Appendix A

Mitigation Actions Support Documents

1. Bureau of Reclamation Upper Colorado Region, "Appendix B Water Supply/Hydrosalinity." *Dolores Project Colorado – Supplement to Definite Plan Report*. January 1988.
2. ADS, Inc. Drainage Handbook, "Figure 3-1 Discharge Rates for ADS Corrugated Pipe with Smooth Interior Liner." July 2014.
3. High Desert Conservation District/NRCS, "Full Service Area Center Pivot Assessments – 2016 Irrigation Season." 2016.

Dolores Project
Colorado

SUPPLEMENT TO DEFINITE PLAN REPORT

JANUARY 1988

APPENDIX B

WATER SUPPLY/HYDROSALINITY

BUREAU OF RECLAMATION

UPPER COLORADO REGION

ATTACHMENT F

CANAL SEEPAGE METHOD

Attachment F summarizes seepage and salt loading calculations for preproject conditions, future conditions without salinity, and future conditions with salinity. These categories are further broken down by individual sections, canal, and seepage rate.

Canal seepage study
Future conditions with salinity control features

Page 1 of 2

Seepage number	Seepage rate (cfd) Minimum	Seepage rate (cfd) Maximum	Maximum flow (cfs)	Wetted perimeter (feet)	Length (feet)	Time in days/year	Seepage (acre-feet/year) Minimum	Seepage (acre-feet/year) Maximum	TDS Drain	TDS Canal	Tons/year Minimum	Tons/year Maximum
Upper Hermana												
1	0.100	0.100	110	20	2,605	187	22	22	2,300	490	55	55
4	.200	.330	110	18	10,260	187	159	262	2,500	490	433	715
5	.330	.460	92	17	2,200	187	53	74	2,600	491	152	212
5	.330	.460	87	17	13,218	187	318	444	2,600	491	913	1,273
3	.130	.200	87	17	4,032	187	38	59	2,500	491	105	161
4	.200	.330	87	17	6,181	187	90	149	2,500	491	246	407
Lone Pine												
1	.100	.100	162	26	7,040	187	79	79	2,930	240	287	287
1	.100	.100	162	26	11,210	187	125	125	2,100	240	317	317
4	.200	.330	128	26	9,236	187	206	340	2,100	240	522	861
1	.100	.100	128	22	5,661	187	53	53	2,000	240	128	128
1	.100	.100	128	22	1,108	187	10	10	2,000	240	25	25
1	.100	.100	109	20	6,864	187	59	59	2,000	240	141	141
5	.330	.460	90	24	5,896	187	200	279	1,400	240	316	441
6	.460	.600	90	24	928	187	44	57	1,400	240	69	91
5	.330	.460	90	24	5,449	187	185	258	1,800	240	393	548
1	.100	.100	71	18	8,431	187	65	65	2,300	240	183	183
1	.100	.100	56	0	4,000	187	0	0	2,300	240	0	0
1	.100	.100	56	15	2,169	187	14	14	2,300	240	39	39
4	.200	.330	46	23	9,900	187	196	323	1,300	240	282	465
4	.200	.330	36	23	4,992	187	99	163	1,300	240	142	234
3	.130	.200	26	22	8,451	187	104	160	2,200	240	277	426
Moonlight												
2	.060	.132	22	9	25,700	187	60	131	2,800	140	216	474
Garrett Ridge												
4	.200	.330	22	8	15,494	187	106	176	2,100	200	275	454
3	.130	.200	18	8	3,606	187	16	25	2,400	200	48	74
Upper Arickaree												
4	.200	.330	28	9	8,004	187	62	102	2,400	150	189	312
3	.130	.200	28	9	8,785	187	44	68	1,690	150	92	142
Drop Ditch												
1	.100	.100	7	7	8,093	187	24	24	2,000	130	62	62
Little Corkscrew												
3	.130	.200	7	7	9,795	187	38	59	2,000	130	97	150
Corkscrew												
1	.100	.100	20	10	2,639	187	11	11	1,200	130	16	16
3	.130	.200	20	10	12,361	187	69	106	1,300	130	110	169

