Irrigation for Green Roofs

Brad Rowe
Michigan State University
Design Intent

Intensive greening

Extensive greening
Why Green Roofs?
Energy Efficiency

Source: National Research Council, Institute for Research in Construction
Urban Heat Island Effect

Source: Environment Canada

Source: Remote Sensing Advanced Technology
Uncommon Ground Restaurant, Chicago
Benefits

- Stormwater management – Quantity and Quality
- Building insulation / Moderation of urban heat island
- Longevity of roof membrane
- Water and air purification, Noise reduction
- Carbon sequestration
- Aesthetics
- Recovery of green space / Human health
- Biodiversity
- Urban food production
Should green roofs be irrigated?
Irrigated roofs

• Efforts to ban or limit irrigation
  • Portland Bureau of Environmental Services adopted laws limiting irrigation on roofs receiving benefits from the city (Schroll et al., 2011)

• Source
  • Potable
  • Collect runoff
  • Grey water
Irrigated roofs - Yes

- Plant establishment/health/survival
- Drought
- Erosion – Wind/Water
- Aesthetics
- Intensive/Extensive (species dependent)
- Rooftop agriculture
- ET – Energy conservation
- Carbon sequestration
Irrigated roofs - No

- Cost
- Maintenance of system
- Water availability
- Wasting water
- Reduces stormwater retention
- Nutrient leaching/pollution
- Plant dependence
- Fewer weeds
Should green roofs be irrigated?

And if so, then how?
Objectives

• Determine irrigation efficiency of overhead, drip, and sub-irrigation for coarse green roof substrates
  • Water retention and distribution
  • Plant growth and health

Green roof substrates

• Shallow depths
  • Must have adequate pore space to allow for drainage

• Coarse
  • Less water holding capacity
  • Little capillary movement
  • Vertical and lateral

• Increase depth
  • Weight limitations
Materials and Methods - Phase I

- MSU Plant Sciences Greenhouses
- LiveRoof modules
  - (30.5 cm x 61 cm x 10 cm)
- Treatments
  - 3 irrigation methods
  - 5 substrates/systems
  - 8 replications
Irrigation methods

- Overhead
  - Fixed spray heads 5 ft matched precipitation rate nozzles
Irrigation methods

• Drip
  • Pressure compensating 3.78 liters/hr (1 gal/hr) emitters
  • 4 emitters per module (spaced 30 cm on 2 lines)
Irrigation methods

• Sub
  • Pressure compensating 3.78 liters/hr (1 gal/hr) emitters on dripper line
  • 4 emitters per module (spaced 30 cm on 2 lines)
Substrates

- LiveRoof
- LiveRoof with 100% vegetation
- Renewed Earth (MSU)
- Renewed Earth (MSU) with Moisture Retention Fabric (MRF)
- Fafard
  - Fafard 3B Professional Formula Potting Mix

- Depth = 10 cm
## Substrate physical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Renewed Earth (MSU)</th>
<th>LiveRoof</th>
<th>Fafard</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM by LOI @ 360 °C (%)</td>
<td>1.2</td>
<td>4.9</td>
<td>54.1</td>
</tr>
<tr>
<td>Bulk density (g/cm³)</td>
<td>1.20</td>
<td>1.04</td>
<td>0.22</td>
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<tr>
<td>Capillary pore space (%)</td>
<td>18.97</td>
<td>19.93</td>
<td>43.45</td>
</tr>
<tr>
<td>Non-capillary pore space (%)</td>
<td>21.33</td>
<td>27.70</td>
<td>28.93</td>
</tr>
<tr>
<td>Infiltration rate (cm/hr)</td>
<td>34.01</td>
<td>90.60</td>
<td>28.60</td>
</tr>
<tr>
<td>Water holding capacity @ 0.1 bar</td>
<td>15.86</td>
<td>19.17</td>
<td>196.35</td>
</tr>
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</table>

A&L Laboratories, Fort Wayne, IN
Substrates

- Moisture retention fabric
  - 0.75 cm thick
  - Capable of holding 5.7 kg/m² of water
Vegetated modules

*Sedum acre* ‘Aureum’
*S. album* ‘Coral Carpet’
*S. floriferum* ‘Weihenstephaner Gold’
*S. rupestre* ‘Angelina’
*S. spurium* ‘Fuldaglut’
*S. takesimense* ‘Gold Carpet’
Data collection

- Water applied
  - 30 minutes
  - Modules dried to VMC = 0 before next application
- Volume of runoff (Wasted water)
  - Collected in tubs
- Water retention
  - Weight of module
    - Initial
    - Final at 40 minutes (Container capacity)
Data collection

• Water dispersal
  • Distance surface water front moved horizontally from emitter at 10, 20, and 30 min

• Volumetric moisture content (Theta probe ML2x, Delta-T Devices, Ltd., Cambridge, U.K.)
Results – Phase I

Letters represent mean separation by Tukey's honestly significant difference (P<=0.05)
Wastewater runoff and water retention 10 minutes after termination of irrigation treatment \((n = 8)\).

