Water Efficiency

In the United States, approximately 340 billion gallons of fresh water are withdrawn per day from rivers, streams and reservoirs to support residential, commercial, industrial, agricultural and recreational activities. This accounts for about one-fourth of the nation's total supply of renewable fresh water. Almost 65% of this water is discharged to rivers, streams and other water bodies after use and, in some cases, treatment.

Additionally, water is withdrawn from underground aquifers. In some parts of the United States, water levels in these aquifers have dropped more than 100 feet since the 1940s. On an annual basis, the water deficit in the United States is currently estimated at about 3,700 billion gallons. In other words, Americans extract 3,700 billion gallons per year more than they return to the natural water system to recharge aquifers and other water sources.

On a positive note, U.S. industries today use 36% less water than they did in 1950 although industrial output has increased significantly. This reduction in water use is largely due to the rigorous water reuse strategies in industrial processes. In addition, the Energy Policy Act of 1992 mandated the use of water-conserving plumbing fixtures to reduce water use in residential, commercial and institutional buildings.

Using large volumes of water increases maintenance and lifecycle costs for building operations and increases consumer costs for additional municipal supply and treatment facilities. Conversely, facilities that use water efficiently can reduce costs through lower water use fees, lower sewage volumes to treat energy and chemical use reductions, and lower capacity charges and limits. Many water conservation strategies involve either no additional cost or rapid paybacks. Other water conservation strategies such as biological wastewater treatment, rainwater harvesting and graywater plumbing systems often involve more substantial investment.

Water efficiency measures in commercial buildings can easily reduce water usage by 30% or more. In a typical 100,000-square-foot office building, low-flow fixtures coupled with sensors and automatic controls can save a minimum of 1 million gallons of water per year, based on 650 building occupants each using an average of 20 gallons per day. Non-potable water volumes can be used for landscape irrigation, toilet and urinal flushing, custodial purposes and building systems. Utility savings, though dependent on the local water costs, can save thousands of dollars per year, resulting in rapid payback on water conservation infrastructure.

Water Efficiency Credit Characteristics

Table 1 shows which credits were substantially revised for LEED-NC Version 2.2, which credits are eligible to be submitted in the Design Phase Submittal, and which project team members are likely to carry decision-making responsibility for each credit. The decision-making responsibility matrix is not intended to exclude any party, rather to emphasize those credits that are most likely to require strong participation by a particular team member.

Overview of LEED® Prerequisites and Credits

WE Credit 1.1
Water Efficient Landscaping—Reduce by 50%

WE Credit 1.2
Water Efficient Landscaping—No Potable Water Use or No Irrigation

WE Credit 2
Innovative Wastewater Technologies

WE Credit 3.1
Water Use Reduction —20%

WE Credit 3.2
Water Use Reduction —30%

Table 1: WE Credit Characteristics

Credit	Significant Change from LEED-NC v2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
WEc1.1: Water Efficient Landscaping: Reduce by 50%	*	*			*	
WEc1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation		*		*	*	
WEc2: Innovative Wastewater Technologies		*			*	
WEc3.1: Water Use Reduction: 20%		*			*	
WEc3.2: Water Use Reduction: 30%		*			*	

1 Point

Water Efficient Landscaping

Reduce by 50%

Intent

Limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Reduce potable water consumption for irrigation by 50% from a calculated mid-summer baseline case.

Reductions shall be attributed to any combination of the following items:

- ❑ Plant species factor
- ❑ Irrigation efficiency
- ❑ Use of captured rainwater
- ❑ Use of recycled wastewater
- ❑ Use of water treated and conveyed by a public agency specifically for non-potable uses

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements. Where irrigation is required, use high-efficiency equipment and/or climate-based controllers.

SS	WE	EA	MR	EQ	ID

Credit 1.2

1 Point
in addition to
WE Credit 1.1

Water Efficient Landscaping

No Potable Water Use or No Irrigation

Intent

Eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Achieve WE Credit 1.1 and:

Use only captured rainwater, recycled wastewater, recycled graywater, or water treated and conveyed by a public agency specifically for non-potable uses for irrigation.

OR

Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation.

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate landscape types and design the landscape with indigenous plants to reduce or eliminate irrigation requirements. Consider using stormwater, graywater, and/or condensate water for irrigation.

SS	WE	EA	MR	EQ	ID
Credit 1					

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Design landscaping with climate-tolerant plants that can survive on natural rainfall quantities after initial establishment. Contour the land to direct rainwater runoff through the site to give vegetation an additional water supply. Minimize the amount of site area covered with turf, and use techniques such as mulching, alternative mowing and composting to maintain plant health. These practices conserve water and help foster optimal soil conditions.

Recommended design principals

1. Planning and Design
   - Develop a site map showing existing or planned structures, topography, orientation, sun and wind exposure, use of space and existing vegetation.
   - Perform shadow profiles of landscape areas for each season, based on middle of the day conditions and illustrate the plant selection within the profiles.
   - Reduce heat island effect by providing adequate shade from trees and buildings; plant hard wood trees to increase shade canopy as necessary.
   - Plan water use zones:

     High – regular watering

     Moderate – occasional watering

     Low – natural rain fall
2. Practical turf areas

   Plant turf grasses only for functional benefits such as recreational areas, pedestrian use, or specifically for soil conservation.
3. Soil analysis and preparation
   - Analyze soil in each zone.
   - Amend soil accordingly.
4. Appropriate use of plant materials
   - Choose plants that will easily adapt to the site.

     A. Consider the mature size and form when choosing plant material for the location and intended purpose.

     B. Consider growth rate.

     C. Determine that texture and color combine with surrounding plantings and building background.

     D. Use no mono-species or excessive multi-species selections.

     E. Diversify species to prevent elimination of a species from diseases or pestinfestation.
5. Effective and efficient watering practices
   - Regularly check irrigation systems for efficient and effective operation; verify watering schedules and duration on a monthly basis.
   - Use drip, micro misters, and subsurface irrigation systems where applicable, and smart irrigation controllers throughout. Provide computer interface for monitoring and schedule modifications from a central location.
   - No irrigation of plants and turf in the months of November to April.
   - No irrigation of shrubs from September to June.
6. Use of mulch on trees, shrubs and flower beds
   - Keep landscape areas mulched to conserve moisture and preventing evaporative water loss from the soil surface to reduce the need for

supplemental irrigation during periods of limited rainfall.

A number of factors, including owner preference, event uses, and maintenance expertise, may also impact plant selection, but the intent of this credit is to create a landscape that maximizes the use of on-site natural resources to limit or eliminate the use of potable water for irrigation. This goal can be achieved by selecting native or adapted plants that require little or no irrigation after initial establishment. This goal also can be achieved by using high-efficiency irrigation equipment, captured rainwater, recycled graywater or treated wastewater to reduce the consumption of potable water. Often times, it is appropriate to use a combination of these strategies to first reduce potable water demand and then meet the irrigation demand in the most sustainable manner.

The use of native or adapted plants is an excellent approach because water conservation is built-in and is not reliant on high-tech equipment and controls. In some climates, it is possible to eliminate the need for permanent irrigation with this strategy. In other climates, irrigation requirements can be cut by 50% or greater compared to conventional building landscapes simply by plant selection.

Technologies

The use of irrigation technology, rainwater capture, and/or advanced wastewater treatment is another excellent approach to achieving this credit because it allows for a broader plant species palette, while still conserving potable water supplies. High-efficiency irrigation strategies include micro-irrigation systems, moisture sensors, rain shut-offs, and weather-based evapotranspiration controllers. Drip systems apply water slowly and directly to the roots of plants, using 30%–50% less water than sprinkler irrigation[1]. Moisture and rain sensors save water by ensuring that plants only receive water when necessary.

A rainwater collection system (e.g., cisterns, underground tanks, ponds) can significantly reduce or completely eliminate the amount of potable water used for irrigation. Rainwater can be collected from roofs, plazas and paved areas and then filtered by combination of graded screens and paper filters to prepare it for use in irrigation. Metal, clay or concrete-based roofing materials are ideal for rainwater harvest, as asphalt or lead-containing materials will contaminate the water. Rainwater with high mineral content or acidity may damage systems or plantings, but pollutants can be filtered out by soil or mechanical systems prior to being applied to plantings. It is important to check local rainfall quantity and quality, as collection systems may be inappropriate in areas with rainfall of poor quality or low quantity.

