Sustainable Sites

Buildings affect ecosystems in a variety of ways. Development of greenfield or previously undeveloped sites consumes land. Development projects must also be sensitive to encroaching on agricultural lands, compromising existing wildlife habitat, and exacerbating local and regional erosion. The impacts of increased impervious surfaces to stormwater runoff should be controlled to mimic natural conditions and protect water quality in receiving waters. Sedimentation caused by erosion may hinder regional waterway navigation, disrupt aquatic life and reduce the quality of local/regional recreation areas. Heat from the sun is absorbed by buildings and paved surfaces and is radiated back, increasing temperatures in surrounding urban areas. External lighting systems may cause light pollution to the night sky and interfere with nocturnal ecology.

A building's location also affects ecosystems based on the occupants' options for travel to and from the site. According to the Federal Bureau of Transportation Statistics, vehicle use in America has nearly tripled, from 1 to 2.85 trillion miles per year, between 1970 and 2002. Vehicles are responsible for approximately 20% of U.S. greenhouse gas emissions annually (NRDC). Vehicle fuel consumption and emissions contribute to climate change, smog, and particulate pollution, all of which have negative impacts on human health. The infrastructure required to support vehicle travel (parking and roadway surfaces, service stations, fuel distribution networks, etc.) increase the consumption of land and nonrenewable resources, alter stormwater flow and absorb heat energy, exacerbating heat island effect.

Project teams undertaking building projects should be cognizant of the inherent impacts of development on land consumption, ecosystems, natural resources and energy use. Preference should be given to buildings with high performance attributes in locations that enhance existing neighborhoods, transportation networks, and urban infrastructures. During initial project scoping, preference should be given to sites and land use plans that preserve natural ecosystem functions and enhance the health of the surrounding community.

Establishing sustainable design objectives and integrating building location and sustainable features as a metric for decision making encourages development and preservation or restoration practices that limit the environmental impact of buildings on local ecosystems.

Sustainable Sites Credit Characteristics

Table 1 shows which credits were substantially revised for LEED for New Construction 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

SS Prerequisite 1
Construction Activity Pollution Prevention

SS Credit 1
Site Selection

SS Credit 2
Development Density & Community Connectivity

SS Credit 3
Brownfield Redevelopment

SS Credit 4.1
Alternative Transportation—Public Transportation Access

SS Credit 4.2
Alternative Transportation—Bicycle Storage & Changing Rooms

SS Credit 4.3
Alternative Transportation—Low-Emitting & Fuel-Efficient Vehicles

SS Credit 4.4
Alternative Transportation—Parking Capacity

SS Credit 5.1
Site Development—Protect or Restore Habitat

SS Credit 5.2
Site Development—Maximize Open Space

SS Credit 6.1
Stormwater Management—Quantity Control

SS Credit 6.2
Stormwater Management—Quality Control

SS Credit 7.1
Heat Island Effect—Non-Roof

SS Credit 7.1
Heat Island Effect—Roof

SS Credit 8
Light Pollution Reduction

Table 1: SS Credit Characteristics

Credit	Significant Change from Version 2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
SSp1: Construction Activity Pollution Prevention	*		*		*	*
SSc1: Site Selection		*		*		
SSc2: Development Density & Community Connectivity	*	*		*	*	
SSc3: Brownfield Redevelopment		*		*		
SSc4.1: Alternative Transportation, Public Transportation Access		*		*		
SSc4.2: Alternative Transportation, Bicycle Storage & Changing Rooms		*			*	
SSc4.3: Alternative Transportation, Low-Emitting & Fuel-Efficient Vehicles	*	*		*	*	
SSc4.4: Alternative Transportation, Parking Capacity		*		*	*	
SSc5.1: Site Development, Protect or Restore Habitat			*	*	*	*
SSc5.2: Site Development, Maximize Open Space		*		*	*	
SSc6.1: Stormwater Management, Quantity Control	*	*			*	
SSc6.1: Stormwater Management, Quality Control	*	*			*	
SSc7.1: Heat Island Effect, Non-Roof	*		*		*	*
SSc7.2: Heat Island Effect, Roof	*	*			*	*
SSc8: Light Pollution Reduction	*	*			*	

Construction Activity Pollution Prevention

SS	WE	EA	MR	EQ	ID
Prerequisite 1					

Required

Intent

Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

Requirements

Create and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project. The ESC Plan shall conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit OR local erosion and sedimentation control standards and codes, whichever is more stringent. The Plan shall describe the measures implemented to accomplish the following objectives:

- ❑ Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- ❑ Prevent sedimentation of storm sewer or receiving streams.
- ❑ Prevent polluting the air with dust and particulate matter.

The Construction General Permit (CGP) outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) program. While the CGP only applies to construction sites greater than 1 acre, the requirements are applied to all projects for the purposes of this prerequisite. Information on the EPA CGP is available at: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

Potential Technologies & Strategies

Create an Erosion and Sedimentation Control Plan during the design phase of the project. Consider employing strategies such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps and sediment basins.

Summary of Referenced Standard

Storm Water Management for Construction Activities (USEPA Document No. EPA 832R92005), **Chapter 3**

U.S. Environmental Protection Agency Office of Water,

www.epa.gov/OW

Internet download link for Chapter 3 (72 pages): www.epa.gov/npdes/pubs/chap03_conguide.pdf

Download site for all sections: http://yosemite.epa.gov/water/owrccatalog.nsf, search by title index. Hardcopy or microfiche (entire document, 292 pages): National Technical Information Service (order # PB92-235951),

www.ntis.gov

(800) 553-6847

This standard describes two types of measures that can be used to control sedimentation and erosion. Stabilization measures include temporary seeding, permanent seeding and mulching. All of these measures are intended to stabilize the soil to prevent erosion. Structural control measures are implemented to retain sediment after erosion has occurred. Structural control measures include earth dikes, silt fencing, sediment traps and sediment basins. The application of these measures depends on the conditions at the specific site.

Approach and Implementation

Erosion on existing sites typically results from foot traffic killing the vegetation, steep slopes where stormwater sheet flow exceeds vegetation holding power, runoff that exceeds vegetation holding power, or vehicle traffic on unpaved areas. Identifying and eliminating these and other causes will minimize soil loss and preserve receiving water quality.

This prerequisite effectively extends NPDES requirements for construction activities, which currently only apply to projects 1 acre and larger, to all projects pursuing LEED certification.

Typically, the civil engineer identifies erosion-prone areas and soil stabilization measures. The contractor then adopts a plan to implement the measures presented by the civil engineer and responds to rain events and other activities accordingly. It is recommended that the Erosion and Sedimentation Control (ESC) Plan be incorporated into the construction drawings and specifications, with clear

Table 1: Technologies for Controlling Erosion & Sedimentation

Control Technology	Description
Stabilization	
Temporary Seeding	Plant fast-growing grasses to temporarily stabilize soils
Permanent Seeding	Plant grass, trees, and shrubs to permanently stabilize soil
Mulching	Place hay, grass, woodchips, straw, or gravel on the soil surface to cover and hold soils
Structural Control	
Earth Dike	Construct a mound of stabilized soil to divert surface runoff volumes from distributed areas or into sediment basins or sediment traps
Silt Fence	Construct posts with a filter fabric media to remove sediment from stormwater volumes flowing through the fence
Sediment Trap	Excavate a pond area or construct earthen embankments to allow for settling of sediment from stormwater volumes
Sediment Basin	Construct a pond with a controlled water release structure to allow for settling of sediment from stormwater volumes

instructions regarding responsibilities, scheduling, and inspections.

If a Storm Water Pollution Prevention Plan (SWPPP) is required for the project via the National Pollutant Discharge Elimination System (NPDES) or local regulations, an ESC Plan may already be required. In that case, the only action required is to confirm that the plan meets the Requirements of this prerequisite and is implemented. If an ESC Plan is not required for purposes other than LEED, use the Referenced Standard listed above as a guideline on how to compose the plan.

Calculations

There are no calculations associated with this prerequisite.

Exemplary Performance

There is no Exemplary Performance point available for this prerequisite.

Submittal Documentation

This prerequisite is submitted as part of the **Construction Submittal**.

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

- ❑ Provide copies of the project drawings to document the erosion and sedimentation control measures implemented on the site.
- ❑ Provide confirmation regarding the compliance path taken by the project (NPDES Compliance or Local Erosion Control Standards).
- ❑ Provide a narrative to describe the Erosion and Sedimentation control measures implemented on the project. If a local standard has been followed, please provide specific information to demonstrate that the local standard is equal to or more stringent than the referenced NPDES program.

Considerations

Environmental Issues

The loss of topsoil is the most significant on-site consequence of erosion. Topsoil is the soil layer that contains organic matter,

Photo Credit: CTG Energetics, Inc.

Example of Structural Control. Silt fence: fabric filter media removes sediment from stormwater volumes flowing through the fence.

plant nutrients and biological activity. Loss of topsoil greatly reduces the soil's ability to support plant life, regulate water flow, and maintain the biodiversity of soil microbes and insects that controls disease and pest outbreaks. Loss of nutrients, soil compaction, and decreased biodiversity of soil inhabitants can severely limit the vitality of landscaping. This can lead to additional site management and environmental concerns, such as increased use of fertilizers, irrigation and pesticides; and increased stormwater runoff that heightens the pollution of nearby lakes and streams.

The off-site consequences of erosion from developed sites include a variety of water quality issues. Runoff from developed sites carries pollutants, sediments and excess nutrients that disrupt aquatic habitats in the receiving waters. Nitrogen and phosphorous from runoff hasten eutrophication by causing unwanted plant growth in aquatic systems, including algal blooms that alter water quality and habitat conditions. Algal blooms can also result in decreased recreation potential and diminished diversity of indigenous fish, plant and animal populations.

Sedimentation also contributes to the degradation of water bodies. The build-up of sedimentation in stream channels can lessen flow capacity, potentially leading to increased flooding. Sedimentation also affects aquatic habitat by increasing turbidity levels. Turbidity reduces sunlight penetration into the water and leads to reduced photosynthesis in aquatic vegetation, causing lower oxygen levels that cannot support diverse communities of aquatic life.

Economic Issues

Erosion and sedimentation control measures are required in most areas in order to minimize difficult and expensive mitigation measures in receiving waters. The cost of erosion and sedimentation control on construction sites will include some minimal expense associated with installing and inspecting measures, particularly before and after storm events. The cost will vary depending on the type, location, topography and soil conditions of the project.

Resources

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

In addition to the resources below, check with state and local organizations for information on erosion and sedimentation control specific to your region.

Web Sites

CPESC Inc.

www.cpesc.net

(828) 655-1600

Search the directory on this Web site to find certified erosion and sedimentation control professionals in your state.

Environment Canada's Freshwater Web – Sediment Page

www.ec.gc.ca/water/en/nature/sedim/e_sedim.htm

(819) 953-6161

This site includes information on the environmental effects of sedimentation.

EPA Erosion and Sediment Control Model Ordinances

www.epa.gov/owow/nps/ordinance/erosion.htm

(202) 566-1155

This resource, developed by the EPA, is geared towards helping municipalities draft ordinances for erosion and sedimentation control and might serve as a helpful tool in developing company policies for meeting this LEED for New Construction Prerequisite.

Erosion Control Technology Council

www.ectc.org

(651) 554-1895

This nonprofit organization develops performance standards, testing procedures, and guidance on the application and installation of rolled erosion control products.

International Erosion Control Association (IECA)

www.ieca.org

(970) 879-3010

This organization's mission is to connect, educate and develop the worldwide erosion and sediment control community.

Soil Erosion and Sedimentation in the Great Lakes Region

www.great-lakes.net/envt/pollution/erosion.html

(734) 971-9135

This resource from the Great Lakes Information Network provides links to general resources, education and training opportunities, materials, manuals, maps and other resources related to soil erosion, sedimentation and watershed management.

Definitions

Erosion is a combination of processes in which materials of the earth's surface are loosened, dissolved or worn away, and transported from one place to another by natural agents (such as water, wind or gravity).

Sedimentation is the addition of soils to water bodies by natural and human-related activities. Sedimentation decreases water quality and accelerates the aging process of lakes, rivers and streams.

SS	WE	EA	MR	EQ	ID
Prerequisite 1					

Site Selection

SS	WE	EA	MR	EQ	ID
Credit 1					

1 Point

Intent

Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

Requirements

Do not develop buildings, hardscape, roads or parking areas on portions of sites that meet any one of the following criteria:

- ❑ Prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5)
- ❑ Previously undeveloped land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by FEMA (Federal Emergency Management Agency)
- ❑ Land that is specifically identified as habitat for any species on Federal or State threatened or endangered lists
- ❑ Within 100 feet of any wetlands as defined by United States Code of Federal Regulations 40 CFR, Parts 230-233 and Part 22, and isolated wetlands or areas of special concern identified by state or local rule, OR within setback distances from wetlands prescribed in state or local regulations, as defined by local or state rule or law, whichever is more stringent
- ❑ Previously undeveloped land that is within 50 feet of a water body, defined as seas, lakes, rivers, streams and tributaries which support or could support fish, recreation or industrial use, consistent with the terminology of the Clean Water Act
- ❑ Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt)

Potential Technologies & Strategies

During the site selection process, give preference to those sites that do not include sensitive site elements and restrictive land types. Select a suitable building location and design the building with the minimal footprint to minimize site disruption of those environmentally sensitive areas identified above.

Summary of Referenced Standards

U.S. Department of Agriculture Definition of Prime Agricultural Land as stated in

United States Code of Federal Regulations Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5)

www.gpoaccess.gov/cfr/index.html (Go to "Browse and/or search the CFR.")

See also "Identification of Important Farmlands": http://a257.g.akamaitech.net/7/257/2422/11feb20051500/edocket.access.gpo.gov/cfr_2005/janqtr/pdf/7cfr657.5.pdf

This standard states: "Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. Examples of soils that qualify as prime farmland are Palouse silt loam, 0 to 7 percent slopes; Brookston silty clay loam, drained; and Tama silty clay loam, 0 to 5 percent slopes."

Federal Emergency Management Agency (FEMA) 100-Year Flood Definition

Federal Emergency Management Agency

www.fema.gov

(202) 646-4600

This referenced standard addresses flood elevations. FEMA defines a 100-Year Flood as the flood elevation that has a 1% chance of being reached or exceeded each year. It is not the most significant flood in a 100-year period. Instead, 100-year floods can occur many times within a 100-year period. See the FEMA Web site for comprehensive information on floods and other natural disasters such as wildfires and hurricanes.

Endangered Species Lists

U.S. Fish and Wildlife Service's List of Threatened and Endangered Species,

www.fws.gov/endangered/

This referenced standard addresses threatened and endangered wildlife and plants. The Service also maintains a list of plants and animals native to the United States that are candidates for possible addition to the federal list.

National Marine Fisheries Service's List of Endangered Marine Species,

www.nmfs.noaa.gov/pr/species/esa_species.htm

Consult state agencies for state-specific lists of endangered or threatened wildlife and plant species.

Definition of Wetlands in the United States Code of Federal Regulations, 40 CFR,

Parts 230-233, and Part 22

www.gpoaccess.gov/cfr/index.html

(888) 293-6498

This referenced standard addresses wetlands and discharges of dredged or filled material into waters regulated by states. The definition of wetland areas pertaining to this credit, found in Part 230, is as follows:

"Wetlands consist of areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Approach and Implementation

One of the most important factors in creating sustainable buildings is locating them on an appropriate site. Developing a building on an inappropriate site can result in the loss of prime farmland or key habitat. Before a project site is selected, evaluate the potential environmental disturbance that will occur as a result. Channel development into previously developed areas to prevent sprawl and habitat loss.

Avoid developing sites that exhibit any of the characteristics listed in the restricted criteria. Consider the proposed use of the building, and set a preference for previously developed sites that complement the use, thereby reducing associated parking needs and vehicular miles traveled. The site selection process might include landscape architects, ecologists, environmental engineers and civil engineers, as well as local professionals who can provide site-specific expertise. Have a government official, ecologist or other qualified professional perform a site survey to inventory the important environmental characteristics, including wetlands, sloped areas, unique habitat areas and forested areas. Zoning requirements of the local municipality and the community master plan should be integrated to the greatest extent possible. Community coordination and consideration of public comments can help preempt negative community reaction.

Regarding the fifth bullet point of the Requirements, the Clean Water Act is vague in defining "water body" and thus requires interpretation. Small man-made ponds, such as those used in stormwater retention, fire suppression and recreation are not to be included in this definition for LEED purposes. Man-made wetlands and other water bodies created to restore natural habitat and ecological systems are not exempt. Wetlands are addressed specifically by the fourth bullet point of the Requirements.

Where feasible, integrate neighboring activities to create a development with shared amenities and spaces. When designing the building, consider a smaller footprint, and set aside large contiguous areas for natural space on the project site to minimize disruption of the environmentally sensitive areas identified above. Build in dense blocks to limit the development footprint and site disturbance to the smallest area possible. Incorporate site features into the design such as natural features that already exist on the site, natural shelter from trees or terrain, natural areas for outdoor activities, and water features for thermal, acoustic and aesthetic benefit.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

There is no Exemplary Performance point available for this credit.

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:

- ❑ Provide confirmation that the project site does not meet any of the prohibited criteria. Special circumstances for

individual projects and site compliance should be noted.

AND (For Projects with Special Circumstances)

- ❑ Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

As non-urban development increases, the importance of prudent site selection increases as well. Prevention of habitat encroachment is an essential element of sustainable site selection. The best strategy for selecting a building site is to choose a previously developed site. Since these sites have already been disturbed, damage to the environment is limited and sensitive land areas can be preserved. The site surrounding a building defines the character of the building and provides the first impression for occupants and visitors to the building. Creative and careful site designs can integrate the natural surroundings with the building(s), providing a strong connection between the built and natural environments and minimizing adverse impacts on the non-built portions of the site.

Habitat preservation is the most effective means to meet the requirements of the Endangered Species Act and to minimize developmental impacts on indigenous wildlife. Not building on inappropriate sites preserves these areas for wildlife, recreation and ecological balance. Building on inappropriate sites such as floodplains can be detrimental to ecosystems.

Economic Issues

Site selection can play an important role in the way that the public responds to, and is involved with, the proposed development. Channeling development away from sensitive ecological areas in favor of previously disturbed sites can encourage public support for a project and speed public review periods, thus minimizing or preventing obstacles traditionally encountered during project scoping. Economically, this can also save on mitigation costs that a developer would incur if the proposed development were approved within a sensitive area.

Appropriate site selection can reduce the risk of property damage due to natural events such as landslides, floods, sinkholes and soil erosion. Higher first costs may be encountered due to site survey and selection activities. Increased property values can offset these costs in the future. Proper site selection can also avoid potential loss of property due to potential litigation resulting from harm to endangered species.

Resources

Web Sites

ESRI

www.esri.com/hazards

This software company creates tools for GIS mapping. Its Web site includes an option to make a map of all of the flood areas within a user-defined location.