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Water front movement

Drip

Sub

10 min 20 min 30 min
Materials and Methods - Phase II

• Substrate (10 cm)
  • Renewed Earth with and w/o MRF
• Irrigation
  • OH, drip, sub, and no irrigation
• Plants
  • Sedum album
  • Sedum floriferum (S. kamtschaticum var. floriferum)
  • 8 plugs of each species per module
• 4 replications per treatment
Data collection

• Survival
• Growth
• Plant stress (Chlorophyll fluorescence)
• Substrate volumetric moisture content
• Harvested dry weights (day 84)
## Influence of irrigation method on plant growth and health

<table>
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<tr>
<th>Irrigation method</th>
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<th>Root:Shoot Ratio</th>
<th>Chlorophyll Fluor (day 63)</th>
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Influence of irrigation method on plant growth and health

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<th>Chlorophyll Fluor (day 63)</th>
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</thead>
<tbody>
<tr>
<td><strong>Sedum album</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>OH MRF</td>
<td>1.05 A</td>
<td>0.11 AB</td>
<td>0.792 A</td>
</tr>
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<td>0.817 A</td>
</tr>
<tr>
<td>Drip MRF</td>
<td>0.59 AB</td>
<td>0.03 D</td>
<td>0.821 A</td>
</tr>
<tr>
<td>Sub No MRF</td>
<td>0.40 B</td>
<td>0.05 CD</td>
<td>0.728 B</td>
</tr>
<tr>
<td>No Irrigation</td>
<td>0.09 C</td>
<td>0.13 A</td>
<td>0.449 C</td>
</tr>
<tr>
<td><strong>Sedum floriferum</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>OH No MRF</td>
<td>1.64 A</td>
<td>0.14 B</td>
<td>0.834 A</td>
</tr>
<tr>
<td>OH MRF</td>
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</tr>
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<td>0</td>
<td>0</td>
<td>0.026 D</td>
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</table>

Means separation with Tukey’s adjustment (n=16). Upper case letters denote differences in columns.
### Influence of irrigation method on plant growth and health

<table>
<thead>
<tr>
<th>Irrigation method</th>
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<th>Chlorophyll Fluor (day 63)</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

Means separation with Tukey’s adjustment (n=16). Upper case letters denote differences in columns.
Conclusions

• Overhead was most efficient.
• Perceived water conservation with drip or sub-irrigation may be shortsighted and result in wasting water.
• Moisture retention fabric improved performance of drip and sub-irrigation.
• Must choose most cost effective and environmentally friendly method based on climate, design intent, plant selection, and substrate depth and composition.
Other considerations

• Results for these substrates and conditions
• Substrate composition (capillary action) and depth
• Irrigation scheduling
• Emitter flow rates
• Increase number of emitters
• Recirculate runoff
• Wind
• Evaporation
• Plant establishment vs. Growth
• Crop grown
Options and Trends for Remote Monitoring and Control of Pumping Systems

Richard Embry
General Manager
ProPump & Controls, Inc.
Today’s Speaker has been working with irrigation, pumps, and controls for over 44 years.

Which may have been too long.
Background Information

ProPump & Controls is an independent contractor specializing in sales, installation, and service of pumps, pump stations, pump controls, and SCADA systems.

We work in several different markets: Turf and Agricultural irrigation, Municipal Water and Waste Water, and Industrial.
Background Information

In 2004, operating then as Flowtronex Field Service, our personnel in what is now ProPump & Controls began immersing ourselves in technology in everyday use in SCADA applications, in a big step beyond the pump station monitoring systems of the time.

Today’s pump station monitoring systems have advanced considerably since 2004, with the utilization of ethernet capable PLC’s and data storage in the Cloud.
So What is SCADA?

Supervisory Control And Data Acquisition.

(With emphasis on DATA Acquisition)
SCADA combines automation controls and data acquisition with telemetry.
Four Components of a SCADA System

- Field Hardware
- Communications or Telemetry
- Central Station (PC or Master Controller)
- Integration: HMI software Package
Water Tower RTU
Telemetry Means

- **Hardwire**—common for equipment within close proximity

- **Telephone Modems** - Dedicated (Leased) Line, Dial Up—early technology, 1200 bps

- **Fiber Optic**—fast and impervious to noise, lightning and electrical surges
Hard-Wired Systems
1200 Baud Bell Modem for Dial-up Connections
Telemetry Means

- Radio—Licensed (UHF/VHF) and Unlicensed Spread Spectrum (900 Mhz/2.4 GHz)
- Cellular—including carrier frequencies
- Internet—DSL, LAN networks
- Satellite--Commonly used where DSL and Cellular communications are not available.
VHF-UHF 5 watt Licensed Radios
UHF and VHF Narrow-Band Licensed Radios

• Require FCC licenses and fees
• Frequency “refarming” has made licenses easier to obtain.
• Use with PLC’s for store and forward capability.
UHF and VHF Narrow-Band Licensed Radios

• Robust, with longer range better penetration of vegetation than higher frequency radios.
• Line of sight may not be required.
• Not enough throughput for many modern requirements.
Spread Spectrum Radios—900 MHz & 2.4 GHZ
Unlicensed Spread Spectrum Radios

• Serial and ethernet models available.
• Each radio has repeater capability.
• Frequencies ranging from 900 MHz to 2.4 GHz for “long range” radios.
• Baud rates up to 80 kbps to 4Mbps (Freewave)
Unlicensed Spread Spectrum Radios