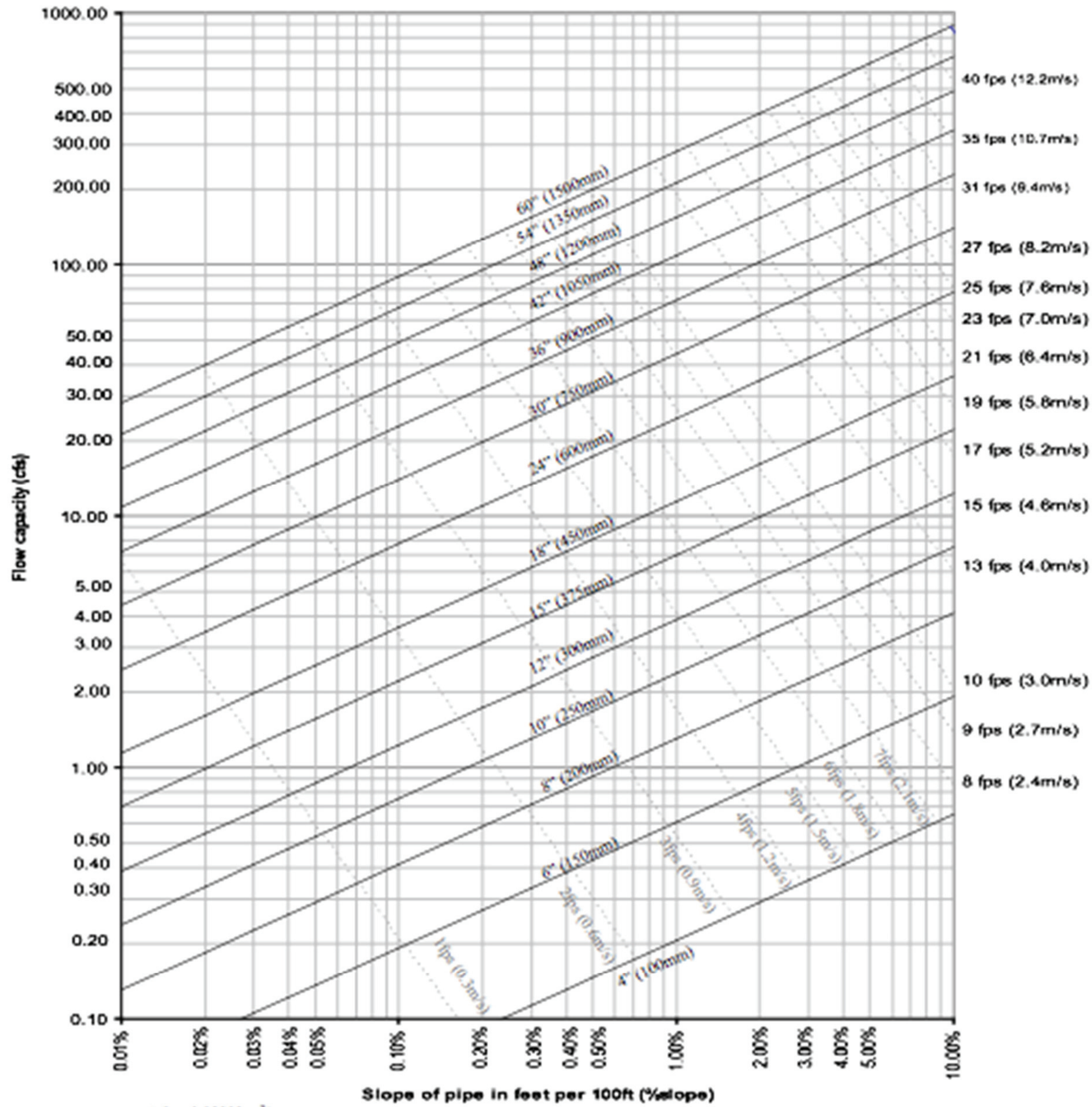
ATTACHMENT F (Continued)