Natural Resources Defense Council

www.nrdc.org

(212) 727-2700

NRDC uses law, science, and a large membership base for protection of wildlife and wild places to ensure a safe and healthy environment.

Print Media

Constructed Wetlands in the Sustainable Landscape by Craig Campbell and Michael Ogden, John Wiley & Sons, 1999.

Holding Our Ground: Protecting America's Farms and Farmland by Tom Daniels and Deborah Bowers, Island Press, 1997.

Saved By Development: Preserving Environmental Areas, Farmland by Rick Pruetz, Arje Press, 1997.

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping by Ralph W. Tiner, Lewis Publishers, 1999.

Definitions

A **Community** is an interacting population of individuals living in a specific area.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

An **Ecosystem** is a basic unit of nature that includes a community of organisms and their nonliving environment linked by biological, chemical, and physical process.

An **Endangered Species** is an animal or plant species that is in danger of becoming extinct throughout all or a significant portion of its range due to harmful human activities or environmental factors.

Previously Developed Sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

A **Threatened Species** is an animal or plant species that is likely to become endangered within the foreseeable future.

Wetland Vegetation consists of plants that require saturated soils to survive, as well as certain tree and other plant species that can tolerate prolonged wet soil conditions.

SS	WE	EA	MR	EQ	ID
Credit 1					

Development Density & Community Connectivity

SS | WE | EA | MR | EQ | ID

Credit 2

1 Point

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

Intent

Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

Requirements

OPTION 1 — DEVELOPMENT DENSITY

Construct or renovate building on a previously developed site AND in a community with a minimum density of 60,000 sq.ft. per acre net. (Note: density calculation must include the area of the project being built and is based on a typical two-story downtown development.)

OR

OPTION 2 — COMMUNITY CONNECTIVITY

Construct or renovate building on a previously developed site AND within 1/2 mile of a residential zone or neighborhood with an average density of 10 units per acre net AND within 1/2 mile of at least 10 Basic Services AND with pedestrian access between the building and the services.

Basic Services include, but are not limited to:

1) Bank; 2) Place of Worship; 3) Convenience Grocery; 4) Day Care; 5) Cleaners; 6) Fire Station; 7) Beauty; 8) Hardware; 9) Laundry; 10) Library; 11) Medical/Dental; 12) Senior Care Facility; 13) Park; 14) Pharmacy; 15) Post Office; 16) Restaurant; 17) School; 18) Supermarket; 19) Theater; 20) Community Center; 21) Fitness Center; 22) Museum.

Proximity is determined by drawing a 1/2 mile radius around the main building entrance on a site map and counting the services within that radius.

Potential Technologies & Strategies

During the site selection process, give preference to urban sites with pedestrian access to a variety of services.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

The general approach for achieving this credit is to give preference to sites within an existing urban fabric. Work with local jurisdictions and follow the urban development plan to meet or exceed density goals. Consider synergies with neighbors and choose sites based on infrastructure, transportation and quality-of-life considerations. Sites with redevelopment plans that will achieve the required development density by the completion of the project should not be excluded from consideration. This credit can be achieved by choosing to develop a site where community revitalization is occurring provided the required development density or basic services adjacency is in place or in construction by the project's completion.

Calculations

Option 1 — Development Density

To determine the development density of a project, both the project density and the densities of surrounding developments must be considered. The calculations detailed below refer to the building(s) that comprise the project pursuing certification, the project site area, and the area and density of the surrounding buildings.

Note: The LEED for New Construction Submittal Template can be used to perform these calculations.

1. Determine the total area of the project site and the total square footage of the building. For projects that are part of a larger property (such as a campus), define the project area that is defined in the LEED project's scope. The project area must be defined consistently throughout LEED documentation.
2. Calculate the development density for the project by dividing the total square footage of the building by the total site area in acres. This development density must be equal to or greater than 60,000 sq.ft. per acre (see **Equation 1**).

Project Site Area (acres)

3. Convert the total site area from acres to sq.ft. and calculate the square root of this number. Then multiply the square root by three to determine the appropriate density radius. (Note: the square root function is used to normalize the calculation by removing effects of site shape.) (See **Equation 2**).
4. Overlay the density radius on a map (see **Figure 1**) that includes the project site and surrounding areas, originating from the center of the site. This is the density boundary.
5. For each property within the density boundary and for those properties that intersect the density boundary, create a table with the building square footage and site area of each property. Include all properties in the density calculations except for undeveloped public areas such as parks and water bodies. Do not include public roads and right-of-way areas. Information on neighboring properties can be obtained from your city or county zoning department.

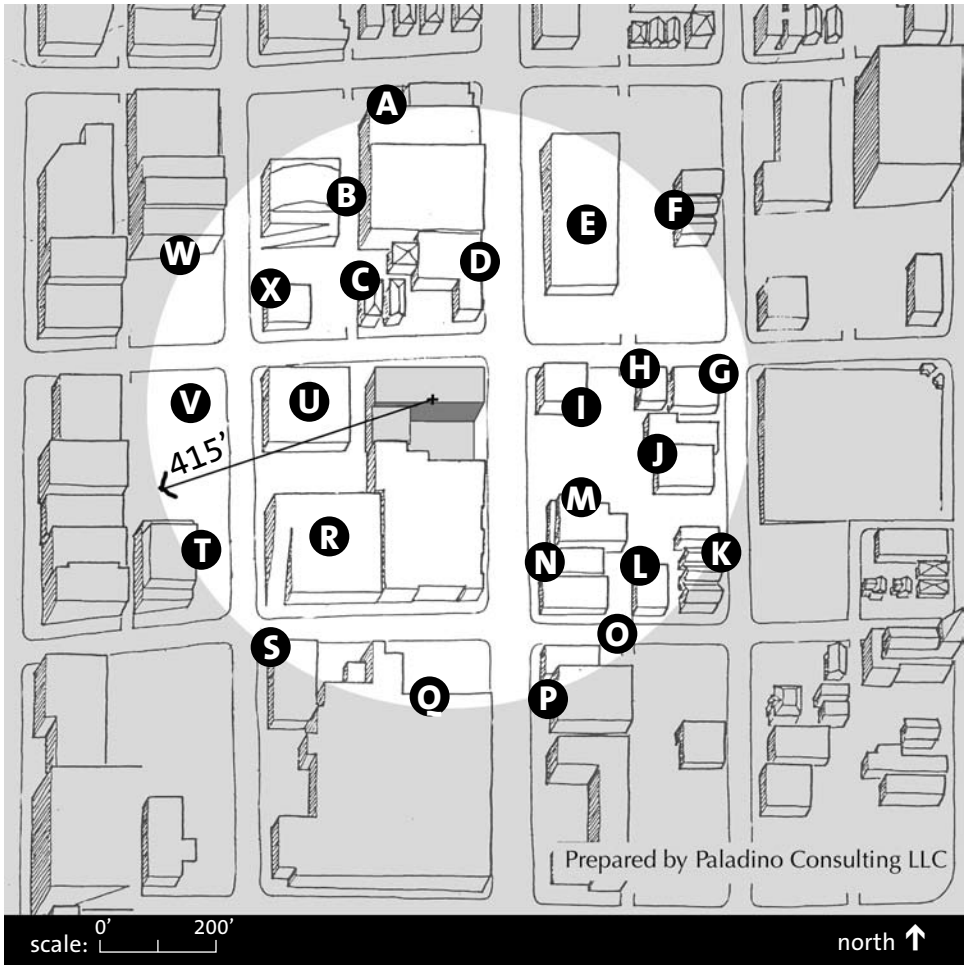
Equation 1

$$\text{Development Density (sq.ft./acre)} = \frac{\text{Gross Building Square Footage (sq.ft.)}}{\text{Project Site Area (acres)}}$$

Equation 2

$$\text{Density Radius (LF)} = 3 \times \sqrt{(\text{Property Area [acres]} \times 43{,}560\ \text{[sq.ft./acre]})}$$

Figure 1: An illustration of a Sample Area Plan



6. Add all the square footage values and site areas. Divide the total square footage by the total site area to obtain the average property density within the density boundary. The average property density of the properties within the density boundary must be equal to or greater than 60,000 sq.ft. per acre.

Example

The following example illustrates the property density calculations: A 30,000-sq.ft. building is located on a 0.44-acre urban site and the calculations are used to determine the building density. The property density is above the minimum density of 60,000 sq.ft. per acre required by the credit (see **Table 1**).

Table 1: Property Density Calculation

Project Buildings	Building Space [SF]	Site Area [acres]
Project	30,000	0.44
Density [SF/acre]		**68,182**

Next, the density radius is determined. A density radius of 415 feet is calculated (see **Table 2**). The density radius is applied to an area plan of the project site and surrounding area. The plan identifies all properties that are within or are intersected by the density radius. The plan includes a scale and a north indicator.

Table 3 summarizes the information about the properties identified on the map (see **Figure 1**). The building space and site area are listed for each property.

Table 2: Density Radius Calculation

Density Radius Calculation	
Site Area [acres]	0.44
Density Radius [LF]	415

These values are summed and the average density is calculated by dividing the total building space by the total site area.

For this example, the average building density of the surrounding area is greater than 60,000 sq.ft. per acre, thus, the example qualifies for one point under this credit.

OR

Option 2—Community Connectivity

To determine the connectivity of a project, both residential and commercial adjacencies must be considered. The calculation process is described in the following steps:

Prepare a site map (**Figure 2**) and draw a 1/2-mile radius around the main building entrance. Radiuses may be drawn around multiple entrances for projects with multiple buildings or more than one main entrance. The combination of the area in these radiuses would then be considered the project radius. Mark all residential developments within the radius. At least one area zoned for residential development of 10 units per acre or greater must be present within the radius for the project to earn this credit.

Mark all commercial buildings within the radius. At least 10 community services must be present within the radius for the project to earn this credit.

Services may include: Bank, Place of Worship, Convenience Grocery, Day Care, Cleaners, Fire Station, Beauty, Hardware, Laundry, Library, Medical/Dental, Senior Care Facility, Park, Pharmacy, Post Office, Restaurant, School, Supermarket, Commercial Office, and Community Center. Other services will be considered on a project-by-project basis.

With the exception of restaurants, no service may be counted more than once in the calculation. Up to 2 restaurants may be counted towards achievement of this credit. Only count those services for which there is pedestrian access between the service and the project. Pedestrian access is assessed by confirming that pedestrians can walk to the services without being blocked by walls, highways, or other barriers.

Table 3: Sample Area Properties

Buildings within Density Radius	Building Space [SF]	Site Area [acres]	Buildings within Density Radius	Building Space [SF]	Site Area [acres]
A	33,425	0.39	N	28,740	0.30
B	87,500	1.58	O	6,690	0.15
C	6,350	0.26	P	39,000	0.39
D	27,560	0.32	Q	348,820	2.54
E	66,440	1.17	R	91,250	1.85
F	14,420	1.36	S	22,425	0.27
G	12,560	0.20	T	33,650	0.51
H	6,240	0.14	U	42,400	0.52
I	14,330	0.22	V	-	0.76
J	29,570	0.41	W	19,200	0.64
K	17,890	0.31	X	6,125	0.26
L	9,700	0.31	Y	5,000	0.30
M	24,080	0.64	Z	4,300	0.24
			Total Building Space [SF]	997,665	
			Total Site Area [acres]		16.04
			Average Density [SF/acres]		**62,199**

Figure 2: Example Map for Community Connectivity (Source: Google Maps)

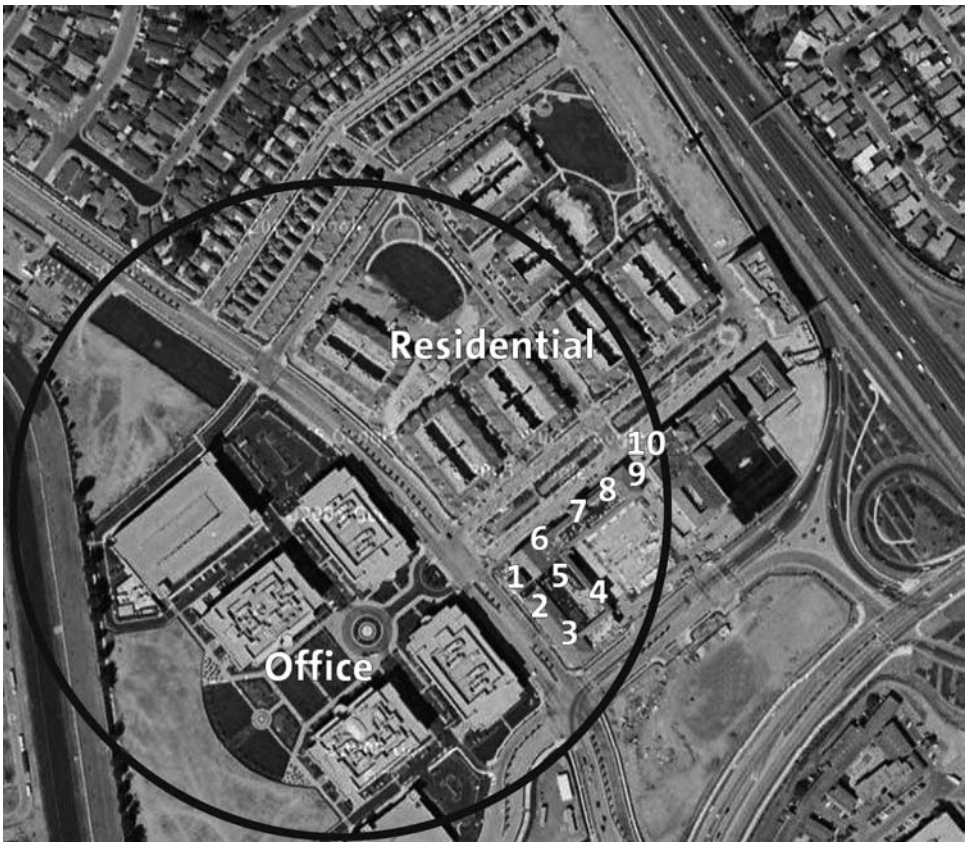


Table 4: Example Community Connectivity Tabulation

Service Identification (Corresponds to Uploaded Vicinity Plan)	Business Name	Service Type
1	Restaurant 1	Restaurant
2	Grocery 1	Convenience Grocery
3	Urgent Care 1	Medical
4	Pharmacy 1	Pharmacy
5	Gym 1	Fitness
6	Hair Care 1	Beauty
7	Bank 1	Bank
8	Restaurant 2	Restaurant
9	Cleaners 1	Cleaners
10	Post Office 1	Post Office

Prepare a table (see **Table 4**) listing each of the identified services, the business name, and the service type to confirm compliance.

Exemplary Performance

Based on evidence that higher density locations can achieve substantially and quantifiably higher environmental benefits, the following threshold requirements can be used to qualify a project for an exemplary performance Innovation Credit:

A LEED for New Construction project must first meet the requirements of Option 1 of SSc2 (density path) in LEED for

New Construction v2.2. Additionally, the project must meet one of the two following requirements:

- ❑ The project itself must have a density of at least double that of the average density within the calculated area (see equation 2).

OR

- ❑ The average density within an area twice as large as that for the base credit achievement must be at least 120,000 square feet per acre. To double the area, use equation 2 but double the property area first.

These requirements are based on the decision that a project achieving exemplary performance for this credit should:

- ❑ Not lower the existing average density of the area,
- ❑ Achieve a density of at least twice the threshold of the base credit,

AND/OR

- ❑ Locate within an area of established density that is larger than that required for the base credit, which is why the radius used in the base credit has been doubled.

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:

Option 1 – Development Density

- ❑ Provide a site vicinity plan showing the project site and the surrounding sites and buildings. Sketches, block diagrams, maps, and aerial photos are all acceptable for this purpose. Draw the density boundary on the drawing or note the drawing scale.
- ❑ Project site and building area (sq.ft.)
- ❑ Submit a listing of site and building areas for all surrounding sites within the density radius.

OR

Option 2 – Community Connectivity

- ❑ Provide a site vicinity drawing showing the project site, the 1/2 mile community radius, and the locations of the community services surrounding the project site. Sketches, block diagrams, maps, and aerial photos are all acceptable for this purpose. Either draw the 1/2 mile radius on the drawing or note the drawing scale.
- ❑ Project site and building area (sq.ft.)
- ❑ Submit a listing (including business name and type) of all community services within the 1/2 mile radius.

AND (For Projects With Special Circumstances – Either Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Consider the functional adjacencies of the site with respect to transportation and productivity. Community developments with at least 10 of the basic services listed in this credit within a 1/2-mile radius reduce transportation impacts. Making access to basic services walkable may improve productivity by reducing the time spent driving between services and accessing parking. In addition, occupant health can be improved by increased levels of physical activity.

Urban redevelopment affects all areas of site design including site selection, transportation planning, building density and stormwater management. Urban sites often involve the rehabilitation of an existing building, with a reduction

of construction waste and new material use. The potential trade-offs of sites in dense areas are limited open space and possible negative IEQ aspects such as contaminated soils, undesirable air quality or limited daylighting applications.

Economic Issues

A significant economic benefit of infill development is the reduction or elimination of new infrastructure, including roads, utility services and other amenities already in place. If mass transit serves the urban site, significant cost reductions are possible by downsizing the project parking capacity. Urban infill development sometimes requires significant additional costs when compared with suburban development due to site constraints, contaminated soils and other issues. Municipal and county incentives for urban infill projects may also be available.

Community Issues

Urban sprawl affects quality of life because commuters must spend increasing amounts of time in their automobiles. In addition, families often need more vehicles to accommodate family needs, resulting in a higher cost of living and less free time. The redevelopment of urban areas helps restore, invigorate and sustain established urban living patterns, creating a more stable and interactive community.

Resources

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

Web Sites

Congress for New Urbanism

www.cnu.org

Urban Land Institute

ULI Washington

www.washington.uli.org

(703) 390-9217

The Urban Land Institute is a nonprofit organization based in Washington D.C. that promotes the responsible use of land in order to enhance the total environment.

The International Union for the Scientific Study of Population

www.iussp.org

33 1 56 06 21 73

The IUSSP promotes scientific studies of demography and population-related issues.

Print Media

Changing Places: Rebuilding Community in the Age of Sprawl by Richard Moe and Carter Wilkie, Henry Holt & Company, 1999.

Density by Design: New Directions in Residential Development by Steven Fader, Urban Land Institute, 2000.

Green Development: Integrating Ecology and Real Estate by Alex Wilson, et al., John Wiley & Sons, 1998.

Once There Were Greenfields: How Urban Sprawl Is Undermining America's Environment, Economy, and Social Fabric by F. Kaid Benfield, et al., Natural Resources Defense Council, 1999.

Suburban Nation: The Rise of Sprawl and the Decline of the American Dream by Andres Duany, et al., North Point Press, 2000.

Definitions

Building Density is the floor area of the building divided by the total area of the site (square feet per acre).

Greenfields are sites that have not been previously developed or built on, and which could support open space, habitat or agriculture.

