# SITE DESIGN

This chapter provides guidelines for:

Optimum Building Orientation (Guideline SD1)

Landscaping to Provide Shade to HVAC Equipment, Buildings, and Paved Areas (Guideline SD2)

Landscape Design and Management (Guideline SD3)

Impervious Surfaces (Guideline SD4)

Native and Drought-Tolerant Plants (Guideline SD5)

Landscaping Soil, Amendments, and Mulch (Guideline SD6)

Integrated Weed, Disease, and Pest Management (Guideline SD7)

Environmentally Responsible Job-Site Management (Guideline SD8)

Indoor Air Quality During Construction (Guideline SD9)

Site Protection During Construction (Guideline SD10)

## OVERVIEW

Site design is a fundamentally important aspect of high performance design. The choices made during site selection and site planning reverberate throughout the entire school. All aspects of high performance design — from energy and water efficiency, to acoustic comfort and environmental impacts — are affected. Furthermore, every site and district will face unique constraints. Some districts have the luxury of choosing between several options while other districts have known for years the precise site that must be used. It is important to remember that regardless of what site is chosen, and whether it is in an urban or rural landscape, the site can be developed wisely to incorporate ideas that support the high performance goals of the entire project.

*Objectives regarding the protection and retention of existing landscaping as well as the site's natural contours and features should be established early during the programming phase. NREL/PIX 11341*

Open spaces at schools typically fall into two categories: hard surfaces and lawn. Districts can and should move beyond this approach to create more vibrant and environmentally responsive site designs. Even if the opportunities for a particular site seem modest, there are better ways to pave a parking lot, water a soccer field, and manage stormwater than are typically practiced.

Site selection and design can either support or detract from the overall performance of the building. Table 1 summarizes some of the benefits associated with wise site planning.

*Table 1 – Site Design Considerations*

| Goal | Site Design Considerations |
|---|---|
| Energy Efficiency | Energy efficiency is improved with effective building location, orientation and massing, and the placement of vegetation for shade or wind protection. |
| Water Efficiency | Standard irrigation practices typically waste significant amounts of water. Using native plants and water-efficient irrigation technologies are two straightforward methods of reducing demand. More resource-efficient water management might include captured water, green roofs, and natural stormwater management strategies like vegetated swales and ponds. (See the Water Conservation chapter for more information on irrigation and stormwater management.) |
| Protection of the Natural Ecosystem | The majority of site planning decisions will directly affect the overall level of impact to the natural environment: water conservation, treatment of surface water, building orientation, preservation and restoration of natural habitats, use of native plants and appropriate landscaping materials, etc. |
| Material Efficiency | The site should incorporate salvaged landscaping materials or those made from recycled materials. Vegetation waste should be composted. |
| Acoustic, Thermal, and Visual Comfort | Comfort is heavily dependent upon orientation and building envelope. Glazing type, size, and orientation are particularly important.<br>The relationship of buildings, especially classrooms, to sources of exterior noise such as roadways must be taken into account to achieve adequate background noise levels. Double glazed windows will reduce excessive exterior noise. Conversely, the relationship of HVAC equipment, recreation areas, and other noise producers will impact the surrounding neighborhood.<br>Reducing the “heat island effect” decreases air conditioning loads during the summer by minimizing hard surfaces and using trees or shade structures. |
| Health and Indoor Air Quality | Sites cannot contain hazardous chemicals or airborne pollutants that endanger student health. Well-designed sites improve opportunities for natural ventilation and reduce carbon dioxide levels. |
| Security and Safety | Building placement, landscaping, protected courtyards, and well-situated access and circulation points all heavily impact safety and security. |
| Connection to Neighborhood and Surrounding Community | Consider community gardens, school parks, meeting rooms, multi-use facilities such as day care, laundry, café, etc, to connect the school to the community. Joint-use partnerships with local nonprofit organizations are an excellent way to fund and share facilities or park space and improve security. |
| Learning | Use nature as a teaching tool for science, math, history, art, and health programs; use gardens to connect students to natural concepts. Consider the potential opportunities for real-life lessons in business and economics through on-site programs involving growing and selling or trading products. |
| Playing | Install creative play areas utilizing a wide variety of natural elements. Consider a schoolyard landscape rich with soil, water, and “critters,” rather than simply formal, planted hedges and groomed turf. |

## *Resource-Efficient Site Design Process*

Resource-efficient site planning is adaptable to all school sites. It balances ecological, social, and economic needs and emphasizes long-term, cost-effective strategies over immediate short-term results. It should be an open process and include the input of the school staff and local community.

Site selection is crucial in the resource efficiency of school design, and districts must balance cost, student demographics, and environmental concerns during the site selection process. In some cases, school sites have been determined years in advance, eliminating some options for districts and designers when the school is being built. However, when the district can select sites, being conscious of ecosystem protection, careful building orientation, and a design that controls urban heat islands can significantly lower the school’s environmental impact.

When selecting a site, maintaining the health of students should be the first concern. Sites must not contain toxins, pollutants, or safety hazards that will impact student health, such as:

*Once a site is selected, address areas of the site targeted for conservation, development, or natural enhancement. NREL/PIX 11333*

- Hazardous agents, including industrial, agricultural, and naturally occurring pollutants such as asbestos and heavy metals.
- Nearby facilities that might emit hazardous air emissions or handle hazardous or acutely hazardous materials.
- Other objects that are potentially harmful near a school, such as hazardous pipelines, high voltage power-line easements, railroad tracks, adverse levels of traffic noise, and airports.

The district should also address issues of land use and open space, including:

- Developing sites that are centrally located for the student population. Both schools and parents spend significant time, energy, and money transporting students to and from school. Cars driven by parents, guardians, or the students themselves are the largest resource users and producers of transportation-related pollution. Centrally located sites mean that cars do not have to travel as far and encourage more students to walk or bike to school.
- Develop joint-use agreements with community organizations to share parts of the school buildings, parks, or recreation space. As part of a growing trend, schools are being integrated with a variety of organizations, from laundromats and coffee shops, to police stations and park districts. Benefits include better campus security, improved community relationships, and reduced site acquisition and construction costs.
- Avoiding development on prime farmland, public parkland, flood zones, and on habitats for threatened or endangered species.
- Preserve undeveloped lands. By not developing on greenfields, which are sites that have not been previously developed, or have been restored to park or farm use, urban redevelopment can reduce environmental impacts.
- Promoting alternative transportation, by locating the school close to public transportation and creating bike facilities. (See the Transportation chapter for additional information.)

Once a site is selected, use educational specifications and the schematic design to address areas of the site targeted for conservation, development, or natural enhancement. Select and specify environmentally preferable site materials — building products that use raw materials efficiently and do not introduce pollutants or degradation to the project site or atmosphere, and building systems that conserve water and energy. (For additional information about materials, see the Resource-Efficient Building Products chapter.) All stakeholders should meet to review the baseline data and discuss the opportunities and constraints based upon the initial site analysis and program. These stakeholders help define the project's "vision," which guides development of the plan. Their involvement is essential

throughout the planning and design process. The plan, developed by the design team and approved by the community, might include many, or all, of these principles:

- Identify and protect existing natural features and ecosystems.
- Repair and restore damaged natural areas and create habitat to promote biodiversity.
- Respect and incorporate historic, cultural, and artistic resources.
- Use stormwater management to reduce pollution and the load on local infrastructure.
- Create healthy landscapes that evolve over time and survive intensive use.
- Develop a responsible maintenance and management program that incorporates an objective monitoring and evaluation strategy.
- Provide a strong link to the surrounding neighborhood and become an active part of the community.

## *Design Goals and Guidelines*

Site design activities for a high performance school seek to achieve one or more of the following three primary goals:

1. Protect and/or restore the site.
2. Incorporate the site's natural features to achieve high performance.
3. Select environmentally preferable products.

## *Protect and Restore the Site*

During construction, literally hundreds of opportunities exist to work toward fulfilling the environmental goals of a high performance school or, alternatively, to compromise them. To ensure the construction process is consistent with these goals, contractors should be made aware of them up front, as part of the bidding process. Ideally, the selected contractor should have experience with some of the practices recommended in this Best Practices Manual. At a minimum, they should be aware of, and responsive to, the goals set for the project. The clearer the expectation that contractors will play an important role in achieving these goals, the more likely the construction process will go smoothly in this regard.