Canal seepage study
Future conditions with salinity control features

Page 2 of 2

Seepage number	Seepage rate (cfd) Minimum	Seepage rate (cfd) Maximum	Maximum flow (cfs)	Wetted perimeter (feet)	Length (feet)	Time in days/year	Seepage (acre-feet/year) Minimum	Seepage (acre-feet/year) Maximum	TDS Drain	TDS Canal	Tons/year Minimum	Tons/year Maximum
						West Lateral						
4	.200	.330	58	12	36,090	187	372	614	1,100	114	499	823
						East Lateral						
4	.200	.330	60	15	19,878	187	256	422	1,500	130	477	787
						Lower Arickaree						
3	.130	.200	10	12	10,400	187	70	107	3,400	490	276	424
						May Lateral						
4	.200	.330	29	8	7,674	187	53	87	3,500	470	217	358
4	.200	.330	29	8	2,053	187	14	23	3,500	470	58	96
4	.200	.330	19	10	6,127	187	53	87	3,500	470	217	358
3	.130	.200	15	10	7,835	187	44	67	3,500	470	180	277
						Rocky Ford						
5	.330	.460	13	8	7,000	32	13	18	2,000	130	32	45
						Goodland						
3	.130	.200	20	15	15,355	187	129	198	1,400	130	222	342
4	.200	.330	20	15	4,143	187	53	88	2,000	130	136	224
						Cortez						
3	.130	.200	20	6	24,058	187	81	124	3,000	329	293	450
						Duncan						
1	.100	.100	10	5	18,018	187	39	39	6,500	130	335	335
						Ute Mountain Lateral						
4	.200	.330	5	6	6,739	187	35	57	5,900	130	272	449
5	.330	.460	5	5	17,200	187	122	170	6,800	130	1,105	1,541
						Towaoc Canal						
11	.070	.070	420	27	10,000	191	83	83	2,420	130	257	257
1	.100	.100	420	45	10,000	191	198	198	2,300	130	585	585
1	.100	.100	370	42	9,000	191	167	167	2,300	130	491	491
1	.100	.100	370	42	5,200	191	96	96	2,000	130	245	245
11	.070	.070	370	52	11,800	191	189	189	2,000	130	482	482
11	.070	.070	370	26	14,200	191	112	112	2,250	130	323	323
11	.070	.070	370	52	6,000	191	96	96	3,580	130	452	452
11	.070	.070	344	49	25,300	191	382	382	6,410	130	3,263	3,263
11	.070	.070	303	47	11,500	191	166	166	6,010	130	1,327	1,327
11	.070	.070	286	46	16,000	191	225	225	5,090	130	1,517	1,517
11	.070	.070	244	41	6,500	191	81	81	4,400	130	473	473
11	.070	.070	244	41	2,500	191	31	31	4,400	130	182	182
11	.070	.070	173	35	4,200	191	44	44	4,400	130	258	258
11	.070	.070	173	35	1,526	191	16	16	4,400	130	94	94
11	.070	.070	135	31	15,250	191	147	147	6,500	130	1,273	1,273

Figure 3-1
Discharge Rates for ADS Corrugated Pipe with Smooth Interior Liner[1]



1cfs = 0.02832 m³/s
1ft/s = 0.30480 m/s
1% = 0.01 ft/ft

1. Applicable products: N-12®, MEGA GREEN®, N-12 STIB, N-12 WTIB, HP STORM, SaniTite®, SaniTite HP, N-12 Low Head

Note: Based on a design Manning's "n" of 0.012.
Solid lines indicate pipe diameters. Dashed lines indicate approximate flow velocity.
Redeveloped from FHWA HDS 3 – Design Charts for Open-Channel Flow[2]

Full Service Area Center Pivot Assessments

2016 IRRIGATION SEASON

Summary of Field Observations of Existing Center Pivots in Full Service Area Montezuma County, CO

High Desert Conservation District/NRCS

Tel 970-529-8365 travis.custer@highdesertconservation.org

Contents

Project Summary

The following report outlines field observations and data collected on existing center pivot irrigation systems in the Full Service Area (FSA) of Montezuma County, CO during the 2016 season. The FSA services 118 irrigators utilizing 300 delivery points to irrigate 28,985 acres in the northern area of the county. Irrigators receive their irrigation water via McPhee reservoir and the Dolores Water Conservancy District.

Through partnership between the High Desert Conservation District (HDCD) and the Dolores Water Conservancy District (DWCD) it was identified that there was a high priority amongst producers in the Full Service Area (FSA) to upgrade systems from sideroll irrigation to center pivot technologies. Some producers in the FSA already utilize center pivots and have seen significant reductions in labor while maintaining high quality crop production.

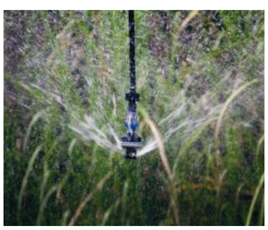
In an attempt to provide expanded outreach to the FSA and look for opportunities to provide resources to area producers the HDCD and Cortez NRCS field office worked with DWCD to develop plans to assess current pivots. Under current specifications (CO NRCS Standard 442) outlined in EQIP for center pivots, land exceeding 3% slope on 50% or more of the field, or 5% slope on 50% or more of the field (for fine and course textured soils, respectively) would not qualify for funding. Area NRCS engineer will review current and future data to assess whether changes can be made to slope criteria within the 442 spec, and/or allow for individual project variances.

