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A Comparison of Fairway Distribution Uniformity Computed with Catch Can Data and with Soil Moisture Data at Three Sampling Depths

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Spectrum[®]
Technologies, Inc.
"To Measure Is To Know"

Acknowledgments:

- **Dan Dinelli and Matt Leinen,
North Shore Country Club**
- **Cynthia Turski and Tom Ebeling,
Spectrum Technologies**

U.S. Golf Course Water Consumption

- **2.1 billion gallons of water per day.**
- **149 million gallons per course annually in southwest U.S.**
- **High - Southwest (\$107,880/year)**
Low – North-Central (\$4,700/year)

U.S. Golf Course Water Consumption

- **90% of facilities have never had an irrigation audit.**
- **16% of courses have been subject to stringent water restrictions.**
- **High - Northeast (33%)**
Low – North-Central and Pacific (3%)

Traditional Audit

- Set up catch cans.
- Measure volumes
- Calculate distribution uniformity

$$DU_{lq} = \frac{\overline{V}_{lq}}{\overline{\overline{V}}_{total}}$$

- Compute a run-time adjustment

Traditional Audit

- **Advantages**
 - **Allows calculation of precipitation rate.**
 - **IA has published quality standards**

Estimated DU_{iq} for golf systems by sprinkler type and system quality

Sprinkler Type	Excellent (achievable)	Good (expected)	Poor
			(if lower than this, consider not scheduling or improving irrigation system)
Rotary Sprinklers	80%	70%	55%
Spray Sprinklers	75%	65%	50%

Traditional Audit

- **Disadvantages**
 - **Time consuming.**
 - **Only tells how well water reached surface**

Soil Moisture Audit

There has been recent interest in using data from portable soil moisture probes to calculate uniformity.

Advantages

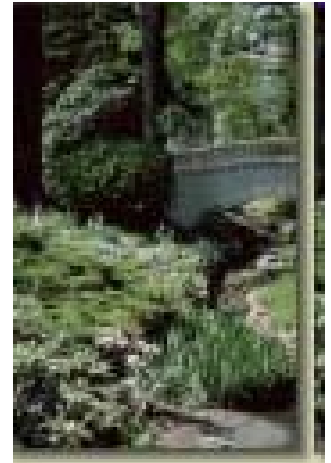
- **Faster data collection**
- **Measures water in the root zone**

U.S. Golf Course Water Consumption

- Green



- Landscape



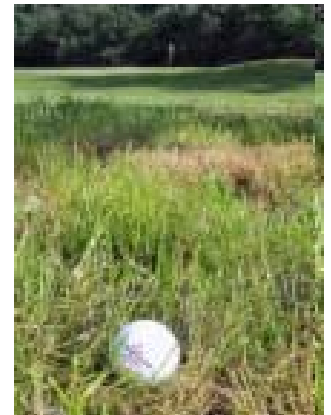
- Tee box



- Fairway



- Rough



U.S. Golf Course Water Consumption

- **Fairways and roughs offer potential water savings opportunities.**
 - **Larger irrigated area**
 - **More margin for error**

Objectives

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- Study the effect on the spatial variability of soil moisture due to:
 - Traffic level
 - Soil depth

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- Compare catch can and soil moisture DU_{LQ} on a fairway.
- Study the effect on the spatial variability of soil moisture due to:
 - Traffic level
 - Soil depth
- Identify a minimum number of catch cans necessary to calculate an accurate precipitation rate

Data Collection

- **Fairway 12 at North Shore Country Club (Glenview, IL).**
- **July 14 and August 11 sampling dates.**
- **High-, Medium-, and Low-traffic areas identified by superintendent.**



Data Collection

Catch Can Data

- 9x9 grid laid out with nails between adjacent sprinkler heads (65' x 90').
- Catch cans (d=5.9") placed at each nail.
- Irrigation system run for 12 minutes and collected volumes measured.



Data Collection

Soil Moisture Data

- Soil moisture readings taken at each nail before and after irrigation cycle
 - July (1.5, 3, and 5 inch)
 - August (5 inch only)
- TDR 300 portable soil moisture probe geo-referenced with a Garmin 72 GPS receiver.



Data Collection

- Sensitive to the bulk dielectric permittivity of the soil
- Permittivity affects the speed of an electromagnetic wave in the soil
- Reflectometer measures average volumetric water content (Θ).



