HYDROBULL No 4
A TECHNICAL BULLETIN from HYDROGOLD
INT'L WATER MANAGEMENT CONSULTANTS
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SPRINKLER UNIFORMITY

This is the first in a series on the ***hot topic of "Irrigation Efficiency"***. Pressure is on our limited fresh water resources with the increasing demands of the agriculture, industry and the population (along with our lifestyles).

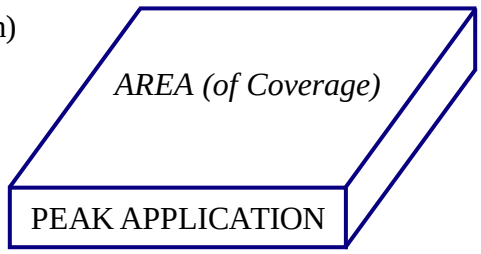
Sprinkler Uniformity is the cornerstone of Irrigation Efficiency. It is the single-most important part of irrigation design and many designers do not pay sufficient attention to this. Fortunately there are tools that help the professional designer do this.

1 INTRODUCTION TO SPRINKLER UNIFORMITY

From Hydrobull No 3 (Watering Window), we used the following diagram to calculate the irrigation volume:

Basic Irrigation Parameters

- Area of Coverage
- Peak Application (Depth)
- Watering Window



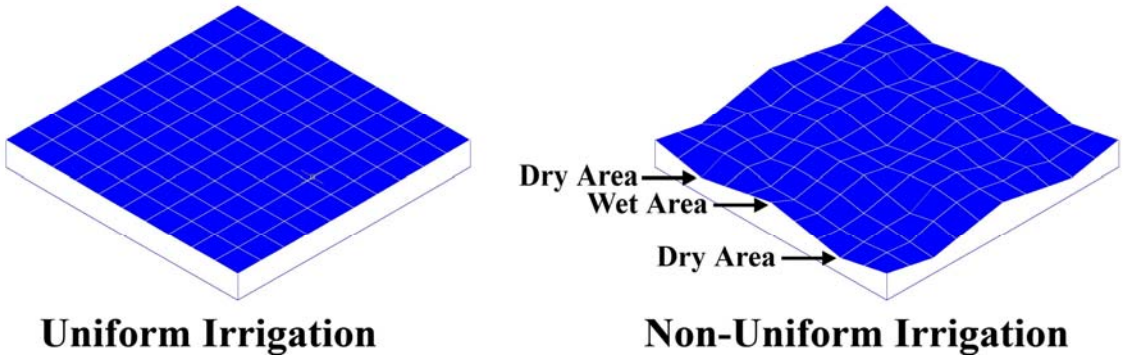
Irrigation Volume = Area * Peak Application (Depth)

This diagram assumes an even (perfectly uniform) depth of coverage.

However, the reality is that irrigation is never uniform.

There are many factors that affect sprinkler uniformity: The sprinkler nozzle (including wear), operating pressure, flow rate, speed & uniformity of rotation, spacing of the sprinklers, pattern of the sprinkler grid (triangular, rectangular or irregular) and (of course) wind.

Reputable manufacturers invest huge sums into the development of sprinklers and nozzles. But this alone is not enough. ***Aside from good quality equipment, the system has be professionally designed, installed and maintained to achieve an efficient system.***



This graphic shows the difference between the ideal (perfectly uniform irrigation) on the left and a more realistic (non-uniform irrigation) on the right.

2 THE IMPORTANCE OF UNIFORMITY

A feature of non-uniform irrigation is dry and wet spots. For example. We have a ***target application of 6 mm***. If we have an ***average application of 6 mm***, the ***dry areas only receive 3 mm*** while the ***wet areas receive 9 mm***.

If we irrigate so that the driest areas (3 mm) are properly irrigated (6 mm), we would need to double the amount of water put on by the system. It also means that the wettest areas would now be receiving a massive 18 mm application (and creating soggy areas). We may just get away with this wasteful practice when the turf is on a sand-base; but never on heavier soils.

The problems with non-uniform irrigation are:

- Dry Spots - Turf does not grow or needs expensive hand-watering
- Wet Spots - Ground is soggy and turf does not grow
- Over-watering - Waste of Water and Electricity
- Wasted Fertiliser and Herbicide (by over-application)
- Poor (non-uniform) Turf Quality

An irrigation system with good uniformity will prevent these problems.