Property Area is the total area within the legal property boundaries of a site and encompasses all areas of the site including constructed areas and non-constructed areas.

Site Area is defined the same as property area.

The **Square Footage** of a building is the total area in square feet of all rooms including corridors, elevators, stairwells and shaft spaces. Only 2 stories of a parking structure may be counted as part of building square footage. Surface parking (only 1 story of parking) cannot count as part of building square footage; this is to ensure efficient use of land adjacent to the building footprint. Both structured and stacked parking are allowable in square footage calculations.

Pedestrian Access implies that pedestrians can walk to the services without being blocked by walls, freeways or other barriers.

Case Study

Capital Area East End Complex (Building 225)

Sacramento, CA

Owner: State of California
Department of General Services

Photo courtesy of: Fentress Bradburn Architects

Building 225 in the Capital Area East End Complex achieved LEED® v2.0 Gold in 2003. Built on land that had been identified by an Urban Land Institute panel as an area at high risk for blight, this design-build project was part of a larger effort to revitalize downtown Sacramento. Building 225 is an integral part of a series of state office buildings that incorporate offices, parking, public space, and joint-use facilities in a mixed-use neighborhood. The building is close to public transit, allowing employees to commute downtown to work.

Brownfield Redevelopment

SS	WE	EA	MR	EQ	ID
Credit 3					

1 Point

Intent

Rehabilitate damaged sites where development is complicated by environmental contamination, reducing pressure on undeveloped land.

Requirements

Develop on a site documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment or a local Voluntary Cleanup Program) OR on a site defined as a brownfield by a local, state or federal government agency.

Potential Technologies & Strategies

During the site selection process, give preference to brownfield sites. Identify tax incentives and property cost savings. Coordinate site development plans with remediation activity, as appropriate.

Summary of Referenced Standards

ASTM E1903-97 Phase II Environmental Site Assessment

ASTM International

www.astm.org

This guide covers a framework for employing good commercial and customary practices in conducting a Phase II environmental site assessment of a parcel of commercial property. It covers the potential presence of a range of contaminants that are within the scope of CERCLA, as well as petroleum products.

EPA Brownfields Definition

EPA Sustainable Redevelopment of Brownfields Program

www.epa.gov/brownfields

With certain legal exclusions and additions, the term "brownfield site" means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant (source: Public Law 107-118, H.R. 2869 – "Small Business Liability Relief and Brownfields Revitalization Act"). See the Web site for additional information and resources.

Approach and Implementation

Gain community support by highlighting the environmental, economic and community-related benefits of brownfield redevelopment. Negotiate with local municipalities and landowners for below-market purchase prices for brownfield real estate. Also, obtain tax incentives by meeting the locally applicable requirements of EPA brownfield tax credits. The advantages and disadvantages of brownfield redevelopment should be carefully considered during the site selection process.

Utilize remediation experts to develop a master plan for site remediation. Prioritize site remediation activities based on available funds and specific site considerations, and establish time frames for completing remediation activities. Test for toxicity and hazardous levels of pollution on the proposed site. To earn this credit, a site with existing hazardous substances present or potentially present must be selected, and remediation efforts must be performed to identify, contain and mitigate the hazard.

Clean the site using established technologies that have minimal disruption on the natural site features, both above ground and underground. Consider in-situ remediation schemes that treat contaminants in place instead of off-site. Once remediation is complete, continue to monitor the site for the identified contaminants to ensure that contamination problems do not return.

Remediation efforts on brownfield sites are sometimes costly and time-intensive due to the potentially extensive effort required to characterize the contamination, evaluate cleanup options and perform cleanup activities. However, substantially lower property costs can offset remediation costs and time delays. The cost of remediation strategies varies by site and region. Several remediation strategies should be considered in order to identify the strategy with the greatest benefit and lowest cost to the property owner. The appropriate technology for a specific site depends on the contaminants present, hydrogeologic conditions and other factors. Traditional remediation efforts for contaminated groundwater are termed "pump-and-treat." Pump-and-treat technologies involve pumping contaminated groundwater to the surface and treating the water using physical or chemical processes. Contaminated soils can be remediated in a variety of ways. Advanced technologies such as bioreactors and in-

situ applications are sometimes more cost-effective than hauling large quantities of contaminated soil to an approved disposal facility. Innovative remediation efforts such as solar detoxification technologies are currently being developed and are expected to reduce remediation costs in the future. It is important to consider the environmental implications of all remediation strategies being investigated for your project to ensure the solution does not cause problems elsewhere.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

There is no Exemplary Performance point available for this credit.

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:

- ❑ Provide confirmation whether the project site was determined contaminated by means of an ASTM E1903-97 Phase II Environmental Site Assessment or the site was defined as a brownfield by a local, state or federal government agency.
- ❑ Provide a detailed narrative describing the site contamination and remediation efforts undertaken by the project.

Considerations

Environmental Issues

Many potential building sites in urban locations have been abandoned due to real or potential contamination from previous industrial or municipal activities. These sites can be remediated and redeveloped for reuse. Environmental and economic concerns are key issues when evaluating brownfield redevelopment. Costs incurred to remediate site contamination and land prices can be additive or can offset each other. Perception of the building site by the building owner and future building occupants must also be weighed. Building owners may be wary of cleanup requirements and the potential for liability associated with contaminants migrating off-site and impacting downstream neighbors. Building occupants may worry about health risks from breathing contaminated air or coming into contact with contaminated soil. These concerns must be investigated and resolved before making the final decision to redevelop a brownfield site.

Remediation efforts remove hazardous materials from brownfield sites' soil and groundwater. This reduces the exposure of humans and wildlife to health risks as a result of environmental pollution. Redevelopment of brownfield sites provides an alternate option to developing on greenfield sites. Preservation of greenfield sites for future generations decreases the overall environmental impact of development. Brownfields often have existing infrastructure improvements in place including utilities and roads, reducing the need for further environmental impacts due to construction of new infrastructure. In some instances, rather than remediate the contamination, it may be more sensible to leave contaminants in place, choosing instead to stabilize and isolate the contaminants from human exposure.

Brownfields can offer an attractive location and are often inexpensive when compared to comparable uncontaminated properties. It is essential to weigh the value of the remediated property against cleanup costs to determine if the site is economically viable for redevelopment.

Developers have been reluctant to redevelop brownfield sites in the past due to potential liability associated with taking responsibility for the cleanup of others' contamination. In recent years, the EPA and many state and local government agencies have begun to provide incentives for brownfield redevelopment by enacting laws that reduce the liability of developers who choose to remediate contaminated sites. Before embarking on a brownfield development effort, it is important to contact state and local regulators to determine the rules governing these sites and available financial assistance programs. It may also be helpful to contact the regional EPA's Office of Solid Waste and Emergency Response (OSWER), which may provide site characterization and remediation support.

Economic Issues

Remediation and reclamation of contaminated sites can contribute to social and economic revitalization of depressed or disadvantaged neighborhoods. Local liabilities can be turned into valuable community assets and catalyze increased community investment. Clean up of contaminated properties can renew and augment a sense of community pride in local residents.

Resources

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

Web Sites

Brownfields Technology Support Center

www.brownfieldstsc.org

A public cooperative effort that provides technical support to federal, state and local officials on items related to site investigation and cleanup.

EPA Sustainable Redevelopment of Brownfields Program

www.epa.gov/brownfields

A comprehensive site on brownfields that includes projects, initiatives, tools, tax incentives and other resources to address brownfield remediation and redevelopment. For information by phone, contact your regional EPA office.

Print Media

ASTM Standard Practice E1739-95: Risk-Based Corrective Action Applied at Petroleum Release Sites, American Society for Testing & Materials

www.astm.org

(610) 832-9585

This document is a guide for risk-based corrective action (RBCA), a decision making process that is specific to cleaning up petroleum releases at contaminated sites. It presents a tiered approach to site assessment and remedial actions. It also includes a comprehensive appendix with risk calculations and sample applications.

EPA OSWER Directive 9610.17: Use of Risk-Based Decision-Making in UST Correction Action Programs, U.S. Environmental Protection Agency, Office of Underground Storage Tanks,

www.epa.gov/swerust1/directiv/od961017.htm

(703) 603-7149

This document addresses the application of risk-based decision-making techniques to properties where leaking underground storage tanks (USTs) have created risks to human health and the environment. Guidelines are included to assist in making decisions in a manner consistent with federal law, specifically CERCLA and RCRA programs. Risk-based decision-making is a method that utilizes risk and exposure assessment methodology to determine the extent and urgency of cleanup actions. The goal is to protect

human health and the environment. This standard includes several examples of state programs that use risk-based decision-making in leaking UST legislation.

Definitions

Bioremediation involves the use of microorganisms and vegetation to remove contaminants from water and soils. Bioremediation is generally a form of in-situ remediation, and can be a viable alternative to landfilling or incineration.

CERCLA refers to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. CERCLA addresses abandoned or historical waste sites and contamination. It was enacted in 1980 to create a tax on the chemical and petroleum industries and provided federal authority to respond to releases of hazardous substances.

Ex-Situ Remediation involves the removal of contaminated soil and groundwater. Treatment of the contaminated media occurs in another location, typically a treatment facility. A traditional method of ex-situ remediation is pump-and-treat technology that uses carbon filters and incineration. More advanced methods of ex-situ remediation include chemical treatment or biological reactors.

In-Situ Remediation involves treatment of contaminants in place using technologies such as injection wells or reactive trenches. These methods utilize the natural hydraulic gradient of groundwater and usually require only minimal disturbance of the site.

RCRA refers to the Resource Conservation and Recovery Act. RCRA focuses on active and future facilities. It was enacted in 1976 to give the EPA authority to control hazardous wastes from cradle to grave, including generation, transportation, treatment, storage and disposal. Some non-hazardous wastes are also covered under RCRA.

Remediation is the process of cleaning up a contaminated site by physical, chemical or biological means. Remediation processes are typically applied to contaminated soil and groundwater.

Risk Assessment is a methodology used to analyze for potential health effects caused by contaminants in the environment. Information from the risk assessment is used to determine cleanup levels.

A **Site Assessment** is an evaluation of above-ground (including facilities) and subsurface characteristics, including the geology and hydrology of the site, to determine if a release has occurred, as well as the extent and concentration of the release. Information generated during a site assessment is used to support remedial action decisions.

SS	WE	EA	MR	EQ	ID
Credit 3					

Alternative Transportation

Public Transportation Access

SS	WE	EA	MR	EQ	ID
Credit 4.1					

1 Point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Locate project within 1/2 mile of an existing—or planned and funded—commuter rail, light rail or subway station.

OR

Locate project within 1/4 mile of one or more stops for two or more public or campus bus lines usable by building occupants.

Potential Technologies & Strategies

Perform a transportation survey of future building occupants to identify transportation needs. Site the building near mass transit.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Select a site that has convenient access to existing transportation networks to minimize the need for new transportation lines. Local telephone books and community Web sites provide maps and directories that will be helpful in determining the transportation options available. Look for functional and direct sidewalks, paths and walkways to existing mass transit stops. Provide incentives such as transit passes to encourage occupants to use mass transit.

If a light rail or subway station is sited, planned and funded at the time the project is completed, it satisfies the intent of the credit.

Calculations

Use an area drawing to indicate mass transit stops within 1/2 mile of the project. Remember that the project is required to be within a 1/2 mile pedestrian route to a commuter rail, light rail or subway station or within 1/4 mile of two or more bus lines. **Figure 1** shows two bus lines within 1/4 mile of the project location. The map includes a scale bar and a north indicator.

Figure 1: Sample Area Drawing

Exemplary Performance

Projects may be awarded one innovation point for Exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

Based on evidence that locations with higher transit density can achieve substantially and a quantifiably higher environmental benefit, meeting the following threshold qualifies a project for exemplary performance Innovation Credit. This follows the Center for Clean Air Policy's finding that average transit ridership increases by 0.5% for every 1.0% increase in growth of transit service levels, which leads to the conclusion that quadrupling transit service generally doubles transit ridership.

To accomplish this quadrupling of service and doubling of ridership, at a minimum:

❑ Locate the project within ½ mile of at least two existing commuter rail, light rail, or subway lines, OR locate project within ¼ mile of at least two or more stops for four or more public or campus bus lines usable by building occupants;

AND

❑ Frequency of service must be such that at least 200 transit rides per day are available in total at these stops. A combination of rail and bus is allowable. This strategy is based on the assumption that the threshold of the base credit would provide, in most cases, at least 50 transit rides per day (half-hourly service 24 hours per day or more frequent service for less than 24 hours per day). If, on average, transit ridership increases by 0.5% for every 1.0% increase in transit service, then quadrupling the number of rides available would, on average, double the transit ridership. (4 x 50 rides = 200 rides). Include a transit schedule and map within your LEED certification submittal.

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:

Commuter Rail Service

❑ Provide a site vicinity drawing showing the project site and the location of all (existing/proposed) fixed rail stations within 1/2 mile of the site.

❑ A listing of each fixed rail station and the distance from the station to the project site (miles).

OR

Bus Service

❑ Provide a site vicinity drawing showing the project site and the location of all existing bus stops within 1/4 mile of the site.

❑ A listing of each bus line that serves the site vicinity and the distance from the bus stop to the project site (miles).

AND (For Projects With Special Circumstances—Either Compliance Path)

❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The environmental effects of automobile use include vehicle emissions that contribute to smog and air pollution as well as environmental impacts from

oil extraction and petroleum refining. Increased use of public transportation can improve air quality. A surprisingly large number of people are willing to use alternative means of transportation such as mass transit if it is convenient and facilities are provided to encourage their use. Encouraging the use of mass transit reduces the energy demand for transportation needs and affects building sites by reducing the space needed for parking lots, which encroach on green space on the building site. Minimizing parking lots reduces the building footprint and sets aside more space for natural areas or greater development densities

Reduction in private vehicle use reduces fuel consumption and air and water pollutants in vehicle exhaust. On the basis of passenger miles traveled, public transportation is approximately twice as fuel efficient as private vehicles. Another benefit of public transportation is the associated reduction in the need for infrastructure used by vehicles. Parking facilities and roadways for automobiles have negative impacts on the environment because impervious surfaces like asphalt increase stormwater runoff while contributing to urban heat island effects.

Economic Issues

Many occupants view proximity to mass transit as a benefit and this can influence the value and marketability of the building. For building occupants, costs associated with traveling to and from the workplace can be significantly reduced if access to public transportation is available. For this reason, providing access to public transportation may provide an economic benefit associated with attracting and retaining employees. Existing building project teams have little to no control over their building's proximity to mass transit. If a building is not near mass transit, a shuttle can be provided to earn this credit, but this would be an added operating cost for the building.

Reducing the size of parking areas based on anticipated use of public transit by building occupants may alter operating costs associated with parking lot maintenance. If local utilities charge for stormwater based on impervious surface area, minimization of these areas can result in lower stormwater charges.

Resources

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

Web Sites

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

www.epa.gov/otaq/

US EPA Web site provides information on the types and effects of air pollution associated with automobile use, information for consumers, and links to resources for organizations interested in promoting commuter choice programs.

Best Workplaces for Commuters

www.bestworkplacesforcommuters.gov/index.htm

(888) 856-3131

This program, established by the US EPA and DOT, publicly recognizes employers for their exemplary commuter benefits programs. It provides tools, guidance and promotions to help employers incorporate commuter benefits into their employee benefits plan, reap financial benefits and gain national recognition.

Advanced Transportation Technology Institute

www.atti-info.org

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

Mass Transit is a publicly or privately operated transportation service that provides transportation, for the general public, to multiple fixed stops on a scheduled basis. Mass transit vehicles are typically capable of serving 10 or more occupants, such as buses, trolleys, light rail, etc.

Public Transportation is bus, rail or other transportation service for the general public operating on a regular, continual basis that is publicly or privately owned.

Case Study

Johnson & Johnson Pharmaceutical Research and Development

Pfizer Global Research & Development, La Jolla Campus

TKG Consulting Engineers Corporate Offices

La Jolla, CA

Photo © Johnson & Johnson

Owner: Johnson & Johnson, Pfizer, and TKG Consulting

Photo © Pfizer

Three separate projects attained LEED® Certification in part by connecting their building occupants to public transportation via a common shuttle bus program. The Johnson & Johnson Pharmaceutical Research & Development project (v2.0 2005 Certified), the Pfizer Global Research & Development, La Jolla Campus project (v2.0 2004 Certified), and TKG Consulting Engineers Corporate Offices (v2.0 2004 Gold), all utilize The Sorrento Valley Coaster Connection, a shuttle service provided by the North San Diego County Transit District, to offer an alternative means of transportation for their employees. This shuttle transports its riders from various locations in the area to the Sorrento Valley Station, which offers connections to regional light rail and multiple bus lines.

Photo © Ted Walton

SS	WE	EA	MR	EQ	ID
Credit 4.1					

Alternative Transportation

Bicycle Storage & Changing Rooms

SS	WE	EA	MR	EQ	ID
Credit 4.2					

1 Point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

For commercial or institutional buildings, provide secure bicycle racks and/or storage (within 200 yards of a building entrance) for 5% or more of all building users (measured at peak periods), AND, provide shower and changing facilities in the building, or within 200 yards of a building entrance, for 0.5% of Full-Time Equivalent (FTE) occupants.

OR

For residential buildings, provide covered storage facilities for securing bicycles for 15% or more of building occupants in lieu of changing/shower facilities.

Potential Technologies & Strategies

Design the building with transportation amenities such as bicycle racks and showering/changing facilities.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Select a site that provides convenient access to safe bicycle pathways and secure bicycle storage areas for cyclists. Provide shower and changing areas for cyclists that are easily accessible from bicycle storage areas.

During the site selection process, survey potential building occupants and determine if the available bike routes and their compatibility with mass transit options meet their needs. Look for functional and direct paths that can be used by bicycle commuters. This information will help inform the size, type, and location of bike racks and showering facilities for the project.

There are a number of different types of secure bike storage systems, and design and costs will vary. Secure bicycle storage means that bikes can be individually locked and stored, for example to a rack. For residential projects, bike storage must be covered to protect bicycles from weather as well as theft.

For projects that are located on a campus or similar setting, showering facilities can be shared between buildings as long as the facilities are within 200 yards of the entrance to the building pursuing LEED certification.

Calculations

To determine the number of secure bicycle spaces and changing/showering facilities required for the building, follow the calculation methodology as follows:

1. Identify the total number of full-time and part-time building occupants.
2. 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 a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Estimate the Transient occupants, such as students, visitors and customers, for the peak period for the facility.
4. Calculate peak building users by combining FTE occupants and Transient occupants.
5. The minimum number of **secure bicycle spaces** required is equal to 5% of the peak building users (see **Equation 2**) or 15% of the building occupants for residential projects. Secure bicycle spaces include bicycle racks, lockers and storage rooms. These spaces should be easily accessible by building occupants during all periods of the year, and free of charge.