Data Analysis

- DU_{LQ} calculated for each data set.
- Each data set mapped with SpecMaps ProTurf web mapping utility.
- Precipitation rates calculated for full 81-cup data sets as well as for pre-selected subsets ranging from 4 to 41 cups.

Results - DU

Summary of lower quartile distribution uniformity (DU_{lq}) calculations.

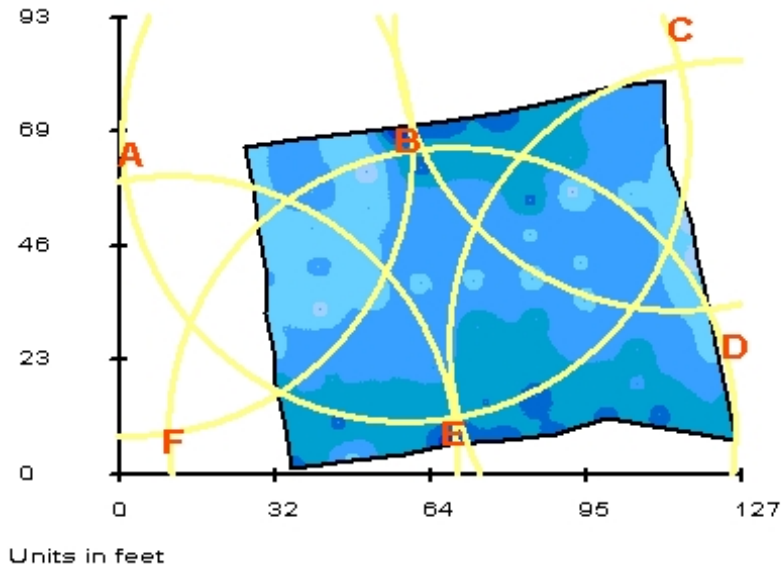
Date	Traffic	Audit Type							Wind speed
	Level	CC	5Pre	5Post	3Pre	3Post	1.5Pre	1.5Post	(mph)
July 14	High	62	92	88	89	86	90	88	5
	Medium	78	87	87	88	85	89	86	5
	Low	65	83	84	83	83	85	84	2
August 11	High	76	89	88	-	-	-	-	4
	Medium	66	84	83	-	-	-	-	6
	Low	70	81	81	-	-	-	-	2

CC, results from catch-can audit; Pre, data taken prior to irrigation; Post, data taken following irrigation; Numbers in Audit Type columns (5, 3, 1.5) refer to data from TDR300 connected to 4.8", 3", and 1.5" rods respectively.

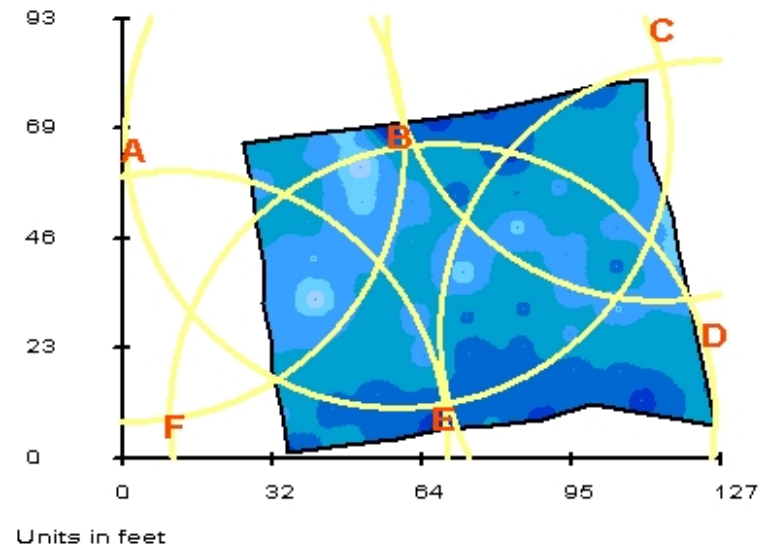
- **Catch can DU always lower than soil moisture DU.**
- **No difference seen for different soil depths.**
- **Trend toward increasing DU with increasing traffic.**

Results - Maps

Before and After Irrigation (Medium Traffic, 5" rods)