In practice, requiring the contractor to produce and implement a job-site operations plan has proven to be the most effective way to ensure that environmental goals will be given equal treatment along with other project goals. In addition, including a requirement to produce and implement a job-site operations plan in bid documents and in the contract language of specifications, levels the bidding playing field.

Environmentally responsible job-site operational costs are generally minimal, and cost benefits can be significant. Planning helps minimize costs and liabilities, including expensive delays, stoppages, and callbacks due to mistakes made during construction. Savings resulting from job-site waste reduction practices are well documented. Contractors familiar with environmentally responsible job-site operations will know the benefits and understand that these are not complicated practices. Contractors unfamiliar with them, however, will assume they cost more and bid accordingly. Bid packages should contain references to existing resources to help contractors familiarize themselves with these types of plans as well as provide tools to estimate costs and benefits more accurately.

An environmentally friendly job-site operation will use a combination of contract language, signage, weekly job-site meetings, and incentives/rewards to educate and motivate field personnel to ensure everyone works towards this goal. Brief presentations, signage that both informs and motivates by reporting progress on environmental goals, and contractor's field guides can be helpful communication aids. On most construction sites, signage and other printed instructions will need to be written so individuals for whom English is a second language can easily understand.

In addition, the most successful contractors identify an individual (often the safety officer) who can enforce the job-site operations plan on a day-to-day basis. With many recommended job-site practices, it is difficult to determine whether they actually occur without regular monitoring. Ideally, the same individual monitoring compliance would take an active role in training and other on-site educational efforts.

The natural functions of a site (hydrologic, geologic, and micro-climatic) can also be seriously disrupted by the operation of a building. The design of a high performance school will consider ways that natural site features can be protected — perhaps even restored — through the design, development, and construction processes. For example, preserving natural vegetation reduces overall disturbance to the site. Soil amendments help restore the health of disturbed soils. And designing to reduce impervious surfaces mitigates stormwater runoff caused by construction and protects the hydrologic functions of the site.

Site protection and restoration objectives include:

- Minimizing disturbance to the site.
- Mimicking (or restoring) natural processes in disturbed areas.
- Protecting water quality.

*Site design can create opportunities for outdoor classrooms and environmental learning projects. NREL/PIX 02682*

### *Incorporate the Site's Natural Features to Achieve High Performance*

A high performance school responds to the site. Building placement, orientation, massing, and layout decisions made early in the school design process can profoundly affect the energy impacts of the building. These decisions also bear on the resulting indoor environment since they either capture or lose opportunities for daylighting and natural ventilation. Other implications include acoustic comfort, safety, and visual quality. The design of a high performance school incorporates the site's natural advantages and features to achieve the school's high performance goals.

In addition, the high performance school site and building should "teach" environmental protection concepts. Site design will take into consideration opportunities for outdoor classrooms and environmental learning projects. With careful planning and coordination with school staff, such projects can be identified and then facilitated during construction. For example, stream restoration by students

and staff can take place more easily if a culvert has been removed during construction. Or a wetland graded during construction can be planted as part of lessons about the natural ecosystems.

Site planning objectives that fall into this category include:

- Reducing the demand for water
- Reducing energy demand
- Selecting environmentally preferable materials.

A steadily increasing number and variety of environmentally preferable products are available for sitework and landscaping. Salvaged materials, originating from both on-site and off-site, should also be used where possible. These products include landscaping accessories made with post-consumer and post-industrial recycled materials (parking stops, bike racks, tree cuffs, grates, landscaping ties, planters, outdoor furniture, and lighting and sign posts), recycled concrete asphalt aggregate for fill or road base, concrete made with flyash, and recycled content soil amendments.

Specific examples include:

- Synthetic surfacing for exterior sports surfaces, playgrounds, and other surfaces. Made from 84% to 98% post-consumer rubber from used tires.
- Fencing made with recycled plastic or salvaged wood or metal.
- Running track surfaces made with 100% recycled rubber/tires.

While maintenance will vary by product, in most cases maintenance needs are reduced compared to conventional products. For example, plastic lumber is more durable and requires less ongoing maintenance than wood.

In addition, the selection of environmentally preferable materials has an added benefit as a teaching tool. Prominent interpretive signage can inform students, staff, parents, and the community about environmentally preferable materials and their attributes.

Table 2 summarizes the site design goals and objectives described above, and shows the correspondence of these objectives to the guidelines provided in this chapter.

*Table 2 – Site Planning Goals and Relationship to Guidelines*

| | SD1: Optimum Building Orientation | SD2: Landscaping to Provide Shade to HVAC Equipment, Buildings, and Paved Areas | SD3: Landscape Design and Management | SD4: Impervious Surfaces | SD5: Native and Drought-Tolerant Plants | SD6: Landscaping Soil Amendment and Mulch | SD7: Integrated Weed, Disease, and Pest Management | SD8: Environmentally Responsible Job-Site Management | SD9: Indoor Air Quality During Construction | SD10: Site Protection During Construction |
|---|---|---|---|---|---|---|---|---|---|---|
| **Goals** | | | | | | | | | | |
| **Protect and Restore the Site** | | | | | | | | | | |
| *Minimize disturbance to the site* | | | | | ● | | | ● | | ● |
| *Mimic natural process* | | | | ● | | ● | | | | |
| *Protect water quality* | | | | | | ● | ● | | | |
| **Incorporate the Site's Natural Features to Achieve High Performance** | | | | | | | | | | |
| *Reduce water demand* | | | ● | | ● | ● | ● | | | |
| *Reduce energy demand* | ● | ● | | | | | | | | |
| **Select Environmentally Preferable Materials** | | | ● | ● | | ● | | | ● | |

## *Resources*


Architects, Designers and Planners for Social Responsibility (ADPSR) West Coast. 1998. *Architectural Resource Guide.* Contact: ADPSR, PO Box 9126, Berkeley CA. Tel: (510) 273-2428. Resources and information on green and healthy buildings, including many sources for materials.

Barnett, D.L. 1995. *A Primer on Sustainable Building.* Snowmass, CO: Rocky Mountain Institute. An excellent overview of issues and benefits of sustainable building. http://www.rmi.org.

Center of Excellence for Sustainable Development, U.S. Department of Energy, Energy Efficiency and Renewable Energy Network (EREN). Provides web pages on green building and green development. http://www.sustainable.doe.gov.

Crowther, R.L. 1992. *Ecological Architecture*. Boston: Butterworth Architecture. Primer on ecological design, emphasizing the importance of holistic building design and its integration with natural systems. Includes design guidelines for design, landscaping, and planning.

King County, Washington. *Construction and Landscaping Materials Specifications*. http://www.metrokc.gov/procure/green/const.htm.

Los Angeles, City of. *Sustainable Building Reference Manual.* Contact: Nady Maechling. Tel: (213) 473-8226. Contains local information and resources.

Lyle, J.T. 1994. *Regenerative Design for Sustainable Development*. New York: John Wiley & Sons. One of the seminal books on the theory, design, and construction of regenerative systems and the practical application of ecological design.

Marsh, W. M. 1991. *Landscape Planning: Environmental Applications.* New York: John Wiley & Sons. A definitive reference for landscape architects, planners, and designers on the definition and application of environmental design principles to landscape and site planning.

Maryland State Department of Education. *Conserving and Enhancing the Natural Environment, A Guide for Planning, Design, Construction, and Maintenance on New & Existing School Sites* and *Building Ecology and School Design*. 1999. To order, contact the Maryland State Department of Education, Division of Business Services, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201. Phone for Capital Projects Assistant Manager: (410) 767-0097

Mason, Gary et al. *An Ecosystem-based Approach to Planning Communities: An Ecosystem Manager's Workbook*, USDA Forest Service, Center for Urban Forestry, 1994, 1996, 1998.

Moore, Robin C. and Wong, Herb H. 1997. *Natural Learning: Creating Environments for Rediscovering Nature's Way of Teaching*, MIG Communications.

Rocky Mountain Institute.1998. *Green Development: Integrating Ecology and Real Estate.* New York: John Wiley & Sons.

