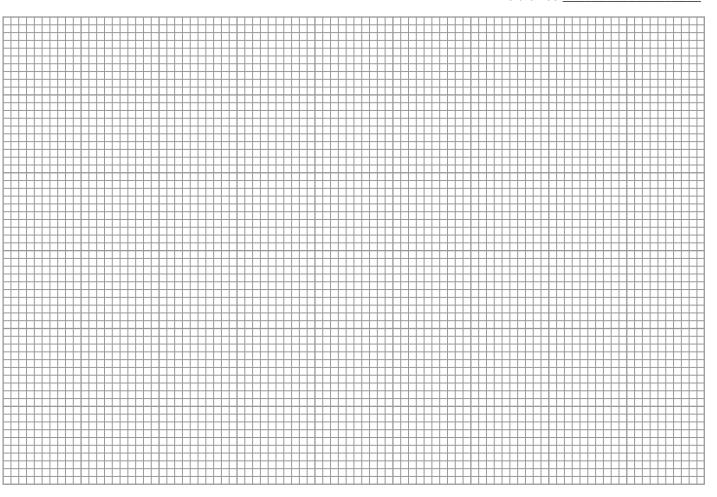


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Time - minutes

Land user	
Date	
Field office	

Advance and recession curves

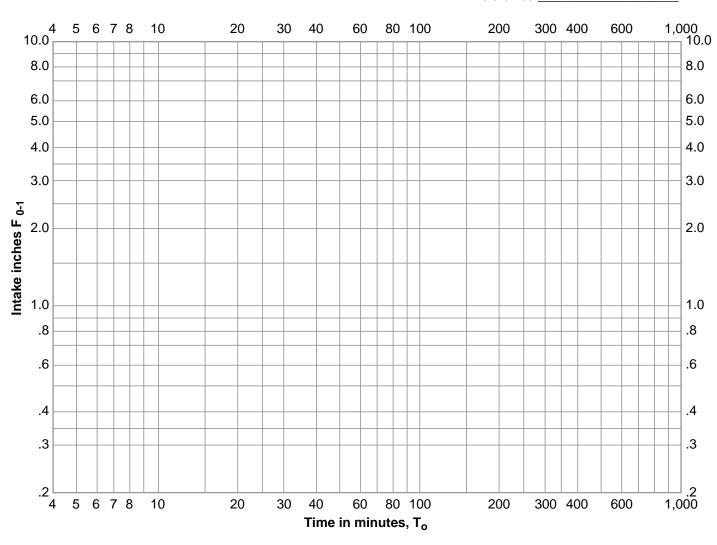


Distance (stations) - feet x 100

Land user Date Flow volume curves Field office 14,000 12,000 10,000 8000 Volume - Gallons 6000 4000 2000 200 700 0 100 500 600 300 400 Real time (hours)

Land ւ	iser
Date _	
Field o	ffice

Soil water intake curves



Surface Irrigation System Detailed Evaluation Contour Ditch Irrigation System Worksheet

Land user	Field office					
Field name/num	ber					
Observer	Date	Checke	Checked by			
Field Data Inve	ntory:					
Field size	acres					
Crop	Root zone depth _	ft MAD 1/		% MAD ½/	in	
Stage of crop						
Soil-water data	:					
(Show locaca	tion of sample on grid map of	irrigated area.)				
Soil moisture	determination method					
Soil series na	me					
Depth	Texture	AWC ^{2/} (in)	SWD 3/ (%)	SWD ^{3/} (in)		
	iotai					
Comments abou	ut soils:					
Typical irrigation	duration	hr, irrigation fre	quency	days		
Typical number	of irrigations per year				_	
Type of delivery	system, (earth ditch, concrete	e ditch, pipeline)				
					_	
	turn water out (shoveled oper	•				
	with Greek 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) = $(in^2) \times (in^2) \times (in^2) = (in^2) \times (in^2) \times (in^2) = (in^2) \times (in^2) \times$ Actual total depth infiltrated, inches: Depth, inches - (Irrigated volume, ac-in) - (Runoff volume, ac-in) (Irrigated area, acres) Depth, inches = _____ in Gross application, F_q, inches: F_q = (Total inflow volume, ac-in) = _____ in (Irrigated area, acres) Distribution uniformity low 1/4 (DU): DU = (Average depth infiltrated (adjusted) low 1/4, inches) (Average depth infiltrated (adjusted), inches) DU = _____ Runoff, RO, inches: RO, inches = (Runoff volume, ac-in) = _____ in (Irrigated area, ac)

RO, % = (Runoff depth, inches) x 100 = _____ = ____ %

(Gross application, F_a, inches)

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Contour Ditch Irrigation System Detailed Evaluation Worksheet