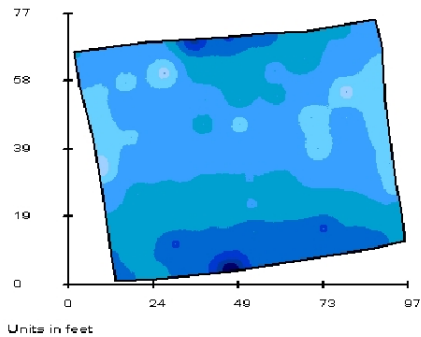
**August
pre-irrigation**



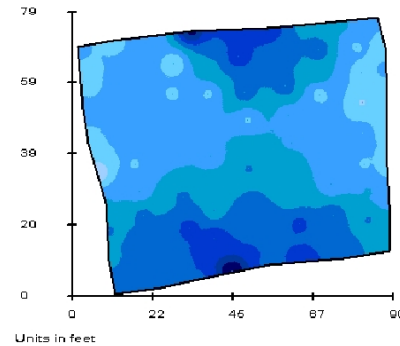
**August
post-irrigation**

Results - Maps

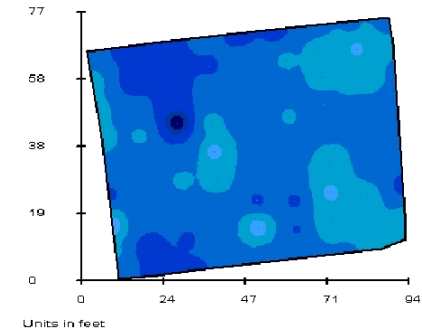
Same Traffic Level (Medium Traffic)



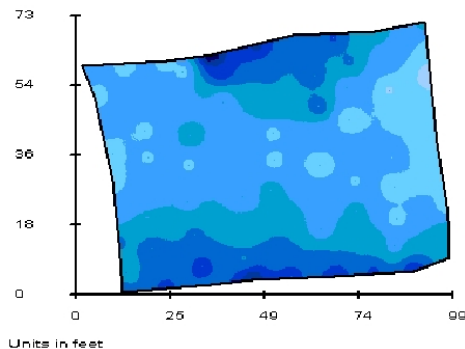
July Soil Moisture 1.5"



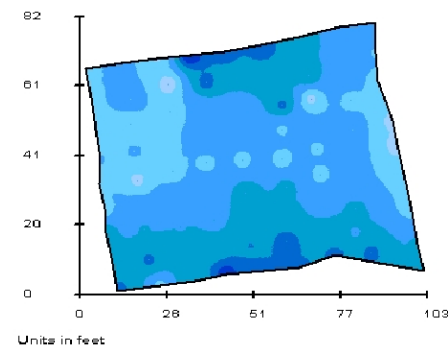
July Soil Moisture 3"



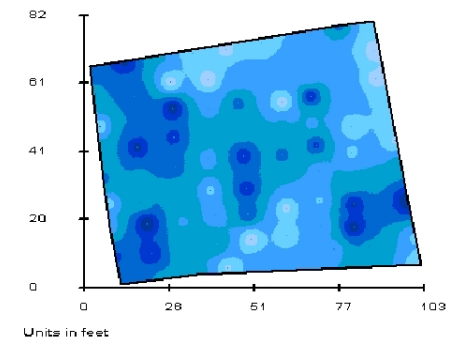
Catch Can July



July Soil Moisture 5"



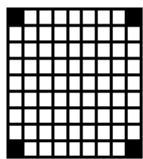
August Soil Moisture 5"



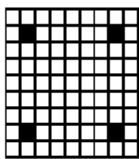
Catch Can August

Results – Precipitation Rate

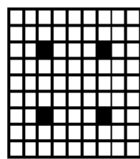
Calculated precipitation rate for all 81 cups as well as for pre-selected sub-sets.



