Reclaimed Water Considerations for Field Irrigation

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Objectives

• How much water do I need?
  • How do I determine this?

• What water quality do I need?
  • How do I obtain this?

• How do I manage a “less than ideal” water quality situation?

• What should I be thinking about for future planning?
Speaker Background

• Practicing irrigation consultant for over 20 years (1,000+ Projects)
• Degree in Bio-Resource/Agricultural Engineering
• East coast practice (Boston, MA and Charlotte, NC)
• Athletic complexes, golf courses, green buildings, commercial development, U.S. State Department (OBO)
• Athletic Fields
  • Professional, NCAA, Municipal
Determining Irrigation Water Demand

- Irrigated Area
- Reference Evapotranspiration (ETo)
- Rainfall
  - Typically equal to 0 when designing a system for peak demand
- Plant Type
  - Seed Versus Sod
- Irrigation System Type/Efficiency
Determining Irrigation Water Demand

• Demand = Area x ETc / Efficiency

• Demand in gallons per week:
  • Area in acres
  • ETc in inches per week
  • Efficiency as decimal
    • (0.70 for most common athletic field gear drive rotors)
  • Conversion Constant: 27,154 gallons per acre-inch
Crop Evapotranspiration (ETc)

• Reference ET
  • Several Sources (Online)
  • NOAA Regional Climate Centers
  • EPA Water Sense
    • https://www.epa.gov/watersense/water-budget-data-finder

• Crop/Species Coefficient
  • Online Sources
  • Changes with Month
### Turfgrass Crop Coefficients (Kc) (University of California Davis)

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<thead>
<tr>
<th>Month</th>
<th>Cool-Season</th>
<th>Warm-Season</th>
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</thead>
<tbody>
<tr>
<td>January</td>
<td>0.61</td>
<td>0.61</td>
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<td>February</td>
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<tr>
<td>March</td>
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<td>April</td>
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<tr>
<td>May</td>
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<td>0.79</td>
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<td>June</td>
<td>0.88</td>
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<tr>
<td>July</td>
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<td>August</td>
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<td>September</td>
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<tr>
<td>October</td>
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<td>0.54</td>
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<tr>
<td>November</td>
<td>0.69</td>
<td>0.58</td>
</tr>
<tr>
<td>December</td>
<td>0.60</td>
<td>0.55</td>
</tr>
</tbody>
</table>

*Annual Average* 0.80 0.60
Example Calculation of Water Demand

- Soccer field grass limits are 120 yds x 80 yds with Kentucky Bluegrass
- Local $\text{ET}_0$ is 5.8 inches in July, Average RF is 3.5 inches (July)
- Sprinklers are up to date gear drive rotary sprinklers
- Sprinkler Distribution Uniformity is 80%
- What is the expected peak daily demand?
Example Demand Calculation Continued

- 360ft x 240ft x 1 acre/43,560sf = 1.98 acres
- Daily ET₀ = 5.8 inches/month/31days/month = 0.187”/day
- ETc = Eto x Crop Coefficient for July = 0.187”/day x 0.94 = 0.176”/day
- For peak daily demand, omit rainfall
- Daily Demand = 1.98 acres x 27,154 gallons/acre-in x 0.176”/day
- Answer = **9,460 gallons per day**
- If irrigation only occurs 3 days per week:
  - 9460 gal/day x 7 days/wk / 3 days/wk = **22,079 gallons per day**
Established Grass Versus New Construction

• Root depth, soil volume and soil type impacts irrigation demand.
• Established grass requires less frequent irrigation.
• When planning a new system, determine early on if its sod.
• New sod could require twice as much water immediately after installation. Make sure there is enough water to support sod establishment. A supplemental supply may be required during then interim establishment period.
• Sandy soils require more water, especially in climates that receive appreciable rainfall during the growing season.
Water Quality