*Second Nature: Adapting Los Angeles's Landscape for Sustainable Living.* 1999. Published by TreePeople.

Sorvig, K. 1996. *Sustainable Building Technical Manual*. Washington DC: Public Technologies Inc. Chapter 7, Site Materials and Equipment, offers a concise, valuable overview that highlights design considerations for soil amendments, plant materials and management, paving materials, and materials for site construction and furnishings.

Spurgeon, Richard. 1988. *Ecology: A Practical Introduction with Projects & Activities.* Osborne Publishing Ltd.

For additional information about environmentally preferable materials, see the Material Selection and Research section in the Introduction to this manual.

## *Acknowledgments*

The following resources were particularly useful for developing this chapter on site planning:

BUILT GREEN™ Handbook. 1999. BUILT GREEN is a program of the Master Builders Association of King and Snohomish Counties (MBA) in partnership with King County, Washington, and Snohomish County, Washington. http://www.builtgreen.net/.

Partnership for Resource-Efficient Schools. 1998. *Recommended Best Management Practices Promoting Energy Efficiency, Resource Conservation, and Environmental Quality.* A publication of the Seattle Public Schools Building Excellence Program and the City of Seattle (Solid Waste Utility, Water Department and Seattle City Light). The following web site provides information about the Partnership for Resource-Efficient Schools project and a link to download the Best Management Practices manual: http://www.cityofseattle.net/util/rescons/susbuild/partnership.htm

Santa Monica, City of. 1999. *Santa Monica Green Building Design and Construction Guidelines.* Available on-line at http://greenbuildings.santa-monica.org/main.htm.

Sustainable Building Task Force. The Sustainable Building Task Force was formed by a number of California agencies to institutionalize resource-efficient building practices into state construction projects. The task force meets on a monthly basis to discuss strategies for implementing resource-efficient building practices in all future and current state buildings, including those leased by the State.
See http://www.ciwmb.ca.gov/GreenBuilding/TaskForce/ for more information and links to member agencies.

# GUIDELINE SD1: OPTIMUM BUILDING ORIENTATION

## *Recommendation*

When site conditions permit, orient buildings so that major windows face either north or south. Position classrooms so that light and air can be introduced from two sides. Solar orientation should guide the placement of building and site features. Reduce the impact of exterior noise sources by locating noise sensitive areas, such as classrooms, away from noise producers, like roadways, train tracks, etc.

*Orientation plays a key role in the landscaping and daylighting design. NREL/PIX09704*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ■ | Programming | ■ |
| Library | ■ | Schematic | ■ |
| Multi-Purpose | ■ | Design Dev. | ■ |
| Gym | ■ | Contract Docs. | □ |
| Corridors | ■ | Construction | □ |
| Administration | ■ | Commissioning | □ |
| Toilets | ■ | Operation | □ |
| Other | ■ | | |

## *Description*

Space heating and cooling accounts for nearly 20% of all energy consumption in the U.S. Optimal orientation of the building creates opportunities to utilize the potential contributions of the sun, topography, and existing vegetation for increased energy efficiency by maximizing heat gain (or minimizing heat loss) in winter and minimizing heat gain in summer. In the case of existing buildings, arrangement of interior spaces, strategic landscaping, and modifications to the building envelope can mitigate unfavorable orientation.

## *Applicability*

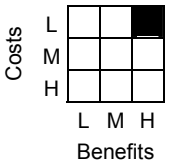
All climates. Primarily for new buildings and site planning, with some applicability to retrofitting existing buildings for greater efficiency.

## *Integrated Design Implications*

Knowledge of the existing site soils, vegetation, and microclimate are critical to understanding how to best arrange site elements to create the least disruption to the site and orient structures and spaces appropriately. Integrate existing site features; proposed landscape design; orientation, height, and finish of walls; architectural design; impervious surfaces; location of heating and cooling equipment. Refer to guideline: SD2: Landscaping to Provide Shade to HVAC Systems, Buildings, and Paved Areas and TR2: Safe and Energy-Efficient Transportation.

## *Cost Effectiveness*

Cost implications exist mainly in the design phase. Resulting cost savings will be demonstrated during building operation with lowered heating and cooling requirements.




## *Benefits*

Reduced energy consumption will result in cost savings for year-round heating and cooling. The arrangement of interior and outdoor spaces with thoughtful solar orientation allows optimal natural lighting and user-friendly spaces. Studies have shown that students in classrooms with the most daylighting have

a 21% improvement in learning rates over students in classrooms with poor natural light.[1] See the Daylighting and Windows chapter for more information on this research.

## *Design Tools*

Many utilities offer the use of heliodons for accurate modeling of daylighting effects. A physical model is mounted on the heliodon and a simulated sun shows shadows and solar exposure for different times of the day and the year. Most are coupled with a video camera for recording the test.

A sun angle calculator is a handy tool for studying sun position for different times of the day and year. It can be used to determine the required distance between buildings needed for adequate solar exposure and for determining the effect of shading obstructions such as adjacent buildings.

## *Design Details*

Consider east-west orientation to maximize north-south daylighting opportunities. Single-story designs offer toplighting daylight strategies for all spaces. Keep width of building to less than 60 ft to increase daylight and ventilation opportunities.

*Timesaver Standards for Landscape Architects* presents the following site planning and building orientation information:

- Plan site clearing and planting to take advantage of solar access. Solar orientation, cloud cover, and topography create unique site attributes. A site's latitude determines the sun's altitude and associated azimuth for a given time or day. Orient the building to take advantage of solar energy for passive and active solar systems. The building should take advantage of shade and airflows to maximize summer cooling and to optimize passive solar energy for heating and wind protection during winter months. Orient solar collectors for maximum sun exposure.
- Orient building entrances and outdoor gathering spaces to maximize safety, ease of access, and protection from elements.

Solar angles, soils, and topography determine plant species and distribution, as well as vulnerability of the land to erosion by runoff. The extent of disruption to the site during construction can be minimized with careful orientation of buildings and site elements. Align long buildings and parking areas parallel to landscape contours.

Building orientation can have a significant impact on the acoustical performance of a building. Locating noise producers away from noise sensitive areas is the primary goal. Barriers of solid walls or berms of earth, which break the line-of-site between the noise source and the receiver (e.g. classroom), can be effective in reducing sound intrusion. A single row of trees or shrubs will be ineffective in reducing unwanted sound. Since windows are frequently the "weakest link" acoustically in a building structure, double glazed windows are often the only alternative to controlling exterior noise. Normal therma-pane double paned windows with ¼ in. or ½ in. airspace are not effective acoustically. The small airspace, and the two panes of similar glass severely limit its acoustical performance. To be effective acoustically, at least the outer pane should be laminated glass. Additional airspace between the two panes of glass is also very important. It is not uncommon to require 2 in. to 4 in. airspace and thicker laminated glass to control exterior traffic and/or aircraft noise, which contain substantial low frequency energy.

## *Operation and Maintenance Issues*

None.

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[1] Heschong Mahone Group and New Building Institute. "Re-Analysis Summary: Daylighting in Schools, Additional Analysis." On behalf of the California Energy Commission Public Interest Energy Research (PIER) Program, Feburary 2002.

## *Commissioning*

None.

## *References/Additional Information*


American Institute of Architects Research Corporation. *Solar Dwelling Design Concepts.* Washington, DC: U.S. Department of Housing and Urban Development, 1976.

Balcomb, John Douglas. "Using Energy-10 to Design Low Energy Buildings." National Renewable Energy Laboratory, 1999. A summary report that describes Energy-10 and presents a detailed worked example carrying a particular building from pre-design through preliminary design. http://www.nrel.gov/buildings/energy10/resources.html.

Buffo, John, et al. "Direct Solar Radiation on Various Slopes from 0 to 60 Degrees North Latitude." U.S. Department of Agriculture Forest Service Research Paper PNW-142, 1972, 74pp.

DeChiara, Joseph. *Site Planning Standards.* McGraw-Hill, Inc. 1978.

Durant Road Middle School, Wake County, NC, utilized many recommendations from this guideline.

Harris, Charles. *Timesaver Standard for Landscape Architecture: Design and Construction Data.* McGraw-Hill, Inc. 1998.