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

Equation 2

Secure Bicycle Spaces (non-residential) = Peak Building Users x 0.05

Secure Bicycle Spaces (residential) = Occupants x 0.15

6. The required number of **changing** and **showering facilities** for non-residential buildings is equal to 0.5% of the FTE occupants. Showering facilities can be unit showers or group showering facilities. (See **Equation 3**.)

Example—College Classroom Building

Many college buildings house faculty, staff and students, making the calculation of FTEs complicated. In the example in **Table 1** below, the building occupants are separated into full-time and part-time users to simplify the calculation. The number of persons is multiplied by the number of hours they spend in the building each day and then divided by 8 to calculate the FTE value.

Exemplary Performance

Projects may be awarded one innovation point for exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy and Transient occupancy for the project.
- ❑ Provide project drawings to show the location(s) of the secure bicycle storage areas and shower/changing facilities.

In addition, please provide the following project data and calculation information based on project type:

Non-Residential Buildings

- ❑ Confirm the quantity of shower/changing facilities provided and their distance from the building entry.

Equation 3

Showering Facilities (non-residential buildings) = FTE Occupants x 0.005

Table 1: Sample Occupancy Calculation for College Building

FTE Occupant Calculation			
Occupant Type	**Number**	**Total Person-Hours Per Day**	**Sub Total FTEs**
FULL-TIME (assume 8 hr/day)			
Staff	8	64	8
Faculty	6	48	6
PART-TIME (assume 2 hr/day)			
Faculty	24	48	6
Student Researchers	20	40	5
		TOTAL FTEs	**25**

Transient Occupant Calculation		
Occupant Type	**Number at Peak Period**	**Occupant Value for LEED Calculations**
Students	310	310
	Peak Building Users	**335**

Residential Buildings

❑ No additional documentation is required.

Mixed Non-Residential and Residential Buildings

- Confirm the number of residential units and residential FTE occupants for the project.
- Confirm the quantity of shower/changing facilities provided for the non-residential portion of the project and their distance from the building entry.

AND (For Projects With Special Circumstances— Any Compliance Path)

- Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The environmental effects of automobile use include vehicle emissions that contribute to smog and air pollution as well as environmental impacts from oil extraction and petroleum refining. Bicycling as an alternative to personal vehicle operation offers a number of environmental benefits. Bicycle commuting produces no emissions and has zero demand for petroleum-based fuels. Bicycle commuting also relieves traffic congestion, reduces noise pollution, and requires far less infrastructure for roadways and parking lots. Roadways and parking lots produce stormwater runoff, contribute to the urban heat island effect, and encroach on green space.

Bicycles are more likely to be used for relatively short commuting trips. Displacing vehicle miles with bicycling even for short trips carries a large environmental benefit, since a large portion of vehicle emissions occur in the first few minutes of driving following a cold start, as emissions control equipment is less effective at cool operating temperatures.

Economic Issues

The initial project cost increase for bike storage areas and changing facilities or showers is typically low relative to the overall project cost. Building occupants can realize health benefits through bicycle and walking commuting strategies. Bicycling and walking also expose people to the community, encouraging interaction among neighbors and allowing for enjoyment of the area in ways unavailable to automobile passengers.

Resources

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

Web Sites

Advanced Transportation Technology Institute

www.atti-info.org

(423) 622-3884

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

A **Carpool** is an arrangement in which two or more people share a vehicle for transportation.

Mass Transit includes transportation facilities designed to transport large groups of persons in a single vehicle such as buses or trains.

Public Transportation is bus, rail or other transportation service for the general public operated on a regular, continual basis that is publicly or privately owned.

Alternative Transportation

SS	WE	EA	MR	EQ	ID
Credit 4.3					

1 Point

Low-Emission & Fuel-Efficient Vehicles

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

OPTION 1

Provide low-emitting and fuel-efficient vehicles for 3% of Full-Time Equivalent (FTE) occupants AND provide preferred parking for these vehicles.

OR

OPTION 2

Provide preferred parking for low-emitting and fuel-efficient vehicles for 5% of the total vehicle parking capacity of the site.

OR

OPTION 3

Install alternative-fuel refueling stations for 3% of the total vehicle parking capacity of the site (liquid or gaseous fueling facilities must be separately ventilated or located outdoors).

For the purposes of this credit, low-emitting and fuel-efficient vehicles are defined as vehicles that are either classified as Zero Emission Vehicles (ZEV) by the California Air Resources Board or have achieved a minimum green score of 40 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide.

"Preferred parking" refers to the parking spots that are closest to the main entrance of the project (exclusive of spaces designated for handicapped) or parking passes provided at a discounted price.

Potential Technologies & Strategies

Provide transportation amenities such as alternative fuel refueling stations. Consider sharing the costs and benefits of refueling stations with neighbors.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Establishing alternative fuel refueling stations requires the consideration of a number of legal, technical and safety issues, which vary by fuel type. Consider the following while developing alternative fuel station infrastructure:

- ❑ Poll building occupants to determine which alternative fuel type is in highest demand.
- ❑ Compare the environmental and economic costs/benefits of different alternative fuel types to determine which alternative fuel type would provide the highest benefit.
- ❑ Investigate local codes and standards for refueling stations in the area.
- ❑ Compare different fuel station equipment options and fuel availability. Depending on the type of alternative fuel provided, equipment requirements will differ in terms of expense and complexity of installation. Lack of availability may limit the feasibility of providing refueling stations for some types of fuels.
- ❑ Learn about the safety issues associated with alternative fuel types. Ensure that appropriate building personnel are trained to operate and maintain refueling stations.

Calculations

Option 1

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

To determine the number of alternative fuel vehicles required, follow the calculation methodology as follows:

1. Identify the total number of full-time and part-time building occupants.
2. 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 a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Multiply the number of FTE occupants by 3% to determine the number of vehicles and preferred parking spaces to provide.

Option 2

To determine the number of alternative fuel vehicle parking spaces required, multiply the total number of parking spaces in the project by 5%.

Option 3

To determine the number of alternative fuel vehicle fueling stations required, multiply the total number of parking spaces in the project by 3%.

Exemplary Performance

Projects may be awarded one innovation point for exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy for the project.
- ❑ Provide the total parking capacity of the site.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1—Low-Emitting/Fuel Efficient Vehicles

- ❑ Provide project drawings to show the location(s) of the preferred parking spaces for low-emitting/fuel-efficient vehicles.
- ❑ Confirm the quantity of low-emitting/fuel-efficient vehicles provided and their make, model and manufacturer.
- ❑ Confirm whether each vehicle is a zero-emission vehicle or enter each vehicle's ACEEE vehicle score.

Option 2—Preferred Parking for Low-Emitting/Fuel Efficient Vehicles

- ❑ Provide project drawings to show the location(s) of the preferred parking spaces for low-emitting/fuel-efficient vehicles.
- ❑ Confirm the number of preferred parking spaces provided.

Option 3—Alternative Fuel Refueling Stations

- ❑ Provide project drawings to show the location(s) of the alternative fuel refueling stations.
- ❑ Confirm the fuel type, number of stations, and fueling capacity for each station for an 8-hour period.

AND (For Projects With Special Circumstances—Any Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Operation of vehicles significantly contributes to global change and air quality problems through the emission of greenhouse gases (GHGs) and other pollutants generated from combustion engines and fuel evaporation. Motor gasoline is estimated to account for 60 percent of all carbon dioxide (a major GHG) emitted in the United States in the last 20 years. Personal vehicles also generate large portions of the air pollutants responsible for smog and ground-level ozone, both of which have negative effects on human health.

Alternative fuel and alternative technology vehicles offer the possibility of reducing air pollutants from vehicular travel as well as the environmental effects of producing gasoline. However, the extent to which alternative vehicles produce an environmental benefit depends on the complete lifecycle of their fuels and the vehicle technology. For example, electric vehicles generate zero green house gases (GHGs) during operation, but the amount of GHGs emitted during the production of the electricity that these vehicles run on varies greatly depending on the electricity source. Furthermore, alternative fuels may be superior to conventional gasoline on the basis of one pollutant, but carry a higher pollution load for another pollutant. Because the environmental benefit of alternative fuel and alternative technology vehicles depend on complete fuel-cycle energy-use and emissions, carefully consider available vehicle technologies and fuel sources before purchasing vehicles or installing fuel stations.

Economic Issues

Initial costs for alternative vehicles are higher than for conventional vehicles, and this may delay their purchase. Federal, state and local government may offer tax incentives for purchasing alternative vehicles, which can help offset their higher initial costs. Different alternative fuel vehicles need different refueling stations, and the costs vary. Hybrid vehicles are gaining traction in the marketplace, which should start to drive down their cost. For fuel-efficient vehicles, reduced operating costs on a per-mile basis can offset higher initial purchase prices or higher fuel costs.

Resources

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

Web Sites

Alternative Fuels Data Center

www.afdc.doe.gov

A section of the DOE Office of Transportation Technologies that has information on alternative fuels and alternative fueled vehicles, a locator for alternative refueling stations and other related information.

American Council for an Energy-Efficient Economy (ACEEE)

www.greenercars.com

Online searchable green car guide based on a combination of fuel efficiency and tailpipe emission levels. Also offers hard-copy Green Guide to Cars and Trucks, an annual publication of the American Council for an Energy-Efficient Economy.

CARB Cleaner Car Guide

www.driveclean.ca.gov/en/gv/home/index.asp

(916) 323-6169

The California Air Resources Board (CARB) has developed a comprehensive searchable buyer's guide to find the cleanest cars on the market, which lists advantages clean vehicles offer.

California Certified Vehicles List

www.arb.ca.gov/msprog/ccvl/ccvl.htm

This site provides a list of all vehicles certified by the California Air Resources Board.

Clean Cities Vehicle Buyer's Guide For Consumers

www.eere.energy.gov/cleancities/vbg/

The Vehicle Buyer's Guide for Consumers explains the alternative fuel and advanced technology vehicles, including hybrid and neighborhood electric vehicles available. You can use this site to learn more about the vehicle technologies; obtain pricing and technical specifications; locate the nearest alternative fuel station; contact a dealer, industry expert or manufacturer; research financial incentives and laws in your state; and more.

Clean Cities Vehicle Buyer's Guide For Fleets

www.eere.energy.gov/cleancities/vbg/fleets

The Vehicle Buyer's Guide for Fleets is designed to educate fleet managers and policy makers about alternative fuels and vehicles to help them determine whether the Energy Policy Act of 1992 (EPAct) affects them. Use the site to figure if your fleet is covered under EPAct; obtain pricing and technical specifications for light and heavy-duty AFVs; find an alternative fueling station in your area; or research information about state AFV purchasing incentives and laws.

CREST

www.crest.org/hydrogen/index.html

The Center for Renewable Energy and Sustainable Technology's fuel cell and hydrogen page.

Electric Auto Association

www.eaaev.org

This nonprofit education organization promotes the advancement and widespread adoption of electric vehicles.

Electric Drive Transportation Association

www.electricdrive.org

This industry association promotes electric vehicles through policy, information, and market development initiatives.

Fuel Economy Web Site

www.fueleconomy.gov/feg

This U.S. Department of Energy site allows comparisons of cars based on gas mileage (mpg), greenhouse gas emissions, air pollution ratings, and safety information for new and used cars and trucks.

Natural Gas Vehicle Coalition

www.ngvc.org

The Natural Gas Vehicle Coalition consists of natural gas companies, vehicle and equipment manufacturers, service providers, environmental groups and government organizations.

Rocky Mountain Institute Transportation Page

www.rmi.org/sitepages/pid18.php

This Web site offers information on the environmental impact of transportation, and extensive information about Hypercar vehicles.

Union of Concerned Scientists Clean Vehicle Program

www.ucsusa.org/clean_vehicles

This site provides information about the latest developments in alternative vehicles, the environmental impact of conventional vehicles, and information for consumers such as the guide Buying a Greener Vehicle: Electric, Hybrids, and Fuel Cells.

Definitions

Alternative Fuel Vehicles are vehicles that use low-polluting, non-gasoline fuels such as electricity, hydrogen, propane or compressed natural gas, liquid natural gas, methanol, and ethanol. Efficient gas-electric hybrid vehicles are included in this group for LEED purposes.

Hybrid Vehicles are vehicles that use a gasoline engine to drive an electric generator and use the electric generator and/or storage batteries to power electric motors that drive the vehicle's wheels.

Preferred Parking refers to parking spots that are closest to the main entrance of the project, exclusive of spaces designated for handicapped, or to parking passes provided at a discounted price.

SS	WE	EA	MR	EQ	ID
Credit 4.3					

Alternative Transportation

SS	WE	EA	MR	EQ	ID
Credit 4.4					

1 Point

Parking Capacity

Intent

Reduce pollution and land development impacts from single occupancy vehicle use.

Requirements

OPTION 1 — NON-RESIDENTIAL

❑ Size parking capacity to not exceed minimum local zoning requirements, AND, provide preferred parking for carpools or vanpools for 5% of the total provided parking spaces.

OR

OPTION 2 — NON-RESIDENTIAL

For projects that provide parking for less than 5% of FTE building occupants:

❑ Provide preferred parking for carpools or vanpools, marked as such, for 5% of total provided parking spaces.

OR

OPTION 3 — RESIDENTIAL

❑ Size parking capacity to not exceed minimum local zoning requirements, AND, provide infrastructure and support programs to facilitate shared vehicle usage such as carpool drop-off areas, designated parking for vanpools, or car-share services, ride boards, and shuttle services to mass transit.

OR

OPTION 4 — ALL

Provide no new parking.

NOTES:

"Preferred parking" refers to the parking spots that are closest to the main entrance of the project (exclusive of spaces designated for handicapped) or parking passes provided at a discounted price.

When parking minimums are not defined by relevant local zoning requirements, or when there are no local zoning requirements, either:

A) Meet the requirements of Portland, Oregon, Zoning Code: Title 33, Chapter 33.266 (Parking and Loading)

OR, if this standard is not appropriate for the building type,

B) Install 25% less parking than the building type's average listed in the Institute of Transportation Engineers' Parking Generation study, 3rd Edition.

Potential Technologies & Strategies

Minimize parking lot/garage size. Consider sharing parking facilities with adjacent buildings. Consider alternatives that will limit the use of single occupancy vehicles.

Summary of Referenced Standard

Portland, Oregon, Zoning Code: Title 33, Chapter 33.266 (Parking and Loading)

Available through http://www.portlandonline.com/planning/.

Institute of Transportation Engineers' *Parking Generation*, 3rd Edition

Contact LEED Customer Service for details.

Approach and Implementation

The intent of this credit is to limit availability of parking as a means of encouraging the use of alternative forms of transportation to and from the site. Select a project site that is easily accessible from residential areas by bicycle or public transportation. Once the site is selected, determine the expected number of cars likely to drive to the site and compare this number to local zoning requirements. If parking demand is expected to be less than that required by local codes, consider seeking a variance with the appropriate authorities to provide less parking. However, any on-site parking reductions should be carefully balanced with community needs to avoid needlessly burdening surrounding neighborhoods with excessive street parking.

Where possible, develop transportation demand management strategies in order to reduce the number of parking spaces required to meet the needs of occupants. Transportation demand strategies may include the publishing of an employee roster with addresses to assist people in finding carpool partners, creating incentive programs for carpooling, providing a ride share board, or setting parking fees at a level sufficient to encourage carpooling.

Calculations

Option 1—Non-Residential

Determine the minimum number of parking spaces required by local zoning requirements. Total the parking spaces provided for the project (excluding service lots) and verify that the project parking does not exceed the minimum required.

Determine the number of spaces 5% represents (rounding up to the next whole number) and designate the appropriate square foot area, closest to the building entrance and excluding handicapped spaces, as reserved carpool/vanpool spaces.

Option 2—Non-Residential

For projects that provide parking for less than 5% of FTE building occupants:

1. Identify the total number of full-time and part-time building occupants.
2. 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 a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Determine if the total number of provided parking spaces is less than 5% of FTE occupants.

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

4. Designate project parking (closest to the building entrance and excluding handicapped spaces) equivalent to 5% of the total provided project parking as reserved carpool/vanpool spaces.

Option 3—Residential

No calculations are needed for residential projects beyond what is needed to comply with local zoning requirements.

Option 4—All

No calculations are required for this compliance path.

Exemplary Performance

Projects may be awarded one innovation point for Exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy for the project.
- ❑ Provide the total parking capacity of the site.
- ❑ Confirm the appropriate project compliance path.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1— Non-Residential

- ❑ Provide the number of parking spaces required for the project per local code or ordinance.
- ❑ Provide the number of carpool/vanpool spaces that are on-site.

Option 2— Non-Residential

- ❑ Provide the number of carpool/vanpool spaces that are on-site.

Option 3—Residential

- ❑ Provide a description of the infrastructure/programs that are in place to support and promote ridesharing.

Option 4— All

- ❑ There are no additional items required for this compliance path.

AND (For Projects With Special Circumstances—Any Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Reducing the use of private automobiles saves energy and avoids environmental problems associated with automobile use, such as vehicle emissions that contribute to smog and other air pollutants and the environmental impacts associated with oil extraction and petroleum refining. The environmental benefits of carpooling are significant. For example, 100 people who carpooled (2 people per car) 10 miles to work and 10 miles home instead of driving separately would prevent emission of 7.7 pounds of hydrocarbons, 55 pounds of carbon monoxide, 3.3 pounds of nitrogen oxides, 990 pounds of carbon dioxide and 50 gallons of gasoline per day.

Parking facilities for automobiles also have negative impacts on the environment,

since asphalt surfaces increase stormwater runoff and contribute to urban heat island effects. By restricting the size of parking lots and promoting carpooling, buildings can reduce these effects while benefiting from reduced parking requirements and more and healthier green space.

Economic Issues

Carpooling reduces the size of the parking areas needed to support building occupants, allowing the building to accept more occupants without enlarging the parking area. It helps reduce the cost of land added for parking as well as infrastructure needed to support vehicles. Reduction in parking areas can decrease the amount of impervious surfaces on a site. This may result in reduced stormwater charges, as some local utilities charge for stormwater based on impervious surface area. Also, many municipalities and state governments offer tax incentives for carpooling programs, since fewer cars on the road reduces pollution, traffic congestion and wear and tear to roadways.

Resources

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

Web Sites

Advanced Transportation Technology Institute

www.atti-info.org

(423) 622-3884

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

A **Carpool** is an arrangement in which two or more people share a vehicle for transportation.

Preferred Parking refers to the parking spots that are closest to the main entrance of the project, exclusive of spaces designated for handicapped, or to parking passes provided at a discounted price.

Site Development

Protect or Restore Habitat

SS	WE	EA	MR	EQ	ID
Credit 5.1					

1 Point

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

On greenfield sites, limit all site disturbance to 40 feet beyond the building perimeter; 10 feet beyond surface walkways, patios, surface parking and utilities less than 12 inches in diameter; 15 feet beyond primary roadway curbs and main utility branch trenches; and 25 feet beyond constructed areas with permeable surfaces (such as pervious paving areas, stormwater detention facilities and playing fields) that require additional staging areas in order to limit compaction in the constructed area.