Deep percolation, DP, inches:		
DP, inches = (Gross applic. F_g , in	nches) - (Runoff depth, RO, inches) -	(Soil water deficit, SWD, inches)
DP, inches =		= inches
DP, % = (Deep percolation, DP, i (Gross application, F_g , i	nches) x 100 = nches)	
Application efficiency (E _a):		
(Average depth replaced in root	zone = Soil water deficit, SWD, inche	es)
$E_a\% = (\underline{\text{Average depth replaced}}$ (Gross application, I	in root zone, inches) x 100 = F _g , inches)	=%
Potential water and cost savin	gs	
Present management:		
Estimated present average net a	pplication per irrigation =	inches
Present gross applied per year =	(Net applied per irrigation, inches) (Application efficiency, E _{at}	
Present gross applied per year =	:	_ = inches
Potential management Annual net irrigation requirement	t: inches, for _	(crop)
Potential application efficiency, E	e _{pa} : % (from irrigation	guide or other source)
Potential annual gross applied =	(annual net irrigation requirement (Potential application efficiency, E _{pa}	
Potential annual gross applied =		= inches
Total annual water conserved:		
= (Present gross applied, inche	s) - (Potential gross applied, inches) 12	x Area irrigated, ac)
= () x () =	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

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Contour Ditch Irrigation System Detailed Evaluation Worksheet

Inflow	Outfle	OW					
Type of me	asuring dev	/ice					
Clock 1/ time	Elapsed time (min)	ΔT (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 flo			ume in (ac- psed time (i			=	ft ³ /s
2/ Flow rat To find \	4-hour clock e to volume volume usin me (ac-in) =	factors: g ft ³ /s:	·		ed as 1330 hours.		
	olume usin me (ac-in) =		3 x time (mi	n) x flow (gr	om)		

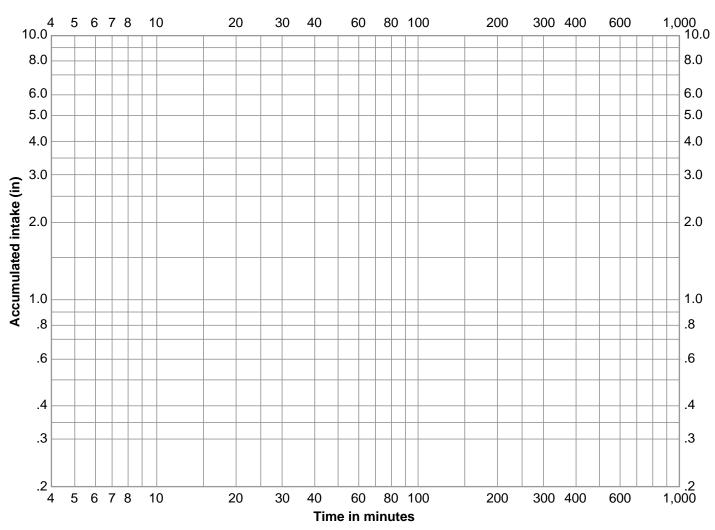
Surface System Detailed Evaluation Contour Ditch Irrigation Systems Worksheet

Grid Data

Grid point	Advance time ^{1/} (hr:min)	Recession time ½/ (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 3/ From "adjusted" cumulat 4/ Adjusted intake for lowes	ive intake curve.	number of poin	ts divided by 4
Average depth infiltrated (ty	pical):		
= Total depth typical	=	=	in
Number of grid points			
Average depth infliltrated (a (Should be close to actu	• •		
= Total depth adjusted	=	=	in
Number of grid points			
Average depth infiltrated (ad	ljusted), low 1/4:		
= Total depth adjusted low	1/4 =	=	in

Number grid points, low 1/4



(210-vi-NEH, September 1997)

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

Эе	Cy	/linder No.	1	(Cylinder No	o. 2	С	ylinder No.	. 3	С	ylinder No.	4	C	ylinder No.	5	نے [
Elapsed time	Time of reading	Hook gage reading	Accum. intake	Average accum. intake												
Min.		Inc	hes	Á												

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

Land user		Pro	epared by		
					SS
Irrigation system ha	ardware inventory:				
Type of system (che	eck one) : Side- roll	Handmove	Lateral tow	Fixed set _	
Sprinkler head: mal	ke, model _	, noz	zle size(s)	by	_ inches
Spacing of sprinkle	r heads on lateral, S $_1$ _	feet			
Lateral spacing alor	ng mainline, S _m	feet, to	tal number of later	als	_
Lateral lengths: ma	x feet, r	ninimum	feet, averag	e	feet
Lateral diameter:	feet of	inches,	feet of _	inche	es
Manufacturer rated	sprinkler discharge,	gpm at	psi giving	feet wett	ed diameter
Total number sprink	der heads per lateral _	, lateral c	diameter	_ inches	
Elevation difference	between first and last	sprinkler on lateral (=	=/-)	_ feet	
Sprinkler riser heigh	nt feet, i	mainline material			
Spray type:	fine (>30psi),	coarse (<30psi)			
Water runoff Erosion System leaks Fouled nozzles Other observations	ry & Computations:				
	, rc	ot zone depth	feet. MAD 1/	%. MAD	1/ inches
Soil-water data (typ					
Moisture de	sample on soil map or setermination and surface texture	·			
Depth	Texture	AWC ½ (in)	SWD ½/(%)	SWD ½ (ir	n)
	т,	stale			