- Programmable for frequency and power output.
- Limited by FCC to 3.4 watts ERP.
- Line of sight recommended.
- Penetration through vegetation, especially pine trees, is poor.
Radio Path Analysis Software

-34.03 dB fade margin
High Infrastructure Costs with Radio Based Systems
Useful tip: In lightning prone areas, use a Fiber Optic Cable Interface to Isolate PLC from Lightning Strike on Radio Antenna
Cell Modem
Cell Modems

• Cell phone systems minimize expenditure for site surveys & antenna systems for a private radio system.
• 2\textsuperscript{nd} and 3\textsuperscript{rd} Generation Cell networks are being phased out by ATT and Verizon in favor of 4G LTE networks.
• Older cell modems subject to attacks by hackers to use them in bot networks or gain access to control panels. New versions are more secure.
• Early drawback of high charges for data by the carriers has been greatly reduced with the development of protocols allowing “Report by Exception” for data transfer.
Cell Modems

• 4G LTE networks allow realistic download speeds of 5-12 Mbps and upload speeds of 2-5 Mbps.

• These speeds allow use with protocols which permit “Report by Exception” messaging to greatly reduce user costs for data.

• Cell phone modems are rapidly becoming the preferred communication link in the turf irrigation industry.
Protocols

A protocol is simply a set of rules which govern the formatting, control procedures, and relative timing between devices in a control system.
Modbus

- Modbus is an open, serial communications Master – Slave protocol widely used for years in conventional SCADA systems.

- With Modbus the master controller has full control of communication, whereas a slave will only respond when polled by the master. Modbus is simple to implement and good for small control applications where a small amount of data needs to be transferred from Point A to Point B.

- Modbus TCP/IP was added later as a means of encapsulating a modbus data packet within a TCP/IP packet. It is fast enough for many monitoring actions, but slow compared to modern ethernet protocols.
Modbus is a request/reply protocol. There are different variations of Modbus

- Initiate request from master controller
- Receives the response
- Slave performs the request and then initiates a response.
Report by Exception

• Newer communication protocols (DNP3 and IEC870) introduced “Report by Exception” and “Polled Report by Exception”.

• In Report by Exception, the RTU stores a list of points which are to be treated as RBE and sends data to the Master controller only when one of these points change by a deadband amount (analog value) or state (digital value).

• Not reporting all values in every poll (Polled Report by Exception) reduces bandwidth requirement.

• Unsolicited Report by Exception requires a fast network like Ethernet which can handle data collisions without slowing the system down or losing data.
The Cloud

- Pumping system manufacturers along with thousands of other businesses have begun using the cloud for data transmission and storage.
- The Cloud offers high speeds, scalability of storage space, and data security by major players specializing in advanced technology, reducing cost compared to hosting private servers.
- Cloud utilization and computing permits linking of an unlimited number of devices, ideal for generating reports. Watertronics and Caltran have collaborated on a system of 350 landscape irrigation stations linked together through the cloud with customized water use reporting on a daily basis. The system also incorporates Toro Sentinel controllers using the cell modems in adjacent pump stations.
Here is something to get (sort of) excited about...
Cellular Networks and the Cloud

Report-by-Exception technology, pooled minutes from Cellular carriers, and secure global access and data storage in the Cloud, enable vendors and end users to employ highly capable SCADA systems without expensive infrastructure and in-house resources.
Universal, low cost SCADA systems available from dozens of vendors
“HMI” or Human Machine Interface, is a software application which presents information to an operator or user about the state of a process, and allows the user to make changes to the machinery or process.

Information is typically displayed in a graphic format, or GUI.
GE Intellution HMI Screen for Well Control
Settings Page on MCI Panel HMI @ Dry Creek WWTP
Interfacing Pumping Stations to Irrigation Control Systems

Pump station controller typically sends data to the irrigation controller—Pump availability, and capacity, real time flow & pressure, alarm status.

Depending on the capabilities of the irrigation controller software, the irrigation controller may:

- Initiate a pump start up and flush filters in preparation for an irrigation program start.
Interfacing Pumping Stations to Irrigation Control Systems

• Irrigation Central selects sprinklers to approximately match calculated flow to real time flow. Reduces water window and operates station at maximum efficiency.

• Compares pump station real time flow to irrigation system calculated flow and take action if discrepancy exceeds predetermined threshold.

• Reduces irrigation flows if a pump faults at pump station. (Rainbird recalculates and reduces demand on the fly. Toro system may pause irrigation, recalculate, and restart under reduced flow.)
Interfacing Pumping Stations to Irrigation Control Systems

• Comparison of real time flow versus irrigation system calculated flow is probably the most valuable feature of either system in that a pipe leak may be detected and result in system shut-down.

• It is a challenge to maintain irrigation databases as accurately as possible, otherwise flow management attempts may not be as efficient as hoped.
Pump Efficiency Calculation

Knowing motor current, discharge pressure, and rate of flow, for an individual pump, we can use a SCADA system to calculate efficiency and compare the relative efficiency of different well pumps.

Case study: 3 Mile Canyon Farm in Boardman Oregon
3 Mile Canyon Farm-Boardman, Ore.
RDO Booster System—14 Pumps—21,000 HP/150,000 GPM
Sequencing Pumps based on power efficiency at Three Mile Canyon Farm

Project to design a PLC algorithm to sequence pumps based on their relative efficiency, i.e. pumps will start in order of highest to lowest efficiency.