In the spring of 2016 HDCD and NRCS staff approached farmers from the FSA during the annual Farmer Advisory Meeting hosted by DWCD looking for participants for center pivot evaluations. Approximately 20 names were received, some of which currently utilize existing pivots and some who would like to upgrade. Beginning in July of 2016 and extending through the end of September, five individual producers participated and data was collected for nine existing center pivots totaling approximately 1,089 acres. Additionally other producers were contacted and experiences and observations regarding their center pivots were discussed.

Travis Custer
High Desert Conservation District
District Conservation Technician
(970) 529-8365

Senninger IWOB

Senninger Super Spray



Nelson R3000 Rotator

Nelson S3000 Spinner

Equipment Inventory

As part of the assessment process Center Pivot Assessment Sheets were utilized from the Florida NRCS, specifically FL ENG-442F. This assessment sheet looks at pivot design and hardware as well as soils information, system data, and catch can collection data.

Nozzles-

Where available manufacturer nozzle packages and precipitation charts were copied from producer files and included in the assessment process. Many irrigators utilizing pivots in the FSA are packaging the system with Senninger IWOB nozzles or similar Nelson Orbitor nozzles.

Although these nozzles are being promoted by the industry for superior uniformity, low pressure applications, and randomized droplet application there are some concerns from a resource conservation standpoint as to their efficacy with local area soils. Because of the low pressure application these wobbler style nozzles promote a larger droplet size which can increase risk of soil sealing and runoff on steeper slopes (>3-5%). However, once sufficient crop canopy is developed, such as in alfalfa, little runoff**[1] was observed in the field, and producers appreciate the uniformity and low maintenance requirements of these nozzles.

Three of the pivots assessed were utilizing older model rotator and spray type nozzles, specifically Senninger Super Sprays, Nelson R3000 Rotators, and Nelson S3000 spinners. These nozzles, although older in design, and requiring more maintenance of moving parts, were observed to have a similar or slightly larger wetted diameter but with smaller droplet sizes. This was due to increased pressure supplied to the nozzles (15-30 psi vs. 10-15 psi on IWOB packages). There was more wind drift observed with these nozzles, but it seemed to be of fairly negligible concern most days. The producer reported that these nozzles required more annual maintenance of moving parts such as bearings, but that less runoff was observed during periods of low residue and groundcover.

[1] ***Runoff is difficult to quantify, however for simplistic purposes this is observable water outside of the intended wetted diameter of the sprinkler system*

With all nozzle types it was important for management to play a key role in water and soil conservation with producers appropriately utilizing precipitation charts. Some pivots assessed in the FSA are over ten years old, and contain original nozzle packages. Improvements have been made in both design and functionality of pressure regulators and nozzles and it was noted that some pivots assessed would benefit from upgraded hardware. Over time moving parts on spinners and rotator type nozzles wear out, and older pressure regulators were observed to clog more often than newer models due to changes in internal orifice size and shape.

On steeper slopes some producers may still benefit from choosing rotator or spray type nozzles to increase wetted diameter and reduce droplet size to help mitigate risks of sealing and runoff.

System Design-

All pivots assessed were designed for between 500 and 850 gallons per minute (gpm) with typical operating pressures of 50-55 psi at the delivery box where flow rates and pressure were measured. Most ranged in size from 7 to 9 towers with average span lengths around 130-140 feet. All but two systems assessed were utilizing end guns between 57 and 116 gpm. None had booster pumps in use. All pivots assessed utilized drops for the nozzles (both flexible and rigid) and were typically around four feet above ground level although nozzle height above ground varied significantly depending on slope and undulations in the field. At times nozzles were observed touching the ground as the center span crested a hill, for example. Other times nozzles were observed 8-10 feet above ground level. This may pose challenges during the design process in anticipating wetted diameter, and can make it difficult in certain situations to achieve a large enough wetted diameters for engineering specifications and design purposes.