Wastewater recovery can be accomplished either on-site or at the municipal level. On-site systems include graywater and/or wastewater treatment. Graywater consists of wastewater from sinks, showers and washing machines; cooling tower bleed down water; condensation from air conditioning systems; and other building activities that do not involve human waste or food processing. In addition, many municipalities treat sewage to tertiary standards in central treatment plants and re-distribute that water regionally for irrigation use.

Calculations

To calculate the percent reduction in potable use for this credit, establish a baseline water use rate for your project and then calculate the as-designed water use rate according to the steps listed below.

Standard Assumptions & Variables

- ❑ All calculations are based on irrigation during the month of July.

- The **Landscape Coefficient** (KL) indicates the volume of water lost via evapotranspiration and is dependent on the landscape species, the microclimate and the planting density. The formula for determining the landscape coefficient is given in **Equation 1**.
- The **Species Factor** (ks) accounts for variation of water needs by different plant species. The species factor can be divided into three categories (high, average and low) depending on the plant species considered. To determine the appropriate category for a plant species, use plant manuals and professional experience. This factor is somewhat subjective but landscape professionals should have a general idea of the water needs of particular plant species. Landscapes can be maintained in acceptable condition at about 50% of the reference evapotranspiration (ET_0) value and thus, the average value of ks is 0.5. (Note: If a species does not require irrigation once it is established, then the effective ks = 0 and the resulting KL = 0.)
- The **Density Factor** (kd) accounts for the number of plants and the total leaf area of a landscape. Sparsely planted areas will have lower evapotranspiration rates than densely planted areas. An average kd is applied to areas where ground shading from trees is in the range of 60% to 100%. This is also equivalent to shrubs and ground cover shading 90% to 100% of the landscape area. Low kd values are found where ground shading from trees is less than 60% or shrub and groundcover is less than 90%. For instance, a 25% ground shading from trees results in a kd value of 0.5. In mixed landscape plantings where trees cover understory groundcover and shrubs, evapotranspiration increases. This represents the highest level of landscape density and the kd value should be between 1.0 and 1.3.
- The **Microclimate Factor** (kmc) accounts for environmental conditions specific to the landscape, including temperature, wind and humidity. For instance, parking lot areas increase wind and temperature effects on adjacent landscapes. The average kmc is 1.0 and this refers to conditions where the landscape evapotranspiration rate is unaffected by buildings, pavements, reflective surfaces and slopes. Higher kmc conditions occur where evaporative potential is increased due to landscapes surrounded by heat-absorbing and reflective surfaces or are exposed to particularly windy conditions. Examples of high kmc areas include parking lots, west sides of buildings, west and south sides of slopes, medians, and areas experiencing wind tunnel effects. Low microclimate areas include shaded areas and areas protected from wind. North sides of buildings, courtyards, areas under wide building overhangs, and north sides of slopes are low microclimate areas.

Step 1—Create Design Case

Determine the landscape area for the project. This number must represent the as-designed landscape area and must use the same project boundary as is used in all other LEED credits. Sort the total landscape area into the major vegetation types (trees, shrubs, groundcover, mixed, and turfgrass), listing the area for each.

Determine the following characteristics for each landscape area: Species Factor (k_s), Density Factor (k_d), and Microclimate Factor (k_{mc}). Recommended values for each of these factors are provided in

Equation 1

$$K_L = k_s \times k_d \times k_{mc}$$

Table 1. Select the "low," "average," or "high" value for each parameter as appropriate for your design. Any variance from these recommended values should be explained in the credit narrative.

Calculate the Landscape Coefficient (K_L) by multiplying the three area characteristics as shown in **Equation 1**.

Determine the reference evapotranspiration rate (ET_0) for your region. The **evapotranspiration rate** is a measurement of the total amount of water needed to grow a certain reference plant (such as grass or alfalfa) expressed in millimeters or inches. The values for ET_0 in various regions throughout the United States can be found in regional agricultural data (see Resources section). The ET_0 for July is used in the LEED calculation because this is typically the month with the greatest evapotranspiration effects and, therefore, the greatest irrigation demands.

Calculate your project-specific evapotranspiration rate (ET_L) for each landscape area by multiplying the (ET_0) by your KL, as shown in **Equation 2**.

Determine your **Irrigation Efficiency** (IE) by listing the type of irrigation used for each landscape area and the corresponding efficiency. **Table 2** lists irrigation efficiencies for different irrigation systems.

Determine, if applicable, the Controller Efficiency (CE). CE is the percent reduction in water use from any weather-based controllers or moisture sensor-based systems. This number must be supported by either manufacturer documentation or detailed calculations by the landscape designer.

Determine, if applicable, the volume of reuse water (captured rainwater, recycled graywater, or treated wastewater) available in the month of July. Reuse water volumes may depend on rainfall volume/frequency, building-generated graywater/wastewater, and on-site storage capacity. On-site reuse systems should be modeled to predict volumes generated on a monthly basis as well as optimal storage capacity. For captured rainwater calculations, project teams may use either the collected rainwater total for July based on historical average precipitation, or the historical data for each month in order to model collection and reuse throughout the year. The latter method allows the project team to determine what volume of water is expected to be in the storage cistern at the beginning of July and add it to the expected rainwater volume collected during the month. This approach also allows the project team to determine the optimal size of the rainwater cistern.

Table 2: Irrigation Types

Irrigation Type	IE
Sprinkler	0.625
Drip	0.90

Table 1: Landscape Factors

Vegetation Type	Species Factor (k_s)			Density Factor (k_d)			Microclimate Factor (k_{mc})		
	low	average	high	low	average	high	low	average	high
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Groundcovers	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed: trees, shrubs, groundcovers	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turfgrass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

Equation 2

$$ET_L\ [\text{in}] = ET_0 \times K_L$$

Now you are ready to calculate your Total Water Applied (TWA) and Total Potable Water Applied (TPWA) for each landscape area and the Design Case. **Equations 3 and 4** show how to calculate these values.

Step 2—Create Baseline Case

The Baseline Case is calculated by setting the Species Factor (ks), Density Factor (kd), and Irrigation Efficiency (IE) to average values representative of conventional equipment and design practices. The same Microclimate Factors (kMC), and the reference Evapotranspiration Rate (ETo) are used in both the Design and Baseline cases. If the design of the project included substitutions of low water-using landscape types (such as shrubs) for high water-using types (such as turfgrass), the landscape areas can be re-allocated in the baseline case, but the total landscape area must remain the same in the two cases. Also, it is unreasonable to assume that the baseline is 100% turfgrass if the project includes substantial areas of trees, shrubs, and planting beds.

Calculate your TWA for the Baseline Case using **Equation 5**.

Step 3—Calculate Percent Reduction in Total Irrigation Water Use (Potable and Reuse) AND Percent Reduction of Potable Water Use for Irrigation

Calculate your percent reduction of potable water use according to **Equation 6**.

If the Percent Reduction of Potable Water is equal to or greater than 50%, WE Credit 1.1 is earned.

If the Percent Reduction of Potable Water is 100%, you must also calculate the Percent Reduction of Total Water (Potable plus Reuse) according to **Equation 7**.

If the Percent Reduction of Potable Water is 100% AND the Percent Reduction of Total Water is equal to or greater than 50%, WE Credit 1.2 is earned in addition to WE Credit 1.1.

Example

An office building in Austin, Texas, has a total site area of 6,000 square feet. The site consists of three landscape types: groundcover, mixed vegetation and turf grass. All of the site areas are irrigated with a combination of potable water and graywater harvested from the building. The reference evapotranspiration rate (ET_0)

Equation 3

Design Case TWA [gal] = (Area [sf] x (ET_L [in] / IE)) x CE x 0.6233 gal/sf/in

Equation 4

Design Case TPWA [gal] = TWA [gal] – Reuse Water [gal]

Equation 5

Baseline Case TWA [gal] = Area [sf] x (ET_L [in] / IE) x 0.6233 gal/sf/in

Equation 6

Percent Reduction of Potable Water [%] = (1 – Design TPWA / Baseline TWA) x 100

Equation 7

Percent Reduction of Total Water [%] = (1 – Design TWA / Baseline TWA) x 100 for Austin in July was obtained from the local agricultural data service and is equal to 8.12. The high-efficiency landscape irrigation case utilizes drip irrigation with an efficiency of 90% and reuses an estimated 4,200 gallons of graywater during the month of July. **Table 3** shows the calculations to determine potable water use for the design case.