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

ypical irrigation duration hr, irrigation frequency days ypical number irrigations per year Distance moved per set ft, Alternate sets? Measured nozzle diameters (using shank of high speed drill bit) Sprinkler no					
ypical irrigation duration hr, irrigation frequency days ypical number irrigations per year iistance moved per set ft, Alternate sets? leasured nozzle diameters (using shank of high speed drill bit) prinkler no iiameter ize check state whether t = tight, m = medium, l = loose) cctual sprinkler pressure and discharge data: Sprinkler number on test lateral 1st end iitial pressure (psi) iial pressure (psi)					
prical irrigation duration					
Distance moved per set ft, Alternate sets? Measured nozzle diameters (using shank of high speed drill bit) Sprinkler no	Present irrigation practices:				
Sprinkler no	Typical irrigation duration	hr, irrigation fre	quency		days
Measured nozzle diameters (using shank of high speed drill bit) Sprinkler no	Typical number irrigations per ye	ar			
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) end Catch volume (gal) end Catch time (sec) end Discharge (gpm) Test: Start stop duration end Atmospheric data: Wind: Direction: Initial during final end Speed (mph): initial final Humidity: low med high					
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) Catch volume (gal) Catch time (sec) Discharge (gpm) Test: Start stop duration = hours Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial final Humidity: low med high	Measured nozzle diameters (usir	ng shank of high speed dr	ill bit)		
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) Catch volume (gal) Catch time (sec) Discharge (gpm) Test: Start stop duration = hours Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial final Humidity: low med high	Sprinkler no				
Actual sprinkler pressure and discharge data: Sprinkler number on test lateral 1st end Initial 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 high	Diameter				
Actual sprinkler pressure and discharge data: Sprinkler number on test lateral	Size check				
Sprinkler number on test lateral 1st	(state whether t = tight, m = medi	ium, I = loose)			
Sprinkler number on test lateral 1st					
1st	Actual sprinkler pressure and o	-	latoral		
Initial pressure (psi)		ophinkler number on test	lateral		
Final pressure (psi)	1st			end	
Final pressure (psi)	Initial pressure (psi)				_
Catch time (sec)	- :!				_
Discharge (gpm)	Catch volume (gal)				_
Test: Start stop duration = hours Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial during final final high Temperature: initial final Humidity: low med high	Catch time (sec)				_
Start stop duration = hours Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial during final Temperature: initial final Humidity: low med high	Discharge (gpm)				_
Start stop duration = hours Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial during final Temperature: initial final Humidity: low med high	Tost·				
Atmospheric data: Wind: Direction: Initial during final Speed (mph): initial during final Temperature: initial final Humidity: low med high		duration	_		houre
Wind: Direction: Initial during final Speed (mph): initial during final Temperature: initial final Humidity: low med high	Start \$top	duration	=_		_ 110015
Speed (mph): initial during final final final high	Atmospheric data:				
Temperature: initial final Humidity: low med high	Wind: Direction: Initial	during	final		
	Speed (mph): initial	during	final		
	Temperature: initial fir	nal Humidity:	low	med	high
Evaporation container: initial final loss inch	Evanoration container: initial	final	loss		inch

Lateral flow data:

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Flow meter reading	gpm
Average discharge of lateral based on sprinkler	head discharge
= [1st gpm75 times (1st gpm - last gpr	m)] times (number of heads)
= =	gpm (ave flow per head)
= heads x gpm/he	ead =gpm
Calculations:	
Gross application per test = $\underline{\text{(flow, gpm)}} \times \text{(time (lateral length)} \times \text{(lateral length)}$	
= (gpm) x (hours) x 96.3 =	inches
= (gpm) x (hours) x 96.3 = (feet) x (feet)	
Gross application per irrigation = (gross application)	ation per test, in) x (set time, hour) (time, hour)
= (inches) x (hour) = (5.95 hour)	inches
Catch container type	
cc (mL) or in, measuring contained	er = inches in container
Total number of containers	
Composite number of containers = Total number	er of containers = = = 2
Total catch, all containers = cc/in	(mL)= inches
Average total catch = Total catch	= = inches
composite no. containers	
Number of composite containers in low $1/4 = \frac{cc}{c}$	omposite no. containers = =
Total catch in low 1/4 composite containers = _	cc(mL) = inche

NOTE: Use for lower value field and forage crops.

Average catch of low 1/4 composite containers =	total catch in le	ow 1/4	
	no. composite low 1	1/4 containers	
-	=	=	inches
Average catch rate = Average total catch, inches	=	=	inch/hour
Test time, hour	ho	our	
NOTE: Average catch rate is application rate at p	plant canopy height.		
Distribution uniformity low 1/4 (DU):			
DU = (Average catch low 1/4 composite container	rs) x 100 =	inches	x 100 =%
Average total catch	_	inches	
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 = Average total catch, inch =	inch	es =	inches
Gross applications/test, 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	=	%	

Application efficiency, (E _a):	
$F_n = (gross application per irrigation) \times E_q = (inches) \times 100 $	= inches
$E_a = \frac{\text{(water stored in root zone)} \times 100 = (\frac{\text{inches)} \times \text{(gross application per irrigation)}}{\text{(inches)}}$	<u>100</u> = %
Losses = (runoff, deep percolation) = gross application per irriga	ation minus SWD
= (= inches
Potential Water and Cost Savings:	
Present management: Gross applied per year = (gross applied per irrigation) x (numbe	er 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	m NEH, Part 623, Ch 11)
Potential annual gross applied = $\frac{\text{(annual net irrigation requirem)}}{\text{Potential E}_q \text{ or E}_H}$	<u>ent)</u> x 100
= (inch	nes) x 100 = inches
Total annual water conserved	
= (Present gross applied - potential gross applied) x (area irrig.	(ac)) = acre/feet
= (inches) - (inches) x (acres	s) =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 p	per year) = \$	_
= () x () = \$		
Water purchase cost:		
= (Cost per acre-foot) x (acre-feet saved per year) =	x	= \$
Cost Savings:		
= Pumping cost + water cost = +	_ = \$	
Recommendations:		