Nozzles dragging on ground

All of the pivots assessed, except one, were outfitted with boombacks on each tower to prevent excess water in wheel tracks. All producers that participated expressed past and current issues with rutting in the tracks and occasional stuck pivots. Area farmers have turned to a local woven aspen erosion rolls to fill in deep ruts and help the pivots pull out of ruts. These "excelsior" rolls are sourced from a manufacturer in Mancos, CO. Boombacks, in general, were effective on many fields, however on steep downslopes water may still run in front of wheels causing potential for rutting and stuck towers.

Field Observations

Field observations were documented on all pivot sites with particular focus on conservation concerns such as runoff and erosion. In seven of the nine pivots assessed very little erosion or runoff was observed in situations of established perennial crops, such as alfalfa on slopes below 5%. Typical application rates for established alfalfa were around 1 inch of water every 72 hours, thereabouts. It should be observed that for this area, during the hot dry portions of the growing season, this closely matches expected evapotranspiration (ET) rates for alfalfa, which are typically around 0.3” per day. Although little runoff was observed in full canopy cover, there was runoff observed on field edges, on bare ground, and on some of the steeper slopes (+5%) directly after cutting when canopy cover was minimized. However, in one instance where the producer reduced application rate post-harvest these effects were mitigated.

Runoff observed approx. 10 days post-harvest. Approx. slope, 6%.

Significant runoff observed on irrigated pinto beans

Where efforts to reduce water in tire tracks failed there were some issues with water running in the tire tracks. In one instance, runoff in the tracks was significant enough to cause erosion in a draw which did leave the field, however in most other cases observed water within the tracks was minimal and did not result in conservation concerns. In annual crop scenarios runoff was observed between rows, where there was insufficient canopy cover to break the velocity of water drops and prevent surface sealing. Although some saturated areas were observed in draws off steeper slopes (greater than 5%), these seemed no more apparent than those observed in sideroll irrigation.

Soils

Soils in the assessment area, overall, tend to be classified as clay-loams or silty-clay-loams. Most are comprised of fine or medium textures and are of mostly eolian deposits. Concerns identified during the assessment associated with local soils include low infiltration rates**[2] (typically between .3" and .5" per hour for the soils in question), and fine silt particles that can lead to surface sealing and thus concern for runoff. Surface crusting was observed on most fields assessed, particularly during annual cropping rotations and post-harvest on perennial hay fields.

Soil pit dug to classify texture

Area NRCS soil scientist and field office staff performed a detailed soil assessment of a representative site location. That report can be found on Appendix A. In this report both slopes and soils were analyzed and compared to criteria in the 442 specifications. Depending on soil textures slope criteria may change from 3% for fine textured soils to 5% for coarse textured soils.

Further soils analysis of other sites is needed to better understand if an increase from 3% to 5% is possible given area soil classifications. This increase could allow certain fields to qualify within the currently available specifications, while allowing more leniency within the design and engineering needs for those fields still requiring potential variances to the 442 spec.

[2]** *Additional infiltration data is needed to better understand differences in onsite variability and soils classification*

Goals identified to reduce conservation concerns in potential pivot design with regards to soils include:

1) Increasing wetted diameter to allow faster movement of pivot through field
2) Increasing pressure at regulators to further atomize water droplets and reduce risk of surface sealing
3) Educate producers on potential management strategies to improve infiltration and limit erosion and runoff concerns, which may include:
    a. Reduced tillage strategies that leave more surface residues
    b. Improved soil health practices to improve infiltration and soil structure such as cover cropping
    c. Appropriate irrigation management based on time of year, ET, crop type, soil moisture and growth stage

Additional benefits in soil management could also be achieved over time including increased water holding capacity, better nutrient management, reduced inputs, reduced disease pressures and increases in crop quantity and quality. These affects could benefit area producers by increasing the resiliency of operations to better withstand changes in water availability during drought years for example while improving bottom lines.

Conclusion

There are clearly understood benefits to the use of center pivot technologies in an operation including labor savings, potential increases in yield, and potential water conservation savings. Although observations from the 2016 pivot assessments were promising, continued onsite visits are needed as well as expansion and follow up on existing assessments before conclusions can be drawn that may effect changes to the NRCS specifications and slope criteria. The following considerations should be taken on existing and additional pivot assessments:

1) **Soils Data:** Because texture dictates the slope criteria used for each site it is important that more data is gathered from existing and additional sites. So far, only one of the nine sites was assessed in this manner.
2) **Infiltration Rates:** It may be necessary to gain a better understanding of infiltration rates at specific sites. Despite an understanding of average area soil infiltration rates, site specific data accompanied with site specific soils data would give more understanding of understanding design and management considerations.
3) **Follow-up Assessments**: It is important to not only assess new sites with existing pivots, but to also follow up with existing sites over time.