PLC is an Allen Bradley Controllogix with high speed scan rate and 5GHz radio system. Pumps are being fitted with individual flowmeters. All pumps have current transducers. System will routinely perform autoscans to track efficiency. Scans will be run only in an efficient operating range.
Sequencing Pumps based on power efficiency at Three Mile Canyon Farm

For pumping water at individual pump stations at 3MCF:

Relative Pump efficiency =

\[
\frac{\text{Flow} \times (\text{Discharge PSI}) \times 2.31}{3960 \times \left(\frac{4160 \times \text{Amps} \times \text{PF} \times 1.73}{746}\right)}
\]
ProPump & Controls
Systems Integrator
Mike Nealy at the RDO booster station
Motivating a programmer to stay on task for 10 hours a day takes sugar and coffee!
Sensors Commonly Used in Other Industries

<table>
<thead>
<tr>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
</tr>
<tr>
<td>Bearing and Winding Temperatures</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>TDS/Salinity</td>
</tr>
<tr>
<td>Turbidity</td>
</tr>
<tr>
<td>Chlorine Residual</td>
</tr>
<tr>
<td>Current</td>
</tr>
<tr>
<td>Voltage</td>
</tr>
</tbody>
</table>

With a communications interface card, any viewable parameter in a VFD can be transmitted to a Central Computer via SCADA
Hach SC200 Controller

Commonly used in municipal water and wastewater plants to monitor pH, Temperature, Chlorine Residual, TDS, Turbidity, Dissolved Oxygen, etc.

Seeing some use in irrigation systems to monitoring pH and TDS.

Useful in blending applications to mitigate excess salinity.
Real Time SCADA Demonstrations

• Optima kV biogas system

• Amelia Island Golf Course Water System
Other Thoughts on Pump Station Control—Dedicated VFD’s

• Dedicated VFD’s are gaining in popularity in Irrigation markets.
• Dedicated VFD’s are smoother in transitions.
• Dedicated VFD’s operating in load sharing mode keep larger pumps from operating on the far left side of the pump curve, which is detrimental to pump life.
• Dedicated VFD’s are simple to troubleshoot.
• Stations with multiple pumps with dedicated VFD’s are common in municipal and industrial applications.
Small Municipal Booster Station with Multiple Drives
Water Booster Station with Dedicated VFD’s—Turks & Caicos Water Co.
Other Thoughts on Pump Station Control—Jockey Pumps

• Jockey pumps with dedicated VFD’s are making a comeback.
• A jockey pump approximately 50% of the size of the main pump is more efficient than operating a larger main pump at low flows and will prolong the life of the main pumps.
• With the jockey pump on a VFD, a PM pump can be eliminated on a new irrigation system which is relatively tight.
• In a system with a single shared VFD for the main pumps, the jockey pump can be restarted between 1\textsuperscript{st} and 2\textsuperscript{nd} main pumps to keep the main pump using the drive from operating at a flow on the left hand side of the curve.
Horizontal Station with 1-30 HP Pump & 2-60 HP Pumps
THE END

GO HAVE SOME FUN!
Thanks for Your Time!

Richard Embry
General Manager
ProPump & Controls, Inc.
Office: 704-528-0677
Cell Phone: 704-658-8083
rembry@propumpservice.com
Guess what? You have been standardized.

Brent Mecham  CID, CLWM, CIC, CLIA, CAIS

Irrigation Association
Small victory

• Successfully renamed Chapter 14 of the ICC International Plumbing Code from Subsurface Landscape Irrigation to Subsurface Graywater Soil Absorption System.

• All references to subsurface landscape irrigation within the chapter were modified.

• Also was successful with a similar change in the International Residential Code.

• Next step is with IAPMO UPC
Provisions in ASHRAE 189.1:

• 33% of improved landscape area can use potable water
• If using on-site alternate water sources = 100% of site can be irrigated
• 40% of improved landscape area any type of plant
• 60% of site = native, adapted or rainfall-ETc compatible plants
  • potable or reclaimed for establishment, no permanent irrigation system
  • only reclaimed for establishment within 200 feet of site
• Conflicting sections on use of reclaimed water
ASHRAE 189.1

• Proposed some changes:
  • Golf courses to be exempt from this standard
  • Remove requirement to use off-site reclaimed water for temporary irrigation
  • A few items to be considered above code and can be selected as optional requirements.

• Challenges
  • Reclaimed water is too good for irrigation—put it back into the ground
  • Vegetated roofs and walls only irrigated with onsite harvested water
IAPMO WE-Stand

• Attempt to add in landscape requirements
  • Only 40% of the landscape can have overhead irrigation with potable water
  • Drip irrigation exempt

• Water efficiency is about landscape plant selection—
Water use efficiency

• Landscape transformation
• Sustainable landscapes
• Local-friendly landscapes
• It is about choosing plants with lower water demand—usually a reduction in ornamental turfgrass
• Position: we are experts at delivering water to plants, but not experts in plant selection.
• Potable water for irrigation needs to be eliminated.
California Energy Commission

• Title 20 Regulations that mandate only pressure regulating spray sprinklers to be sold after October 1, 2020.
• Public comment period: April 26 – June 10, 2019
• Public hearing on June 18, 2019 in Sacramento
• Use EPA WaterSense testing specification
• Table X requires reporting performance. No compliance, no selling.
Spray Sprinkler Bodies

Docket # 19-AAER-01

The California Energy Commission proposes amendments to the Title 20 Appliance Efficiency Regulations that would result in new mandatory water efficiency standards for spray sprinkler bodies. There are currently no water efficiency standards for spray sprinkler bodies.