Land Design/Research, Inc. *Energy Conserving Site Design Case Study*, Burke Center, Virginia. Washington, DC: U.S. Department of Energy, 1979, 60pp.

Marsh, W.M. *Landscape Planning: Environmental Applications.* John Wiley & Sons, New York. 1991.

Marsh, William M., and Dozier, Jeff. *"The Radiation Balance." Landscape: An Introduction to Physical Geography*. Reading, MA: Addison-Wesley, 1981, pp. 21-35.

Sizemore and Associates. *Methodology for Energy Management Plans for Small Communities.* Washington, DC: U.S. Department of Energy, 1978.

Sterling, Raymond, et al. *Earth Sheltered Community Design.* New York: Van Nostrand Reinhold, 1981, 270 pp.

# GUIDELINE SD2: LANDSCAPING TO PROVIDE SHADE TO HVAC EQUIPMENT, BUILDINGS, AND PAVED AREAS

## *Recommendation*

Shade HVAC equipment from direct sun. Ensure landscaping does not block air circulation to or from the building. Use landscaping to shade windows on the east- and west-facing building facades. Use landscaping or shade structures to shade paved areas to reduce the heat island effect.

## *Description*

Shading HVAC equipment from direct sunlight can significantly lower the cooling demand. Landscaping can greatly reduce the impacts of heavy radiation loads on the roof, and east and west exposure in summer. In temperate regions, site planning and design should seek to promote shade and evaporative cooling in warm periods, and block winds and promote heat gain in cool periods, without disrupting favorable summer wind patterns. In hot, arid regions, plan to balance daily temperature extremes by storing energy, increasing humidity, and diverting desiccating winds.

*Landscaping and trees help minimize heat gain to the building and surrounding concrete. NREL/PIX03779*

## *Applicability*

All climates.

**Applicable Climates**

## *Integrated Design Implications*

Integrate landscaping, HVAC design, parking lot design, lighting design, irrigation, and preservation of existing plants with building design and orientation. Wind and moisture patterns should be considered during site planning in conjunction with goals to provide building shade. Design coordination will be needed so that trees and lighting are placed without conflicting with the shade or footcandle requirements. Refer to guideline SD1: Optimum Building Orientation; TR1: Transportation and Site Design; SD4: Impervious Surfaces; Mechanical and Ventilation Systems guidelines; as well as guidelines in the Energy-Efficient Building Shell chapter.

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ☐ | Programming | ■ |
| Library | ☐ | Schematic | ■ |
| Multi-Purpose | ☐ | Design Dev. | ■ |
| Gym | ☐ | Contract Docs. | ☐ |
| Corridors | ☐ | Construction | ☐ |
| Administration | ☐ | Commissioning | ☐ |
| Toilets | ☐ | Operation | ☐ |
| Other | ■ | | |

## *Cost Effectiveness*

Costs will vary depending on the type and extent of vegetation or shading structures used. Costs are minimal for HVAC shading, particularly if incorporated into overall HVAC system and landscaping design. Consult with a qualified HVAC engineer regarding opportunities for downsizing systems due to decreased system load.

| Costs \ Benefits | L | M | H |
|---|---|---|---|
| L | ■ | | |
| M | | | |
| H | | | |

## *Benefits*

Lower energy costs from reduced solar loads on building. Shading HVAC equipment lowers demand for electricity and reduces heat islands.

## *Design Tools*

Charts illustrating distance required between buildings or landscaping to avoid shadows and minimum spacing required to assure adequate light penetration. Solar path, latitude, and altitude charts should also be utilized.

## *Design Details*

Building orientation should be closely integrated with landscape design. Planting deciduous trees on the southeast, southwest, and west side of the building will reduce solar gain in summer during the morning and afternoon. Deciduous vines on arbor structures will provide shade, particularly when used adjacent to the building on the south or west face, sheltering the interior from summer midday sun while allowing solar penetration in winter. Plant low branching deciduous trees on the west side to keep low afternoon sun off west and north walls in summer.

Consider the use of vines against south- and west-facing walls to reduce reflected and absorbed heat and light. This can reduce the temperatures in courtyards and outdoor spaces as well as adjacent buildings and interior spaces.

In urban environments, the site context may include solar windows (gaps between buildings) and shadow corridors (elongated zones which block the sun), which should be considered during site design to maintain sunlight to structures.

Parking lots and paved areas can reflect sunlight and absorb heat that raises temperatures. Shading with trees, shade structures or structures with vines can help lower temperatures.

Locate HVAC equipment so that it is shaded from afternoon sun during the cooling season. Plant trees so that at maturity their canopies shade the unit and the adjacent area during the entire cooling season.

## *Operation and Maintenance Issues*

Design criteria and maintenance guidelines will be needed so that trees shading parking lots and other paved areas can grow to full maturity without excessive pruning. However, care must be taken to avoid contaminating HVAC equipment with leaves or other organic debris. Maintenance must keep plantings from growing too dense and preventing the proper circulation of air around the unit.

## *Commissioning*

None.

## *References/Additional Information*


DeChiara,Joseph. *Site Planning Standards*. McGraw-Hill, Inc. 1978.

Harris, Charles. *Timesaver Standard for Landscape Architecture: Design and Construction Data*. McGraw-Hill, Inc. 1998.

Marsh, W.M. *Landscape Planning: Environmental Applications.* John Wiley & Sons, New York. 1991.

Parker, D.S. “Measured Impacts of Air Conditioner Condensor Shading.” The Tenth Symposium on Improving Building Systems in Hot and Humid Climates. Fort Worth, TX, 1996. Archived at http://www.fsec.ucf.edu/~bdac/pubs/PF302/PF302.htm, 12/15/2000.

Parker, J.H. "The Impact of Vegetation on Air Conditioning Consumption." Proceedings of the Workshop on Saving Energy and Reducing Atmospheric Pollution by Controlling Summer Heat Islands, Berkeley, CA, pp. 45-52, 1989.

# GUIDELINE SD3: LANDSCAPE DESIGN AND MANAGEMENT

## Recommendation

Develop a landscape plan based on an ecological approach, emphasizing plant diversity, natural lawn care, and resource conservation. Use this plan to guide site preparation, site design, and ongoing care of the site. Include objective plans, tasks, standards, and requirements that provide information about how to create a healthy and attractive landscape.

*High performance landscape design emphasizes plant diversity, natural lawn care, and resource conservation. NREL/PIX 11335*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | | Programming | ■ |
| Library | | Schematic | ■ |
| Multi-Purpose | | Design Dev. | ■ |
| Gym | | Contract Docs. | ■ |
| Corridors | | Construction | |
| Administration | | Commissioning | |
| Toilets | | Operation | ■ |
| Other | ■ | | |

## Description

Every site has an ecological dynamism that involves all the physical elements of the landscape. A high performance approach to landscape design and management should be guided by four basic principles that respect this dynamism: resource conservation, diversity, connectivity, and environmental responsibility.

- *Resource Conservation.* Identify, use, and recycle available natural and physical resources that do not degrade the ecosystem. This principle should also be applied to site and landscape accessories.
- *Diversity.* Maintain a healthy natural system that gives primary consideration to habitat, species, and genetic diversity.
- *Connectivity.* Maintain networks of natural resources and interconnecting habitats to maximize healthy ecological functions.
- *Environmental Responsibility.* Protect, restore, and manage resources to maintain a healthy ecosystem in perpetuity.

To apply these principles to landscape care, it's important to understand the difference between landscape *maintenance* and landscape *management*. Maintaining a landscape implies that the landscape deteriorates and needs to be returned to a "correct" condition by the maintenance crew. This static vision belies the natural dynamism of the landscape. Seeking to simply maintain landscapes works against the dynamic tendencies of nature, resulting in great expense of time, energy, and money.

Management, on the other hand, acknowledges the constant change of nature. To manage a landscape is to work with the basic tendency of nature to change. Management based on ecological principles does not try to always return the landscape to a single, static state. Management — as opposed to maintenance — recognizes the dynamic qualities of landscapes and takes advantage of interconnected elements such as water, soil, and pests.