Lateral move system catch can data

Land user	
Date	
Field office	

П																																\perp							
								\perp																															
								\perp																															
																												П											
П	Т	Т	Т	П		П	Т	Т	П		П	Т	Т	П	Т	П	П		П	П		П	П	Т	П		П	П	Т	П	П	П	Т		П	\top	П	Т	
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Land user		Field office		
Observer	Date	Checked by		Date
Field name/number				
Center pivot number	pivot locatio	n in field		
Acres irrigated				
Hardware inventory:				
Manufacturer: name and mod	el			
Is design available?	(attach copy)	Number of towers	Spacing of towers	
Lateral: Material	, lı	nside diameter	inches	
Nozzle: Manufacturer				
Position	Heigh	t above ground		
Spacing				
Is pressure regulated at each i	nozzle?	operating pressure range		
Type of tower drive				
System design capacity	gpn	n, 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 continuous	sly used in corners
End gun capacity	gpm, Pressu	ure psi, b	oosted to	psi
End swing lateral capacity		gpm, pressure		_ psi
Field observations:				
Erosion				
Tower rutting				
System leaks				
Elevation change between pive	ot and end tower			

Wind: Spee	ed	mph Dire	ection (from)				
Line direction	n: From center	to outer tower			moving		
Time of day		, Humidity:	low _	med _	high	, Air temp	
Evaporation	n: start depth	inches	end depth		inches, Eva	aporation	inches
Crop		, Root zo	one depth	foot,	MAD <u>1</u> /	%, MAD	inches
Soil-water	data (typical):(show location of	sample site o	on soil map or	sketch of fie	eld)	
Moistu	re determiniation	method				·	
Soil se	ries name, surfac	ce texture					
Depth	Tex	ture	*AWC (ir	n) ^{1/} *S\	ND (%)½	*SWD (in)1/	
							
		Totals					
Comments	about soils:						
Present irr	igation practice	S:					
Typical syst	em application:						
Crop	Stage	Hours per ^{2/}	Speed	Net			
	of growth	revolution	setting	application			
	percent			(in)			
					_		
					_		
					_		
Hours opera	ated per day		hours				
Approximat	e number of pivo	t revolutions per	season				
1/ MAD = N	lanagement allov	ved depletion, A	VC = Availab	ole water capa	acity, SWD =	Soil water deficit	
2/ To calcula	ate the hours per	revolution aroun	d the field, fir	rst calculate t	he average s	speed the end tower	moves
per cycle (s	tart to start) = dis	stance in feet divi	ded by time i	n seconds.			
Then: hours	s per revolution =	2 (dietono	e to end tow	er in feet) x π			
THEIL HOURS	, her revolution =	(end tower speed		•			
		,	, , , .				

System data:		
Distance from pivot point to: end tower	ft, wetted edge	ft
* End tower speed: Distance between stakes	S	
Time at first stake, T	ime at second stake	
Time to travel between stakes	min	
* This method is satisfactory for a continuous Recommend using end tower move distance end tower represents, 60% = 36 seconds of e	and from start to star. Typically, perce	ent speed setting for
Measured system flow rate	gpm, method	_
Calculations:		_
Evaluation computations: Circumference of end tower:		
(6.2832)		
Distance to end tower x $2\pi =$	x 6.2832 =	_ ft
End tower speed:		
Distance traveled (ft) x 60 =	_ x 60 = ft/hr	
Time in Timutes		
Hours per revolution:		
Circumference at end tower (ft) =	= hr	
End tower speed (ft/hr)		
Area irrigated:		
(3.1416) (Distance to wetted edge) ² $\times \pi =$	x 3.1416 =	_ ac
43,560 square feet/acre 43,56	0	
Gross application per irrigation:		
Hours per revolution x gpm =	= in	
435 x acres irrigated 453 x	ac	
Weighted system average application:		
Sum of: catch x factors = _	= cc (m	1)
(Sum of: factors) x number of containers		

Convert cc (ml) in measuring cylinder to inches depth in catch container:	
cc (ml) = 1 inch in catch container	
Average application = Average catch (cc) = = ir	1
Weighted low 1/4 average application:	
Sum of low 1/4 catch x factors =	cc (ml)
Low 1/4 average application = Average low 1/4 (cc) = = =	_ in
Distribution uniformity low 1/4 a (DU):	
DU = Weighted low 1/4 average applic. =	%
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 = Weighted system average application (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)	

Application: Gross application x hours operated per day $x (E_q \text{ or } E_h)$ Hours per revolution x 100 = _____ in/day Maximum average application rate: Maximum catch inches x 60 = ____ = ___ in/hr Time containers are uncovered in minutes Pivot revolutions required t replace typical annual moisture deficit: (Based on existing management procedures) Annual net irrig. requirement ______ in, for _____ (crop) Pivot revolutions required: Annual net irrig. requirement x 100 = _____ = ____ (E_q or E_h) 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 = Annual net irrig. requirement x 100 Potential E_{pq} or E_{ph}