For questions about this proceeding, contact:

Sean Steffensen
California Energy Commission
Appliances Office
ASABE/ICC 802 Landscape Sprinkler & Emitter Standard

• Revisions
  • Testing for pressure regulating sprinklers—to be the same as EPA WaterSense
  • Check valve test to be more detailed.
  • Changes to definitions to harmonize with California proposed regulations
    • To minimize loopholes
Rainwater Harvesting Standards

• Differentiation between rainwater and stormwater
• ASPE-ARCSA-IAPMO
  • Standard 63 Rainwater Harvesting Standard
  • Standard 78 Stormwater Harvesting Standard
• ICC-CSA 805 Rainwater Harvesting Systems Standard
• Disinfection  UV or Chemical
  • Water temperature above 77 degrees has a 0.5mg/L chlorine residual
Rating Systems

• RESNET  HERS H2O
• Water Efficiency Rating System – WERS
  • Based on a program started by Santa Fe Builders
  • Lower score more water efficient
• NGBS  WRI in appendix
• EPA WaterSense program looking to adopt them as a compliance path for labeling new homes.
• Complicated math
• Mysterious “black box” approach.
• Less lawn, lower gpm zones = lower score.
Rating Systems

• Geared toward residential
• Compare expected or potential water use to a “reference home”
• Considers both indoor and outdoor water use
• Home builders can use the score to differentiate their product
• Irrigation design/build contractor impacted

WERS    NGBS-WRI    HERS_{H2O}
Water Efficiency Rating Score

- Developed by Green Builder Coalition
- 3rd party verification tool.
- Predict water use for new or existing properties.
- Flexible—builder can decide where & how to conserve water.
- Goal to reduce the use of potable water.
- Incentives to use on-site water sources
  - Graywater
  - Rain water harvesting
Outdoor methodology of WERS

• Step 1 – Create an outdoor water budget (based on EPA WaterSense, but modified)

• Step 2 – Determine the outdoor water demand projection via subtractive method
  (Lot – Impervious Surfaces – Undisturbed Areas – Encroachments)

• Step 3 – Offset outdoor water demand with reuse techniques (if applicable)
WERS

Uses a traditional water budget approach based on monthly ETo and Rainfall
Reducing Potable Outdoor Water Use

- Plant selection
- Use of technology—smart controllers, sensors etc.
- Use nonpotable water—gray water, rain water harvesting, etc.
- Compared rated home to a baseline. The lower the score the better.
WERS Compliance Options

EU2 Preliminary / Assessment Design Analysis
(Please note - if using another third-party program for analysis, skip section 2.1 and leave questions as No and values as zeros)

2.1 OPTION ONE: Landscape / Water Requirement Using WERS

Use of the following pull-downs affects the "Average Peak ALLOWABLE Rainfall" percentage.

Rain Sensor present? (10%)  Yes  Smart Controller present? (10%)  Yes

Select the number of lines needed and complete the table below with the information that best describes the outdoor water use.

<table>
<thead>
<tr>
<th>Line</th>
<th>Area Name or Notes (optional)</th>
<th>Irrigated or Non-Irrigated Landscape Area (sf)</th>
<th>Plant / Feature Type &amp; Water Requirement</th>
<th>Ks</th>
<th>Irrigation Type</th>
<th>IE</th>
<th>LWR (G/M) average only - for waiting months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apple tree</td>
<td>200.00</td>
<td>Trees - Medium</td>
<td>0.5</td>
<td>drip-stand</td>
<td>0.7</td>
<td>544.41</td>
</tr>
<tr>
<td>2</td>
<td>Vegetable Garden</td>
<td>200.00</td>
<td>Food Gardens</td>
<td>0.7</td>
<td>drip/micro</td>
<td>0.8</td>
<td>700.75</td>
</tr>
<tr>
<td>3</td>
<td>Sprinkler</td>
<td>1000.00</td>
<td>Sprinkler - Low</td>
<td>0.7</td>
<td>no irrigation</td>
<td>0.7</td>
<td>747.26</td>
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<tr>
<td>4</td>
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<td>0.00</td>
<td>Sprinkler - High</td>
<td>0.7</td>
<td>selected irrigation</td>
<td>0.7</td>
<td>0.98</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>0.00</td>
<td>Sprinkler - High</td>
<td>0.7</td>
<td>selected irrigation</td>
<td>0.7</td>
<td>0.98</td>
</tr>
<tr>
<td>Total Area</td>
<td>1400.00</td>
<td>Landscape / Water Requirement for Site (G/M)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1998.43</td>
</tr>
</tbody>
</table>

2.2 OPTION TWO: Landscape / Water Requirement Via Third-Party Program

OUTDOOR WATER USE CALCULATION PROGRAM
Are non-WERS calculations being done for this home?  Yes

2.3 NON-PERMANENT IRRIGATION AFFIRMATION

Use this section only if there is landscaping but no irrigation for the project.