The baseline case uses the same reference evapotranspiration rate and total site area. However, the baseline case uses sprinklers for irrigation (IE = 0.625), does not take advantage of graywater harvesting, and uses only shrubs and turf grass. Calculations to determine potable water use for the baseline case are presented in **Table 4**.

The example illustrates that the design case has an irrigation water demand of 23,474 gallons. Graywater reuse provides 4,200 gallons towards the demand, and this volume is treated as a credit in the water calculation. Thus, the total potable water applied to the design case in July is 19,274 gallons. The baseline case has an irrigation demand of 62,518 gallons and reuses no graywater. The difference between the two cases results in potable water savings of 69% for the design case.

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted in the **Design Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

- ❑ The project's calculated baseline Total Water Applied (TWA) (gal). This data can be obtained using **Equation 5**.
- ❑ The project's calculated design case Total Water Applied (TWA) (gal). This data can be obtained using **Equation 5**.
- ❑ The total non-potable water supply (gal) available for irrigation purposes.
- ❑ Narrative describing the landscaping and irrigation design strategies employed by the project; description of the water use calculation method-

Table 3: Design Case (July)

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Low 0.2	Avg 1.0	High 1.3	**0.3**	2.11	Drip	2,815
Mixed	3,900	Low 0.2	Avg 1.1	High 1.4	**0.3**	2.50	Drip	10,837
Turfgrass	900	Avg 0.7	Avg 1.0	High 1.2	**0.8**	6.82	Sprinkler	9,822
							Subtotal [gal]	**23,474**
							July Rainwater and Graywater Harvest [gal]	(4,200)
							Net GPWA [gal]	**19,274**

Table 4: Base line Case (July)

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Avg 0.5	Avg 1.0	High 1.3	**0.7**	5.28	Sprinkler	10,134
Turfgrass	4,800	Avg 0.7	Avg 1.0	High 1.2	**0.8**	6.82	Sprinkler	52,384
							Net GPWA [gal]	**62,518**

ology used to determine savings; and for projects using non-potable water, specific information regarding source and available quantity of non-potable supplies.

Considerations

Landscape irrigation practices in the United States consume large quantities of potable water. Outdoor uses, primarily landscaping, account for 30% of the 26 billion gallons of water consumed daily in the United States[2]. Improved landscaping practices can dramatically reduce and even eliminate irrigation needs. Maintaining or reestablishing native or adapted plants on building sites fosters a self-sustaining landscape that requires minimal supplemental water and provides other environmental benefits. Improved irrigation systems can also reduce water consumption. Irrigation typically uses potable water, although non-potable water (e.g., rainwater, graywater or reclaimed water) is equally effective. Irrigation system efficiency varies widely, and high-efficiency irrigation systems can also reduce potable water consumption. For example, high-efficiency drip irrigation systems can be 95% efficient, while sprinkler or spray irrigation systems are only 60% to 70% efficient.[3]

Environmental Issues

Reduction in the amount of potable water used for irrigation lessens demand on limited supplies. Since landscape irrigation uses large amounts of potable water, it is an important opportunity to reduce overall consumption. Native or adapted landscaping can reduce the amount of water needed for irrigation while also attracting native wildlife and creating a building site integrated with its natural surroundings. In addition, native or adapted plants tend to require less fertilizer and pesticides, and thus reduce water quality degradation and other environmental impacts.

Economic Issues

Currently, the most effective strategy to avoid escalating water costs for irrigation is to design landscaping adapted to the local climate and the site's microclimate. The cost can be reduced or eliminated through thoughtful planning and careful plant selection and layout. Native or adapted plants further reduce operating costs because they require less fertilizer and maintenance than turf grass. Although the additional design cost for a drip irrigation system may make it more expensive than a conventional system, a drip system usually costs less to install and has lower water use and maintenance requirements. This usually leads to a very short payback period. Many municipalities offer rebates or incentives for water-efficient irrigation systems, dedicated water meters and rain or moisture sensors.

Community Issues

Water-efficient landscaping helps to conserve local and regional potable water resources. Maintaining natural aquifer conditions is important to providing reliable water sources for future generations. Consideration of water issues during planning can encourage development when resources can support it, and prevent development if it exceeds the resource capacity.

Synergies and Trade-Offs

Successful water-efficient landscaping depends on site location and design. It is advantageous to couple landscape improvements with water use reduction strategies. The use of native or adapted plants can reduce site maintenance needs. Landscape plantings can mitigate climate conditions and reduce building energy consumption, for example by shading south-facing windows. Vegetation can aid passive solar design, serve as a windbreak, provide pleasant views for building occupants, and muffle off-site noise. Native plants can restore habitat for wildlife.

In addition to reducing potable water consumption, rainwater capture systems can be used to manage rainwater runoff. Using graywater for irrigation reduces the amount of wastewater delivered to water treatment facilities.

Resources

Websites

America Rainwater Catchment Systems Association (ARCSA)

www.arcsa-usa.org

ARCSA was founded to promote rainwater catchment systems in the United States. Its web site provides regional resources, publications, suppliers and membership information.

Graywater Systems, Compost Toilets, & Rain Collection

www.rmi.org/sitepages/pid287.php

This web resource from the Rocky Mountain Institute provides general information and links to resources on rain collection and graywater systems.

The Irrigation Association

www.irrigation.org

This nonprofit organization focuses on promoting products that efficiently use water in irrigation applications.

Texas Evapotranspiration Website

http://texaset.tamu.edu

This website provides evapotranspiration data from the state of Texas with a discussion of crop water use and sprinkler efficiencies.

Texas Water Development Board Website

www.twdb.state.tx.us

This website provides data from the state of Texas regarding water resources and services, such as groundwater mapping and water availability modeling. The site also provides published brochures regarding indoor and outdoor water efficiency strategies.

Water-Efficient Landscaping

http://muextension.missouri.edu/xplor/agguides/hort/g06912.htm

This website has general descriptions and strategies for water efficiency in gardens and landscapes.

Water-Efficient Landscaping: Preventing Pollution and Using Resources Wisely

www.epa.gov/owm/water-efficiency/final_final.pdf

This manual from the Environmental Protection Agency provides information about reducing water consumption through creative landscaping techniques.

Water Wiser: The Water Efficiency Clearinghouse

www.awwa.org/waterwiser/

This clearinghouse provides articles, reference materials and papers on all forms of water efficiency.

Print Media

Landscape Irrigation: Design and Management by Stephen W. Smith, John Wiley and Sons, 1996. This text is comprehensive guide to landscape irrigation strategies, techniques, and hardware.

Turf Irrigation Manual, Fifth Edition by Richard B. Choate and Jim Watkins, Telsco Industries, 1994. This manual covers all aspects of turf and landscape irrigation.

Definitions

Conventional Irrigation refers to the most common irrigation system used in the region where the building is located. A common conventional irrigation system uses pressure to deliver water and distributes it through sprinkler heads above the ground.

Drip Irrigation is a high-efficiency irrigation method in which water is delivered at low pressure through buried mains and sub-mains. From the sub-mains, water is distributed to the soil from a network of perforated tubes or emitters. Drip irrigation is a type of micro-irrigation.

Graywater is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Graywater Systems for Single-Family Dwellings," as "untreated household wastewater which has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers." The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Graywater Recycling Systems," as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks." Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with graywater definitions as established by the authority having jurisdiction in their areas.

The **Landscape Area** of the site is equal to the total site area less the building footprint, paved surfaces, water bodies, patios, etc.

Micro-irrigation involves irrigation systems with small sprinklers and micro-jets or drippers designed to apply small volumes of water. The sprinklers and micro-jets are installed within a few centimeters of the ground, while drippers are laid on or below grade.

Potable Water is water suitable for drinking and supplied from wells or municipal water systems.