Greenfield sites are those that are not previously developed or graded and remain in a natural state. Previously developed sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

OR

On previously developed or graded sites, restore or protect a minimum of 50% of the site area (excluding the building footprint) with native or adapted vegetation. Native/adapted plants are plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds.

Projects earning SS Credit 2 and using vegetated roof surfaces may apply the vegetated roof surface to this calculation (if the plants meet the definition of native/adapted), in which case the requirement is 20% of the total site area (including building footprint). This option is intended for urban sites with little or no building setback (i.e. zero-lot-line).

Potential Technologies & Strategies

On greenfield sites, perform a site survey to identify site elements and adopt a master plan for development of the project site. Carefully site the building to minimize disruption to existing ecosystems and design the building to minimize its footprint. Strategies include stacking the building program, tuck-under parking and sharing facilities with neighbors. Establish clearly marked construction boundaries to minimize disturbance of the existing site and restore previously degraded areas to their natural state. For previously developed sites, utilize local and regional governmental agencies, consultants, educational facilities, and native plant societies as resources for the selection of appropriate native or adapted plant materials. Prohibit plant materials listed as invasive or noxious weed species. Native/adapted plants require minimal or no irrigation following establishment, do not require active maintenance such as mowing or chemical inputs such as fertilizers, pesticides or herbicides, and provide habitat value and promote biodiversity through avoidance of monoculture plantings.

SS | WE | EA | MR | EQ | ID

Credit 5.1

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Preserve and enhance natural site elements including existing water bodies, soil conditions, ecosystems, trees and other vegetation. Identify opportunities for site improvements that increase the area of native/adapted vegetation or other ecologically appropriate features. Activities may include removing unnecessary paved areas and replacing them with landscaped areas, or replacing excessive turf-grass areas with native or adapted plantings to promote biodiversity and provide habitat.

During the construction process, establish clearly marked construction and disturbance boundaries and note these site protection requirements in construction documents. Delineate lay down, recycling and disposal areas, and use paved areas for staging activities. Erect construction fencing around the drip line of existing trees to protect them from damage and soil compaction by construction vehicles. Consider the costs/benefits of contractual penalties if destruction of protected areas outside of the construction boundaries occurs. Coordinate infrastructure construction to minimize the disruption of the site and work with existing topography to limit cut-and-fill efforts for the project.

For urban projects earning SS Credit 2, consider installing a vegetated roof. Select native or adapted, non-invasive species, and ensure that the roof structure is designed to support the added weight of the planting beds. Research the species that are likely to utilize this space (primarily birds and insects) and select plants that will help support these species by providing food, forage or nesting areas.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

The project may be awarded one innovation point for exemplary performance in restoring or protecting a minimum of 75% of the site area (excluding the building footprint) with native or adapted vegetation on previous developed or graded sites.

Submittal Documentation

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

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

- ❑ Provide the project site area.
- ❑ Provide the project building footprint area.
- ❑ Provide a narrative describing the project's approach to this credit. Include information regarding any special circumstances or considerations regarding the project.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Greenfield Sites

- ❑ Provide a copy of the project's site/grading drawings highlighting the designated site disturbance boundaries.

Previously Developed/Graded Sites

- ❑ Provide the area (sq.ft.) of the site that has been restored using native and/or adaptive planting.
- ❑ Provide a copy of the project's site/landscape plan that provides information regarding the restored site area and the planting materials.

Considerations

Environmental Issues

Development on building sites often damages site ecology, indigenous plants and regional animal populations. Ecological site damage can be reduced by restoring native and adapted vegetation and other ecologically appropriate features on the site, which in turn provides habitat for fauna. Other ecologically appropriate features are natural site elements beyond vegetation that maintain or restore the ecological integrity of the site. They may include water bodies, exposed rock, bare ground, or other features that are part of the historic natural landscape within the region and provide habitat value. When construction occurs on the site, protection of open space and sensitive areas through the use of strict boundaries reduces damage to the site ecology, resulting in preservation of wildlife corridors and habitat.

Economic Issues

Native or adapted plantings typically reduce maintenance costs over their lifetime by minimizing inputs of fertilizers, pesticides and water. In many cases, trees and vegetation raised off site are costly to purchase and may not survive transplanting. Additional trees and other landscaping, as well as soil remediation and water elements, can incur first costs. It may be advantageous to implement site restoration in phases to spread costs out over time. Strategic plantings can shade the building and site impervious areas, which can decrease cooling loads during warm months and reduce energy expenditures.

Resources

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

Web Sites

American Society of Landscape Architects

www.asla.org

ASLA is the national professional association representing landscape architects. The Web site provides information about products, services, publications and events.

Ecological Restoration

http://ecologicalrestoration.info

This quarterly print and online publication from the University of Wisconsin-Madison Arboretum provides a forum for people interested in all aspects of ecological restoration.

Lady Bird Johnson Wildlife Center

www.wildflower.org

The center, located in Austin, Texas, has the mission of educating people about the environmental necessity, economic value and natural beauty of native plants. The Web site offers a number of resources, including a nationwide Native Plant Information Network and a National Suppliers Directory.

North American Native Plant Society

www.nanps.org

A nonprofit association dedicated to the study, conservation, cultivation and restoration of native plants. Its Web site contains links to state and provincial associations.

Plant Native

www.plantnative.org

This organization is dedicated to moving native plants and nature-scaping into mainstream landscaping practices.

Society for Ecological Restoration International

www.ser.org

Nonprofit consortium of scientists, planners, administrators, ecological consul-

tants, landscape architects, engineers, and others with the mission of promoting ecological restoration as a means of sustaining the diversity of life and reestablishing an ecologically healthy relationship between nature and culture.

Soil and Water Conservation Society

www.swcs.org

An organization focused on fostering the science and art of sustainable soil, water, and related natural resource management.

Print Media

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources by John Tillman Lyle, Island Press, 1999.

This text explores methods of landscape design that function like natural ecosystems.

Landscape Restoration Handbook by Donald Harker, Marc Evans, Gary Libby, Kay Harker, and Sherrie Evans, Lewis Publishers, 1999.

This resource is a comprehensive guide to natural landscaping and ecological restoration, and provides information on 21 different ecological restoration types.

Definitions

The **Building Footprint** is the area on a project site that is used by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

Greenfield sites are those that are not previously developed or graded and remain in a natural state.

Local Zoning Requirements are local government regulations imposed to promote orderly development of private lands and to prevent land use conflicts.

Native (or Indigenous) Plants refers to plants adapted to a given area during a defined time period and are not invasive. In America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Adapted (or introduced) Plants are those that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted plants are considered to be low maintenance but not invasive.

Invasive Plants are both indigenous and non-indigenous species or strains that are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

Open Space Area is as defined by local zoning requirements. If local zoning requirements do not clearly define open space, it is defined for the purposes of LEED calculations as the property area minus the development footprint; and it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. For projects located in urban areas that earn SS Credit 2, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

Previously Developed sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

Site Development

Maximize Open Space

SS | WE | EA | MR | EQ | ID

Credit 5.2

1 Point

Intent

Provide a high ratio of open space to development footprint to promote biodiversity.

Requirements

OPTION 1

Reduce the development footprint (defined as the total area of the building footprint, hardscape, access roads and parking) and/or provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site by 25%.

OR

OPTION 2

For areas with no local zoning requirements (e.g., some university campuses, military bases), provide vegetated open space area adjacent to the building that is equal to the building footprint.

OR

OPTION 3

Where a zoning ordinance exists, but there is no requirement for open space (zero), provide vegetated open space equal to 20% of the project's site area.

ALL OPTIONS:

- ❑ For projects located in urban areas that earn SS Credit 2, vegetated roof areas can contribute to credit compliance.
- ❑ For projects located in urban areas that earn SS Credit 2, pedestrian oriented hardscape areas can contribute to credit compliance. For such projects, a minimum of 25% of the open space counted must be vegetated.
- ❑ Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical:horizontal) or less and are vegetated.

Potential Technologies & Strategies

Perform a site survey to identify site elements and adopt a master plan for development of the project site. Select a suitable building location and design the building with a minimal footprint to minimize site disruption. Strategies include stacking the building program, tuck-under parking and sharing facilities with neighbors to maximize open space on the site.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Choose a development footprint and location that minimizes disturbance to the existing ecosystem. Consider issues such as building orientation, daylighting, heat island effects, stormwater generation, significant vegetation, existing green corridors, and other sustainable building issues. Once the site and building location have been determined, design and construct a compact parking, road and building footprint layout in order to preserve open land and provide connections to adjacent ecosystems. Reduce footprints by tightening program needs and stacking floor plans.

In a campus setting with no zoning requirements, designated open space that is equal to the building footprint can be separate from the project site as long as the open space is preserved as such for the life of the building.

When designing green roofs, attention must be given to support, waterproofing and drainage. Green roofs typically include a waterproof and root repellant membrane, a drainage system, filter cloth, a lightweight growing medium and plants. Modular systems are available, with all layers pre-prepared into movable interlocking grids, or individual layers can be installed separately.

Open space in an urban context that includes hardscape surfaces should be pedestrian oriented and accessible, and provide for passive or active recreation opportunities. Examples of urban open space include pocket parks, accessible roof decks, plazas, and courtyards.

Calculations

Option 1

Determine the zoning requirement for open space. Set-back requirements and lot coverage requirements only qualify as open space requirements if the areas they set aside are required to be vegetated. Calculate the open space required for this credit as shown in **Equation 1**.

Option 2

In cases where there is no local zoning requirement, the open space requirement is equal to the building footprint.

Option 3

In cases where local codes require zero open space, determine the total project site area and multiply by 0.20 to determine the open space required for credit achievement, as shown in **Equation 2**.

This requirement can be met through open space provided at grade or on the roof.

Exemplary Performance

Projects may be awarded an innovation point for exemplary performance by demonstrating that they have doubled the amount of open space required for credit achievement. All designated open space shall be within the LEED project boundary. For example, projects with local zoning requirements must increase the amount of open space provided by 50%

Equation 1

Total Open Space Required = Open Space Required by Zoning x 1.25

Equation 2

Total Open Space Required = Total Project Site Area x 0.20

instead of by 25%; projects with no local zoning requirements must provide open space equal to two times the building footprint; and urban projects where zero open space is required must provide open space equal to 40% of the site area.

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:

- ❑ Provide the project site area.
- ❑ Provide the project building footprint area.
- ❑ Provide a copy of the project's site/landscape drawings highlighting the dedicated vegetated open space.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's credit approach.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1

- ❑ Provide the area (sq.ft.) of open space required by local zoning codes/ordinances.
- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Option 2

- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Option 3

- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Considerations

Environmental Issues

Open space provides habitat for vegetation, which in turn provides habitat for local wildlife. Even small open spaces in urban areas can provide refuges for wildlife populations, which have become increasingly marginalized. Plants that specifically support local species such as insects and other pollinators can help sustain populations up the food chain. Open space also helps reduce urban heat island effect, increases stormwater infiltration, and provides the human population on the site with a connection to the outdoors

Economic Issues

Preserving topsoil, plants and trees on the site can reduce landscaping costs for the building. Even in cases where rent values are high and the incentive for building out to the property line is strong, well designed open space can significantly increase property values. Reducing the footprint of a structure on a given site can have varying economic impacts. Building a vertical structure with the same square footage as a horizontal structure may add a small percentage to first costs depending on building size and use. A structure with a smaller footprint is generally more resource-efficient, resulting in reduced material and energy costs. A more compact building with coordinated infrastructure can reduce initial project costs, as well as operations and maintenance costs. Reduced earthwork, shorter utility lines, and reduced surface parking and paved areas all can reduce initial project costs. Compact paving areas and buildings reduce operations and maintenance costs.

Resources

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

Web Sites

North American Native Plant Society

www.nanps.org (416) 631-4438

A nonprofit association dedicated to the study, conservation, cultivation and restoration of native plants. Contains links to state/provincial associations.

Soil and Water Conservation Society

www.swcs.org (515) 289-2331

An organization focused on fostering the science and art of sustainable soil, water and related natural resource management.

Green Roofs for Healthy Cities

www.greenroofs.org

A nonprofit industry association consisting of public and private organizations and individuals committed to developing a market for green roof infrastructure products and services in cities across North America.

Print Media

Beyond Preservation: Restoring and Inventing Landscapes by A. Dwight Baldwin et al., University of Minnesota Press, 1994.

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources by John Tillman Lyle and Joan Woodward, Milldale Press, 1999.

Landscape Restoration Handbook by Donald Harker, Lewis Publishers, 1999.

Definitions

The **Building Footprint** is the area on a project site that is used by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

Greenfield Sites are those that are not previously developed or graded and remain in a natural state.

Local Zoning Requirements are local government regulations imposed to promote orderly development of private lands and to prevent land use conflicts.

Native (Indigenous) Plants refers to plants adapted to a given area during a defined time period and are not invasive. In America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Adapted (or introduced) Plants are those that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted plants are considered to be low maintenance but not invasive.

Invasive Plants are both indigenous and non-indigenous species or strains that are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

Open Space Area is as defined by local zoning requirements. If local zoning requirements do not clearly define open space, it is defined for the purposes of LEED calculations as the property area minus the development footprint; and it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. For projects located in urban areas that earn SS Credit 2, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

Stormwater Design

Quantity Control

SS	WE	EA	MR	EQ	ID
Credit 6.1					

1 Point

Intent

Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, and managing stormwater runoff.

Requirements

OPTION 1 — EXISTING IMPERVIOUSNESS IS LESS THAN OR EQUAL TO 50%

Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two-year, 24-hour design storms.

OR

Implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies.

OR

OPTION 2 — EXISTING IMPERVIOUSNESS IS GREATER THAN 50%

Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year, 24-hour design storm.

Potential Technologies & Strategies

Design the project site to maintain natural stormwater flows by promoting infiltration. Specify vegetated roofs, pervious paving, and other measures to minimize impervious surfaces. Reuse stormwater volumes generated for non-potable uses such as landscape irrigation, toilet and urinal flushing and custodial uses.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

The approach to this credit may vary significantly depending on the condition of the project site at the beginning of the project. If the project is being constructed on a largely undeveloped site, the goal is to preserve stormwater flows and design the project to respond to the natural soil conditions, habitat, and rainfall characteristics. If the project is a redevelopment of a previously developed site, the goal is typically to improve stormwater management in a way that restores the natural functions of the site to the maximum extent practicable.

The approach to this credit also varies dramatically between different regions and climate zones. The strategies employed in an urban environment where water is discharged to concrete channels and then the ocean are different from the strategies employed at an inland site that discharges to a small stream and lake system.

The most effective method to minimize stormwater runoff volume is to reduce the amount of impervious area. By reducing impervious area, stormwater infrastructure can be minimized or deleted from the project. Strategies to minimize or mitigate impervious surfaces may include:

- ❑ Smaller building footprint
- ❑ Pervious paving materials
- ❑ Stormwater harvesting for reuse in irrigation and/or buildings
- ❑ Green roofs
- ❑ Bioswales/vegetated filter strips
- ❑ Retention ponds
- ❑ Clustering development to reduce paved surfaces (roads, sidewalks, etc.)

Guidelines for Capturing and Reusing Stormwater Runoff

Stormwater captured (or harvested) in cisterns, rain barrels, or other devices, is a primary source of water in many parts of the world. Stormwater should not be used for potable needs if there are sources available that pose less risk to public health. However, harvested stormwater may be used to reduce potable water needs for uses such as landscape irrigation, fire suppression, toilet and urinal flushing, and custodial uses.

Storage and reuse techniques range from small-scale systems (e.g., rain barrels) to underground cisterns that may hold large volumes of water. Whether large or small, stormwater harvesting system designs should consider the following:

1. Water need for the intended use—how will the harvested water be used and when will it be needed? For example, if the water is used to irrigate landscaping for four summer months, the amount of water needed and the how often the storage unit will refill must be considered. Usage requirements and the expected volume and frequency of rainfall must be determined.
2. Drawdown—storage system design must provide for the use or release of water between storm events for the design storage volume to be available.
3. Drainage Area—the size and nature (e.g., percent imperviousness) of the area draining to the storage system determines how much runoff will be available for harvesting.
4. Conveyance System—reused stormwater and graywater systems must not be connected to other domestic or commercial potable water systems. Pipes and storage units should be clearly marked (e.g., "Caution: Reclaimed Water, Do Not Drink").
5. Pretreatment—screens or filters may be used to remove debris and sedi-

ment from runoff and to minimize pollutants.

6. Pressurization—uses for harvested rainwater may require pressurization. For example, most irrigation systems require a water pressure of at least 15 psi to function properly. Stored water has a pressure of 0.43 psi per foot of water elevation, and the water pressure at the bottom of a ten-foot vault would be 4.3 psi (10 ft. x 0.43 psi). Pressurization (e.g., a pump, pressure tank and filter) costs more and creates a more useable system.

The amount of runoff reduced by a stormwater harvesting system may be considered equal to its storage volume. However, volume calculations must also consider how often the system is emptied and the interval between storm events.

Example:

Rainwater will be harvested from a 10,000 sq.ft. roof (100% imperviousness). The system will be designed to capture the runoff from 90% of the average annual rainfall (1 inch of rainfall for humid watersheds). The volume of the proposed storage system is the amount of runoff captured (Vr), which is calculated below in **Equation 1**:

Other design considerations – tank must be emptied before subsequent storm events. Use a tank that is 10 ft x 10 ft x 8 ft deep – Total storage volume (V_s) = 800 cu.ft. Using a design storm interval of three days (72 hours), the drawdown rate (Q_r) is calculated below in **Equation 2**:

In this example, the captured rain must be drained within 3 days or at a minimum rate of 1.4 gpm for the tank to be emptied for the next storm.

Different municipalities, state and local governments have various design requirements for capturing and reuse of stormwater runoff. These requirements range from where stormwater may be captured and used to length of time stormwater can be held in a cistern, to the type of water treatment required before reuse. Designers should check with the governing administrative authority to determine parameters which will affect collection, use, and distribution of captured stormwater.

Calculations

There are two compliance paths for this credit—one for largely undeveloped sites and one for largely developed sites.

Option 1—Existing Imperviousness Is Less Than Or Equal To 50% (Largely Undeveloped Sites)

Option 1-a: Discharge Rate and Quantity

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity and duration. Calculate

Equation 1

$$V_r = \frac{(P)(R_v)(A)}{12'} = \frac{(1')(0.95)(10{,}000\ SF)}{12'} = 791.67\ CF\ (5{,}922\ gal)$$

Where, $R_v = 0.05 + (0.009)(I) = 0.05 + (0.009)(100) = 0.95$
R_v = Volumetric Runoff Coefficient
I = Percent Imperviousness

Equation Source: 2000 Maryland Stormwater Design Manual, Vol. I & II (MDE, 2000)

Equation 2

$$Q_r = \frac{800 c.f.}{259{,}200\ sec} = 0.003\ cfs\ or\ 1.37\ gpm$$

rate and quantity for the one-year and two-year, 24-hour design storms.