And it is not be just a case of buying more water. Sometimes water is just not available.

The peak irrigation season is typically the hottest, driest season when there is simply not water available to waste.

Irrigation Adage: You need the most water when you have the least.

Quote: Benjamin Franklin (1706 to 1790)

"When the well runs dry, we shall know the value of water."

3 HOW WE MEASURE AND CALCULATE UNIFORMITY

There are 3 methods of measuring or calculating uniformity.

3.1 Distribution Uniformity (DU) - Most Practical Measurement

For turf irrigation, this is currently the most popular method due to its simplicity and the ability to measure it in the field.

The most common measurement is the Lower Quartile Distribution Uniformity (LQDU). It is defined at the average water applied to the driest 25% of the irrigated area, *divided by* the average water applied to the total irrigated area.

$$\textbf{LQDU} = \frac{\text{Average of Lowest Quarter of Sample}}{\text{Average of Total Sample}} * 100\%$$

For example:

$$\textbf{LQDU} = \frac{4.5 \text{ mm}}{6.0 \text{ mm}} * 100\% \quad = 75\%$$

Sprinkler LQDU's are typically 70 to 90%.

3.2 Scheduling Coefficient (SC) - Most Accurate

This is the best measure but in-field measurement is impractical.

Scheduling Coefficient is defined as the Average Precipitation Rate of the irrigated area, *divided by* the precipitation rate in the driest ***contiguous*** area. The critical difference between DU and SC is that SC uses a contiguous (technical term meaning "side by side") area. This contiguous area is typically defined as 1%, 2% or 5% of the irrigated area. Typically we use a 5% value. Therefore:

$$\textbf{SC}_5 = \frac{\text{Average Precipitation Rate of Irrigated Area}}{\text{Precipitation Rate for Driest Contiguous 5\% of Irrigated Area}}$$

For example:

$$\textbf{SC}_5 = \frac{6.0 \text{ mm}}{4.5 \text{ mm}} = 1.33$$

Notice this is a coefficient (not a %), a "sort of" reciprocal of LQDU.

The interpretation an SC_5 of 1.33 is that it will take 1.33 times longer to irrigate the driest (contiguous) 5% of the irrigated area. That is, it would extend a 9-hour Watering Window to 12 hours!

Typically the sprinkler SC_5 is in the range 1.1 to 1.4.

3.3 Coefficient of Uniformity (CU) - Obsolete for Turf

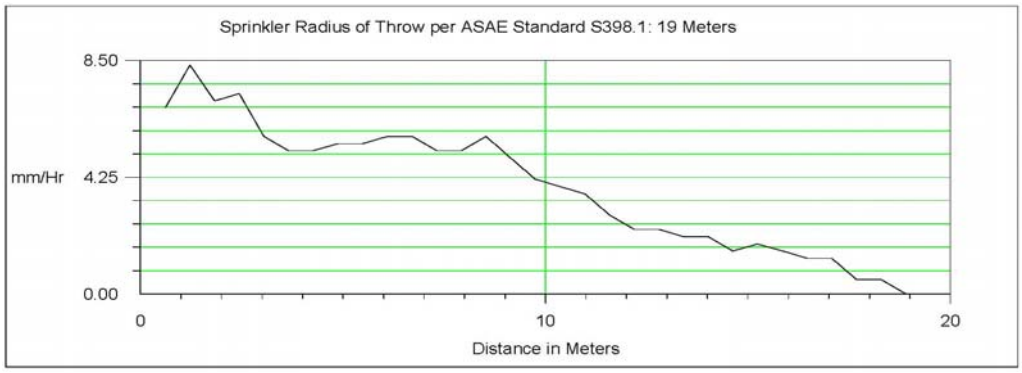
The old (1950s) standard (for Agriculture) was J. E. Christiansen's Uniformity Coefficient (CU). It is more complicated to calculate and not applicable to turf irrigation due to its limited ability to reflect wet and dry areas. It is only mentioned here as a point of historical reference.