Case Study

20 River Terrace (Solaire)

New York, NY

Owner: River Terrace Associates, LLC

Photo © Jeff Goldberg, Esto

Located within the boundaries of Ground Zero in lower Manhattan, the Solaire is a 27-story green residential high-rise building which earned LEED v2.0 Gold in April 2004. The project excelled in Water Efficiency, earning all five WE credits, plus one Innovation & Design credit for exemplary performance in WE Credit 3. A wastewater treatment system treats 100% of the wastewater from the building; water recaptured by the system is used to supply the cooling tower and the building's toilets, and 5,000 gallons per day are provided to the adjacent public park. A stormwater storage tank which harvests rainwater is used for all irrigation needs. 50% less potable water is needed from the municipal water supply than would be used in a conventional apartment building, and no potable water is used outdoors. Low-flow appliances and fixtures were used, and the public restroom facilities use waterless urinals, contributing to a water use reduction of 88% within the building.

SS	WE	EA	MR	EQ	ID
Credit 2					

1 Point

Innovative Wastewater Technologies

Intent

Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Requirements

OPTION 1

Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures (water closets, urinals) or non-potable water (captured rainwater, recycled graywater, and on-site or municipally treated wastewater).

OR

OPTION 2

Treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site.

Potential Technologies & Strategies

Specify high-efficiency fixtures and dry fixtures such as composting toilet systems and non-water using urinals to reduce wastewater volumes. Consider reusing stormwater or graywater for sewage conveyance or on-site wastewater treatment systems (mechanical and/or natural). Options for on-site wastewater treatment include packaged biological nutrient removal systems, constructed wetlands, and high-efficiency filtration systems.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Potable water is used for many functions that do not require high-quality water such as toilet and urinal flushing, and landscape irrigation. Rainwater and graywater systems can significantly reduce potable water demand. Graywater systems reuse the wastewater collected from sinks, showers and other sources for the flushing of toilets, landscape irrigation, and other functions that do not require potable water. Graywater treatment may be required prior to reuse according to end use and state jurisdiction. If it is likely that a graywater system will be used in the future, install dual plumbing lines during the initial construction to avoid the substantial costs and difficulty in adding them later. Rainwater systems provide non-potable water suitable for landscape irrigation, flushing toilets and urinals, and process water needs. Rainwater systems have significantly fewer code requirements than graywater systems and are often less expensive than graywater systems. Rainwater from roofs or site can also be collected and harvested to help displace potable water demand. Rainwater collected from impervious surfaces reduces rainwater runoff and control infrastructure requirements. Rainwater retention or detention systems can be designed with cisterns to hold rainwater runoff for non-potable usage.

The necessity and availability of wastewater reuse and treatment strategies is heavily influenced by the project's size and location. Very large projects or campus settings may provide sufficient economic reason to warrant on-site wastewater treatment. Close proximity to a municipal or private treatment facility can provide an opportunity to reuse treated wastewater to displace potable water demand. In remote locations, it may be more cost-effective to use an on-site wastewater treatment system than to extend existing infrastructure.

Conversely, a project located in a dense urban environment with little available site area may not be able to achieve this credit through development of on-site wastewater systems, graywater or rainwater systems, but may be able to utilize municipally provided recycled water to reduce potable water demand.

This credit has close ties to water efficiency efforts because a greater amount of potable water saved often results in less blackwater generated. For instance, water efficient water closets, urinals, showerheads and faucets not only reduce potable water demand but also reduce blackwater volumes created. Thus, performance results will often overlap with those of WE Credit 3.

Additional energy use may be needed for certain on-site treatment operations or for reuse strategies. These active systems also require commissioning and measurement & verification attention. Reuse of an existing building could hinder adoption of an on-site wastewater treatment facility.

When considering an on-site rainwater, graywater collection or blackwater treatment system it is important to first check with local government agencies for regulations governing the use of this water for irrigation and the permits required.

Each state has its own standards and requirements for the installation and operation of rainwater, graywater and water treatment systems. Texas and California, for example, have standards that encourage the use of graywater systems while other states have regulations that may limit or prohibit graywater use. In many areas, irrigation with graywater must be subsurface, although some regions allow above-ground irrigation.

Projects that plan to treat wastewater on-site should consider a treatment system such as constructed wetlands, a mechanical recirculating sand filter, or anaerobic biological treatment reactor.

In the case of any specialized system, is it imperative that key maintenance staff be trained in the operations and maintenance of the water systems.

Calculations

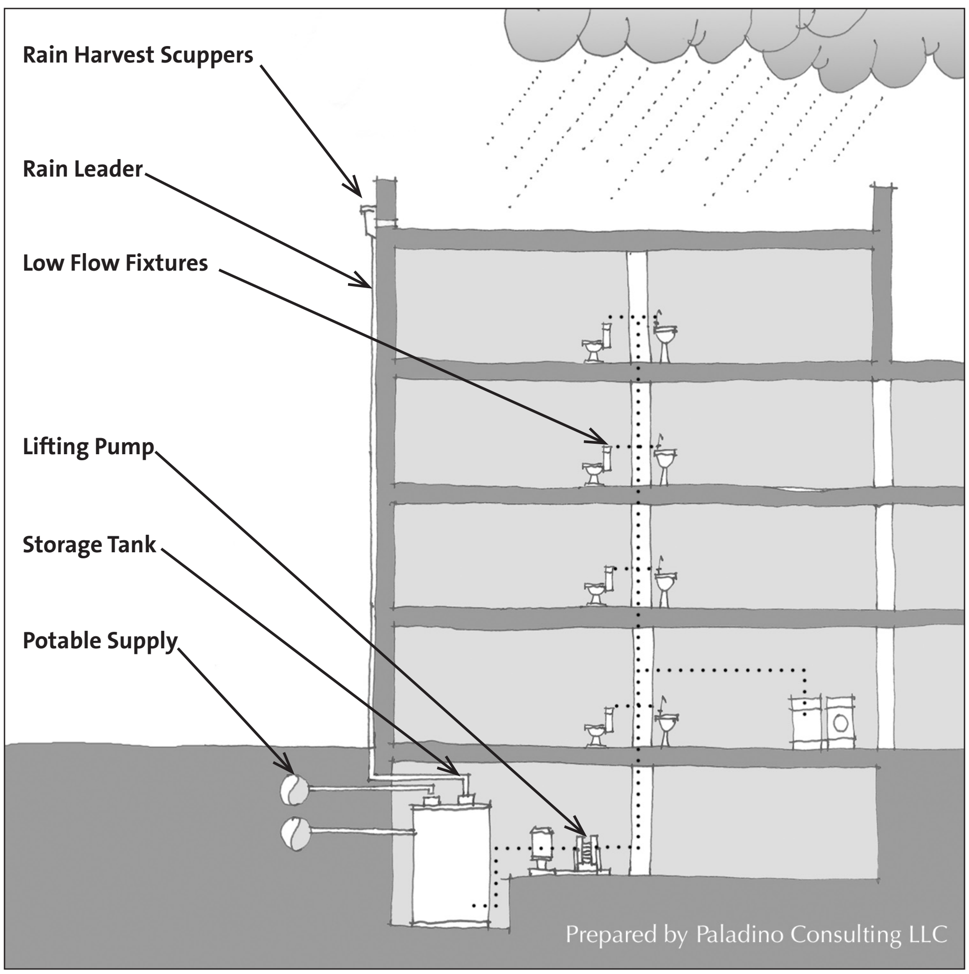
The following calculation methodology is used to support achievement of **Option 1**.

Occupancy

Calculate the **Full-Time Equivalent (FTE)** building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has an FTE value based on their hours per day divided by 8. (Note that FTE calculations for the project must be used consistently for all LEED-NC credits.) In buildings with multiple shifts, use the number of FTEs from all shifts, since this credit is based on annual water consumption.

Estimate the **Transient** building occupants, such as students, visitors and customers. Since this credit is based on annual water consumption, use a transient

Figure 1: An illustration of a Rain Harvesting System



occupancy number that is a representative daily average.

If the building has both FTE and Transient occupants, calculate the water use for each fixture separately for each occupancy type. This separation is necessary to represent the unique use patterns. For residential projects, the number of residents is used as the occupancy number.

Note: WE Credit 3, Table 2 provides default fixture use values for different occupancy types.