Determine the post-development discharge rate and quantity for the project consistent with the pre-development calculations. The post-development rate AND quantity must be equal to or less than the pre-development values to earn this credit.

Option 1-b: Stream Channel Protection

Describe the project site conditions, the measures taken, and controls implemented as part of the project scope that prevent excessive stream velocities and the associated erosion. Include in the description numerical values for pre-development and post-development conditions to demonstrate that the rate and quantity of stormwater runoff in the post-development condition are below critical values for the relevant receiving waterways.

Option 2—Existing Imperviousness Is Greater Than 50% (Largely Developed Sites)

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate rate and quantity for the one-year and two-year, 24-hour design storms.

Determine the post-development discharge rate and quantity for the project consistent with the pre-development calculations. The post-development rate AND quantity must be at least 25% less than the pre-development values to earn this credit.

Exemplary Performance

There is no exemplary performance point available for this credit.

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:

Option 1

- ❑ Provide the pre-development site runoff rate (cfs).
- ❑ Provide the pre-development site runoff quantity (cf).
- ❑ Provide the post-development site runoff rate (cfs).
- ❑ Provide the post-development site runoff quantity (cf).

OR

- ❑ Provide a narrative describing the project site conditions, measures taken, and controls implemented to prevent excessive stream velocities and associated erosion.

Figure 1 (Source Figure 1.4), excerpted from the Maryland Stormwater Design Manual, diagrams the potential increases in critical discharge rate from development.

Option 2

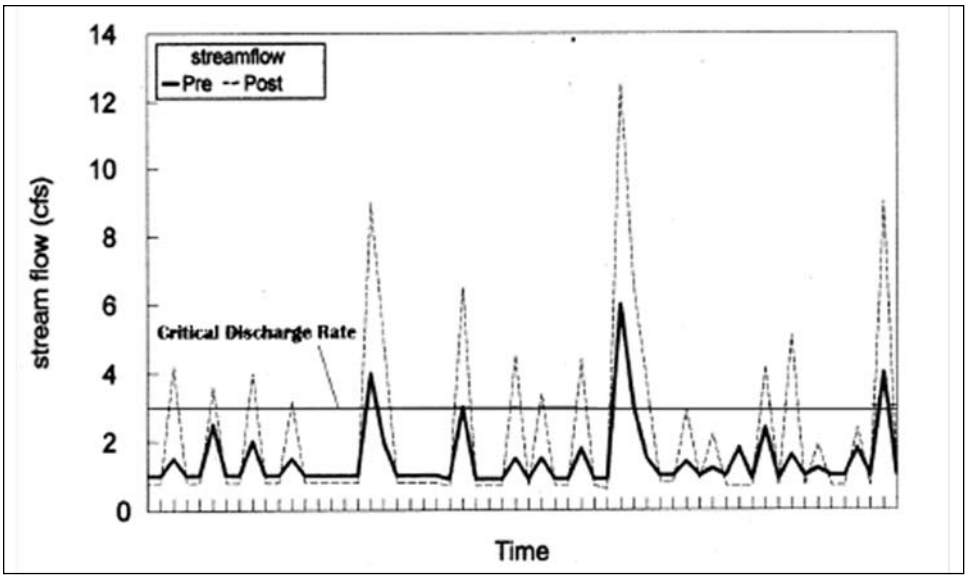
- ❑ Provide the pre-development site runoff rate (cfs).
- ❑ Provide the pre-development site runoff quantity (cf).
- ❑ Provide the post-development site runoff rate (cfs).
- ❑ Provide the post-development site runoff quantity (cf).

Considerations

Environmental Issues

The intent of this credit is to limit the disruption of the natural stormwater flows that results from development. Undevel-

Figure 1: Increased Frequency of Flows Greater than the Critical Discharge Rate in a Stream Channel after Development



oped land has a certain capacity to absorb rainfall in the soils, vegetation and trees. Clearing of vegetation and/or construction of impervious surfaces (i.e., roads, parking lots and buildings) reduce the capacity of the land to absorb rainfall and increase the amount of stormwater runoff.

As areas are constructed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff volumes that are transported via urban infrastructure (e.g., gutters, pipes and sewers) to receiving waters. These stormwater volumes contain sediment and other contaminants that have a negative impact on water quality, navigation and recreation. Furthermore, conveyance and treatment of stormwater volumes requires significant municipal infrastructure and maintenance. Reducing the generation of stormwater volumes helps maintain the natural aquifer recharge cycle and assist in restoring depleted stream base flows. In addition, stormwater volumes do not have to be conveyed to receiving waters by the municipality, and receiving waters are not impacted.

The geometry and health of streams is closely linked to stormwater runoff velocities and volumes. Increases in the frequency and magnitude of stormwater runoff due to development can cause increased bankfull events. As a result, the stream bed and banks are exposed to highly erosive flows more frequently and for longer periods. The resultant impacts may include channel-widening or downcutting or both.

Figures 2 and 3 (Source Figures 1.1 and 1.2), excerpted from the Maryland Stormwater Design Manual show the impact of development of stormwater flows and the increase in the volumetric runoff coefficient as a function of site imperviousness.

Economic Issues

If natural drainage systems are designed and implemented at the beginning of site planning, they can be integrated economically into the overall development. Water detention and retention features require cost for design, installation and maintenance. However, these features can also add significant value as site amenities if planned early in the design. Smaller stormwater collection and treatment systems lessen the burden on municipalities for maintenance and repair, resulting in a more affordable and stable tax base.

Figure 2: Water Balance at a Developed and Undeveloped Site (Source: Schueler, 1987)

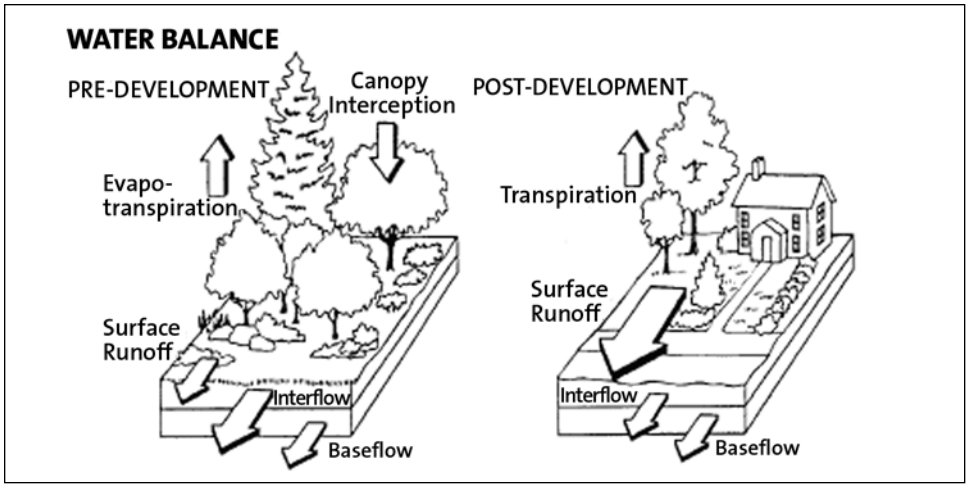
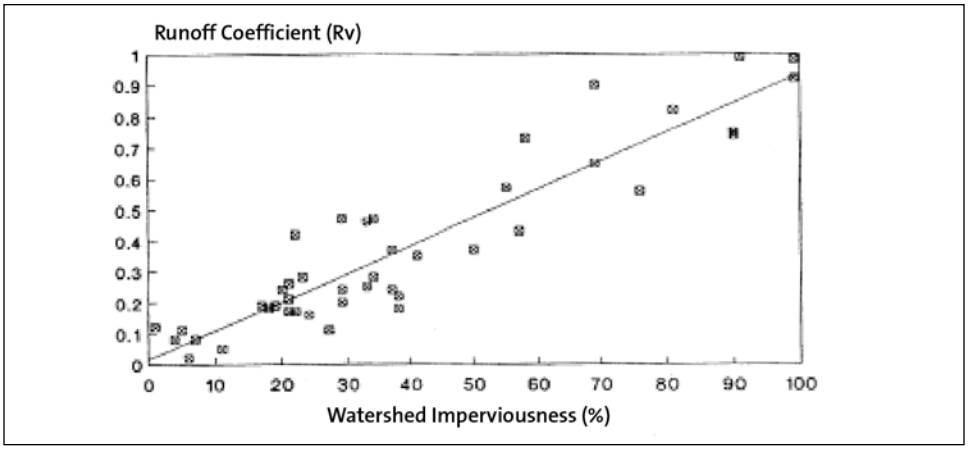


Figure 3: Relationship Between Impervious Cover and the Volumetric Runoff Coefficient (Source: Schueler, 1987)



Synergies and Trade-Offs

Stormwater runoff is affected significantly by site topography, site design, and especially quantity of impervious surface area to support transportation amenity design. It may be possible to reuse stormwater for non-potable water purposes such as flushing urinals and toilets, custodial applications, and building equipment uses. It is helpful to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes can also be reduced by designing the building with underground parking, a strategy that also reduces heat island effects. Pervious paving systems usually have a limit on transportation loads and may pose problems for wheelchair accessibility and stroller mobility. If stormwater volumes are treated on site, additional site area may need to be disturbed to construct treatment ponds or underground facilities. Application of green roofs reduces stormwater volumes that may be intended for collection and reuse for non-potable applications.

Resources

Web Sites

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

Stormwater Best Management Practice Design Guide, EPA/600/R-04/121A, September 2004.

www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121a.pdf

Maryland Stormwater Design Manual

www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Definitions

Impervious Surfaces promote runoff of precipitation volumes instead of infiltration into the subsurface. The imperviousness or degree of runoff potential can be estimated for different surface materials.

Stormwater Runoff consists of water volumes that are created during precipitation events and flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater runoff volumes.

SS	WE	EA	MR	EQ	ID
Credit 6.1					

Stormwater Design

Quality Control

SS	WE	EA	MR	EQ	ID
Credit 6.2					

1 Point

Intent

Reduce or eliminate water pollution by reducing impervious cover, increasing on-site infiltration, eliminating sources of contaminants, and removing pollutants from stormwater runoff.

Requirements

Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall[1] using acceptable best management practices (BMPs).

BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

Potential Technologies & Strategies

Use alternative surfaces (e.g., vegetated roofs, pervious pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration, thereby reducing pollutant loadings.

Use sustainable design strategies (e.g., Low Impact Development, Environmentally Sensitive Design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff.

Summary of Referenced Standard

Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters, January 1993 (Document No. EPA 840B92002)

Internet location: www.epa.gov/owow/nps/MMGI

Hardcopy or microfiche (entire document, 836 pages): National Technical Information Service (order # PB93-234672): www.ntis.gov, (800) 553-6847

U.S. Environmental Protection Agency Office of Water: www.epa.gov/OW

This document discusses a variety of management practices that can be incorporated to remove pollutants from stormwater volumes. Chapter 4, Part II addresses urban runoff and suggests a variety of strategies for treating and infiltrating stormwater volumes after construction is completed. See the Resources section later in this credit for a summary of best management practices listed in the EPA document.

Approach and Implementation

This credit may be achieved using either non-structural or structural stormwater management measures or a combination of the two.

Non-Structural Measures

Non-structural strategies, such as vegetated swales, disconnection of impervious areas, and pervious pavement, can be used to promote infiltration and limit runoff. In these cases, you are "capturing and treating" runoff by allowing it to naturally filter into the soil and vegetation. Pollutants are broken down by microorganisms in the soil and plants.

Structural Measures

Structural measures, such as rainwater cisterns, manhole treatment devices and ponds can be used to remove pollutants from runoff from impervious areas and sometimes reuse the water for irrigation or building flush fixtures.

Non-structural measures are often preferred because they may be less costly to construct and maintain and they help recharge groundwater supplies.

Structural measures are preferred on urban or constrained sites and make it possible to effectively clean the runoff with minimal space allocation and land use. For existing sites with greater than 50% imperviousness, structural techniques may include restoration and repair of deteriorated storm sewers, or separation of combined sewers.

The most effective method to minimize stormwater runoff volume and treatment requirements is to reduce the amount of impervious area. Strategies to minimize or mitigate impervious surfaces may include:

- ❑ Smaller building footprint
- ❑ Pervious paving materials
- ❑ Stormwater harvesting for reuse in irrigation and/or buildings
- ❑ Green roofs
- ❑ Bioswales/vegetated filter strips
- ❑ Retention ponds
- ❑ Clustering development to reduce paved surfaces (roads, sidewalks, etc.)

Calculations

As part of the stormwater management plan process, describe the Best Management Practices (BMPs) employed to capture and/or treat stormwater runoff. Describe how each measure contributes to reducing imperviousness and/or increasing infiltration. Describe how each measure is sized to capture and/or treat 90% of the annual rainfall volume.

Determine the annual rainfall using the following guidelines:

Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from:

1. Humid Watersheds – 1 inch of rainfall;
2. Semi-arid Watersheds – 0.75 inches of rainfall; and
3. Arid Watersheds – 0.5 inches of rainfall.

Where non-structural controls involving infiltration are employed, determine the soil type(s) and associated infiltration rates. Confirm that the soils have the capacity to infiltrate water at a rate and quantity sufficient to absorb at least 90% of the annual rainfall volume.

Where structural controls are used, confirm that the equipment has the capacity to treat at least 90% of the annual rainfall volume. If individual measures are designed to handle less than 90% of the annual rainfall volume, describe how the measures work together to satisfy the requirement.

Water that is infiltrated on-site is assumed to be 100% treated for the purposes of this credit.

Stormwater control measures (or BMPs) that discharge water off-site must meet the following criteria (repeated from the credit requirement):

1. Achieve 80% total suspended solids (TSS) removal.

AND

2. Be designed in accordance with standards and specifications from a state or local program that has adopted these performance standards.

   OR

   Be supported by in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology)for BMP monitoring.

Exemplary Performance

There is no exemplary performance point available for this credit.

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:

Non-Structural Controls

❑ Provide list of Best Management Practices (BMPs), including a description of the function of each BMP and the percent annual rainfall treated.

Structural Controls

❑ Provide list of structural controls, including a description of the pollutant removal of each control and the percent annual rainfall treated.

AND

❑ Provide an optional narrative describing any special circumstances or considerations regarding the approach to the credit.

Considerations

Environmental Issues

As areas are constructed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff volumes that are transported via urban infrastructure (e.g., gutters, pipes and sewers) to receiving

waters. These stormwater volumes contain sediment and other contaminants that have a negative impact on water quality, navigation and recreation. Furthermore, conveyance and treatment of stormwater volumes requires significant municipal infrastructure and maintenance.

Stormwater pollution sources include atmospheric deposition, vehicle fluid leaks, and mechanical equipment wastes. During storm events, these pollutants are washed away and discharged to downstream waters.

Synergies and Trade-Offs

Stormwater runoff is affected significantly by site selection and site design. It may be possible to reuse stormwater for non-potable water purposes such as flushing urinals and toilets, custodial applications, and building equipment uses. It is helpful to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes can also be reduced by consolidating the building footprint and designing the building with underground parking, a strategy that also reduces heat island effects. Pervious paving systems usually have a limit on transportation loads and may pose problems for wheelchair accessibility and stroller mobility. If stormwater volumes are treated on site, additional site area may need to be disturbed to construct treatment ponds or underground facilities. Application of green roofs reduces stormwater volumes that may be intended for collection and reuse for non-potable applications.

Resources

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

Web Sites

Stormwater Best Management Practice Design Guide. EPA/600/R-04/121A. September, 2004.

www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121a.pdf

Maryland Stormwater Design Manual.

www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Technology Acceptance and Reciprocity Partnership

www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

Definitions

Total Suspended Solids (TSS) are particles or flocs that are too small or light to be removed from stormwater via gravity settling. Suspended solid concentrations are typically removed via filtration.

Case Study

Ford Rouge Visitors Center
Dearborn, MI

Owner: Ford Motor Company

Photo © Ford Photographic

In 2003, the Ford Rouge Visitors Center was awarded LEED® v2.1 Gold. The project demonstrated exceptional stormwater management practices, attaining both SS Credits 6.1 and 6.2. In times of rain and snow, sedum plants on the project's green roof capture and cleanse runoff before it returns to the natural watershed, thus preventing contaminated runoff from harming nearby rivers and lakes. Stormwater runoff that is not soaked up by the green roof is collected in stone basins under a porous paving parking lot, then filtered through natural wetlands and bioswales located around the site. The project's natural stormwater management system is potentially much cheaper than installing and operating a traditional stormwater treatment plant.

SS	WE	EA	MR	EQ	ID
Credit 6.2					

Heat Island Effect

Non-Roof

SS	WE	EA	MR	EQ	ID
Credit 7.1					

1 Point

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

OPTION 1

Provide any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots):

- ❑ Shade (within 5 years of occupancy)
- ❑ Paving materials with a Solar Reflectance Index (SRI)[2] of at least 29
- ❑ Open grid pavement system

OR

OPTION 2

Place a minimum of 50% of parking spaces under cover (defined as underground, under deck, under roof, or under a building). Any roof used to shade or cover parking must have an SRI of at least 29.

Potential Technologies & Strategies

Shade constructed surfaces on the site with landscape features and utilize high-reflectance materials for hardscape. Consider replacing constructed surfaces (i.e., roof, roads, sidewalks, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specify high-albedo materials to reduce the heat absorption.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Limit the amount of impervious hardscape areas on the site in order to limit heat island effect. For features such as parking lots, roads and walkways, use open grid pavement systems that are at least 50% pervious, which remain cooler due to reduction of impervious surface area and increased evaporation from the open cell vegetation. Use light colored paving surfaces, and shade paved areas with landscaping. Utilize a parking deck to reduce parking footprint by 50%.

Darker paving materials, such as asphalt, generally exhibit low reflectance and consequently low SRI values. Grey or white concrete has a higher reflectance and a higher SRI. Concrete made with white cement may cost up to twice as much as that made with gray cement. Some blended cements (e.g., slag cements) are very light in color and cost the same or slightly less than portland-only based gray cement (Source: "Albedo: A Measure of Pavement Surface Reflectance," R&T Update #3.05, June 2002, American Concrete Pavement Association, http://www.pavement.com/Downloads/RT/RT3.05.pdf). Micro surfaces and coatings over asphalt pavement can be used to attain the required SRI value for this credit. Coatings and integral colorants can be used in cementitious pavers or cast-in-place parking surfaces to improve solar reflectance.

Vegetation can shade buildings and pavements from solar radiation and cool the air through evapotranspiration. Provide shade using native or adaptive trees, large shrubs and non-invasive vines. Trellises and other exterior structures can support vegetation to shade parking lots, walkways and plazas. Deciduous trees allow buildings to benefit from solar heat gain during the winter months. On-site locations where tree planting is not possible, use architectural shading devices to block direct sunlight radiance.