_____ = _____ inches

Total annual water conserved:

		agra foot
=12	==	acre reer
Cost savings:		
Pumping plant efficiency	kind of fuel	
Cost per unit of fuel	fuel cost per acre foot \$	
Cost savings = fuel cost per aci	re foot x acre foot conserved per ye	ear
=	= \$	
Water purchase cost:		
= Cost per acre foot x acre feet	saved per year =	
= \$		
- Ψ		
	water cost =	=\$
Cost savings = pumping cost +	water cost =	= \$
Cost savings = pumping cost +	water cost =	= \$
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Natural Resources Conservation Service

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

Container spacing _		feet
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Conta	ainer	Catch	Catch (cc)	lcct
No.	1		x Factor	
1	Factor 1	(cc)	A I AUIUI	(in)
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			
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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			
			<u> </u>	L

Conta	ainer	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 = max. catch (in) x 60 = _____ inches/hour 5 minutes

Container catch (inches)

Center pivot lateral evaluation, distribution profile of catch

_		
E _h	=	
E۾	=	

Land user _	
Date	
Field office	

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+	+	H	Н	+	++	+	+	Н	+	+	++	╫	+	H	+	+	H	+	Н	Н	+	Н	+	H	+	+	Н	+	Н	Н	+	H	++	H	+	++	╫	+	+	+	+	+	+	H	++	+	+	+	+	+	+	H	₩	+
+	+	H	Н	Н	++	+	+	H	┰	+	++	┰	+	H	+	+	H	+	H	Н	+	H	+	H	+	+	H	+	H	H	+	+	++	H	+	++	₩	+	+	+	+	Н	Н	Н	++	+	Н	+	+	+	Н	H	₩	+
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Container number

	Date		Prepared by	
Co	ounty	E	ng job class	
ystem hardware invent	ory:			
=	=		, nozzle type	
size	inches,	mm		
er rated discharge,	gpm at	F	osi giving	ft wetted diameter
length,	ft, diamete	er	inches	
spacing	ft			
fference between first ar	nd last location on towp	eath (+/-)	ft or	% slope
height	ft			
material		di	iameter	inches
nventory and computa [lata (typical): ions of sample on soil m	tions: root zone depth	ft, MAD ½	%, MAD ½	
Texture	AWC (in) 1/	,	` ,	
	er rated discharge,	rystem hardware inventory: un make	system hardware inventory: un make	an make

Present irrigation practices:				
Typical irrigation duration	hr, irrigat	tion frequency		days
Typical number of irrigations per ye	ar			
Test:				
Start, Stop	, Du	ration	=	hour
Atmospheric data;				
Wind: Direction: Initial	, during		, final	
Speed (mph): Initial	, during		_, final	
Temperature: initial fi	nal,	humidity:	low	med high
Evaporation container: initial				
Pressure:	psi, at sta	art of test		
	psi, at er	nd of test		
Measured flow into the system		gpm		
Sprinkler travel speed:				
•	ft	min =	ft/min	
, ,				
average			ft/min	
,				
Calculations:				
Gross average depth of water appli			e, gpm) x (1.605)	
	(tow path	spacing, ft) x	(travel speed, ft/r	nin)
= (gpm) x (1.605)	=		in	
(ft) x (ft/min)				
Average overlapped catches	:\		:	
System = (sum all catch totals (number of totals	<u> </u>		in	
(14.11.50) 61 1514.15	/			
Low $1/4 = (\underline{\text{sum of low } 1/4 \text{ catch tot}})$ (number of low $1/4 \text{ catch}$	als	<u>in</u>) =	in	
(number of low 1/4 cato	hes)		
Average application rate =	(Flow apm) x (13 624)		
	path spacing, ft		or, deg.)	
$= (\underline{gpm}) \times (13,624) = \underline{\qquad}$	in/hr			
Maximum application rate = (average)		te.in/hr) v (1	.5)	
application rate - (avoid)	o application la	,, (1	,	

Catch can type _____, ___ cc (mL)/in 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	Left side	Container cate	le of path	Right p side cato	lus left h totals	
spacing (ft)	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 _____

Potential water and cost savings:

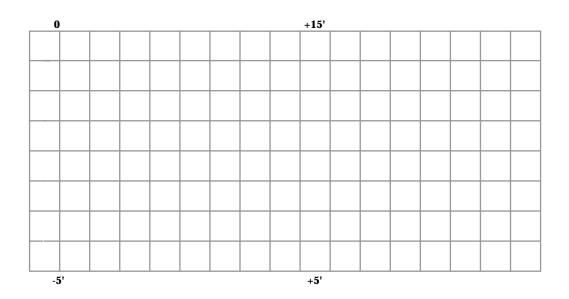
Present ma	anagement:				
Gross appl	ied per year = (Gross a	pplied per irrigat	ion) x (number of	f irrigation) =	in/yr
+ (in) x () =	in/y	r	
Potential n	nanagement:				
	irrigation requirement _		in/yr, fo	or	(crop)
	pplication efficiency (E _q				
	nnual gross applied = (a				in
		Potentia	I E _q or E _h		
= (<u>in</u>) x 100 =	ir	nches		
Total annua	al water conserved				
= (Presen	t gross applied, inches	- potential gross	applied, inches)	x (area irrigated, ac) =	= ac/ft
	12	2			
= (in) - (in) x (ac) =	ac-ft	
		2			
Cost savin	ngs:				
Pumping pl	lant efficiency		kind of energy		
Cost per ur	nit of energy \$		energy cost per a	ac-ft \$	-
Cost saving	gs = (energy cost per ad	c-ft) x (ac-ft cons	erved per year) =	\$	
= () x () = \$			
Water pure	chase cost:				
= (Cost pe	er ac-ft) x (ac-ft saved	per year) = \$	x	= \$	
Cost savin	ngs:				
= Pumping	g cost + water cost =	+	=\$		