Design Case

Wastewater calculations are based on the annual generation of blackwater volumes from plumbing fixtures such as water closets and urinals. The calculations compare the design case with a baseline case. The steps to calculate the design case are as follows:

1. Create a spreadsheet listing each type of blackwater-generating fixture and frequency-of-use data. Frequency-of-use data includes the number of female and male daily uses, and the sewage generated per use. Use the daily use assumptions shown in **Table 1** as the basis for the calculations, unless alternate assumptions on daily use can be supported by specific back-up documentation. Using these values, calculate the total sewage generated for each fixture type and gender (see **Equation 1**).
2. Sum all of the sewage generation volumes used for each fixture type to obtain male and female daily sewage generation volumes.
3. Multiply the male and female sewage generation volumes by the number of male and female building occupants and sum these volumes to obtain the daily total sewage generation volume (see **Equation 2**).
4. Multiply the total daily sewage volume by the number of workdays in a typical year to obtain the total annual sewage generation volume for the building (see **Equation 3**).
5. If rainwater harvest or graywater reuse strategies are employed in the building, subtract these annual volumes from the annual sewage generation volume. The result shows how much potable water is used for sewage conveyance annually.

Table 1 shows example potable water calculations for sewage conveyance for a two-story office building with a capacity of 300 occupants. The calculations are based on a typical 8-hour workday. It is assumed that building occupants are 50% male and 50% female. Male occupants are assumed to use water closets once and urinals twice in a typical work day. Female occupants are assumed to use water closets three times.

When using graywater and rainwater volumes, calculations are required to demonstrate that these reuse volumes are

Equation 1

$$\text{Sewage Volume [gal]} = \text{Uses} \times \text{Duration [mins or flushes]} \times \frac{\text{Water Volume [gal]}}{\text{Use [min or flush]}}$$

Equation 2

$$\text{Daily Sewage Generation [gal]} = \left(\text{Male Occupants} \times \text{Male Sewage Generation [gal]}\right) + \left(\text{Female Occupants} \times \text{Female Sewage Generation [gal]}\right)$$

Equation 3

$$\text{Annual Sewage Generation [gal]} = \text{Total Sewage Generation}\left[\frac{\text{gal}}{\text{day}}\right] \times \text{Workdays [days]}$$

Table 1: Design Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Low-Flow Water Closet (Male)	0	1.1	150	0
Low-Flow Water Closet (Female)	3	1.1	150	495
Composting Toilet (Male)	1	0.0	150	0
Composting Toilet (Female)	0	0.0	150	0
Waterless Urinal (Male)	2	0.0	150	0
Waterless Urinal (Female)	0	0.0	150	0
			Total Daily Volume [gal]	**495**
			Annual Work Days	260
			Annual Volume [gal]	128,700
			Rainwater or Graywater Volume [gal]	(36,000)
			TOTAL ANNUAL VOLUME [gal]	**92,700**

sufficient to meet water closet demands. These quantities are then subtracted from the gross daily total because they reduce potable water usage. In the example in **Table 1**, 36,000 gallons of rainwater are harvested and directed to water closets for flushing.

Baseline Case

Repeat the above calculation methodology for the baseline case. Use Energy Policy Act of 1992 fixture flow rates for the baseline case (see **WE Credit 3, Table 1**). Do not change the number of building occupants, the number of workdays, or the frequency data. Do not include graywater or rainwater harvest volumes.

Table 2 provides a summary of baseline calculations. The baseline case estimates that 327,600 gallons of potable water per year are used for sewage conveyance.

Comparison of the baseline to the designed building indicates that a 72% reduction in potable water volumes used for sewage conveyance is realized (1 – 92,700/327,600). Thus, this strategy earns one point for this credit. When developing the baseline, only the fixtures, sewage generation rates and the water reuse credit are different from the designed building. Usage rates, occupancy and number of workdays are identical for the design case and the baseline case. See **Table 3** for sample fixture flow rates.

When reusing graywater volumes from the building, it is necessary to model the system on an annual basis to determine graywater volumes, generated storage capacity of the system and any necessary treatment processes before reusing the water volumes. Graywater volumes may or may not be consistently available

Table 2: Baseline Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Water Closet (Male)	1	1.6	150	240
Water Closet (Female)	3	1.6	150	720
Urinal (Male)	2	1.0	150	300
Urinal (Female)	0	1.0	150	0
			Total Daily Volume [gal]	**1,260**
			Annual Work Days	260
			TOTAL ANNUAL VOLUME [gal]	**327,600**

Table 3: Sample Fixture Types and GPFs

Fixture Type	[GPF]
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

throughout the year because these volumes are dependent on building occupant activities. For instance, in a typical office building, graywater volumes will change slightly due to vacation schedules and holidays but should be relatively consistent over the year.

In contrast, graywater volumes in a school building will substantially decrease in summer months due to the school calendar, and therefore, graywater volumes may not be available for irrigation.

If the project uses rainwater volume as a substitute for potable volumes in water closets or urinals, it is necessary to calculate water savings over a time period of one year. Rain harvest volume depends on the amount of precipitation that the project site experiences, the rainwater collection surface's area and efficiency, and storage tank capacity. See **Equation 4** and consult a rainwater harvesting guide for more detailed instruction. Rainfall data is available from the local weather service (see the Resources section). Rainwater volume depends on variations in precipitation, and thus, it is necessary to model the reuse strategy on an annual basis. A model of rainwater capture based on daily precipitation and occupant demand is helpful to determine the rainwater volumes captured and storage tank size. Subtract annual rainwater use for sewage conveyance in the design case calculations.

The following calculation methodology is used to support achievement of **Option 2**.

1. Create a spreadsheet listing each type of blackwater-generating fixture and frequency-of-use data. Frequency-of-use data includes the number of female and male daily uses, and the sewage generated per use. Use the daily use assumptions shown in **Table 1** as the basis for the calculations, unless alternate assumptions on daily use can be supported by specific back-up documentation. Using these values, calculate the total sewage generated for each fixture type and gender (see **Equation 1**).
2. Sum all of the sewage generation volumes used for each fixture type to obtain male and female daily sewage generation volumes.
3. Multiply the male and female sewage generation volumes by the number of male and female building occupants and sum these volumes to obtain the daily total sewage generation volume (see **Equation 2**).
4. Multiply the total daily sewage volume by the number of workdays in a typical year to obtain the total annual sewage generation volume for the building (see **Equation 3**).
5. Divide the annual volume of wastewater that is treated and reused and/or infiltrated on site by the calculated annual sewage generation volume for the building to determine the percent reduction of wastewater that is released into the municipal sewer system.

Exemplary Performance

Projects that demonstrate a 100% reduction in potable water use for sewage

Equation 4

Rainwater Volume [gal] = collection area [sf] x collection efficiency [%] x average rainfall [in] x 0.6233 gal/sf/in conveyance, OR, on-site treatment and re-use/infiltration of 100% of generated wastewater will be considered for one additional point under the Innovation in Design category.

Submittal Documentation

This credit is submitted in the **Design Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

- ❑ Upload the applicable plumbing drawings from the construction documents that provide data regarding any on-site wastewater treatment facilities.
- ❑ The project's calculated occupants. The template will use a default one-to-one men to women ratio. Projects with special occupancy situations that result in an unbalanced ratio may enter project specific data for this credit.
- ❑ The project's calculated baseline water usage for sewage conveyance. This data is calculated using typical fixture types (provided in the template) and the project's mix of occupants.
- ❑ The project's calculated design case water usage for sewage conveyance. This data is calculated using project specified fixture types and the project's mix of occupants. Note: project teams must provide the following fixture information for each typical installed flush fixture type: fixture manufacturer, fixture model, flush rate in gallons per flush (gpf).
- ❑ For projects using non-potable water for sewage conveyance, provide the total non-potable water supply (gal) available for sewage conveyance purposes.
- ❑ For projects treating wastewater on-site, provide the annual quantity (gal) of water treated, the annual quantity (gal) of treated water that is infiltrated, and the annual quantity (gal) of treated water that is re-used on-site.
- ❑ Narrative describing the potable water reduction strategies employed by the project. For projects using non-potable water, include specific information regarding any reclaimed water usage (graywater re-use/rainwater reuse/ on-site or municipally treated wastewater). If the project is treating wastewater on-site to tertiary standards, include specific information regarding the use(s) of the treated wastewater.