4 COMPUTER MODELLING OF SPRINKLER UNIFORMITY

The industry standard program is SPACE Pro™ from the Center for Irrigation Technology written by Joe C. Oliphant. It available from http://cati.csufresno.edu/cit/software/ or within Australia from http://capeability.biz/space.htm

While it is a Windows based program, it suffers from a DOS hangover and is not user-friendly. Being US written, it is not the best in metric units either. However, it does do the job (with perseverance).

4.1 The "Single-Leg" Diagram

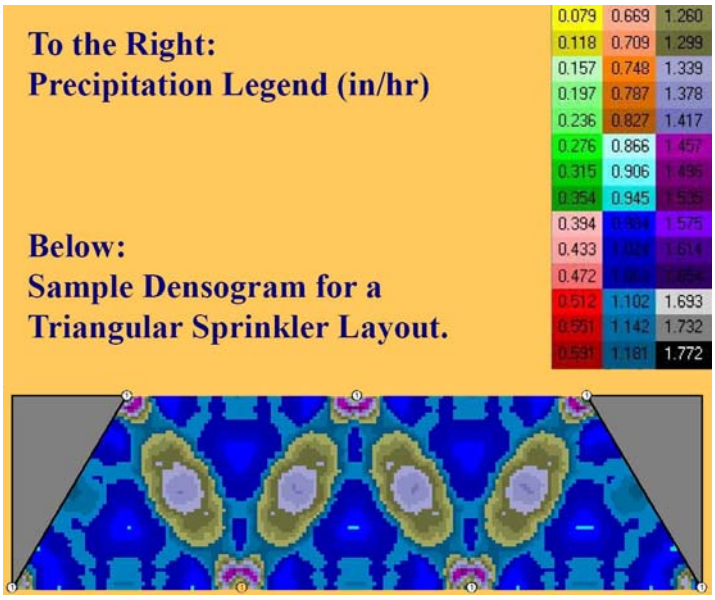


The "Single-Leg Diagram" shows the distribution of water thrown from a nozzle (mm/hr) versus the distance from the nozzle (0 to 20 m in this case). Manufacturer's produce their own data (in .prf files) but it is best that is validated by an independent testing facility (such at the Center for Irrigation Technology).

This profile exhibits the traditional "wedge-shaped" profile. There is a different Single-Leg Diagram for each sprinkler nozzle at each operating pressure.

4.2 The "Densogram"

The SPACE Pro™ program uses this Single-Leg Data to produce a Densogram. Colours show the pattern (uniformity) of the sprinkler's application rate.