Xeriscaping?  No  Percent of softscape: 0.90

I CERTIFY AS THE DESIGN PROFESSIONAL OF RECORD THAT THE LANDSCAPE AS DESIGNED SHOULD NOT REQUIRE WATER BEYOND THAT WHICH IS NEEDED FOR INITIAL ESTABLISHMENT OF PLANTINGS.

SIGNED: ___________________________ DATE: ___________________________

The professional responsible for any calculations must provide backup from any used third-party program along with evidence that they are certified to use the third-party program utilized for calculations. Additionally, drawings with plant lists should be provided along with any irrigation design drawings and irrigation component cut sheets if available.
Water Efficiency Rating Score (WERS)*

• Applicability
  • New or Existing Properties
  • Single Family or Multifamily
  • Design or Audit Tool

• Outputs
  • Score: 0-100 (lower is better)
  • Projected usage in gallons: Daily, monthly and yearly
  • Projected water costs: Daily, monthly and yearly

• Adopted/Implemented
  • State of New Mexico: Tax credit since Jan. 1, 2017
  • City of Santa Fe: Single-family code since March 2017
  • City of Santa Barbara, CA: Multifamily code since Sept. 2018
  • Built Green Canada: Pilots in 2019; implement in 2020

• Future
  • 3 green building programs incorporating into water efficiency chapter
  • WaterSense for Homes 2.0: Under consideration for dual certification
National Green Building Standard

• Points-based system
• Points for doing irrigation efficiently
• Points for not doing irrigation
• Points for not using potable water
• Alternate method is WRI Water Rating Index (Appendix F)
• Based on WERS

Bronze, Silver, Gold, Emerald
More points is better
HERSH\textsubscript{2O} 

- Development by Residential Energy Services Network (RESNET)
  - Home Energy Rating Systems—estimate the amount of energy a home uses based on types of equipment that are installed.
  - HERSH\textsubscript{2O} doing the same for water usage—Water Efficiency Rating Index
    - Indoor and Outdoor
  - Currently developing an ANSI standard
HERS Reference Home

• Attributes of a standard home built about 2006
• Outdoor water use based on data from REUWS 2
• Complicated equations create the modeling worksheet
Reference home outdoor water use:

• Rated home has Net ET <12 inches/year or has automatic irrigation system

\[
\left[ \frac{\exp(A)}{1+\exp(A)} \right] \times 1.18086 \times (2.0341 \times \text{netET}^{0.7154} \times \text{Ref \_ Irr \_ Area}^{0.6227} + 0.5756 \times \text{ind \_ Pool} \times \text{netET})
\]

• Rated home has NetET >12 inches/year AND does not have automatic irrigation

\[
\left[ \frac{\exp B}{1+\exp B} \right] \times 1.22257 \times [1.4233 + 0.6311 \times \text{netET} + 0.9376 \times \text{Ref \_ Irr \_ Area}] + \text{ref \_ Pool}
\]
Where:

- Exp(A) = exponent of \([1.4416 + 0.5069 \times (\text{IrrArea}/1,000)]\)
- Exp(B) = exponent of \([0.6911 + 0.00301 \times \text{netET} \times (\text{IrrArea}/1,000)]\)
- Ref_Irr_Area = The size of the irrigated area in the reference home, calculated in accordance with section 4.4.1
- Rat_Irr_Area = The size of the irrigated area in the rated home
- netET = The annual historic sum of mean reference evapotranspiration minus the mean precipitation for all months that evapotranspiration exceeds precipitation
Irrigated Area

- Lot size of Rated Home <7,000 s.f. the Reference Home shall be calculated as:
  \[ \text{Ref}_\text{Irr\_Area} = \text{Lot\_Area} \times (0.002479 \times \text{Lot\_Area}^{0.6157}) \]

- Lot size of Rated Home >7,000 s. f., the Reference Home shall be calculated as:
  \[ \text{Ref}_\text{Irr\_Area} = \text{Lot\_Area} \times 0.577 \]
Rated home outdoor water use

• Rated home has automatic irrigation system

\[
\frac{\exp(A)}{1 + \exp(A)} \times 1.18086 \times (2.0341 \times \text{netET}^{0.7154} \times \text{Rat}_\text{Irr}_\text{Area}^{0.6227} + 0.5756 \times \text{ind}_\text{Pool} \times \text{netET})
\]

• Rated home does not have automatic irrigation

\[
\left[\frac{\exp(B)}{1 + \exp(B)} \times 1.22257 \times \left[1.4233 + 0.6311 \times \text{netET} + 0.9376 \times \text{Rat}_\text{Irr}_\text{Area}\right]\right] + \text{Pool}_\text{use}
\]
Where:

- \( \text{Exp(A)} = \text{exponent of} \ [1.4416 + 0.5069 \times (\text{Rat}_{\text{Irr\_Area}}/1,000)] \)
- \( \text{Exp(B)} = \text{exponent of} \ [0.6911 + 0.00301 \times \text{netET} \times (\text{Rat}_{\text{Irr\_Area}}/1,000)] \)
- \( \text{Rat}_{\text{Irr\_Area}} = \text{The size of the landscape that might receive supplemental water in the rated home} \)
- \( \text{netET} = \text{The annual historic sum of mean reference evapotranspiration minus the mean precipitation for all months that evapotranspiration exceeds precipitation} \)
- \( \text{ind\_Pool} = \text{Indicator representing the presence or absence of a swimming pool} \)
- \( \text{Pool\_use} = \text{equation 1 (using ind\_Pool = 1)} - \text{equation 1 (using ind\_Pool = 0)} \)
### Example Water Use Calculations

<table>
<thead>
<tr>
<th>User input fields are yellow</th>
<th>Water Use</th>
<th>Cold Wtr</th>
<th>Hot Wtr</th>
<th>Total Wtr</th>
<th>Home characteristics:</th>
<th>Drain Water Heat Recovery:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location (pull down)</td>
<td>Denver, CO</td>
<td>Shower_gpd</td>
<td>7.2</td>
<td>16.9</td>
<td>24.1</td>
<td>CFA 2400</td>
</tr>
<tr>
<td>Distribution system</td>
<td>std</td>
<td>Kitch_f_gpd</td>
<td>4.2</td>
<td>9.9</td>
<td>14.2</td>
<td>Nbr 3</td>
</tr>
<tr>
<td>HW pipe insulation</td>
<td>none</td>
<td>Lav_f_gpd</td>
<td>1.9</td>
<td>4.5</td>
<td>6.4</td>
<td>NF 2</td>
</tr>
<tr>
<td>Shower (gpm)</td>
<td>2.5</td>
<td>Waste_gpd</td>
<td>4.7</td>
<td>11.0</td>
<td>15.7</td>
<td>Bsm 0</td>
</tr>
<tr>
<td>Kitch Faucet (gpm)</td>
<td>2.2</td>
<td>CW_gpd</td>
<td>20.6</td>
<td>3.9</td>
<td>24.5</td>
<td>Tmains = 58.0</td>
</tr>
<tr>
<td>Lav Faucet efficiency</td>
<td>std</td>
<td>DW_gpd</td>
<td>4.3</td>
<td>4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std sys pipe length</td>
<td>89</td>
<td>Toilets_gpd</td>
<td>21.9</td>
<td>21.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recirc sys loop length</td>
<td>159</td>
<td>Soft_gpd</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recirc sys branch length</td>
<td>10</td>
<td>Other_gpd</td>
<td>15.7</td>
<td>2.1</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>Recirc pump Watts</td>
<td>50</td>
<td>EP_gpd</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>gpf 1.6</td>
</tr>
<tr>
<td>DW heat recovery?</td>
<td>no</td>
<td>Indoor_gpd</td>
<td>76.2</td>
<td>52.6</td>
<td>128.9</td>
<td></td>
</tr>
<tr>
<td>Lot Area (ft²)</td>
<td>8,500</td>
<td>Outdoor_gpd</td>
<td>86.7</td>
<td>0.0</td>
<td>86.7</td>
<td>Softener no</td>
</tr>
<tr>
<td>Landscaped Area (ft²)</td>
<td>5,000</td>
<td>Total_gpd</td>
<td>162.9</td>
<td>52.6</td>
<td>215.5</td>
<td></td>
</tr>
</tbody>
</table>

#### Water Softener:

- Inground Pool: no
- Automatic Irrigation: no
- Use RICI: no
- Zone flow rates: 27.0
- Sum of irrigation zone flow rates: 101
- Prof Audit: yes
- Static Pressure: 75

#### Home Characteristics:

- CFA: 2400
- Nbr: 3
- NF: 2
- CSA 55.1 DWHR_e: 54.0%
- TMains: 58.0
- WHinT: 58.0
- WHinTadj: 0.00

#### Drain Water Heat Recovery:

- Dishwasher: std
- Clothes washer: std
- WHinT: 58.0
- WHinTadj: 0.00

#### Other:

- HERS_new = 100
- SaveH2O** = -167

---

*Gallons per year*
<table>
<thead>
<tr>
<th></th>
<th>Indoor_gpd</th>
<th>Outdoor_gpd</th>
<th>Total_gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref_In</td>
<td>76.2</td>
<td>52.6</td>
<td>128.9</td>
</tr>
<tr>
<td>Ref_Out</td>
<td>86.2</td>
<td>0.0</td>
<td>86.2</td>
</tr>
<tr>
<td>Ref_Tot</td>
<td>162.5</td>
<td>52.6</td>
<td>215.1</td>
</tr>
<tr>
<td>Save_Tot</td>
<td>-0.5</td>
<td>0.0</td>
<td>-0.5</td>
</tr>
<tr>
<td>H2O_in</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>H2O_Out</td>
<td>101</td>
<td>100</td>
<td>101</td>
</tr>
<tr>
<td>H2O_Tot</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Water Softener:**
- Softener: no
- gal/removed: 5.0

**Outdoors:**
- Inground Pool?: no
- Automatic Irrigation?: no
- Smart controller?: no
- Use RICI?: no
- Zone flow rates: 27.0
- Prof Audit?: no
- Static Pressure: 75