Considerations

Cost Issues

Commercial and industrial facilities that generate large amounts of wastewater can realize considerable savings by recycling graywater. For example, car washes and truck maintenance facilities generate large volumes of graywater that can be effectively treated and reused. Often, a separate tank, filter and special emitters are necessary for a graywater irrigation system. Dual sanitary and graywater distribution piping doubles construction piping costs. In addition, local codes requiring filtration, disinfection treatment, overflow protection, etc., add to the cost of construction, operation, and maintenance; all of which should be considered by the owner when making a decision to collect graywater. Collection and use of rainwater for non-potable water applications has significantly fewer code requirements and associated costs. The highest cost in most rainwater systems is for water storage. Storage tanks and cisterns come in a variety of sizes and materials. Designers can lower construction costs by finding synergies such as adding a cistern to collect rainwater to a stormwater detention system. In some systems, pumps are required for distribution, incurring additional energy costs required for operation.

Water recovery systems are most cost-effective in areas where there is no municipal water supply, where the developed wells are unreliable, or if well water requires treatment. Collecting and using rainwater or other site water volumes reduces site runoff and the need for runoff devices. It also minimizes the need for utility-provided water, thus reducing some initial and operating costs. In some areas with a decentralized population, collection of rainwater offers a low-cost alternative to a central piped water supply.

A constructed wetland for wastewater treatment can add value to a development as a site enhancement. Wetlands are beneficial because they provide flood protection and stabilize soils on site. Currently, packaged biological wastewater systems have an initial high cost, relative to the overall building cost, due to the novelty of the technology.

Environmental Issues

On-site wastewater treatment systems transform perceived "wastes" into resources that can be used on the building site. These resources include treated water volumes for potable and non-potable use, as well as nutrients that can be applied to the site to improve soil conditions. Reducing wastewater treatment at the local wastewater treatment works minimizes public infrastructure, energy use and chemical use. In rural areas, on-site wastewater treatment systems avoid aquifer contamination problems prevalent in current septic system technology.

By reducing potable water use, the local aquifer is conserved as a water resource for future generations. In areas where aquifers cannot meet the needs of the population economically, rainwater and other recovered water is the least expensive alternative source of water.

Economic Issues

Wastewater treatment systems and water recovery systems involve an initial capital investment in addition to the maintenance requirements over the building's lifetime. These costs must balance with the anticipated savings in water and sewer bills. This savings can minimize the amount of potable water that a municipality must provide, thereby leading to more stable water rates, and resources needed for economic growth.

Regional Issues

Local precipitation throughout the year should be factored into determining the feasibility of rainwater harvesting systems for use in reduction of potable water for plumbing fixture flushing, and landscape irrigation. Local building and health codes/ordinances vary with regards to allowance of graywater or harvested rainwater systems; and they are prohibited in some states. Additionally, codes differ in how alternative plumbing fixtures, such as dual-flush water closets, composting toilets and non-water using urinals are handled. It is critical to confirm acceptability of non-traditional approaches with code officials prior to commitment to specific water saving strategies.

Supply water quality from graywater and recycled water systems should also be considered in fixture selection. Project teams should identify if minimum supply water quality standards have been established for specific fixtures by manufacturers. When recycled graywater or collected rainwater is used with plumbing fixtures designed for use with municipally supplied potable water, it is good practice to verify that supply water quality is acceptable and will not compromise long-term fixture performance.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the Texas Guide to Rainwater Harvesting.

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies

U.S. EPA

EPA Publication No. 832/B-93-005, 1993.

www.epa.gov/owow/wetlands/construc/

The case studies in this document provide brief descriptions of 17 wetland treatment systems that provide water quality benefits while also providing habitat. The projects described include systems involving constructed and natural wetlands, habitat creation and restoration, and the improvement of municipal effluent, urban stormwater and river water quality.

How to Conserve Water and Use it Effectively

U.S. EPA

www.epa.gov/OW/you/chap3_html

A U.S. EPA document that provides guidance for commercial, industrial and residential water users on saving water and reducing sewage volumes.

On-site Wastewater Treatment Systems Manual

U.S. EPA

www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf

This manual provides a focused and performance-based approach to on-site wastewater treatment and system management, including information on a variety of on-site sewage treatment options.

Print Media

Mechanical & Electrical Equipment for Buildings, Eighth Edition by Benjamin Stein and John Reynolds, John Wiley and Sons, 1992.

Sustainable Building Technical Manual, Public Technology, Inc., 1996. (www.pti.org)

On-site Wastewater Treatment Systems Manual

www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf

Provides a focused and performance-based approach to on-site wastewater treatment and system management. This document provides valuable information on a variety of on-site sewage treatment options.

Definitions

Aquatic Systems are ecologically designed treatment systems that utilize a diverse community of biological organisms (e.g., bacteria, plants and fish) to treat wastewater to advanced levels.

Blackwater does not have a single definition that is accepted nationwide. Wastewater from toilets and urinals is, however, always considered blackwater.

Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs may be considered blackwater by state or local codes. Project teams should comply with the blackwater definition as established by the authority having jurisdiction in their areas.

Composting Toilet Systems are dry plumbing fixtures that contain and treat human waste via microbiological processes.

Graywater (also spelled greywater and gray water) is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Gray water Systems for Single-Family Dwellings," as "untreated household wastewater which has not come into contact with toilet waste. Grey water includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers."

The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Graywater Recycling Systems," as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks."

Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with the graywater definitions as established by the authority having jurisdiction in their areas.

On-site Wastewater Treatment uses localized treatment systems to transport, store, treat and dispose of wastewater volumes generated on the project site.

Non-potable Water is water that is not suitable for human consumption without treatment that meets or exceeds EPA drinking water standards.

Potable Water is water that is suitable for drinking and is supplied from wells or municipal water systems.

Process Water is water used for industrial processes and building systems such as cooling towers, boilers and chillers.

Tertiary Treatment is the highest form of wastewater treatment that includes the removal of nutrients, organic and solid material, along with biological or chemical polishing (generally to effluent limits of 10 mg/L BOD_5 and 10 mg/L TSS).

A **Non-Water-Using Urinal** is a urinal that uses no water, but instead replaces the water flush with a specially designed trap that contains a layer of buoyant liquid that floats above the urine layer, blocking sewer gas and urine odors from the room.

1 Point

Water Use Reduction

20% Reduction

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilet systems and non-water using urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing and custodial uses.

SS	WE	EA	MR	EQ	ID

Credit 3.2

1 Point
in addition to
We Credit 3.1

Water Use Reduction

30% Reduction

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilets and waterless urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing, mechanical systems and custodial uses.

Summary of Referenced Standard

The Energy Policy Act (EPAct) of 1992

This Act was promulgated by the U.S. government and addresses energy and water use in commercial, institutional and residential facilities. The water usage requirements of the Energy Policy Act of 1992 are provided in **Table 1**.

Approach and Implementation

Water use strategies depend on the site location and site design. Project sites with no access to municipal potable water service typically use groundwater wells to satisfy potable water demands. Site locations with significant precipitation volumes may determine that reuse of these volumes is more cost-effective than creating stormwater treatment facilities. Potable water use is significant for irrigation applications and is directly correlated with the amount of wastewater generated on-site.

Some water-saving technologies impact energy performance and require commissioning and Measurement & Verification (M&V) attention. Reuse of existing buildings may hinder water efficiency measures due to space constraints or characteristics of existing plumbing fixtures.

While graywater collection and storage may not be a water reduction method that many owners and designers have the opportunity to include in their projects, high-efficiency plumbing fixtures are. Early planning should focus on the code related issues associated with installation and use of water harvesting and collection systems, and high-performance plumbing fixtures such as non-water-using urinals.

Effective methods to reduce potable water use include: reuse of roof runoff or collected graywater volumes for non-potable applications; installation and maintenance of automatic fixture sensors or metering controls; installation of flow restrictors and/or reduced flow aerators on lavatory, sink, and shower fixtures; installation of low-consumption fixtures such as dual-flush water closets and ultra-low flush urinals; installation of dry fixtures such as composting toilet systems and non-water-using urinals.