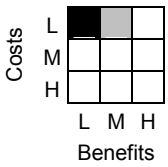
## Applicability

All climate regions.

## *Integrated Design Implications*

Planning for landscape management should be integrated and coordinated with Guideline SD5: Native and Drought-Tolerant Plants; Guideline SD6: Landscaping Soil, Amendments, and Mulch; and Guideline SD7: Integrated Weed, Disease, and Pest Management. All landscape planning should also take into account irrigation system parameters to help maximize water efficiency (see Guideline WC1: Water-Efficient Irrigation Systems).

## *Cost Effectiveness*




Costs will vary depending on the extent of the site and scope of management plan. Native grasses save money on maintenance with reduced or eliminated mowing schedules. Recycled-content landscaping products are comparable in cost to conventional options.

## *Benefits*

High performance landscape design and management, which seeks to bring the designed landscape into a closer adherence with the region's natural systems, provides a high level of benefit. A well-designed and implemented landscape management plan results in water conservation; soil improvement; the use of less intensive practices to manage plants; and the preservation, enhancement, or creation of habitat. The use of recycled content products helps alleviate waste disposal problems and reduces energy use and consumption of natural resources during manufacturing.

Landscape management, including natural lawn care practices, can help make the school grounds healthier for students and staff; protect beneficial soil organisms; and protect the environment through reduced use of water, pesticides, fertilizers, and pollution-producing mowers and maintenance equipment.

Properly designed earth berms can shield the school from nearby roadways, train tracks, etc. However, landscaping, trees, and shrubs cannot be used to reduce the level of exterior noise at the building façade.

## *Design Tools*

To identify high performance landscape and site planning strategies, consider consulting with a landscape professional that has expertise in ecological approaches to vegetation management.

## *Design Details*

***Key Elements of a Landscape Management Plan***

A landscape management plan needs to take into account three different functions: managing the vegetation, including lawn care; managing the site's infrastructure; and managing those responsible for its care. A landscape management plan should contain the following components:

- *Management vs. Maintenance*: Briefly discuss the basis of an ecological approach, the concept of maintenance vs. management, and the principles of ecosystem-based management.
- *Vegetation Types and Locations*: Discuss the concept of vegetation types, including diversity of vegetation. Also describe the landscape management zones, and list and describe the types of vegetation to be included in each zone. Provide standards that describe the desired condition of each vegetation type. Vegetation types include trees (young, street, native, ornamental, naturalized, riparian); shrubs (ornamental, naturalized, riparian, native); perennials; vegetables; meadow; lawn; groundcover; vines; and weeds and undesirable plants.
- *Infrastructure Standards*: Discuss standards for infrastructure care to achieve the desired condition.
- *Designating Responsibility*: Discuss who is responsible for each aspect of the landscape management, and delineate responsibility on a site map.

- *Sustaining the Landscape*: Describe the general tasks necessary to implement the landscape management specifications, including a yearly calendar of tasks as well as monthly task checklists to monitor the work and the health of the landscape.

***Establishing Landscape Management Zones***

A high performance design should divide a landscape into management zones based on each zone's differing design intents and maintenance requirements. In general, three landscape management zones exist:

- *Ornamental Zone*: The more traditional landscape areas next to buildings, parking areas, streets, and other public use facilities. This zone creates strong identity and focus for the schools. The landscape in this zone is typically designed to be organized, attractive, and lush. This zone requires the highest level of management to maintain a visually pleasing and healthy appearance.
- *Natural or Native Zone*: Existing natural areas on, or adjacent to, the site that are to be preserved, enhanced, or expanded.
- *Buffer Zone*: The interface areas between the other two zones. The management goal is to provide a visually pleasing landscape that bridges the ornamental zone and the native, or more natural, areas.

***Natural Lawn Care***

Lawns are typically the most intensively managed type of vegetation on a school site. A high performance approach to lawn care starts with lawn placement at the site. Lawn can be divided into different zones, based on how it will be used and how it needs to be cared for. Typically, three standards of care should be considered:

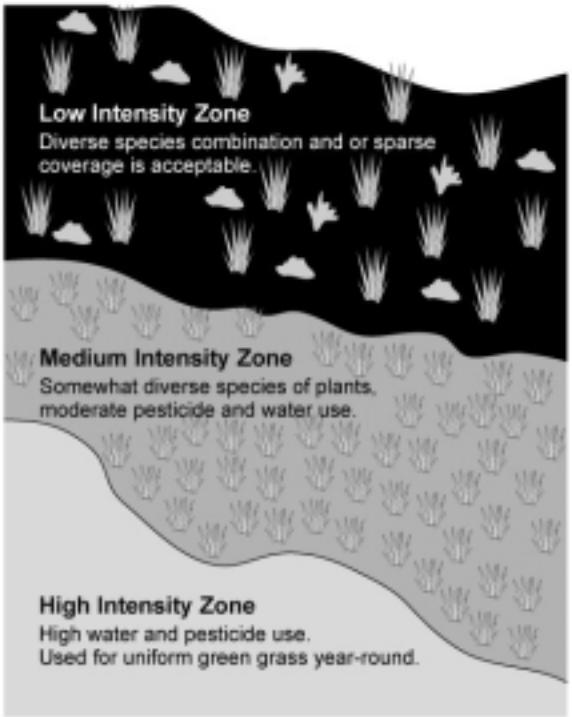



*Figure 1 – Landscape Management Zones*

- *High Intensity*: Requires uniform species composition, high irrigation demands, high synthetic fertilizer use, and regular pesticide and herbicide use. Used when primarily concerned with having uniform green grass year round with no weed, pest, or soil organisms.

- *Medium Intensity*: Allows for more diverse species composition, less demanding irrigation, moderate organic fertilizer use, and integrated pest management approach. Green is important, but not essential year round. Building soil structure over time is an important goal.
- *Low Intensity*: Diverse species composition and/or sparse coverage is tolerable. Alternatives to lawn are considered, with other vegetation taking precedence over lawn.

Plants depend on soil organisms to recycle nutrients, protect them from disease, and build loose fertile soil. Overusing soluble fertilizers and pesticides can disrupt this ecosystem and contribute to landscape and lawn problems like thatch buildup and soil compaction. Ecological approaches to landscape management and natural lawn care practices can help make lawns healthier for students and staff, protect beneficial soil organisms, and protect the environment.

A natural approach to lawn care produces lawns that stay healthy and are easier on the environment. Strategies include soil preparation/amendment, choosing groundcovers or no-mow lawn varieties, minimizing turf areas, "grass cycling" (leaving clippings to decompose quickly, releasing valuable nutrients back into the soil), mowing at the proper height, minimal use of pesticides, applying smaller amounts of fertilizers at regular intervals, appropriate watering, and accepting an appropriate threshold for some weeds.

## *Operation and Maintenance Issues*

Consider a variety of alternatives to traditional school staff for maintenance. For example, Conservation Corps or job training programs for restoration and habitat areas.

Landscape management is a different approach from conventional landscape maintenance. Planning, education, and training are key to a program's success. Each school district should develop and implement a written landscape management policy and program.

## *Commissioning*

None.

## *References/Additional Information.*


*Clean Air Lawn Care,* South Coast Air Quality Management District. Available on-line at http://www.aqmd.gov/monthly/garden.html.

Cook, Tom and Roy L. Goss. *Construction and Maintenance of Natural Grass Athletic Fields*. Washington State University Cooperative Extension, Publication PNW0240. This bulletin provides the basis for developing and maintaining high quality fields for different purposes under different conditions. Explains construction, establishment, drainage, irrigation, maintenance, and some troubleshooting. Rev. 1992. 28 pages. To order, call (800) 723-1763.

Craul, Phillip J. *Urban Soil in Landscape Design.* John Wiley & Sons, Inc. 1992.

Hunter, Charles D. *Suppliers of Beneficial Organisms in North America.* California Environmental Protection Agency, Department of Pesticide Regulation, Environmental Monitoring and Pest Management Branch. 1997.

Los Angeles County Department of Public Works. *The Natural Approach to Lawn Care.* Available on-line at http://www.smartgardening.com/grassrecycling.htm.

Olkowski, William et al. *Common Sense Pest Control.* The Taunton Press. 1991.