Recommendations:	

Micro Irrigation System Detailed Evaluation Worksheet

Land us	ser	[Date	Prepared by	
District			County		
Crop: _		age	plant and row sp	pacing	
Soil:	mapping unit		surface textu	ıre	
	actual depth		AW	C	inches/feet
Irrigatio	n: duration	frequency	MAD	%	inches/feet
Irrigatio	n system hardware:				
Filter: p	oressure at: inlet	psi, outlet	psi, loss _	psi	
Emitter:	manufacturer	type	spacing		-
Rated d	lischarge per emitter (emission point):	gr	oh at	psi
	Emission points per p	plant	giving	gallons per plar	nt per day
Later: o	diameter:	material	length	15	spacing

Sketch of micro irrigation system layout:



Micro Irrigation System Detailed Evaluation Worksheet

System dischar	rge: gpm, number of i	gpm, number of manifolds and						
Average test ma	anifold emission point discharges at _	ps	i					
Manifold =	(sum of all averages gph) (number of averages)	=gph	1					
	(number of averages)							
Low 1/4 =	(sum of low 1/4 averages g		_ gph					
	(number of low 1/4 averages)						
Adjusted avera	ge emission point discharges at	psi						
System = (DCF) x (manifold avera	age) =	gph					
Low 1/4 = (DCF	x (manifold low 1/	'4) =	gph					
Discharge test	volume collected in	ninutes (1.0 aph = 63 ML/mi	n)					

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 Bave								
2/3 down	A B ave								
far end	A Bave								

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		
		%	%	%	%		
Estimat	ed average SMD in wetted soil v	olume					
Minimu	m lateral inlet pressures, MLIP, o	n all operating, m	anifolds:				
Manifol	d ID: Test						Ave.
pressur	re, psi						
Dischar	ge correction factor, DCF, for the	system is:					
	2.5 x (average MLII			=		psi	
	(average MLIP psi			psı)			
or if the	emitter discharge exponent, x =	is	known,				
DCF =	(average MLIP	<u>psi)</u> x =		_ psi			
	(test MLIP	osi)					
Comme	ents:						

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 en	aine:			
		hp at	rpm	
·	•		·	
	_	ear drive belt drive		
Pumps				
Type: (centrifugal,				
turbine, submers.)				
Make				
Model				
Impeller diameter		<u> </u>		
Number of impellers				
Rated flow rate (gpm)				
at head of (ft)				
at rpm				
Pump curves: Attache	d	(yes or no)		
Comments about cond	iton of equipment			

Pumping Plant Detailed Evaluation Worksheet

Land user	Field office
Existing suction or turbine column set-up (sketch showing dim	nensions)
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 outletpsi	
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) + misc	cellaneous =
	= feet
Flow rate:	
Flow meter:	
Flow rate = gpm	
Velocity meter:	
Pipe ID inches	
Velocityfeet/second	
Flow rate, Q, in gpm = (Velocity, in feet/second) x (2.45) x (pip	pe ID ²) =
=	= apm

Pumping Plant Detailed Evaluation Worksheet

Land user	Field office	
Water horsepower:		
whp = (flow rate, in gpm) x (TDH, in feet) =	=	hp
3960		
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 = (3.6) x (disk rev) x (Kh) x (PTR) x (CTR) =		(kwh/h)
(time, in seconds)		
Diesel or gasoline:		
Evaluation time: hours minutes	_ = hours	
Fuel use gallons (a small quantity of fuel mag	y also be weighed, at 7.05 lb/g	al for diesel and 6.0 lb/gallon
for gasoline)		
(fuel use, in gallons) =	==	gallons/hour
(time, in hours)		
Propane:		
Evaluation time: hours minutes =	= hours	
Fuel use lb (weigh fuel used from small p	oortable tank)	
(fuel use, in lb) =	= g	allon/hours
(4.25 lb/gal) x (time, in hr)		
Natural gas:		
Evaluation time: hours minutes	= h	ours
Meter reading: End minus Sta		
<u> </u>		
(fuel used, in mcf) =	=	mcf/hr
(time, in hr)		