Although water efficient dishwashers, clothes washers and other water consuming fixtures are not counted in the calculations for this credit they may be included in exemplary performance calculations. (See Exemplary Performance for this credit) A variety of low-flow plumbing fixtures and appliances are currently available in the marketplace and can be installed in the same manner as conventional fixtures.

To determine the most effective strategies for a particular condition, the project team should analyze the water conservation options available to the project based on location, code compliance, and overall project function. Using the EPAct num-

Table 1: Design Case

Fixture	Energy Policy Act of 1992 Flow Requirement
Water Closets [gpf]	1.6
Urinals [gpf]	1.0
Showerheads [gpm]*	2.5
Faucets [gpm]*	2.5
Replacement Aerators [gpm]*	2.5
Metering Faucets [gal/cy]	0.25

***At flowing water pressure of 80 pounds per square inch (psi)* bers as a baseline, estimate the potable water needs for the project based on estimated occupant uses. Determine areas of high water usage and evaluate potential alternative water saving technologies. Using the same calculation method, examine the impacts of alternative fixture types and technologies. Compare the design case water usage to the calculated EPAct baseline to determine the optimal water savings for the project.

In order to ensure continued water savings and owner/occupant satisfaction, it is imperative that key maintenance staff is trained in the operations and maintenance of any specialized equipment. For example, non-water using urinals generally need to be cleaned according to manufacturer's specifications and their chemical traps appropriately maintained.

Calculations

The following section describes the calculation methodology for determining water use savings under this credit. The calculated water use reduction for the project is the difference between the calculated design case and a baseline case. The credit percentage is determined by dividing the design case usage by the baseline usage.

The methodology differs from traditional plumbing design where the calculations are based on fixture counts; under this credit, the water use calculation is based on estimated occupant usage and fixture flow rates. Estimated occupant usage is determined by calculating Full-Time Equivalent (FTE) and transient occupants and applying appropriate fixture use rates to each type of occupant.

Occupancy

Calculate the **Full-Time Equivalent (FTE)** building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has an FTE value based on their hours per day divided by 8. (Note that FTE calculations for the project must be used consistently for all LEED-NC credits.) In buildings with multiple shifts, use the number of FTEs from all shifts, since this credit is based on annual water consumption.

Estimate the **Transient** building occupants, such as students, visitors, and customers. Since this credit is based on annual water consumption, use a transient occupancy number that is a representative daily average.

If the building has both FTE and Transient occupants, calculate the water use for each fixture separately for each occupancy type. This separation is necessary to represent the unique use patterns. For residential projects, the number of residents is used as the occupancy number.

Table 2 provides default fixture use values for different occupancy types. These values should be used in the calculations for this credit unless special circumstances exist within the project to require modification. The FTE uses are identical to those used in LEED-NC v2.1. The uses for the other occupancy types are provided as compromise default values based on v2.1 projects. Note that most buildings with Student/Visitor and Retail Customer occupants will also have FTE occupants. The Student/Visitor category is intended for college buildings, libraries, museums, and similar building types. 50% of all Student/Visitor occupants are assumed to use a flush fixture and a lavatory faucet in the building and are not expected to use a shower or kitchen sink. 20% of Retail Customer occupants are assumed to use a flush and a flow fixture in the building and no shower or kitchen sink. The default for Residential occupants is 5 uses per day of flush and flow fixtures, 1 shower, and 4 kitchen sink uses.

For consistency across LEED projects, the calculations require the use of a balanced, one-to-one gender ratio unless

Table 2: Standard Fixture Uses by Occupancy Type

Fixture Types	FTE	Student/ Visitor	Retail Customer	Resident
	Uses/Day			
Water Closet				
female	3	0.5	0.2	5
male	1	0.1	0.1	5
Urinal				
female	0	0	0	n/a
male	2	0.4	0.1	n/a
Lavatory Faucet (duration 15 sec; 12 sec with autocontrol)	3	0.5	0.2	5
Shower (duration 300 sec)	0.1	0	0	1
Kitchen Sink, non-residential (duration 15 sec)	1	0	0	n/a
Kitchen Sink, residential (duration 60 sec)	n/a	n/a	n/a	4

specific project conditions warrant an alternative. For these special situations, the project team will need to provide a narrative description to explain the unique circumstances.

The total fixture uses by all occupants must be consistent in the design and baseline cases.

Design Case

The design case annual water use is determined by totaling the annual volume of each fixture type and subtracting any reuse of stormwater/graywater. The design case must use the actual flow rates and flush volumes for installed fixtures. The flow and flush data should be obtained from manufacturer's published product literature.

In addition to the typical fixtures shown on the flush and flow fixture charts (**Table 3**), the project team may add others, as applicable.

Table 4 provides an example design case water use calculation. Note that flush fixtures, which include water closets and urinals, differentiate between females and males. The calculation should ensure that both the male and female occupants are appropriately represented. Zeros may be used when appropriate.

Where on-site collected graywater or rainwater is used for sewage conveyance, the

Table 3: Eaxmple Flush and Flow Fixtures and Baseline Flow Rates

Flush Fixture	Flowrate [GPF]	Flow Fixture	Flowrate [GPM]
Conventional Water Closet	1.6	Conventional Lavatory	2.5
Low-Flow Water Closet	1.1	Low-Flow Lavatory	1.8
Dual-Flush Water Closet (Full-Flush)	1.6	Ultra Low-Flow Lavatory	0.5
Dual-Flush Water Closet (Low-Flush)	0.8	Kitchen Sink	2.5
Composting Toilet	0.0	Low-Flow Kitchen Sink	1.8
Conventional Urinal	1.0	Shower	2.5
Low-Flow Urinal	0.5	Low-Flow Shower	1.8
Non-Water Urinal	0.0		

project team should enter the estimated quantity in the calculation. The total annual graywater quantity is subtracted from the total annual design case water usage.

Baseline Case

The baseline case annual water use is determined by duplicating the Design Case table and then setting the fixture flush rates and flow rates to the EPAct default values (as opposed to actual installed values in the Design Case). **Table 5** provides an example design case water use calculation, based on the Design Case presented in **Table 4**.

Eligible Fixtures

This credit is limited to savings generated by water using fixtures regulated by the Energy Policy Act of 1992. EPAct

Table 4: Sample Design Case Water Use Calculation

Flush Fixture	**Daily Uses**	**Flowrate [GPF]**	**Duration [flush]**	**Occupants**	**Water Use [gal]**
Ultra Low-Flow Water Closet (Male)	0	0.8	1	150	0
Ultra Low-Flow Water Closet (Female)	3	0.8	1	150	360
Composting Toilet (Male)	1	0.0	1	150	0
Composting Toilet (Female)	0	0.0	1	150	0
Waterless Urinal (Male)	2	0.0	1	150	0
Waterless Urinal (Female)	0	0.0	1	150	0
Flush Fixture	**Daily Uses**	**Flowrate [GPM]**	**Duration [sec]**	**Occupants [gal]**	**Water Use [gal]**
Conventional Lavatory	3	2.5	12	300	450
Kitchen Sink	1	2.5	12	300	150
Shower	0.1	2.5	300	300	375
				Total Daily Volume [gal]	**1335**
				Annual Work Days	260
				Annual Volume [gal]	347,100
				Rainwater or Graywater Volume [gal]	(36,000)
				TOTAL ANNUAL VOLUME [gal]	**311,100**

Table 5: Baseline Case

Flush Fixture	**Daily Uses**	**Flowrate [GPF]**	**Duration [flush]**	**Auto Controls N/A**	**Occupants**	**Water Use [gal]**
Conventional Water Closet (Male)	1	1.6	1		150	240
Conventional Water Closet (Female)	3	1.6	1		150	720
Conventional Urinal (Male)	2	1.0	1		150	300
Conventional Urinal (Female)	0	0.0	1		150	0
Flush Fixture	**Daily Uses**	**Flowrate [GPM]**	**Duration [sec]**	**Occupants [gal]**	**Water Use [gal]**	
Conventional Lavatory	3	2.5	15		300	563
Kitchen Sink	1	2.5	15		300	188
Shower	0.1	2.5	300		300	375
					Total Daily Volume [gal]	**2,386**
					Annual Work Days	260
					TOTAL ANNUAL VOLUME [gal]	**620,360**

covers the following fixture types: lavatories, kitchen sinks, showers, hand wash fountains, janitor sinks, water closets and urinals. Project teams are encouraged to apply for Innovation in Design credits for water use reduction in non-EPAct regulated and process water consuming fixtures. Examples of non-regulated and process water use include but are not limited to dishwashers, clothes washers and cooling towers.