*People's Park Landscape Management: Vegetation and Infrastructure Program.* A program developed for the University of California, City of Berkeley, and the Park/Community Advisory Group. This program uses an ecological approach to the renovation and care of the landscape. Information available from Wolfe Mason Associates at http://www.wolfemason.com.

*Profiles: A Special Report on Grounds Care*. A report of grounds maintenance challenges at Georgetown University, Washington, DC, the University of Texas Southwestern Medical Center in Dallas, and the Orange County Public School District in Orlando, Florida. Available on-line at http://www.facilitiesnet.com/fn/NS/NS3m9li.html.

# GUIDELINE SD4: IMPERVIOUS SURFACES

## *Recommendation*

Minimize impervious surface areas to reduce stormwater runoff. Use material-efficient products for installed pervious and impervious surfaces.

## *Description*

Impervious areas, such as roofs, driveways, sidewalks, and streets, increase stormwater runoff by preventing the infiltration of surface water into the ground. This increased stormwater runoff results in increased erosion, higher flow rates, higher ambient temperatures, and incdreased sediment in nearby waterways. Additionally, as stormwater flows over buildings, parking lots, and play fields, it collects pollutants, such as oil, litter, and dirt. These waterborne pollutants often discharge directly into waterways. Conversely, permeable surfaces reduce peak stormwater runoff and treat stormwater pollutants. In addition, impervious surfaces create higher ambient temperatures on the site compared to permeable or vegetated alternatives.

*Minimizing impervious surfaces maximizes the area available for soils and vegetation to receive and treat surface water. NREL/PIX 11414*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ☐ | Programming | ■ |
| Library | ☐ | Schematic | ■ |
| Multi-Purpose | ☐ | Design Dev. | ■ |
| Gym | ☐ | Contract Docs. | ☐ |
| Corridors | ☐ | Construction | ☐ |
| Administration | ☐ | Commissioning | ☐ |
| Toilets | ☐ | Operation | ☐ |
| Other | ■ | | |

Strategies to limit impervious surfaces on the building site include:

- Using permeable (or porous) pavement systems in lieu of impervious asphalt or concrete. Examples:
  - Porous asphalt, paver blocks, or large aggregate concrete for parking and high use bicycle and pedestrian areas.
  - Lattice blocks that permit grass growth for fire lanes and overflow parking.
  - Crushed stone or brick for lightly used pedestrian paths.
- Minimizing the amount of paving by designing for multiple uses. Uses can include access, parking, pathways, meeting places, and game courts. Surfacing materials can vary depending on intensity of use, e.g., access roads paved and parking gravel, turf block for emergency access, and decomposed granite for secondary paths. All surfacing materials can utilize porous paving techniques.
- Retaining or substituting vegetation in lieu of hard surfaces.
- Designing to distribute runoff from impervious surfaces over large vegetated areas prior to reaching a stormwater conveyance system. This reduces the flow velocity, removes pollutants, and promotes groundwater infiltration.
- Installing a vegetated roof.

- Using natural or constructed wetlands to provide on-site retention and treatment of stormwater.
- Minimizing the building footprint through design. (Note: Minimizing building footprint usually means building "up" rather than "out." For schools, this may not be desirable because of conflicts with higher priority goals, such as daylighting and natural ventilation.)

Where impervious surfaces are necessary, use resource-efficient materials. Examples include:

- Rubber modified asphalt or recycled concrete asphalt.
- Recycled aggregate for base course of new parking lots and roadways.
- Concrete made using flyash, a byproduct of coal combustion, to replace a portion of the Portland cement, a high-embodied energy material.

*Note: One limitation of porous pavement is its tendency to clog if improperly maintained. Once it is clogged, it is difficult and costly to rehabilitate and often must be completely replaced. Clogging can be prevented most easily by not installing it in areas where erosion is a concern and by waiting until all other phases of construction are complete and vegetation is stabilized to install the pavement. Other concerns include the lack of expertise of pavement engineers and pavement contractors. Also, some studies indicate that porous systems have slightly higher deformation in porous pavement compared to conventional.*

*A vegetated roof reduces the amount of rainwater runoff while simultaneously minimizing heat build-up and providing insulation.*
*NREL/PIX 11411*

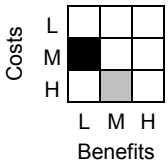
## Applicability

All climates.

## Integrated Design Implications

Strategies to minimize impervious surfaces should be integrated with decisions about landscaping design; shading of the building, site, and heat rejection equipment; building orientation and design (footprint); roofing selection; stormwater management; parking lot and paving design; building layout; vegetated roof design; and parking lot design.

## Cost Effectiveness




Minimizing paved areas means less paving material overall, which translates into lower initial cost.

The cost of permeable paving systems will vary depending on the system used. For example, porous (no fines) concrete may be comparable to conventional pavement. (This material requires a contractor familiar with the process, however.) Grid types, pavers, and brick systems have a cost premium. Cost is offset by its dual purpose as a stormwater system. Less land is needed for this type of system, because an area for detention, retention, or infiltration is not necessary.

## Benefits

Minimizing impervious surfaces helps preserve the hydrological and geological functions of a developed site by maximizing the area available for soils and vegetation to receive and treat surface water and facilitates groundwater recharge. The flow, velocity, and quantity of surface water is decreased overall, reducing the sediment and pollutant load on local waterways as well as the burden on municipal water management systems.

Ancillary benefits include reduced heat, local heat build-up (heat islands) from the shading and cooling effects of vegetation, vegetated roofing, and whitetopping. These translate into reduced cooling loads and energy consumption. Several permeable pavement systems are manufactured with recycled content, making them material efficient. Impervious paving that uses recycled concrete aggregate for base or flyash in concrete is also material efficient.

## Design Tools

Applicable state and local stormwater and surface water management design manuals.

***Permeable Paving***

Specifications, if any, for porous pavement will vary from state to state. As an example of the types of guidelines states can provide, the documents listed below are used in Washington State:

*Interim Guidelines for the Construction of Portland Cement Pervious Pavement or "No Fines" Concrete*, a working document of the Washington State Aggregates and Concrete Association, soon to be updated.

*BMP T3.40, Porous Pavement,* from the *Final Draft, Stormwater Management Manual for Western Washington, Volume V*, *Runoff Treatment BMPs*. Washington State Department of Ecology, Water Division. August 1999, revised August 2000. This document can be downloaded at http://www.ecy.wa.gov/biblio/9915.html or call (360) 407-6614.

***Whitetopping***

American Concrete Paving Association (ACPA), Whitetopping, State of the Practice. Publication EB210P. This engineering bulletin covers of all aspects of concrete overlays on existing asphalt pavement. Its five chapters include: Introduction (uses and benefits), History and Performance, Design Practices (conventional whitetopping), Construction Practices, and Ultra-Thin Whitetopping (UTW). The last chapter presents the interim procedure for determining the load-carrying capacity of UTW based on research and performance surveys. 1998. Order from the ACPA, http://www.pavement.com/.

## Design Details

*Effective* surfaces are those, pervious or impervious, that are connected via sheet flow (shallow or concentrated surface flow) or discrete conveyance (such as drainage ditch) to a drainage system. *Effective impervious surface* is a measure of the performance of the lot with respect to stormwater flows, which provides a way of monitoring impact due to construction. Methods to minimize runoff can be expressed: (1) prescriptively, such as using pervious surfaces, or (2) performance-based, such as providing zero effective impervious surface (no net increase in runoff). Specific strategies will depend upon the specific site and local requirements.

*Concrete manufactured with flyash can be used for paving. NREL/PIX04358*

Where impervious pavement must be used, specify the use of recycled asphalt, concrete manufactured with flyash for paving, and/or rubberized asphalt pavement. In hot climates, look for opportunities to whitetop asphalt surfaces with heat-reflecting white concrete.

For concrete work, use reusable steel forms, expansion joint filler with recycled content, and least toxic release methods.

When using porous paving or on-site bio-filtration swales, it is critical that sub-base soils are tested so that designs are sufficient to process the stormwater flow.

Utilize surface stormwater flow wherever possible. Introduce oil/water separators at catch basins.

Note that design considerations should assume a minor loss in porosity in the first four to six years.