- **Human Health Consequences**
- **Plant Health Consequences**
  - Root and Foliar
- **Soil Health (Structure) Consequences**
  - Leads to plant health decline
- **Ecological Health Consequences**
- **Aesthetics Consequences**
  - Staining hardscapes, buildings, etc.
- **Irrigation System “Health” Consequences**
Human Health and Safety

• Most water used for sprinkler (overhead) irrigation where there is the potential for public exposure must be treated to Class A Standards

• Class A treated water can be used on the following in conjunction with necessary permits (Check with your specific state):
  • Irrigation of food crops
  • Residential landscape irrigation
  • School ground landscape irrigation
  • Open access landscape irrigation
Class A+ Reclaimed Water

- There are no detectable fecal coliform organisms in four of the last seven daily reclaimed water samples taken.
- The single sample maximum concentration of fecal coliform organisms in a reclaimed water sample is less than 23 / 100 ml.
- The 5-sample geometric mean concentration of total nitrogen in a reclaimed water sample is less than 10 mg / L.
Treated Waste Water (Reclaimed/Recycled) Versus Rain Water Harvesting

• Reclaimed or Recycled water is the process of converting waste water effluent into a suitable product that can be reused. Reclaimed water is typically used to meet non-potable water demand such as irrigation.

• Storm water runoff/reclamation is water collected from drainage areas such as parking lots, sidewalks or landscaped areas (Rain Water Harvesting per ICC)

• Roof runoff is water collected from roofs (Rain Water Harvesting per ICC)
Reclaimed Water Quality

• Reclaimed water purveyor or on site water treatment system to disinfect water to the required treatment threshold (Class A).
  • Chlorine
  • Ultraviolet
  • Ozone
  • Ultra-filtration
  • Reverse Osmosis

• Nitrogen rich (even with denitrification) – “Free” Fertilizer

• High in TDS (total dissolved solids) – PRIMARY AGRONOMIC CONCERN
Salinity

• Class A water treatment does little to effect dissolved mineral content.
• What minerals/compounds negatively impact plants and soils?
  • Sodium – Primary
    • Root absorption
    • Foliar absorption
    • Soil structure
  • Chloride – Primary
    • Root absorption
    • Foliar absorption
Sodium

• Recommended to be below 210 ppm (root injury)
  • Below 70 ppm for foliar injury to sensitive plants
• Can damage plants through root/shoot accumulation injury
• Can damage plants through direct foliar contact via overhead sprinkler irrigation
• Can break down the soil structure if unbalanced with magnesium and calcium (Sodium Adsorption Ratio, SAR)
Sodium Adsorption Ration (SAR)

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{++} + \text{Mg}^{++}}{2}}}$$
How Do I Calculate SAR?

• Have the lab do it
• Obtain concentrations of Sodium (Na), Calcium (Ca) and Magnesium (Mg)
• Convert the concentrations (provided in mg/L or ppm) of each to milliequivalents per liter (meq/L)
• 1 ppm = 1mg/L = meq/L x equivalent weight
• Na in ppm x 0.043 = Na in meq/L
• Ca in ppm x 0.050 = Ca in meq/L
• Mg in ppm x 0.083 = Mg in meq/L
SAR Values Determined – Now What?

• If value is less than 3, no concern (ornamental plants and turf)
• If value is greater than 9, irrigation water can cause permeability problems when applied to fine-textured (clay) soils
  • High SAR can cause deflocculation of soil clay particles, reducing soil aeration and water infiltration rate
• High SAR values not as much of a concern on sports fields constructed with high sand content root zone mixes due to good drainage and low clay content
• If SAR is between 3 and 9, sensitive plants can be affected.
Chloride

- Recommended to be below 350 ppm (root injury)
  - Below 100 ppm for foliar injury to sensitive plants
- Chloride is typically higher in concentration than sodium in recycled water is NaCl (table salt) is 39.3% Na and 60.7% Cl by weight.
Monitoring Salts

• Electrical conductivity (EC) of irrigation water is directly proportional to total dissolved solids (TDS).

• Electrical conductivity can be measured with conductivity probes in the field.