Alternatively, place parking under cover. This can include using multi-story or subterranean parking structures, or placing parking under a shade structure. Parking cover must also meet the same SRI requirements as non-roof impervious surfaces.

Calculations

Option 1

1. Identify all non-roof hardscape surfaces on the project site and sum the total area (T).
2. Identify all of the hardscape surfaces that have an open grid paving system that are at least 50% pervious and sum the total area (O).
3. Identify all of the hardscape features that have an SRI of at least 29 and sum the total area (R).

   SRI is calculated using the LEED Submittal Template by inserting both emissivity and reflectance values into the worksheet and pressing "Click to Calculate SRI". Emittance is calculated according to ASTM E 408 or ASTM C 1371 and Reflectance is calculated according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Alternatively, **Table 1** provides a list of SRI values for typical paving materials; where these materials are used, the SRI values from this table may be used in lieu of obtaining specific Emissivity and Reflectance measurements.
4. Identify all of the hardscape features that will be shaded by trees or other landscape features. Shade coverage shall be calculated at 10 a.m., 12 noon, and 3 p.m. on the summer solstice.

Table 1: Solar Reflectance Index (SRI) for Standard Paving Materials

Material	Emissivity	Reflectance	SRI
Typical New Gray Concrete	0.9	0.35	35
Typical Weathered* Gray Concrete	0.9	0.20	19
Typical New White Concrete	0.9	0.7	86
Typical Weathered* White Concrete	0.9	0.4	45
New Asphalt	0.9	.05	0
Weathered Asphalt	0.9	.10	6

* Reflectance of surfaces can be maintained with cleaning. Typical pressure washing of cementious materials can restore reflectance close to original value. Weathered values are based on no cleaning.

Equation 1

$Q = (O + R + S)$

Equation 2

$Q > T/2$

The arithmetic mean of these three values will be used as the effective shaded area. Calculate the effective shaded area (S).

5. Sum the open space paving, high reflectance paving and shaded areas to get the qualifying area (Q) (See **Equation 1**.)

   (Note that each surface should be counted only once. For example, a 10 square foot area that is 55% pervious, has an SRI of 30 and is shaded by a tree contributes only 10 square feet to the total.)

6. The total qualifying area must be greater than or equal to 50% of the total hardscape area (T), as in **Equation 2**.

Option 2

1. Calculate the total number of parking spaces for the project.
2. Calculate the number of parking spaces that are under cover (including underground, under the building, and under shade structures. This number must equal at least 50% of the total number of parking spaces.

Exemplary Performance

Projects may be awarded an innovation point for exemplary performance by demonstrating that either, 1) 100% of non-roof impervious surfaces have been constructed with high-albedo materials and/or open grid paving and/or will be shaded within five years; OR 2) 100% of the on-site parking spaces have been located under cover.

Submittal Documentation

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

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

- ❑ Provide project site drawings, highlighting the location of specific paving materials, landscape shading, and/or underground or covered parking.

AND

Option 1

Provide the following data in the submittal template:

- ❑ The measured reflectance and emittance of each paving material installed on-site (to calculate the SRI—OR—the actual SRI for each paving material installed on-site—OR—the default SRI value for typical materials from **Table 1**.
- ❑ Total area of site hardscape
- ❑ Total area of hardscape to be shaded within 5 years

- ❑ Total area of installed SRI compliant hardscape materials
- ❑ Total area of open grid pavement

OR

Option 2

- ❑ Total number of parking spaces provided on-site
- ❑ Total number of covered parking spaces on-site

AND (For Either Compliance Option)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.
- ❑ Confirm that the roof material covering (or shading) the parking has an SRI of at least 29.

Considerations

Environmental Issues

As the built environment grows and replaces natural settings, it also relinquishes associated ecological services. Vegetation cools the area surrounding it via shade and evapotranspiration. The use of dark, non-reflective surfaces for parking, roofs, walkways and other surfaces contributes to heat island effects created when radiation from the sun is absorbed and transferred through convection and conduction back to surrounding areas. As a result of heat island effects, ambient temperatures in urban areas can be artificially elevated by more than 10°F when compared with surrounding suburban and undeveloped areas. This results in increased cooling loads in the summer, requiring larger HVAC equipment and electrical demand resulting in more greenhouse gas and pollution generation, and increased energy consumption for building operations. Heat island effects can be mitigated through the application of shading and the use of materials that reflect the sun's heat instead of absorbing it.

Heat island effects are detrimental to site habitat, wildlife and migration corridors. Plants and animals are sensitive to higher temperatures and may not thrive in areas that are increasingly hot. Reduction of heat island effect minimizes disturbance of local microclimates. This can reduce summer cooling loads that in turn reduce energy use, greenhouse gas and pollution generation, and infrastructure requirements.

Higher reflectance pavements do increase overall light levels and may allow the designer to use fewer fixtures. Designers should weigh the benefits of using highly reflective pavements to reduce heat island effect against possible energy savings from reduced site lighting requirements. Lighting evaluations should include the evaluation of the inter-reflected component, and reflections off of high reflectance materials, such as white concrete, which can result in glare and cause disabled vision and increased light pollution. Steps should be taken to minimize the amount of light that is directed from site lighting fixtures directly down onto reflective paving surfaces.

Economic Issues

According to the EPA, about $40 billion is spent annually in the United States to air-condition buildings—one-sixth of all electricity generated in a year. Reduction in heat islands lowers the cost of cooling and HVAC equipment needs. Energy to cool buildings is a substantial cost over a building's lifetime. Higher initial costs may result from installation of additional trees and architectural shading devices. However, these items have an acceptable payback when integrated into a whole systems approach that maximizes energy savings.

Resources

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

Web Sites

American Concrete Pavement Association

www.pavement.com

(847) 966-2272

National association representing concrete pavement contractors, cement companies, equipment and material manufacturers, and suppliers. See the R&T Update #3.05, June 2002, "Albedo: A measure of Pavement Surface Reflectance" (http://www.pavement.com/Downloads/RT/RT3.05.pdf).

Heat Island Group

Lawrence Berkeley National Laboratory

http://eetd.lbl.gov/HeatIsland/

LBL conducts heat island research to find, analyze, and implement solutions to minimizing heat island effect, with current research efforts focusing on the study and development of more reflective surfaces for roadways and buildings.

Heat Island Effect

U.S. Environmental Protection Agency

www.epa.gov/heatisland

(202) 343-9343

Basic information about heat island effect, its social and environmental costs, and strategies to minimize its prevalence.

Definitions

Albedo is synonymous with solar reflectance.

Emissivity is the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature.

Heat Island Effects occur when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces that contribute to the heat island effect include streets, sidewalks, parking lots and buildings.

Infrared Emittance is a parameter between 0 and 1 that indicates the ability of a material to shed infrared radiation. The wavelength of this radiant energy is roughly 5 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Non-Roof Impervious Surfaces include all surfaces on the site with a perviousness of less than 50%, not including the roof of the building. Examples of typically impervious surfaces include parking lots, roads, sidewalks and plazas.

Open-Grid Pavement is defined for LEED purposes as pavement that is less than 50% impervious and contains vegetation in the open cells.

Perviousness is the percent of the surface area of a paving material that is open and allows moisture to pass through the material and soak into the earth below the paving system.

Solar Reflectance Index (SRI) is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90°F (50 °C) in full sun, and a standard white surface has a temperature rise of 14.6°F (8.1°C). Once the maximum temperature rise of a given material has been computed, the SRI can be computed by interpolating between the values for white and black.

Materials with the highest SRI values are the coolest choices for paving. Due to

the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database)

Underground Parking is a "tuck-under" or stacked parking structure that reduces the exposed parking surface area.

SS	WE	EA	MR	EQ	ID
Credit 7.2					

1 Point

Heat Island Effect

Roof

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

OPTION 1

Use roofing materials having a Solar Reflectance Index (SRI)[3] equal to or greater than the values in the table below for a minimum of 75% of the roof surface.

OR

OPTION 2

Install a vegetated roof for at least 50% of the roof area.

OR

OPTION 3

Install high albedo and vegetated roof surfaces that, in combination, meet the following criteria:

(Area of SRI Roof / 0.75) + (Area of Vegetated Roof / 0.5) >= Total Roof Area

Roof Type	Slope	SRI
Low-Sloped Roof	≤ 2:12	78
Steep-Sloped Roof	> 2:12	29

Potential Technologies & Strategies

Consider installing high-albedo and vegetated roofs to reduce heat absorption. SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Summary of Referenced Standards

ASTM Standard E1980-01—Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

This standard describes how surface reflectivity and emissivity are combined to calculate a Solar Reflectance Index (SRI) for a roofing material or other surface. The standard also describes a laboratory and field testing protocol that can be used to determine SRI.

ASTM E408-71(1996)e1—Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

www.astm.org

(610) 832-9585

This standard describes how to measure total normal emittance of surfaces using a portable inspection-meter instrument. The test methods are intended for large surfaces where non-destructive testing is required. See the standard for testing steps and a discussion of thermal emittance theory.

ASTM E903-96—Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

www.astm.org

(610) 832-9585

Referenced in the ENERGY STAR® roofing standard, this test method uses spectrophotometers and need only be applied for initial reflectance measurement. Methods of computing solar-weighted properties from the measured spectral values are specified. This test method is applicable to materials having both specular and diffuse optical properties. Except for transmitting sheet materials that are inhomogeneous, patterned, or corrugated, this test method is preferred over Test Method E1084. The ENERGY STAR roofing standard also allows the use of reflectometers to measure solar reflectance of roofing materials. See the roofing standard for more details.

ASTM E1918-97—Standard Test Method for Measuring Solar Reflectance of Horizontal And Low-Sloped Surfaces in the Field

www.astm.org

(610) 832-9585

This test method covers the measurements of solar reflectance of various horizontal and low-sloped surfaces and materials in the field, using a pyranometer. The test method is intended for use when the sun angle to the normal from a surface is less than 45 degrees.

ASTM C1371-04—Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

www.astm.org

(610) 832-9585

This test method covers a technique for determination of the emittance of typical materials using a portable differential thermopile emissometer. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque, highly thermally conductive materials near room temperature as a parameter in evaluating temperatures, heat flow, and derived thermal resistances of materials.

ASTM C1549-04—Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

www.astm.org

(610) 832-9585

This test method covers a technique for determining the solar reflectance of flat opaque materials in a laboratory or in the field using a commercial portable solar

reflectometer. The purpose of the test method is to provide solar reflectance data required to evaluate temperature and heat flows across surfaces exposed to solar radiation.

Approach and Implementation

To maximize energy savings and minimize heat island effects, materials must exhibit a high reflectivity and a high emissivity over the life of the product. Since multiple testing methods are available for measuring emissivity and reflectance, check manufacturer literature carefully to ensure use of appropriate data. For example, some manufacturers measure visible reflectance, which differs from the solar reflectance measurement referenced in this credit. Visible reflectance correlates to solar reflectance but the two quantities are not equal because solar gain covers a wider range of wavelengths than visible light. A material that exhibits a high visible reflectance usually has a lower solar reflectance. Typically, white roof products exhibit higher performance characteristics than non-white products. Performance varies by roofing materials as well as brand. Check with roofing manufacturers and the Lawrence Berkeley National Laboratory's Cool Roofing Materials Database (http://eetd.lbl.gov/CoolRoofs) for specific information. **Table 1** provides example SRI values for typical roof surfaces. These values are for reference only and are not for use as substitutes for actual manufacturer data. Individual products may perform better. Reflectance and emittance data for manufacturers are available from the Cool Roof Rating Council Web site, www.coolroofs.org. Note that the infrared emittance of aggregates and cementitious materials is always 0.9.

Green roofs are vegetated surfaces that reduce heat island effect by replacing heat-absorbing surfaces with plants, shrubs and small trees that cool the air through evapotranspiration (or evaporation of water from leaves). Green roofs provide insulating benefits, aesthetic appeal, and lower maintenance than standard roofs. Some green roofs require plant maintenance and are considered active gardens, while other gardens have grasses and plants that require no maintenance or watering. All types of green roofs require

Table 1: Solar Reflectance Index (SRI) for Typical Roofing Materials

Example SRI Values for Generic Roofing Materials	Solar Reflectance	Infrared Emittance	Temperature Rise	Solar Reflectance Index (SRI)
Gray EPDM	0.23	0.87	68F	21
Gray Asphalt Shingle	0.22	0.91	67F	22
Unpainted Cement Tile	0.25	0.9	65F	25
White Granular Surface Bitumen	0.26	0.92	63F	28
Red Clay Tile	0.33	0.9	58F	36
Light Gravel on Built-Up Roof	0.34	0.9	57F	37
Aluminum Coating	0.61	0.25	48F	50
White-Coated Gravel on Built-Up Roof	0.65	0.9	28F	79
White Coating on Metal Roof	0.67	0.85	28F	82
White EPDM	0.69	0.87	25F	84
White Cement Tile	0.73	0.9	21F	90
White Coating - 1 Coat, 8 mils	0.8	0.91	14F	100
PVC White	0.83	0.92	11F	104
White Coating - 2 Coats, 20 mils	0.85	0.91	9F	107

Source: LBNL Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data. Individual products may perform better.

semiannual inspection but have longer lifetimes than conventional roofs.

Calculations

1. Calculate the total roof surface area of the project. Deduct areas with equipment, solar energy panels, and appurtenances.
2. Determine the roof surface area that meets the applicable SRI criteria and/or the area that is covered by green roof.
3. Determine whether the areas of cool roof and green roof meet the credit requirement, using **Equation 1**.

   Note: a weighted average calculation may be performed for buildings with multiple roof surfaces to demonstrate that the total roof area has an average SRI that meets the credit requirements.

Exemplary Performance

This credit may be eligible for exemplary performance under the Innovation & Design section if 100% of the project's roof area (excluding mechanical equipment, photovoltaic panels, and skylights) is comprised of a green roof system.

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:

❑ Provide copies of the project's roof drawings to highlight the location of specific roof materials and/or green roof systems.

AND

Option 1

❑ Total area of installed SRI compliant roofing materials

❑ Provide a listing of installed roofing materials and their SRI values

OR

Option 2

❑ Total area of installed green roof systems

OR

Option 3

❑ Total area of installed green roof systems

❑ Total area of installed SRI compliant roofing materials

❑ Provide a listing of installed roofing materials and their SRI values

AND

❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The heat island effect raises the localized temperature, impacting local microclimate. Plants and animals that are sensitive to large fluctuations in daytime and nighttime temperatures may not thrive in areas affected by heat islands. Heat islands also exacerbate air pollution for two reasons. First, smog is produced faster at higher temperatures. Secondly, rising temperatures lead to increased cooling requirements, requiring energy and causing associated emissions.

Equation 1

(Area of SRI Roof / 0.75) + (Area of vegetated roof / 0.5) >= Total Roof Area

Garden roofs reduce stormwater volumes that may be collected and used for nonpotable purposes. Stormwater runoff volumes from garden roofs depend on the local climate, depth of soil, plant types, and other variables. However, all garden roofs decrease runoff volumes substantially.

Economic Issues

Green roofs or roofs with high Solar Reflectance Indexes reduce costs associated with cooling and HVAC equipment. Green roofs typically require an additional up-front investment, while cool roofs may or may not cost more than other roofs. However, any up-front investment is likely to result in energy cost savings throughout the lifecycle of the project. In addition, an increasing number of localities are beginning to require the use of cool roofs on new building projects.

Buildings in very cold climates may not experience year-round energy benefits from reflective roofing due to high emittance and low absorption, which may increase heating costs. However, increasing the reflectance of a roof reduces annual cooling energy use in almost all climates.

Resources

Web Sites

Cool Roof Rating Council

www.coolroofs.org

A nonprofit organization dedicated to implementing and communicating fair, accurate, and credible radiative energy performance rating systems for roof surfaces, supporting research into energy-related radiative properties of roofing surfaces, including durability of those properties, and providing education and objective support to parties interested in understanding and comparing various roofing options.

EPA ENERGY STAR® Roofing Products

www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products

This site provides solar reflectance levels required to meet ENERGY STAR labeling requirements.

Extensive Green Roofs

http://www.wbdg.org/design/greenroofs.php

This Whole Building Design Guide article by Charlie Miller, PE details the features and benefits of constructing green roofs.

Greenroofs.com

www.greenroofs.com

The green roof industry resource portal offers basic information, product and service directory, and research links.

Lawrence Berkeley National Laboratory Heat Island Group–Cool Roofs

http://eetd.lbl.gov/HeatIsland/CoolRoofs/

This site offers a wealth of information about cool roof research and technology, including links to the Cool Roofing Materials Database.

Penn State Center for Green Roof Research

http://hortweb.cas.psu.edu/research/greenroofcenter/

The Center has the mission of demonstrating and promoting green roof research, education and technology transfer in the Northeastern United States.

Definitions

Albedo is synonymous with solar reflectance.

Heat Island Effects occur when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces

that contribute to the heat island effect include streets, sidewalks, parking lots and buildings.

Infrared or Thermal Emittance is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 3 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9.Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Solar Reflectance (albedo) is the ratio of the reflected solar energy to the incoming solar energy over wavelengths of approximately 0.3 to 2.5 micrometers. A reflectance of 100% means that all of the energy striking a reflecting surface is reflected back into the atmosphere and none of the energy is absorbed by the surface. The best standard technique for its determination uses spectro-photometric measurements with an integrating sphere to determine the reflectance at each different wavelength. An averaging process using a standard solar spectrum then determines the average reflectance (see ASTM Standard E903).

Solar Reflectance Index (SRI) is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90°F (50°C) in full sun, and a standard white surface has a temperature rise of 14.6°F (8.1°C). Once the maximum temperature rise of a given material has been computed, the SRI can be computed by interpolating between the values for white and black.

Materials with the highest SRI values are the coolest choices for roofing. Due to the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database)

Light Pollution Reduction

SS	WE	EA	MR	EQ	ID
Credit 8					

1 Point

Intent

Minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments.

Requirements

FOR INTERIOR LIGHTING

The angle of maximum candela from each interior luminaire as located in the building shall intersect opaque building interior surfaces and not exit out through the windows.

OR

All non-emergency interior lighting shall be automatically controlled to turn off during non-business hours. Provide manual override capability for after hours use.

AND

FOR EXTERIOR LIGHTING

Only light areas as required for safety and comfort. Do not exceed 80% of the lighting power densities for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section, without amendments.

All projects shall be classified under one of the following zones, as defined in IESNA RP-33, and shall follow all of the requirements for that specific zone:

LZ1 — Dark (Park and Rural Settings)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.01 horizontal and vertical footcandles at the site boundary and beyond. Document that 0% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2 — Low (Residential Areas)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.10 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 10 feet beyond the site boundary. Document that no more than 2% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

LZ3 — Medium (Commercial/Industrial, High-Density Residential)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.20 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 5% of the total initial designed fixture

lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

LZ4 — High (Major City Centers, Entertainment Districts)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.60 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 10% of the total initial designed site lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

Potential Technologies & Strategies

Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Minimize site lighting where possible and model the site lighting using a computer model. Technologies to reduce light pollution include full cutoff luminaires, low-reflectance surfaces and low-angle spotlights.