Additional information is needed to grasp a better understanding of pivot efficacy and effect of slope on conservation concerns over time. For example, changes in crop, and management strategies on a given site could affect conservation concerns in a positive or negative way if observed over the course of an entire rotation. Because it is challenging to quantify runoff it will be important to have on site field observations over the course of a few seasons and use this information to draw further conclusions.

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet – Heermann and Hein Method

Cooperator: ______________ Field Office: ______________

Observer: ________ Date: ________ Checked by: ____________ Date: ______

Field name/number: ______________________________

Center pivot number: ______ Pivot location in field: ______________

Acres irrigated: ____________

Hardware Inventory:

Manufacturer: (name and model) ______________________

Is design available? ______ (attach copy) Number of towers: ___ Spacing of towers: ______

Lateral: Material: ______________ Inside diameter: ____ inches

Nozzle: Manufacturer: ______________________

Position: __________ Height above ground: ______________

Spacing: ______________________

Is pressure regulated at each nozzle? ________ Operating pressure range: ______ psi

Type of tower drive: ______________________

System design capacity: ____ gpm, System operating pressure: ______ psi

Nozzle data, design: Pivot end

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

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

End gun capacity: ______ gpm, Pressure: ______ psi., boosted to: ______ psi

End swing lateral capacity: ______ gpm, Pressure: ______ psi

Field observations:

Crop uniformity: ______________________

Runoff: ______________________

Erosion: ______________________

Tower rutting: ______________________

System leaks: ______________________

Elevation change between pivot and end tower: ______________

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Wind: Speed ______________ mph; Direction (from) ______________
Line direction: From center to outer tower ______________ moving: ______________
Time of day: __________; Humidity: [ ] low [ ] med [ ] high; Air temp: __________
Evaporation: start depth: ______ inches; end depth: ______ inches; Evaporation: ______ inches

Crop: __________; Root zone depth: ________ foot; MAD[1/] : ______%; MAD: ______ inches

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

Moisture determination method ______________________________
Soil series name, surface texture ______________________________

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

Comments about soils:

Present irrigation practices:

Typical system application:

Crop	Stage of Growth Percent	Hours [2/] per Revolution	Speed Setting	Net Application in

Hours operated per day: ______________ hours
Approximate number of pivot revolutions per season: ______________

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

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

Then: hours per revolution = $\dfrac{2\ (\text{distance to end tower in feet}) \times \pi}{(\text{feet/hour})}$

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

System data:

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

* End tower speed: Distance between stakes: __________________

Time at first stake: _______________, Time at second stake: _________________

Time to travel between stakes: _________________ minutes

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

Measured system flow rate: ________ gpm, method: __________________________

Calculations: ____

Evaluation computations:

Circumference of end tower:

Distance to end tower x 2 π = (__________________) x 2 x 3.1416 = ________________________ ft

End tower speed:

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

Hours per revolution:

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

Area irrigated:

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

Gross application per irrigation:

$$\frac{\text{Hours per revolution x gpm}}{\text{453 x acres irrigated}} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_}{\text{453 x (\_\_\_\_\_\_\_\_) ac}} = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ in}$$

Weighted system average application:

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

$$\text{Inches in catch container} = \frac{\text{cc (ml) measured in cylinder x 0.077698 (in}^3\text{/ml)}}{\text{Catch can diameter (in)}^2} = \frac{(\_\_\_\_\_\_)}{(\_\_\_\_\_\_)^2} = \_\_\_\_\_\_ \text{ in}$$

$$\frac{\text{Sum of: catch (in.) x distance from pivot}}{\text{(Sum of: distance from pivot)}} = \frac{(\_\_\_\_\_\_\_\_\_\_\_\_)}{(\_\_\_\_\_\_\_\_\_\_\_\_)} = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ in}$$

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Heermann and Hein uniformity coefficient (CU_H):

$$CU_H = 100\left[1 - \frac{\sum_{i=1}^{n} S_i\left|D_i - \overline{D}\right|}{\sum_{i=1}^{n} S_i D_i}\right] = \_\_\_\_\_\_\_\_\_\_ \%$$

Where:

CU_H = Heermann and Hein uniformity coefficient;
n = number of catch cans used in the evaluation;
i = number assigned to identify a particular catch can beginning with i = 1 for the catch can located nearest the pivot point and i = n for the most remote catch can from the pivot point;
D_i = the depth of water collected in the ith catch can;
S_i = distance of the ith catch can from the pivot point;
$\overline{D}$ = weighted average of the depth of water caught; It is computed as:

$$\overline{D} = \frac{\sum_{i=1}^{n} S_i D_i}{\sum_{i=1}^{n} S_i}$$

(Use Excel spreadsheet, titled *Pivot HHCU.xls*, to calculate CU_H. The spreadsheet and corresponding instructions can be downloaded from the FL NRCS website, http://www.fl.nrcs.usda.gov/technical/program.html. The actual procedure for determining the modified Heerman and Hein coefficient of uniformity is in accordance with ASABE Standard S436.1 *"Test Procedure for Determining the Uniformity of Water Distribution of Center Pivot and Lateral Move Irrigation Machines Equipped with Spray or Sprinkler Nozzles"*. This publication is available to all USDA employees from the ASABE website, http://asae.frymulti.com/request.asp?search=1&JID=2&AID=14838&CID=s2000&v=&i=&T=2.)

Effective portion of water applied (R_e):

R_e = Weighted system average application (in) / Gross application (in) = (________) / (________) = ________

Average application efficiency (E_h):

E_h = CU_H x R_e = (________)(________) = ________ %

(Use for low value field and forage crops)

Application rate: Gross application x hours operated per day x E_h / Hours per revolution x 100

= (________)(________)(________) / (________) = ________ in/day

Maximum average application rate:

Maximum catch inches x 60 / Time containers are uncovered in minutes = (________) / (________) x 60 = ________ in/hr

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Pivot revolutions required to replace typical annual moisture deficit:

(Based on existing management procedures)

Annual net irrigation requirement ______________ in, for ______________ (crop)

Pivot revolutions required:

$\frac{\text{Annual net irrigation requirement} \times 100}{E_h \times \text{gross application per irrig.}} = \frac{(\_\_\_\_\_\_)}{(\_\_\_\_\_\_)(\_\_\_\_\_\_)} =$ ______ inches

Potential water and cost savings

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

= (______________) (______________) = ______________ in/yr

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

Potential annual gross applied = $\frac{\text{Annual net irrigation requirement} \times 100}{\text{Potential } E_{pq} \text{ or } E_{ph}}$

$= \frac{(\_\_\_\_\_\_)(\_\_\_\_\_\_)}{(\_\_\_\_\_\_)} =$ ______________ inches

Total annual water conserved:

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

$= \frac{(\_\_\_\_\_\_ - \_\_\_\_\_\_)(\_\_\_\_\_\_)}{12} =$ ______________ acre feet

Cost savings:

Pumping plant efficiency ______________ kind of fuel ______________

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

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

= ______________ x ______________ = $ ______________

Recommendations:

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Line 1: Container spacing ________feet Catch can diameter _______inches

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
53				
54				
55				
56				
57				
58				
59				
60				
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
75				
76				
77				
78				
79				
80				
81				
82				
83				
84				
85				
86				
87				
88				
89				
90				
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Line 1 (cont.): Container spacing ________feet Catch can diameter ________inches

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
105				
106				
107				
108				
109				
110				
111				
112				
113				
114				
115				
116				
117				
118				
119				
120				
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
135				
136				
137				
138				
139				
140				
141				
142				
143				
144				
145				
146				
147				
148				
149				
150				

Sum: ___________ **Sum:** ___________

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Line 2: Container spacing _________feet Catch can diameter ________inches

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
53				
54				
55				
56				
57				
58				
59				
60				
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
75				
76				
77				
78				
79				
80				
81				
82				
83				
84				
85				
86				
87				
88				
89				
90				
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				

Sprinkler Irrigation System Detailed Evaluation
Center Pivot Lateral Worksheet - cont.

Line 2 (cont.): Container spacing ________feet   Catch can diameter ________inches

Cont. No.	Dist. from Pivot	Catch (cc)	Catch (in)	Catch (in) x Dist.
105				
106				
107				
108				
109				
110				
111				
112				
113				
114				
115				
116				
117				
118				
119				
120				
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
135				
136				
137				
138				
139				
140				
141				
142				
143				
144				
145				
146				
147				
148				
149				
150				

Sum: ___________   **Sum:** ___________

$E_h =$ ____________

Pivot System Evaluation Distribution Profile