**Note:**
- HERS_{H2O} = 100
- SaveH2O* = -167
<table>
<thead>
<tr>
<th></th>
<th>Indoor_gpd</th>
<th>Outdoor_gpd</th>
<th>Total_gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>76.2</td>
<td>256.0</td>
<td>332.3</td>
</tr>
<tr>
<td></td>
<td>52.6</td>
<td>0.0</td>
<td>52.6</td>
</tr>
<tr>
<td></td>
<td>128.9</td>
<td>256.0</td>
<td>384.9</td>
</tr>
</tbody>
</table>

**Water Softener:**
- Softener: no
- gal/removed: 5.0

**Outdoors:**
- Inground Pool?: no
- Automatic Irrigation?: yes
- Smart controller?: no
- Use RICI?: no
- Zone flow rates: 27.0
- Prof Audit?: no
- Static Pressure: 75

**Operation Summary:**
- Ref_In = 76.2
- Ref_Out = 252.8
- H2O_in = 100
- H2O_Out = 101
- H2O_Tot = 101
- HERS_H2O = 101

**Performance Metrics:**
- H2O_Tot: 101
- Save_H2O*: -1,200
<table>
<thead>
<tr>
<th></th>
<th>Indoor_gpd</th>
<th>Outdoor_gpd</th>
<th>Total_gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref_In</td>
<td>76.2</td>
<td>52.6</td>
<td>128.9</td>
</tr>
<tr>
<td>Ref_Out</td>
<td>252.8</td>
<td>0.0</td>
<td>252.8</td>
</tr>
<tr>
<td>Ref_Tot</td>
<td>329.0</td>
<td>52.6</td>
<td>381.6</td>
</tr>
<tr>
<td>Save_Tot</td>
<td>35.1</td>
<td>0.0</td>
<td>35.1</td>
</tr>
</tbody>
</table>

Water Softener:
- Softener: no
- gal/removed: 5.0

Outdoors:
- Inground Pool?: no
- Automatic Irrigation?: yes
- Smart controller?: yes
- Use RICI?: no
- Zone flow rates: 27.0
- Prof Audit?: no
- Static Pressure: 75

HERS = 91
SaveH2O* = 12,819
<table>
<thead>
<tr>
<th></th>
<th>Indoor_gpd</th>
<th>Outdoor_gpd</th>
<th>Total_gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of gpd</td>
<td>76.2</td>
<td>206.8</td>
<td>283.0</td>
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<tr>
<td>Water Softener</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gal/removed</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ref_In =</th>
<th>Ref_Out =</th>
<th>Ref_Tot =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of gpd</td>
<td>76.2</td>
<td>252.8</td>
<td>329.0</td>
</tr>
<tr>
<td>Outdoors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inground Pool?</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic Irrigation?</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smart controller?</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use RICI?</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone flow rates</td>
<td>27.0</td>
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<td></td>
</tr>
<tr>
<td>Prof Audit?</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static Pressure</td>
<td>75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>H2O_in =</th>
<th>H2O_Out =</th>
<th>H2O_Tot =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of gpd</td>
<td>100</td>
<td>82</td>
<td>86</td>
</tr>
<tr>
<td>HERS_{H2O}</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SaveH2O*</td>
<td>16,791</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DW heat recovery?</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot Area (ft²)</td>
<td>8,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landscaped Area (ft²)</td>
<td>5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Outdoor H2O</td>
<td>62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref Irr_Area</td>
<td>4,905</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tot_Ref Irr_ratio</td>
<td>57.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net_Lscape_ratio</td>
<td>68.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot size (acres)</td>
<td>0.195</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Water Softener: 
- **Softener**: no
- **gal/removed**: 5.0

### Outdoors: 
- **Inground Pool?**: no
- **Automatic Irrigation?**: yes
- **Smart controller?**: yes
- **Use RICI?**: no
- **Zone flow rates**: 27.0
- **Prof Audit?**: yes
- **Static Pressure**: 75

### Calculations:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tr>
<td>Total_gpd</td>
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<tr>
<td>Ref_In</td>
<td>76.2</td>
</tr>
<tr>
<td>Ref_Out</td>
<td>252.8</td>
</tr>
<tr>
<td>Ref_Tot</td>
<td>329.0</td>
</tr>
<tr>
<td>Save_Tot</td>
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<td>H2O_in</td>
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<td>H2O_Out</td>
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<tr>
<td>H2O_Tot</td>
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</tr>
<tr>
<td>HERS_H2O</td>
<td>88</td>
</tr>
<tr>
<td>SaveH2O*</td>
<td>16,791</td>
</tr>
</tbody>
</table>
Voluntary Programs
Voluntary Programs

- Prerequisites or requirements (prescriptive)
- Options to earn credits or points (performance)
- Levels of accomplishment
  - Green
  - Greener
  - Greenest
  - Greenisimo
Summary:

• Market trends toward sustainability affect the irrigation industry.
• Trends in landscapes is to use native/native-type plants—no irrigation.
• Reducing potable water use in the landscape.
• Standards, codes & ordinances are being adopted.
• Volunteer programs for commercial landscapes
  • Prerequisites and credits or points
• Rating systems for residential properties
  • Third-party verification
  • EPA WaterSense proposing to use rating systems for new homes
• Opportunity to understand and help clients who embrace sustainability.