Summary of Referenced Standard

ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential - Lighting, Section 9 (without amendments)

American Society of Heating Refrigeration and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

Standard 90.1–2004 was formulated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. Standard 90.1 establishes minimum requirements for the energy-efficient design of buildings, except low-rise residential buildings. The provisions of this standard do not apply to single-family houses, multifamily structures of three habitable stories or fewer above grade, manufactured houses (mobile and modular homes), buildings that do not use either electricity or fossil fuel, or equipment and portions of building systems that use energy primarily for industrial, manufacturing or commercial processes. The standard provides criteria in the following general categories: building envelope (section 5); heating, ventilating and air-conditioning (section 6); service water heating (section 7); power (section 8); lighting (section 9); and other equipment (section 10). Within each section, there are mandatory provisions that must always be complied with, as well as additional prescriptive requirements. Some sections also contain a performance alternate. The Energy Cost Budget option (section 11) allows the user to exceed some of the prescriptive requirements provided energy cost savings are made in other prescribed areas. However, in all cases, the mandatory provisions must still be met.

Section 9 of the Standard provides requirements for the lighting of buildings. Only the exterior lighting requirements (exterior site lighting & exterior building feature/façade lighting) apply to this credit. **Table 1** lists the ASHRAE 90.1-2004 allowable building exterior lighting power densities.

Approach and Implementation

The credit is comprised of three main compliance requirements that deal with light pollution through the control of; 1) interior building lighting; 2) exterior lighting power density; and 3) exterior light distribution.

Interior Building Lighting

Option 1

Design interior lighting to maintain the majority of direct beam illumination within the building. To accomplish this, project teams should strive to locate interior lighting fixtures in such a way that the direct beam illumination produced by the interior luminaires intersects solid/opaque building surfaces, preventing light spill through transparent and translucent surfaces to exterior areas. Manufacturer's candela plots or photometric data should be used to determine the direction of maximum luminous intensity for each fixture type. Overlay the data for each fixture type on building plans and sections to confirm that the maximum candela angle does not intersect transparent or translucent building surfaces that face exterior areas.

Option 2

An alternate compliance path requires that all non-emergency interior lighting fixtures be automatically controlled and programmed to turn off following regular business hours. Controls may be automatic sweep timers, occupancy sensors, or programmed master lighting control panels.

Table 1: ASHRAE 90.1-2004 Lighting Power Densities for Building Exteriors (Table 9.4.5)

	Applications	Lighting Power Densities
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**	
	Parking Lots and drives	**0.15**W/ft2
	Building Grounds	
	Walkways less than 10 feet wide	**1.0**W/linear foot
	Walkways 10 feet wide or greater Plaza areas Special Feature Areas	**0.2**W/ft2
	Stairways	**1.0**W/ft2
	Building Entrances and Exits	
	Main entries	**30**W/linear foot of door width
	Other doors	**20**W/linear foot of door width
	Canopies and Overhangs	
	Canopies (free standing and attached and overhangs)	**1.25W**/ft2
	Outdoor Sales	
	Open areas (including vehicle sales lots)	**.05W**/ft2
	Street frontage for vehicle sales lots in addition to "open area" allowance	**20W**/linear foot
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	**Building Facades**	**0.2**W/ft2 for each illuminated wall or surface or **5.0**W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	**270**W per location plus 90W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	**1.25**W/ft2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	**0.5W**/ft2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Drive-up windows at fast food restaurants	**400W** per drive-through
	Parking near 24-hour retail entrances	**800W** per main entry

Manual override capabilities that enable lights to be turned on for after-hours use must be included in the design.

Exterior Lighting Power Density

Design the project's exterior lighting to achieve lighting power densities that are less than the requirements set forth in ASHRAE 90.1-2004, Section 9, Table 9.4.5. Lighting for exterior areas, such as parking lots, building grounds and plazas, should be designed to achieve an overall lighting power density that is 20% below the referenced standard. Building façade and landscape feature lighting should be designed to achieve an overall

lighting power density that is 50% below the referenced standard. Projects should consider selecting efficient fixtures using efficacious sources to reduce lighting power and illumination intensity.

Exterior Light Distribution

Design the project's exterior lighting to comply with the light pollution requirements for the specific project zone. The lighting requirements address the overall site illumination level and the luminaire distribution. The exterior lighting must meet the light distribution requirements under pre-curfew conditions (prior to 10 p.m. or business closing). Curfew timers and controls can be effective components of the overall lighting strategy, and may be used to mitigate a specific, extenuating circumstances; but controls cannot be used to make otherwise non-compliant exterior areas comply with the credit.

Projects should consider the use of low intensity, shielded fixtures as well as curfew controllers to turn off non-essential site lighting after 10:00 p.m. or immediately after closing (whichever is later) to further reduce the effects of light pollution. Projects should minimize the lighting of architectural and landscape features. Where lighting is required for safety, security, egress or identification, utilize down-lighting techniques rather than up-lighting.

For example, in environments that are primarily dark (Zone LZ1), no landscape features should be illuminated, and architectural lighting should be designed only as a last resort when other strategies cannot provide the minimum amount of required lighting. In areas of high ambient brightness (Zones LZ3 & 4), some low level (subtle) lighting of features, facades or landscape areas may be appropriate in pedestrian environments or for identification and way finding in other areas where light trespass is not likely to be an issue. However, even in areas of high ambient brightness, all non-essential lighting, including landscape and architectural lighting, should be minimized or turned off after hours. If shielded, low brightness sources are used to selectively light features, they should be properly aimed so that light from the luminaires cannot be measured across project boundaries. In all cases, controls should be used wherever possible to turn off non-essential lighting after normal operating hours or in post-curfew periods. Consider at least the following strategies when designing the exterior lighted environment:

1. Employ a lighting professional to assess the project's lighting needs and provide recommendations based specifically on lighting for a sustainable design environment.
2. Carefully review and respond to any applicable lighting ordinances or by-laws that might impact the lighting design for the project site.
3. Determine the type of environmental zone that the project falls under from Wilderness Area (Zone LZ1) to High-Population City Centers (Zone LZ4). Understand the design implications of the environmental zone that best fits the project and study neighboring areas to identify potential light trespass problems.
4. Use the least amount of lighting equipment possible to achieve the goals of the project, but balance the quantity of equipment used with the need to provide for glare control and uniform lighting. In most cases, it is better to have two luminaires with lower light output and good glare control than one higher output luminaire.
5. Select all lighting equipment carefully. Any type of luminaire, whether it is full cut-off, semi-cutoff or non-cutoff, can produce excessive brightness in the form of glare. For example, horizontal lamp positions in full cutoff luminaires tend to produce much less glare than vertical lamps. Selecting high-perfor-

mance equipment of good quality is not only essential in maintaining visual quality and providing sustainable lighting, but also will quickly pay for itself in reduced maintenance costs.

6. Design exterior lighting to produce minimal upward illumination from reflected light sources. Select luminaire locations carefully to control glare and contain light within the design area. Pay special attention to luminaires that are located near the property line to ensure that minimal measurable light from these luminaires crosses the project boundary.
7. Use the minimum amount of light necessary and only light areas that require it. Design and develop a control scheme to minimize, or turn lighting off, after hours or during post-curfew periods.
8. Create a computer model of the proposed electric lighting design and simulate system performance. Use this tool to provide point by point horizontal illuminance information or an iso-footcandle contour map demonstrating that illuminance values are as required at the project boundary. Where luminaires are within 2.5 times their mounting height from the project boundary and the light levels are not zero at the boundary, light trespass is more likely to be a problem.
9. After the lighting system is constructed, it should be commissioned to ensure that it is installed and operating properly. Maintenance should be performed on the system on a regular basis to ensure that it continues to operate correctly, and that light pollution is minimized.

Calculations

Interior Building Lighting

The direction of maximum luminous intensity can be determined from the photometric data published by the manufacturer. For example, in **Table 2**, the maximum intensity of 869 candela occurs at a horizontal angle of 45 degrees and a vertical angle of 5 degrees.

Table 2: Sample Fixture Candela Table

Angle	0	22.5	45	67.5	90
0	862	862	862	862	862
5	848	847	869	860	862
10	838	837	858	848	850
15	814	815	845	840	844
20	785	790	819	818	824
25	747	754	785	786	792
30	693	704	738	751	759
35	636	652	695	712	723
40	566	589	642	669	682
45	492	524	586	622	636
50	409	454	525	566	580
55	331	385	465	509	523
60	257	315	398	439	438
65	189	247	328	327	323
70	135	188	235	224	210
75	85	127	142	119	106
80	44	64	61	40	33
85	15	15	11	13	13
90	0	0	0	0	0

This direction is then traced from each luminaire position (where this fixture type is used) to determine if this particular light ray will directly reach any exterior areas.

Exterior Lighting Power Density

Calculate the lighting power density (LPD) for the project's exterior lighting fixtures using the fixture wattage (lamp & ballast) provided by the manufacturer. Separate the exterior fixtures into two categories: 1) Exterior Areas—includes parking, walkway, plaza, and other outdoor area lighting; and 2) Facades/Landscape Areas—includes any vertical surface illumination (façade/signage) and any accent or landscape lighting. **Calculation 1** provides an example of the calculation methodology.

After calculating the LPDs for the project, determine if the lighting design complies with the requirements for LPD reduction.

Exterior Light Trespass

In order to measure compliance with the light trespass requirements, projects should utilize lighting design software to develop a site illumination model. The model should show the full extents of the site and all installed exterior lighting fixtures. A horizontal calculation grid should be set up to measure the site illumination at the ground plane and vertical calculation grid should be set at the property boundary and at the extents of the LZ requirements (10 feet beyond the site boundary for LZ2 and 15 feet beyond the site boundary for LZ3/LZ4) to measure vertical illumination. The calculation grid spacing should be a maximum of 10' x 10' and should exclude building interior areas. Additionally, teams should utilize the model to determine maximum and minimum illumination levels and the overall site uniformity (max/min ratio).

Utilizing manufacturers' fixture data, determine the initial lamp lumens for each luminaire. Additionally, from photometric data, determine the number of initial lamp lumens that are emitted at or above 90 degrees from nadir. Enter this data into **Table 3** to determine the percentage of lumens at or above 90 degrees. This number must be less than or equal to the value referenced for the selected site LZ.

Calculation 1: Sample Exterior Lighting Power Density Calculation

Site Lighting Power Density Calculation						
Site Lighting						
Fixture	**Fixture Power (Watts)**	**Total Fixtures (Qty)**	**Total Fixture Power (Watts)**	**Site Location**	**Site Area (SF)**	**LPD (W/SF)**
Pole Fixture 1	250	14	3,500	Parking 1	32,000	0.11
Pole Fixture 1	250	8	2,000	Parking 2	18,000	0.11
Pole Fixture 2	115	1	115	Walkways 1	875	0.13
Bollard Fixture 1	40	4	160	Walkways 1	875	0.18
Bollard Fixture 1	40	6	240	Courtyard 1	1,500	0.16
Wall Washer 1	50	5	250	Building Facade N	2,500	0.10
Site Areas						
Identification	**Area (SF)**	**ASHRAE 90.1.2004 Allowable LPD (W/SF)**	**Actual LPD (From Site Lighting Table)**	**Actual LPD Reduction (%)**	**Required LPD Reduction (%)**	**Complies (Yes/No)**
Parking 1	32,000	0.25	0.11	27%	20%	YES
Parking 2	18,000	0.15	0.11	26%	20%	YES
Walkways 1 (10' wide)	875	0.2	0.16	21%	20%	YES
Courtyard 1	1,500	0.2	0.16	20%	20%	YES
Building Facade N	2,500	0.2	0.10	50%	50%	YES

Table 3: Lamp Lumen Calculation

Luminaire Type	Quantity of Installed Luminaires	Initial Fixture Lumens per Luminaire	Total Fixture Lumens (column 2 x column 3)	Initial Fixture Lumens from Luminaire above 90 Degrees (from nadir-straight down)	Total Fixture Lumens above 90 Degrees (column 2 x column 5)
A	10	4,600	46,000	100	1,000
B	20	11,900	238,000	0	0
C	5	2,000	10,000	2,000	10,000
Total			**294,000**		**11,000**

Note: luminaires without photometric distribution shall be assumed to have 100% of its initial lamp lumens at or above 90 degrees. Luminaires with limited adjustability shall be assumed to have maximum tilt applied and lumens at or above 90 degrees shall be calculated from maximum tilted orientation. Luminaires with full range of adjustability (those that can be aimed above 90 degrees from nadir) shall be assumed to have 100% of the emitted fixture lumens at or above 90 degrees.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation & Design section.

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:

- ❑ Provide copies of the project lighting drawings (interior and site) to document the location and type of fixtures installed. Interior drawings should clearly show exterior building surfaces to confirm that the maximum candela from interior fixtures does not intersect transparent or translucent building surfaces.
- ❑ Provide confirmation that the interior lighting design has been evaluated to ensure that the maximum candela from each interior luminaire intersects opaque interior surfaces and does not exit through windows, OR, that automatic controls have been installed to turn off interior lighting during non-occupied hours.

AND

For Projects With No Exterior Lighting

- ❑ Confirm that no exterior lighting has been installed.

For Projects With Exterior Lighting

- ❑ Complete the Lighting Power Density tables on the Submittal Template for both exterior site lighting and façade/landscape lighting. The following data will be required to complete the template: location and ID of each installed exterior luminaire; site area (sq.ft.) to be illuminated by the luminaire(s); installed LPD; and ASHRAE-allowable LPD.
- ❑ Confirm the site zone classification for the project.
- ❑ Complete the Site Lumen Calculation on the submittal template. The following data will be required to complete the template: luminaire type/ID; quantity installed; initial lamp lumens per luminaire; initial lamp lumens above 90 degrees from nadir.

AND

- ❑ Provide a narrative that includes specific information regarding the light trespass analysis conducted to determine compliance. Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

Outdoor lighting is necessary for illuminating connections between buildings and support facilities such as sidewalks, parking lots, roadways and community gathering places. However, light trespass from poorly designed outdoor lighting systems can affect the nocturnal ecosystem on the site, and light pollution limits night sky access. Through thoughtful design and careful maintenance, outdoor lighting can address night sky visibility issues and site illumination requirements, while minimizing the negative impact on the environment.

Sensitively designed outdoor lighting can extend access and use of many areas into the nighttime hours. We can gain a unique appreciation for a place at night because of sensitively and creatively designed lighting systems. But any time lighting is added to an exterior environment, the potential of light pollution exists. Even with the best full cutoff luminaires and the lowest wattage lamp packages, the added light will be reflected off surfaces and into the atmosphere. Using the minimum amount of lighting equipment, limiting or eliminating all landscape lighting, and avoiding light pollution through the careful selection of lighting equipment and controls allows nocturnal life to thrive while still providing for nighttime activity.

Economic Issues

Carefully designed exterior lighting solutions can reduce infrastructure costs and energy use when compared to common practice solutions. Energy and maintenance savings over the lifetime of the project can be substantial.

Community Issues

Minimizing light pollution allows for night sky access by the surrounding community. Another key benefit is better visual comfort and improved visibility. Sensitively designed lighting systems that minimize glare and provide more uniform light at lower levels will help create aesthetically pleasing environments that are safer and more secure. A carefully designed and maintained outdoor lighting system can help a project be a non-intrusive member of the community.

Resources

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

Web Sites

American Society of Heating Refrigeration and Air-Conditioning Engineers

www.ashrae.org

ASHRAE/IESNA Standard 90.1-2004: Energy Standard for Buildings Except Low-Rise Residential

Illuminating Engineering Society of North America

www.iesna.org

This organization provides general exterior lighting design guidance and acts as a link to other IESNA outdoor lighting

California Energy Commission (CEC) - 2005 California Energy Efficiency Building Standards – Lighting Zones

www.energy.ca.gov/title24/2005standards/outdoor_lighting/2004-09-30_LIGHTING_ZONES.PDF

Provides a description of the outdoor lighting zones developed for use in the 2005 California Energy Efficiency Building Standards (Title 24).

International Dark-Sky Association

www.darksky.org/ida/ida_2/index.html

A nonprofit agency dedicated to educating and providing solutions to light pollution.

New England Light Pollution Advisory Group

http://cfa-www.harvard.edu/cfa/ps/nelpag.html

A volunteer group to educate the public on the virtues of efficient, glare-free outdoor night lighting as well as the benefits of no lighting for many outdoor applications.

Sky &Telescope

http://skytonight.com/resources/darksky

Includes facts on light pollution and its impact on astronomy, and information about purchasing light fixtures that minimize light pollution.

Print Media

Concepts in Practice Lighting: Lighting Design in Architecture by Torquil Barker, B.T. Batsford Ltd., 1997.

The Design of Lighting by Peter Tregenza and David Loe, E & FN Spon, 1998.

Definitions

Angle of Maximum Candela is the direction in which the luminaire emits the greatest luminous intensity.

Curfew Hours are locally determined times when greater lighting restrictions are imposed. When no local or regional restrictions are in place, 10:00 p.m. is regarded as a default curfew time.

Footcandle (fc) is a unit of illuminance and is equal to one lumen of light falling on a one-square foot area from a one candela light source at a distance of one foot.

Light Pollution is waste light from building sites that produces glare, is directed upward to the sky or is directed off the site.

Outdoor Lighting Zone Definitions (Developed by IDA for the Model Lighting Ordinance) provide a general description of the site environment/context and basic site lighting criteria.

Outdoor Lighting Zone Definitions

Zone	Ambient Illumination	Criteria
LZ1	Dark	For population densities of less than 200 people per square mile, according the last U.S. census. Also for developed areas in state and national parks, areas near astronomical observatories, zoos, and ANY area where residents have expressed a desire to maintain a natural nighttime environment.
LZ2	Low	For population densities of 200-3,000 people per square mile, according the last U.S. census. This would include most areas zoned "residential" and is the default zone for residential areas.
LZ3	Medium	For population densities greater than 3,000 people per square mile, according the last U.S. Census. This lighting zone is intended for high density urban neighborhoods, shopping and commercial districts and industrial parks. This is the default zone for commercial and industrial areas.
LZ4	High	This is for major city centers (with population densities greater than 100,000, according to the last U.S. Census), thematic attractions, entertainment districts and major auto sale districts.

Endnotes

[1] In the United States, there are three distinct climates that influence the nature and amount of rainfall occurring on an annual basis. Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from:

(a) Humid Watersheds – 1 inch of rainfall;

(b) Semi-arid Watersheds – 0.75 inches of rainfall; and

(c) Arid Watersheds – 0.5 inches of rainfall.

[2] The Solar Reflectance Index (SRI) is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM E 1980-01. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

[3] The Solar Reflectance Index (SRI) is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Endnotes