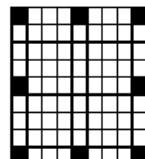
4-Square Large



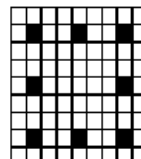
4-Square Medium



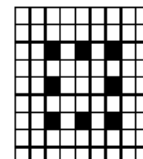
4-Square Small



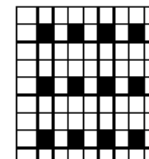
8 Square Large



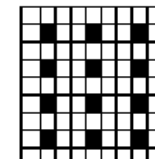
8 Square Medium



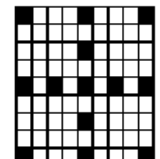
8 Square Small



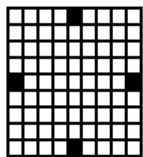
12 Square Horizontal



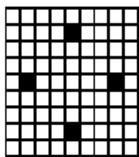
12 Square Vertical



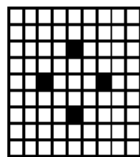
13 +-Cross/Corner



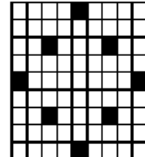
4-Diamond Large



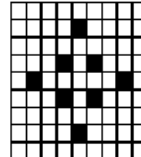
4-Diamond Medium



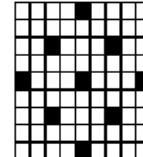
4-Diamond Small



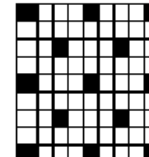
8 Diamond Large



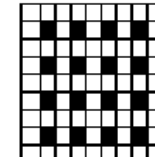
8 Diamond Medium



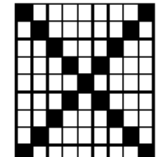
9 Diamond



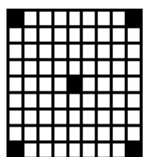
13 X-cross/middles



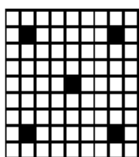
16 Square



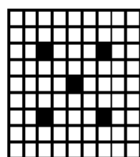
17 X-cross



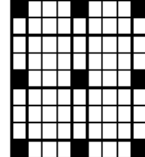
5 X-cross Large



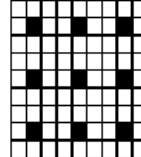
5 X-cross Medium



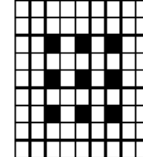
8 X-cross Small



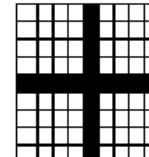
9 Square Large



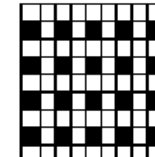
9 Square Medium



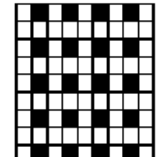
9 Square Small



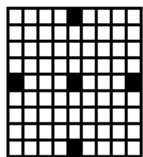
17 +-cross