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

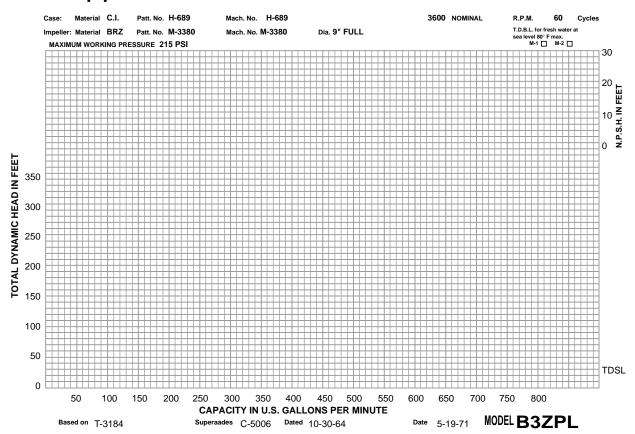
Pumping Plant Detailed Evaluation Worksheet

Land user		Field office				
irrigation pumping		ndard for a good o		the Nebraska Standards for ated plant. If the comparison		
Nebraska perfor	mance rating:					
Nebraska pumpin	g plant performance criteria	I				
	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 Nehraska sta	andards assume 75% pump	and 88% electric	motor efficiency			
		aa 5575 5.555				
Percent of Nebras	ska performance rating					
=	(whp) x (100)	=				
(energy input)	x (Nebraska criteria, in whp	-h/unit)				
_		_	%			
=		=	/0			
Horsepower input	:					
Electric:						
(* (1)40						
(input kW)	_	=	bhp			
(0.746 kW/bh _l	ρ)					
Diesel:						
(16.66) x (ene	ergy input, in gal/hr) =		=	bhp		
Propane:						
(0.20) v (opor	gy input, in gal/hr) =		_	hhn		
(9.20) X (ener	gy input, in gai/iii) =		=	bhp		
Natural gas:						
(82.20) x (ene	ergy input, in mcf/hr) =		=	bhp		

Pumping Plant Detailed Evaluation Worksheet

Land user				
Pumping plant efficiency:				
Epp = (water horsepower output, whp) x (100) =		=	%
(brake horsepower input, b				_ / -
(brake horsepower input, i	,,,p)			
Energy cost per acre-foot:				
Fuel cost per unit	\$/kW-hr, or \$/gal, or \$/ı	mcf		
Cost, in $\frac{5431}{x}$ (fuel cost, in		kW, gal/hr, or mcf/hr)	
	(flow rate, in gpm)			
=		= \$	/acre-foot	
Recommendations:				

Pump performance curve



Soil Description

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

Soil												File N	lo.	
Area								Date)			Stop	No.	
Classi	fication													
Locati	ion													
N. veg	ı. (or cro	pp)							С	imate				
	t materia													
	ography													
Relief			Drainage						S	alt or al	kali			
Elevat			Gr. water							onines				
Slope			Moisture						10.					
Aspec			Root distrib).					%	Clay*				
Erosic				Coarse	fragmen	ts*					er than	V.F.S.*	,	
	ability			, C Cu.cc	ago				170	- COUITO	or trium	VIII 101		
	onal not	es												
, . 														
										*Con	trol co	ction a	vorago	
		-	1				0.1.					Clion a	verage	
Hori-	Depth	Со	ior	Texture	Struc-	Color		Reac-	Boun-	Effer-	Roots	Pore	Line	
zon	•	Dry	Moist		ture	Dry	Moist	Wet	tion	aary	vesc- ence			
		-												
				1										
				+										
				1										

(210-vi-NEH, September 1997)

U.S. Department of Agriculture Natural Resources Conservation Service

Cylinder Infiltrometer Test Data

NRCS-ENG-322 05-96

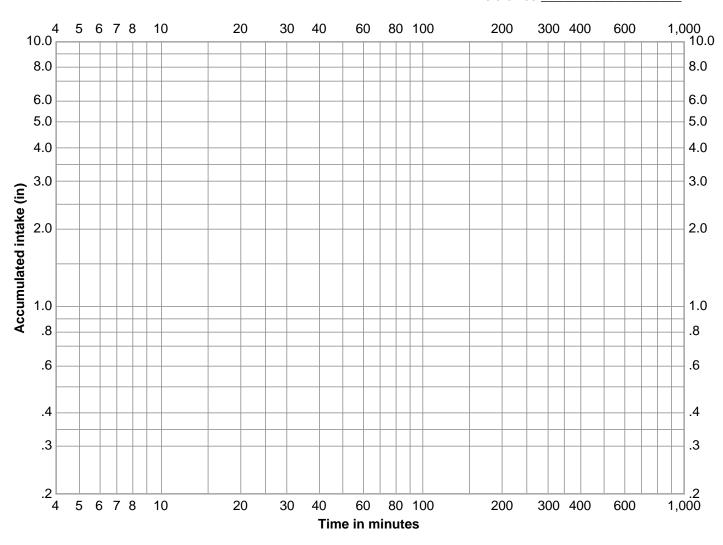
FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE		
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:			
CROP	STAGE OF GROWTH					

GENERAL COMMENTS

ЭE	Cy	/linder No.	1	(Cylinder No	o. 2	С	ylinder No.	. 3	C	ylinder No.	4	C	ylinder No.	5	ے ا
Elapsed time	Time of reading	Hook gauge reading	Accum. intake	Average accum. intake												
Min.		Inc	hes	₹												
	l		l		l											<u> </u>