Avoid compaction of site soils in adjacent areas during construction to retain infiltration and water holding capacity of existing soils.

## *Operation and Maintenance Issues*

For bio-swales and constructed wetlands, the design intent is to create a self-sustaining system that requires little maintenance. Monitoring and maintenance as the landscape matures provide educational opportunities. As bio-swales and constructed wetlands provide wildlife habitat, mowing and thinning plants should be minimal unless soils testing shows that impurities from runoff are high. In that case, mowing and thinning will help remove toxins that may accumulate in the vegetation.

In parking areas, prune plants as needed to maintain sight lines and the desired aesthetic. If storm drains are used, clear as needed to prevent blockages. Avoid soil compaction in vegetated areas.

For porous asphalt and concrete, vacuum with a hydrovac to maintain or restore porosity by removing sediment from the paving surface. If areas become deformed by traffic, drill compacted areas to restore porosity. Keep underdrains, overflow drains, and edge drains clear.

Grassed paving systems need to be mowed. Tall grasses create a less-permeable surface. If this type of system is perceived as unmaintained, it may discourage potential users. The durability of the system depends on soil type and climate; however, maintenance is decreased with the use of appropriate groundcover plants in lieu of lawn. Some groundcovers can take foot traffic but lawn, in turf block or grids, is best used where there is auto traffic.

Unit pavers on a permeable subgrade settle after the initial installation, and therefore require that a joint-filler material be swept in. Permeability decreases over time as the joints become compacted.

The systems mentioned above are conducive to “spot fixes” should replacement of small areas be required due to damage. It should also be noted that maintenance is reduced where snow removal is significant, as snow melts faster on permeable surfaces.

Longevity of the system depends on the type of system used, the amount of use it receives, and the appropriate match of system to site.

## *Commissioning*

None.

## *References/Additional Information*


California Integrated Waste Management Board. *Designing with Vision: A Technical Manual for Material Choices in Sustainable Construction*. See Chapter 8, “Strategies to Reuse Materials and Reduce Material Use in Construction,” *Designing with Vision* can be downloaded in four parts from http://www.ciwmb.ca.gov/GreenBuilding. Chapter 8 is in Part D. Revised July 2000.

International Erosion Control Association. Provides technical assistance and an annual Erosion Control Products and Services Directory. (800) 455-4322. http://www.ieca.org/.

*Stormwater and Urban Runoff Seminars — Guide for Builders and Developers,* NAHB, Edited by Susan Asmus, Washington DC, (800) 368-5242 x538 or http://www.nahb.com/.

Stockdale, E.C. *Freshwater Wetlands, Urban Stormwater, and Nonpoint Pollution Control: A Literature Review and Annotated Bibliography*. 2nd Ed. WA Dept. of Ecology, Olympia, WA. 1991.

Strecker, E.W., J.M. Kersnar, E.D. Driscoll & R.R. Horner. *The Use of Wetlands for Controlling Stormwater Pollution*. The Terrene Institute, Washington, DC. April 1992.

U.S. Environmental Protection Agency. *Natural Wetlands and Urban Stormwater: Potential Impacts and Management*. EPA843-R-001. Office of Wetlands, Oceans and Watersheds, Washington, DC. February 1993.

U.S. Environmental Protection Agency. *Stormwater Management For Construction Activities: Developing Pollution Prevention Plans And Best Management Practices: Summary Guidance*. EPA#833-R-92-001, Office of Wastewater Management, 401 M St. SW, Mail Code EN-336, Washington DC, 20460. October 1992. (800) 245-6510, (202) 260-7786 or http://www.epa.gov/owm/sw/construction/.

# GUIDELINE SD5: NATIVE AND DROUGHT-TOLERANT PLANTS

## *Recommendation*

Use vegetation that is drought-tolerant and native to the school's climate area. Preserve existing vegetation, especially groups of plants or significant specimens wherever possible. Design for plant survival since many landscape areas in schools can be destroyed by intensive use. Design landscapes with a minimal water-use budget, using low-flow irrigation systems.

*Water needs for irrigation can be minimized by protecting existing vegetation and using native planting.*

*NREL/PIX 11340*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | | Programming | |
| Library | | Schematic | |
| Multi-Purpose | | Design Dev. | ■ |
| Gym | | Contract Docs. | ■ |
| Corridors | | Construction | ■ |
| Administration | | Commissioning | |
| Toilets | | Operation | ■ |

## *Description*

Native vegetation is adapted to regional climate conditions. They are easy to establish, are drought-tolerant (require little or no irrigation once established), and are naturally disease-resistant and pest-resistant. Planting for minimal water use is also referred to as "xeriscaping" or "drought-tolerant" landscaping.Existing vegetation is the easiest and most cost-effective way to landscape the site. It also provides historical connection to the surrounding neighborhood.

Plant survival can be increased by using tough plants that can take foot traffic such as plants grown from corms or bulbs. Good examples include *Dietes vegeta, Acanthus mollis, Phorium sp.,* and many of the grasses, reeds and sedges. These tough plants should anchor corners and edges of planted areas. Also raised beds, curbs, and temporary but artistic barriers can help protect plants into maturity. Preparing designs and management programs that layer plant types, use a mixture of sizes at initial plantings, and plan for plant succession will also help.

## *Applicability*

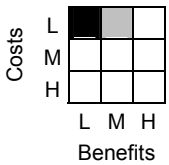
This guideline applies to all climates

## *Integrated Design Implications*

Drought-tolerant landscaping should be integrated/coordinated with Guideline SD2: Landscaping to Provide Shade to HVAC Systems, Buildings, and Paved Areas; Guideline SD3: Landscape Design and Management; and Guideline SD7: Integrated Weed, Disease, and Pest Management. All landscape planning should also take into account irrigation system parameters to assist in the goal of maximum efficiency. See Guideline WC1: Water-Efficient Irrigation Systems.

## *Cost Effectiveness*

Costs are competitive with, or only slightly higher than, conventional landscape design. Additional cost benefit occurs if reusing existing vegetation.



## *Benefits*

The use of drought-tolerant, native species conserves water (thereby reducing water costs), provides lots of attractive planting options, presents minimal disease and pest problems, thrives with little fertilization, requires low pruning and maintenance, provides wildlife habitat, and saves valuable landfill space. If retaining native vegetation in a landscape (rather than removing them and then replanting), added benefits include excellent erosion, sediment, dust, and pollution control.

## *Design Tools*

Landscaping for minimal irrigation also requires careful planning of plant groupings, the “right plant, right place” concept, soil considerations, and other landscape design practices. The use of a landscape professional with expertise in native and drought-tolerant vegetation for the school’s climate region is recommended.

Landscape Auditors certified by the Irrigation Association (703) 536-7080, Web site: http://www.irrigation.org/.

## *Design Details*

Add language into construction specs to protect existing plants, especially trees and root systems.

Soils are often disturbed during construction activities, and native vegetation may not thrive in degraded soils. Unless soil amendments are used to restore disturbed soil, it may be more appropriate to use water-efficient, non-native vegetation. See Guideline SD6 for using soil amendments.

Clearly define planting zones by intended use, e.g., lawns for play, tree groves for shade and habitat, shrub masses for buffering and screening.

Introduce plants to increase habitat, e.g., butterflies and hummingbirds.

Create a diversity of landscape areas, e.g., ponds, meadows and groves; community gardens; vines and perennials.

## *Operation and Maintenance Issues*

Native, drought-tolerant plants are usually hardier and more pest-resistant, requiring less fertilizer and pesticide use. Use organic, slow release fertilizers and integrated pest management for pest control. See Guideline SD7 on integrated pest management.

Recommend that the landscape contractor specify in the maintenance contract that new landscaped areas be maintained for a two to three year plant establishment period. Monthly findings on plant establishment should be reported to the owner.

## *Commissioning*

None.

## *References/Additional Information*


Arizona Native Plant Society, http://www.aznps.org/.

Arkansas Native Plant Society, http://www.anps.org/

Carnegie Library of Pittsburgh, http://www.trfn.clpgh.org/Lifestyle/Gardening/nativeplants.html. The Native Plants page has links to Pennsylvania resources, as well as national information.