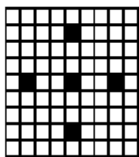
20 horizontal



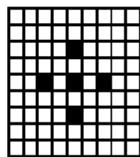
20 vertical



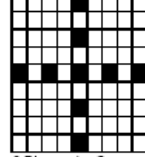
5 Diamond Large



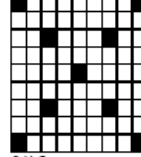
5 Diamond Medium



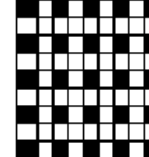
5 Diamond Small



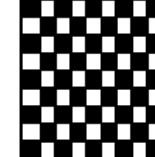
9 Diamond +-Cross



9 X-Cross



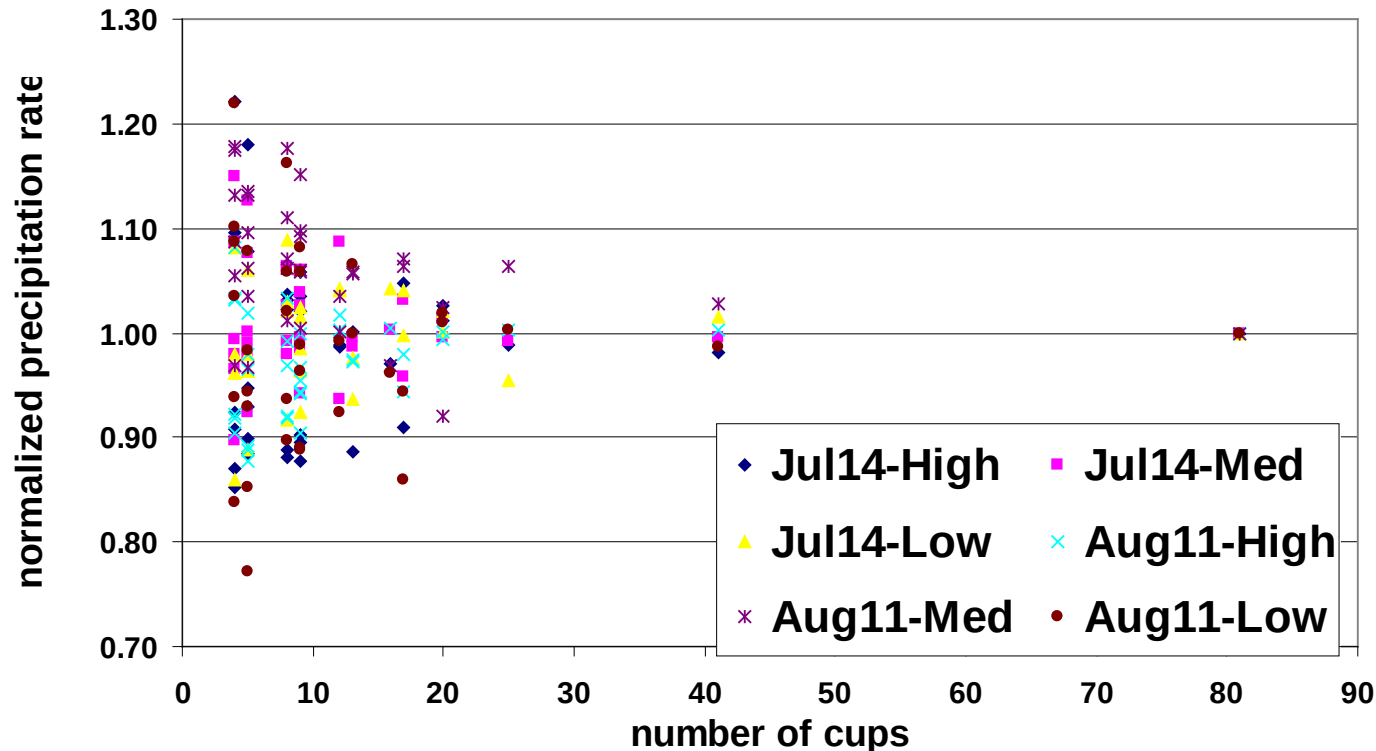
25



41

Results – Precipitation Rate

- Precipitation rates normalized by dividing by the 81-cup number.
- At 41 cups, see differences of 3%



Results – Precipitation Rate

Summary of precipitation rate calculations from 4- and 5-cup combinations

Pattern	July			August			Mean	StDev
	Hi	Med	Low	Hi	Med	Low		
5 Diamond Large	0.93	1.08	0.89	0.97	0.97	0.94	0.96	0.06
5 X-cross Small	0.88	0.98	0.96	0.89	1.13	0.93	0.96	0.09
5 X-cross Medium	0.95	0.99	0.98	1.02	1.06	0.85	0.97	0.07
5 X-cross Large	0.90	0.92	0.96	0.98	1.04	1.08	0.98	0.07
4-Square Small	0.85	0.96	0.96	0.92	1.17	1.04	0.99	0.11
4-Diamond Large	0.91	1.09	0.86	1.03	0.97	1.09	0.99	0.09
4-Square Medium	0.92	0.98	0.98	1.08	1.09	0.94	1.00	0.07
4-Square Large	0.87	0.90	0.96	1.03	1.05	1.22	1.01	0.13
5 Diamond Small	1.18	1.00	1.06	0.89	1.13	0.77	1.01	0.15
5 Diamond Medium	1.08	1.13	1.06	0.88	1.10	0.98	1.04	0.09
4-Diamond Small	1.22	0.99	1.08	0.92	1.18	0.84	1.04	0.15
4-Diamond Medium	1.09	1.15	1.08	0.90	1.13	1.10	1.08	0.09

Hi, Med, and Lo refer to data from the High-, Medium- and Low-Traffic areas respectively.