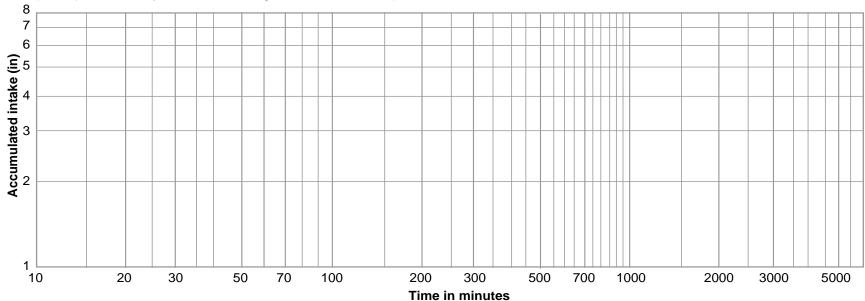
Land user ______ Date _____ Field office _____

Soil water intake curves



Intake curve overlay (Clear plastic overlay is available through NRCS State Office)

Land user	
Date	
Field office	



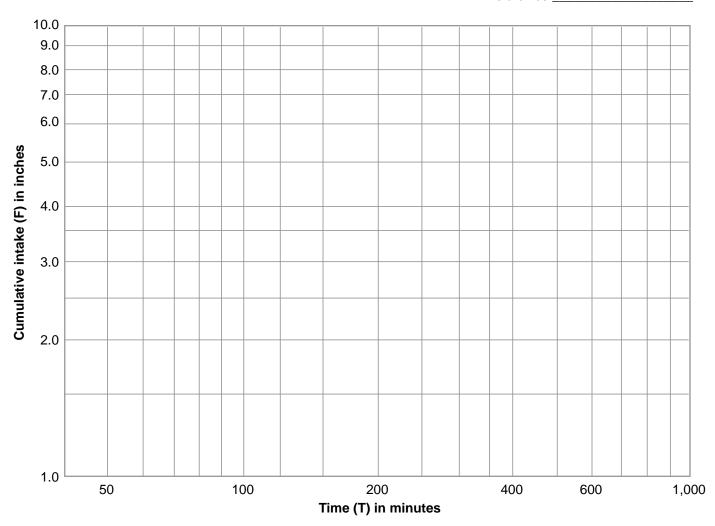
Intake Grouping for Border Irrigation Design

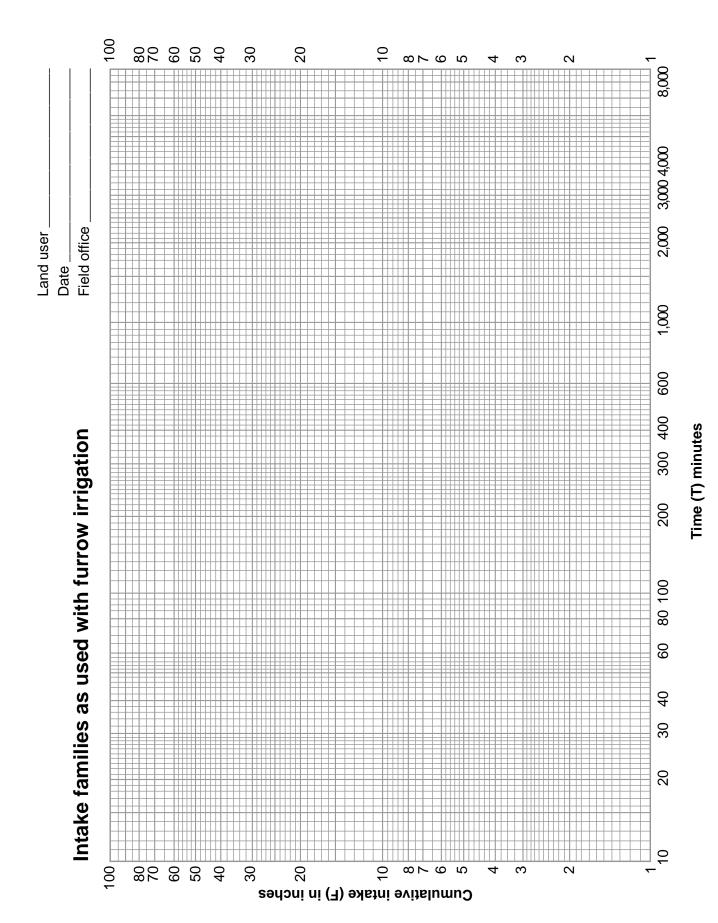
Instructions

- 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





(210-vi-NEH, September 1997)



Natural Resources Conservation Service

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;
- 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	Zone	USDA texture	Field capacity*	AWC for layer	Water available	Water need
(inches)	(inches)		(percent)	(inches)	(inches)	(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	
Net irrigation requirement or need	3.1

Fine sand and loamy fine sand soils

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	

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

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.

A	Available water capacity 1–4, 2–1, 2–2, 2–3, 2–4, 2–5,	Continuous move 6–43, 6–52, 9–41, 9–42, 9–152, 9–146,
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9-67, 9-102	2-28, 2-34, 2-37, 4-7, 6-6,	9-151, 9-152, 9-155, 9-156,
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11–18	Bubbler 3–15, 5–2, 5–5, 5–10,	Crop evapotranspiration 1–4,
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