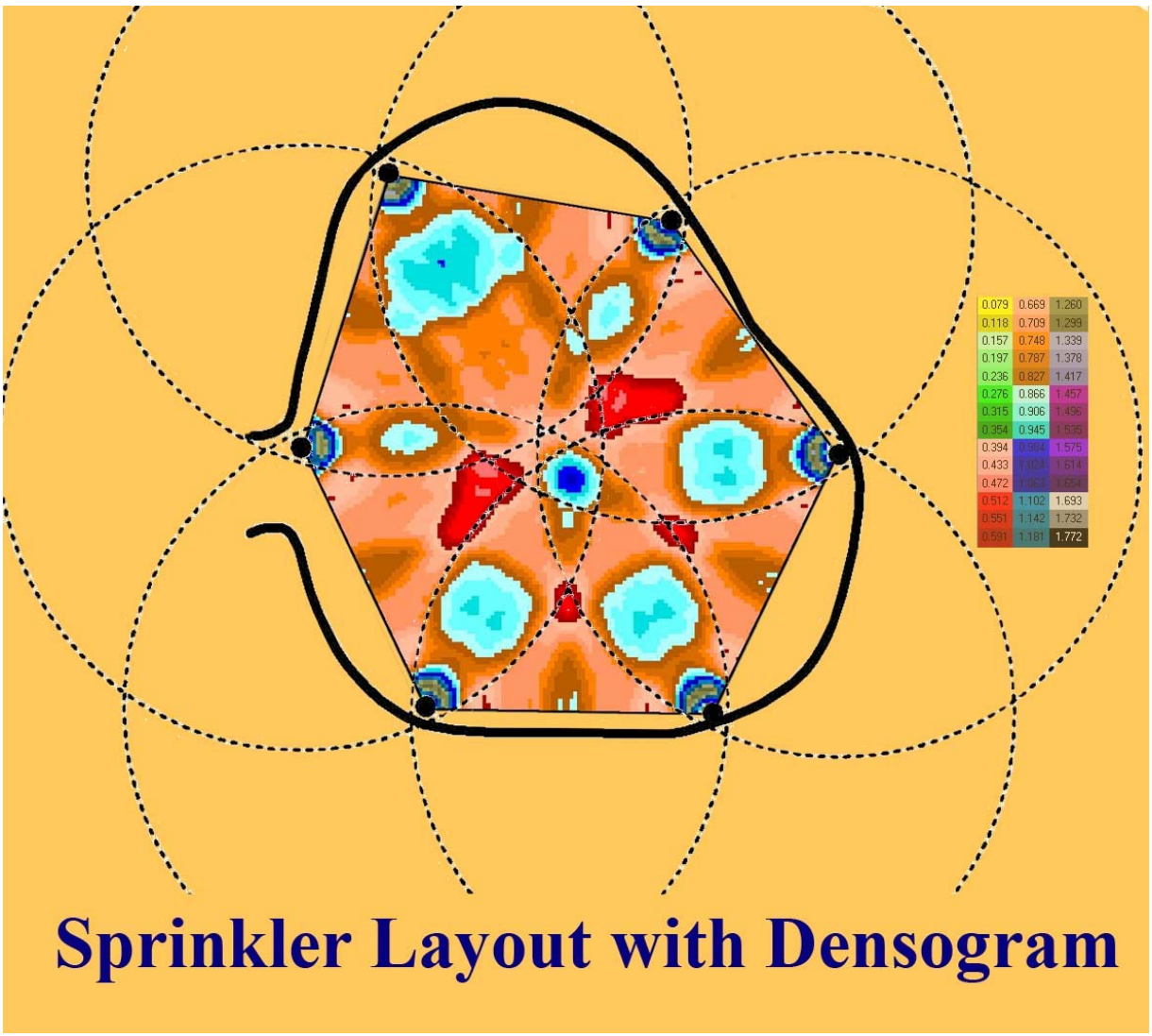


4.3 A Case Study - Green No 3 of the Garden Course at Tanah Merah Country Club

Below is the sprinkler layout (with densogram) for this 1,700 square metre island green. Hydrogold designed the sprinkler layout for this green using the SPACE Pro™ program.

Understandably the Club did not want a sprinkler in the middle of the green but with a minimum distance across the green of 40 m, we could not use the traditional "Head to Head" approach. The SPACE program allowed Hydrogold to test several different sprinklers, nozzles and patterns to design the optimum solution.

The result is a green that waters with a Distribution Uniformity of 83% in the typically calm night-winds of Singapore. Not perfect but acceptable given the geometry of the green.



At 1,700 square metres, it's the largest green in Singapore. And an island green as well. It is Green No 3 on the Garden Course at Tanah Merah Country Club. The golf course was designed by Phil Jacobs. Hydrogold used the SPACE Pro™ *program to design a unique irrigation solution for this green without placing a sprinkler in the centre. The shortest distance across the green was 40 m.*

5 IN SUMMARY…

Sprinkler uniformity is the cornerstone of Irrigation Efficiency. While some changes can be implemented retro-actively (after the system is installed), it is essential that Irrigation Efficiency is incorporated at the design stage.

How important is Sprinkler Uniformity?

It is only important if you want a good, consistent playing surface within a controlled budget. If you have an abundance of water, good drainage and no budget constraints, Sprinkler Uniformity is not critical (but it will still help).

The following 3 examples show golf courses in stressed (dry) conditions.

- *The top golf course is shows a highly non-uniform irrigation*
- *The middle golf course is coping quite well*
- *The bottom golf course is about as good as it gets in stressed conditions*

Employ Hydrogold to:

- Design an efficient irrigation system for you
- Review an existing design before it is installed to ensure efficiency
- Retro-actively improve the efficiency of an existing system
- Minimise Water, Fertiliser and Pesticide Use
- Minimise Electricity Bills
- Optimise Turf Quality
- Audit an existing system for efficiency (we have Certified Irrigation Auditors)

  Irrigation systems are not static. There is wear and tear as well as unplanned additions. ***Regular irrigation audits ensure optimum system efficiency.***