Results – Precipitation Rate

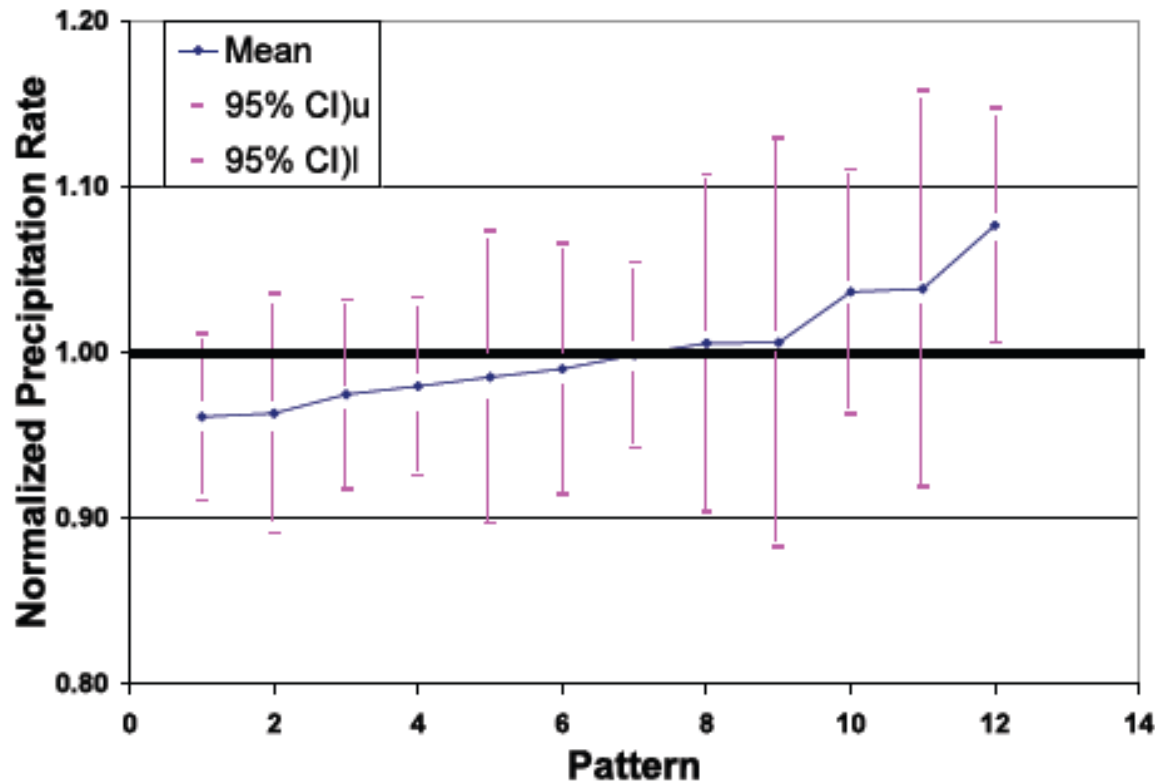
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5 X-cross Large	0.90	0.92	0.96	0.98	1.04	1.08	0.98	0.07
4-Square Small	0.85	0.96	0.96	0.92	1.17	1.04	0.99	0.11
4-Diamond Large	0.91	1.09	0.86	1.03	0.97	1.09	0.99	0.09
4-Square Medium	0.92	0.98	0.98	1.08	1.09	0.94	1.00	0.07
4-Square Large	0.87	0.90	0.96	1.03	1.05	1.22	1.01	0.13
5 Diamond Small	1.18	1.00	1.06	0.89	1.13	0.77	1.01	0.15
5 Diamond Medium	1.08	1.13	1.06	0.88	1.10	0.98	1.04	0.09
4-Diamond Small	1.22	0.99	1.08	0.92	1.18	0.84	1.04	0.15
4-Diamond Medium	1.09	1.15	1.08	0.90	1.13	1.10	1.08	0.09

Hi, Med, and Lo refer to data from the High-, Medium- and Low-Traffic areas respectively.

Results – Precipitation Rate

Precipitation rates for 4- and 5-cup combinations with 95% confidence intervals.



Conclusions

- **Distribution uniformities calculated from soil moisture data are greater than those calculated from catch can data.**
- **Pattern of soil moisture spatial variability not greatly influenced by depth of sampling.**
- **Soil properties (texture, compaction, ...) may have more influence on moisture distribution than application uniformity.**
- **A greatly reduced number of catch cans can give a reasonable estimate of sprinkler precipitation rate. As few as 9 or 10 would give a result less vulnerable to the effect of being placed in an unusually low or high application area.**

Future Needs

The current method of evaluating the quality of an irrigation system is based on catch can DU_{LQ} . New recommendations need to be formulated to incorporate soil moisture uniformity.

Estimated DU_{iq} for golf systems by sprinkler type and system quality

Sprinkler Type	Excellent (achievable)	Good (expected)	Poor
			(if lower than this, consider not scheduling or improving irrigation system)
Rotary Sprinklers	80%	70%	55%
Spray Sprinklers	75%	65%	50%

THANK YOU