• EC typically provided in decisiemens per meter (dS/m) or millimhos per centimeter (mmho/cm)

• 1 mmho/cm = 1 dS/m

• EC (dS/m) x 640 = TDS in ppm
Conductivity Sensors
Soil Salinity Sensors – Integrated with Irrigation Central Control
Salinity Management

• Select turf species that can withstand direct, overhead water applications with the expected concentrations of Na and Cl.

• Optimize drainage
  • Sand, underdrainage (both)

• If insufficient rainfall occurs to flush salts, conduct periodic leaching of the soils to force (leach) accumulated salts out of the soil profile and into the under drainage system. Soils must be saturated to a point where effective drainage occurs.
Relative Tolerances of Turfgrass to EC

<table>
<thead>
<tr>
<th>Sensitive Species (&lt;3 dS/m)</th>
<th>Moderately Sensitive (3 to 6 dS/m)</th>
<th>Moderately Tolerant (6 to 10 dS/m)</th>
<th>Tolerant (&gt; 10 dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Bluegrass</td>
<td>Annual Ryegrass</td>
<td>Perennial Ryegrass</td>
<td>Alkaligrass</td>
</tr>
<tr>
<td>Colonial Bentgrass</td>
<td>Creeping Bentgrass</td>
<td>Tall Fescue</td>
<td>Bermudagrasses</td>
</tr>
<tr>
<td>Kentucky Bluegrass</td>
<td>Fine-leaf Fescues</td>
<td>Zoyziagrasses</td>
<td>Seashore paspalum</td>
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<tr>
<td></td>
<td>Buffalograss</td>
<td></td>
<td>St. Augustinegrass</td>
</tr>
</tbody>
</table>

Values are for well drained, permeable soils only.
Recommended to maintain EC below 3 dS/m (TDS 2,000ppm)

Other Dissolved Solids/Chemical Constituents of Concern

• Boron (B)
  • Recommended concentration under 2.0 ppm
• Bicarbonate (HCO₃)
  • Recommended concentration under 500 ppm
• Sulfate (SO₄)
  • Recommended concentration under 180 ppm
• Chlorine (Cl₂)
  • Recommended concentration under 5.0 ppm
Residual Sodium Carbonate (RSC)

• If carbonates (bicarbonate and carbonate) are high, they can react and combine with available Ca and Mg, stealing them from the irrigation water and soil, increasing the SAR.

• RSC = (HCO₃ + CO₃) – (Ca + Mg)

• Concentrations shall be in meq/L

• RSC above 2.5 meq/L is not suitable for irrigation
Additional Considerations for Recycled Water Management

• Irrigation piping, valve boxes and general appurtenances must be purple (widely accepted indication of recycled water)
• Public notification and proper signage
• No ponding or overspray onto areas outside of the intended irrigated landscape
• Regular audits/inspections
Storm Water and Rain Water Sources

• Stormwater: Collection from grade-level areas
  • Sidewalks
  • Tennis/basketball courts
  • Parking lots
  • Landscape

• Roofs
  • Non-vegetative roofs, not actively used by the public

• Naturally free of dissolved minerals
  • High Water Quality
Rain Water Harvesting Regulations

• Organizations still fighting for “turf” ($$)
• Recent code publication by the International Code Council (ICC) and the CSA: CSA B805/ICC 805, 2018
• Some differences between grade level collection and non-vegetative roofs
• Tier 1 end use versus Tier 3 end use
  • Sprinkler irrigation on restricted areas versus non-restricted areas.
  • If Tier 3, disinfection required
  • The water supply plan (WSP) shall establish whether a given application has restricted or unrestricted access or exposure
For Non-Residential Applications, Tier 3 (Unrestricted Sprinkler Irrigation) from Roof Harvesting Only:

- Water from roof surfaces must be disinfected. If UV is the method, water shall be disinfected to 30mJ/cm² (UV Dosage) with at least 0.5 mg/L chlorine residual
- UV lights shall have pre-filtration at 5µm (micron)
For Non-Residential Applications, Tier 3 (Unrestricted Sprinkler Irrigation) from at Grade Storm Water Runoff:

- Water from at grade surfaces must be disinfected. If UV is the method, water shall be disinfected to 40mJ/cm² (UV Dosage) with at least 0.5 mg/L chlorine residual
- UV lights shall have pre-filtration at 5µm (micron)
- Treatment shall also be third-party certified to Class A or NSF/ANSI 55 or Validated to U.S. EPA UVDGM
Rain Water Harvesting Today

• American Rainwater Catchment Systems Association (ARCSA)
  • https://www.arcsa.org
• Keeps Track of Current Codes Governing Rain Water Harvesting Throughout the Country
• Employ Good, Responsible (and Feasible) Practices Regardless
Rain Water Harvesting **Guidelines**

- When using sprinkler irrigation, some level of disinfection should be employed regardless of source (roof, surface or combination).
- Some RWH systems combine water from HVAC air handling units which could add legionella bacteria.
- UV is a non-toxic, safe method of disinfection.
- UV systems can be designed for “on-demand” treatment.
- Recommend a dose of 30mJ/cm²
Ultra-Violet Disinfection
UV Disinfection

- Treatment (350 micron recommended) prior to storage reservoir
  - Basket Screen
  - Storm Separator
- Storage
- Pumping
- Final Filtration (5µm recommended in ICC 805 and UV manufacturers)
- UV lights
- To Irrigation System
UV Disinfection Continued

- UV Lights shall require periodic replacement
  - Once a year?
- Lights require clearance for removal and replacement
  - 40 to 56 inches away from bulb canisters
- Significant purchase cost for the equipment
  - 50 to 100 gpm automatic, remotely monitored pump system could cost in the range of **$75,000 to $130,000**
Pre-Treatment
RWH Lessons Learned from the Field

• Optimize water clarity
  • Increased turbidity reduces UVT (transmittance)
• Clay/colloidal particles will foul filters
• Clean, non-vegetative roofs are preferred
• 5 µm filters are problematic
  • Typically use 15 to 15 um filters
• Storm separators can sometimes pass large material
• Preference to basket strainers with high flow by-pass, self cleaning
RWH in the Future

• Having to introduce chlorine for non-potable, RWH systems will add another layer of complexity and cost.
  • Cl₂ can be phytotoxic
  • Chemical storage and containment

• If 5 µm pre-filters are mandated, consideration for a staged filtration system, with pre-storage filtration, 25-micron auto-back-flushing, followed by 5 µm cartridge filters.
Reclaimed Water and RWH in the Future

• The days of readily available, affordable and publicly accepted use of potable water for irrigation are coming to an end (are over in some areas).

• New England is now employing both
  • Private and Public Development
  • LEED, SITES, Etc.

• Understand your options
  • Capital and Life Cycle Costs
Limitations on RWH – Plan for Tomorrow

• Extended Droughts (45 to 60 days)
  • Cisterns Empty
  • Must Have a Back-Up Supply
    • Well, Potable, Reclaimed As Back-Up

• Site Design to Consider Future Reclaimed Water Supply
• Purple Pipe
• Good Drainage
• Plant Selection
U.S. Drought Monitor
Massachusetts

November 1, 2016
(Released Thursday, Nov. 3, 2016)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

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<tr>
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<th>None</th>
<th>D0-D4</th>
<th>D1-D4</th>
<th>D2-D4</th>
<th>D3-D4</th>
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<tbody>
<tr>
<td>Current</td>
<td>0.70</td>
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<td>63.45</td>
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<td>Last Week 10/22/2016</td>
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<td>3 Months Ago 8/3/2016</td>
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<td>Start of Calendar Year 12/24/2015</td>
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<td>Start of Water Year 4/1/2016</td>
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<td>100.00</td>
<td>86.15</td>
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<td>One Year Ago 11/19/2015</td>
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<td>77.66</td>
<td>23.58</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
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</table>

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Deborah Bathke
National Drought Mitigation Center

http://droughtmonitor.unl.edu/