Exemplary Performance

In addition to earning WE Credits 3.1 and 3.2, project teams that achieve a projected water savings of 40% are eligible for an exemplary performance ID credit.

Project teams may also achieve an ID credit for demonstrating potable water use reduction in process and non-regulated water consuming fixtures. The calculation methodology for demonstrating process and non-regulated water savings is similar to the calculation outlined above for regulated water use. Project teams define reasonable usage assumptions and calculate design and baseline water consumption based on high efficiency and standard water use fixtures. Process and non-regulated water use savings is then compared to regulated water use. If the process and non-regulated water use savings is at least 10% of the total design regulated water use, the project team is eligible for an Innovation in Design point.

Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

- ❑ The project's calculated occupant(s). The template will use a default one-to-one men to women ratio. Projects with special occupancy situations that result in an unbalanced ratio may enter project specific data for this credit.
- ❑ The project's calculated design case water usage (flush and flow fixtures.) This data is calculated using project specified fixture types and the project's mix of occupants. Note: project teams must provide the following fixture information for each typical installed flush fixture type: fixture manufacturer, fixture model, flush rate in gallons per flush (gpf) or flow rate in gallons per minute (gpm).
- ❑ The project's calculated baseline water usage (flush and flow fixtures.) This data is calculated using typical fixture types (provided in the template) and the project's mix of occupants.
- ❑ For projects using non-potable water for sewage conveyance, provide the total non-potable water supply (gal) available for sewage conveyance purposes.
- ❑ Narrative describing the potable water reduction strategies employed by the project. For projects using non-potable water, include specific information regarding any reclaimed water usage (graywater re-use/rainwater reuse/on-site treated wastewater).

Considerations

Cost Issues

Water-conserving fixtures that use less water than requirements in the Energy Policy Act of 1992 may have higher initial costs. Additionally, there may be a longer lead time for delivery because of their limited availability. However, installation of water-efficient fixtures and equipment can result in significant, long-term financial and environmental savings.

For example, the first cost of non-water-using urinals is marginally higher than conventional urinals and additional training of maintenance personnel is required to ensure that O&M staff understands the specific cleaning and maintenance procedures. Minor construction savings may be realized by eliminating the urinal supply piping. Significant long-term operational savings can occur as a result of reduced sewage generation and elimination of potable water use.

Environmental Issues

The reduction of potable water use in buildings for toilets, showerheads and faucets reduces the total amount withdrawn from rivers, streams, underground aquifers and other water bodies. Another benefit of potable water conservation is reduced energy use and chemical inputs at municipal water treatment works.

Water use reductions, in aggregate, allow municipalities to reduce or defer the capital investment needed for water supply and wastewater treatment infrastructure. These strategies protect the natural water cycle and save water resources for future generations.

Economic Issues

Reductions in water consumption minimize overall building operating costs. Reductions can also lead to more stable municipal taxes and water rates. By handling reduced water volumes, water treatment facilities can delay expansion and maintain stable water prices.

Accelerated retrofits of high-efficiency plumbing fixtures through incentive programs has become a cost-effective way for some municipalities to defer, reduce or avoid capital costs of needed water supply and wastewater facilities.

Regional Issues

Local weather conditions should be factored into determining the feasibility of rainwater harvesting systems for use in reduction of potable water for flushing. Local building and health codes/ordinances vary with regards to allowance of graywater or harvested rainwater for use in sewage conveyance. Additionally, codes differ in how alternative plumbing fixtures, such as dual-flush water closets, composting toilets and non-water using urinals are handled. It is critical to confirm acceptability of non-traditional approaches with code officials prior to commitment to specific water saving strategies.

Supply water quality from graywater and recycled water systems should also be considered in fixture selection. Project teams should identify if minimum supply water quality standards have been established for specific fixtures by manufacturers. When recycled graywater or collected rainwater is used with plumbing fixtures designed for use with municipally supplied potable water, it is good practice to verify that supply water quality is acceptable and will not compromise long-term fixture performance.

Resources

Websites

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the Texas Guide to Rainwater Harvesting.

Choosing a Toilet

www.taunton.com/finehomebuilding/pages/h00042.asp

An article in *Fine Homebuilding* that includes several varieties of water efficient toilets.

Composting Toilet Reviews

www.buildinggreen.com/features/mr/waste.html

(802) 257-7300

An *Environmental Building News* article on commercial composting toilets.

National Climatic Data Center

www.ncdc.noaa.gov/oa/climate/aasc.html

Useful site for researching local climate data, such as rainfall data for rainwater harvesting calculations. Includes links to state climate offices.

Rocky Mountain Institute

www.rmi.org/sitepages/pid15.php

This portion of RMI's website is devoted to water conservation and efficiency. The site contains information on commercial, industrial and institutional water use, watershed management, and articles on policy and implementation.

Smart Communities Network

www.sustainable.doe.gov/efficiency/weinfo.shtml

This U.S. Department of Energy project provides information about water efficiency and national and regional water efficiency assistance programs, and links to additional resources.

Terry Love's Consumer Toilet Reports

www.terrylove.com/crtoilet.htm

This website offers a plumber's perspective on many of the major toilets used in commercial and residential applications.

Water Closet Performance Testing

www.ebmud.com/conserving_&_recycling/toilet_test_report/default.htm

This site provides two reports on independent test results for flush performance and reliability for a variety of different toilets.

Water Efficiency Manual for Commercial, Industrial and Institutional Facilities

www.p2pays.org/ref/01/00692.pdf

A straightforward manual on water efficiency from a number of different North Carolina government departments.

Water Measurement Manual: A Water Resources Technical Publication

www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/

This U.S. Department of the Interior publication is a guide to effective water measurement practices for better water management.

Water Use Efficiency Program

www.epa.gov/owm/water-efficiency

This website provides an overview of the U.S. EPA's Water Use Efficiency Program and information about using water more efficiently.

Water Wiser: The Water Efficiency Clearinghouse

www.awwa.org/waterwiser

(800) 926-7337

This web clearinghouse provides articles, reference materials and papers on all forms of water efficiency.

Definitions

Blackwater does not have a single definition that is accepted nationwide. Wastewater from toilets and urinals is, however, always considered blackwater.

Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs may be considered blackwater by state or local codes. Project teams should comply with the blackwater definition as established by the authority having jurisdiction in their areas.

Composting Toilet Systems are dry plumbing fixtures that contain and treat human waste via microbiological processes.

Automatic Fixture Sensors are motion sensors that automatically turn on/off lavatories, sinks, water closets and urinals. Sensors may be hard wired or battery operated.

Graywater (also spelled greywater, gray water) is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Gray water Systems for Single-Family Dwellings " as "untreated household wastewater which has not come into contact with toilet waste. Gray water includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers. "

The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Gray Water Recycling Systems "as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks."

Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with the graywater definitions as established by the authority having jurisdiction in their areas.

Metering Controls are generally manual on/automatic off controls which are used to limit the flow time of water. These types of controls are most commonly installed on lavatory faucets and on showers.

Potable Water is water that is suitable for drinking and is supplied from wells or municipal water systems.

Process Water is water used for industrial processes and building systems such as cooling towers, boilers and chillers.

A **Non-Water-Using Urinal** is a urinal that uses no water, but instead replaces the water flush with a specially designed trap that contains a layer of buoyant liquid that floats above the urine layer, blocking sewer gas and urine odors from the room.

Endnotes

[1] Bilderback, T.E., and M.A. Powell. Efficient Irrigation. North Carolina Cooperative Extension Service, Publication Number AG-508-6, March 1996. 21 January 2005. www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag508_6.html

[2] United States Environmental Protection Agency, Office of Water. Water-Efficient Landscaping. EPA Publication 832-F-02-002, September 2002. 21 January 2005. www.epa.gov/owm/water-efficiency/final_final.pdf

[3] Connellan, Goeff. Efficient Irrigation: A Reference Manual for Turf and Landscape. University of Melbourne. 2002. 21 January 2005. www.sewl.com.au/sewl/upload/document/WaterConManual.pdf