City of Fort Collins. (March 1999). Xeriscape: a New Kind of Landscaping.
A summary of environmentally responsive landscaping resources, including a list of very low, low, and moderate water consumption.

http://www.ci.fort-collins.co.us/utilities/water/conserv/xeriscap.htm.

Connecticut Botanical Society, http://www.ct-botanical-society.org/

Florida Native Plant Society, http://www.fnps.org/.

Gardening to Preserve Maine's Native Landscape, University of Maine Cooperative Extension Bulletin #2500, http://www.nps.gov/plants/pubs/gardenME/

Georgia Native Plant Society, http://www.gnps.org/.

Idaho Native Plant Society, http://www.idahonativeplants.org/Index2.html.

Illinois Native Plant Society, http://www.inhs.uiuc.edu/inps/

Indiana Native Plant and Wildflower Society, http://www.inpaws.org/

Marsh, W. M. 1991. *Landscape Planning: Environmental Applications.* John Wiley & Sons, New York. A definitive reference for landscape architects, planners, and designers on the definition and application of environmental design principles to landscape and site planning.

Maryland Native Plant Society, http://www.mdflora.org/

Minnesota Native Plant Society, http://www.stolaf.edu/depts/biology/mnps/

Missouri Native Plant Society, http://www.missouri.edu/~umo_herb/monps/

Montana Native Plant Society, http://www.umt.edu/mnps/

Nevada Native Plant Society, http://www.state.nv.us/nvnhp/nnnps.htm

Texas Native Plant Database. Run by Texas A&M University and the Dallas Arboretum, this site features a searchable database with photos of native Texas trees and plants. http://www.dallas.tamu.edu/native

The Lady Bird Johnson Wildflower Center. Links page has contact information for native plant organizations for most states. http://www.wildflower.org/links.html.

U.S. Environmental Protection Agency, Great Lakes Region. This site is a thorough resource for native landscaping in the Great Lakes area. http://www.epa.gov/greenacres/

Utah Native Plant Society, http://www.unps.org/.

Virginia Native Plant Society, http://www.vnps.org/.

WaterWiser — a program of the American Water Works Association operated in cooperation with the U.S. Bureau of Reclamation. The web site provides information and resources including links for all aspects of outdoor and indoor water conservation, recycled water collection and reuse, irrigation, landscaping, and efficient fixtures and appliances. AWWA number is (202) 628-8303. http://www.waterwiser.org/.

Washington State University Cooperative Extension. This site contains a database with detailed information on plants native to the Pacific Northwest. http://www.gardening.wsu.edu/nwnative/

# GUIDELINE SD6: LANDSCAPING SOIL, AMENDMENTS, AND MULCH

## *Recommendation*

Use organic soil amendments to help restore the health of disturbed soils. Where feasible and appropriate, use soil amendments and mulch with recycled content.

## *Description*

The appropriate use of organic soil amendment will offset degradation in soil health due to construction activities, reduce runoff, help treat stormwater pollutants, and help ensure establishment of vegetation. Where feasible, use soil amendments from composted green waste and mulch from shredded bark, which adheres better to the soil.

*Amendments protect the health of soil. NREL/PIX01791*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ☐ | Programming | ☐ |
| Library | ☐ | Schematic | ■ |
| Multi-Purpose | ☐ | Design Dev. | ■ |
| Gym | ☐ | Contract Docs. | ▒ |
| Corridors | ☐ | Construction | ▒ |
| Administration | ☐ | Commissioning | ☐ |
| Toilets | ☐ | Operation | ■ |
| Other | ■ | | |

## *Applicability*

All climates.

## *Integrated Design Implications*

Soil amending should be integrated/coordinated with Guideline SD2: Landscaping to Provide Shade to HVAC Systems, Buildings, and Paved Areas; Guideline SD3: Landscape Design and Management; and Guideline SD5: Native and Drought-Tolerant Plants.

## *Cost Effectiveness*

Medium.

## *Benefits*

Research at the University of Washington has shown that, compared to traditional lawn installations, landscape grown on composted-amended soils:

| Costs | L | M | H |
|---|---|---|---|
| L | | | |
| M | | ■ | ▒ |
| H | | | |

Benefits

- Uses less water for irrigation.
- Requires less fertilizer and pesticide.
- Covers and “greens up” more quickly.
- Has improved appearance.
- Reduces stormwater runoff.

## *Design Tools*

Appropriate use of soil amendments requires site soil testing and analysis to determine type and amount of amendment.

## *Design Details*

Key steps in creating and maintaining healthy soil and amendments include:

- Minimize disturbance of existing soil.
- Test the horticultural suitability of existing soil.
- Strip and save suitable existing soil for re-use in landscape areas.
- All existing soil in areas to be planted that have been degraded and compacted from building construction must be scarified before planting. In general, and depending on soil type, planting soils can not be compacted more than 80% so that air and water can percolate through the soil cross section.
- Incorporate organic soil amendments from composted green waste to help restore the health of disturbed soils.
- Use a minimum 3 in. to 4 in. layer of mulch at all planting areas to help retain soil moisture and discourage weed growth. Some types of mulch can also take foot traffic.

Urban development often involves clearing, removing topsoil, cuts, and fills. Once the work is done, the remaining soil is often much less healthy than the original, native soil.

*Table 3 – Characteristics of Healthy vs. Disturbed Urban Soil*

| Healthy Native Soil | Disturbed Urban Soil |
|---|---|
| • Stores water and nutrients — Contains a rich, diverse makeup of organisms, organic matter, and pores. Healthy soil acts like a giant sponge, storing and slowly releasing water, oxygen, and nutrients to plants as needed.<br>• Regulates water flow — Maintains the natural water cycle by slowly discharging to streams and lakes and recharging aquifers.<br>• Neutralizes pollutants — Soil rich in organic matter contains microorganisms that can immobilize or degrade pollutants. | • Compacted — The removal of topsoil exposes subsoil that is often compacted. Heavy construction equipment can further compact soils. These dense layers resist plant root penetration and lack pores needed for adequate aeration. As a result, the soil is less able to absorb, retain, and filter (purify) groundwater.<br>• Reduced storage capacity — Because subsoil is less able to retain water, more stormwater ends up as runoff, disrupting the natural water cycle and degrading the health of nearby streams and waterways.<br>• Poorer quality — The subsoil layer generally contains less organic matter and fewer nutrients than rich topsoil. This soil is less able to immobilize or degrade pollutants. |

The result is increased erosion and stormwater runoff, as well as higher flow rates, higher temperatures, and increased sediment in nearby streams from disturbed urban soil. In addition, developed sites with poor soil typically require more irrigation, pesticides, and fertilizers to establish and maintain landscaping. Increased water usage as well as pesticide/fertilizer runoff causes further habitat damage.

## *Operation and Maintenance Issues*

Vegetation grown on amended soils establishes more quickly and requires less ongoing maintenance compared to vegetation grown on un-amended, disturbed urban soil.

## *Commissioning*

None.

## *References/Additional Information.*

U.S. Composting Council. This non-profit organization is involved in research, public education, composting, and compost standards. Their website has links to composting resources throughout the country. Web site: http://www.compostingcouncil.org/

# GUIDELINE SD7: INTEGRATED WEED, DISEASE, AND PEST MANAGEMENT

## *Recommendation*

Control and manage weeds, disease, and pests within tolerable limits to maintain the landscape in a manner that achieves attractive and healthy growth for plants, animals, and people while conserving energy and water.

*Outdoor learning areas like this must be kept free of harmful chemical pesticides and herbicides. NREL/PIX10675*

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ☐ | Programming | ☐ |
| Library | ☐ | Schematic | ☐ |
| Multi-Purpose | ☐ | Design Dev. | ■ |
| Gym | ☐ | Contract Docs. | ■ |
| Corridors | ☐ | Construction | ■ |
| Administration | ☐ | Commissioning | ☐ |
| Toilets | ☐ | Operation | ■ |
| Other | ■ | | |

## *Description*

The most effective weed, pest, and disease control measure is to keep plants healthy. When a problem is caused by an adverse environmental condition, chemically treating the problem will not prevent its recurrence, but will only treat the symptoms. Control of disease and pests includes, but is not limited to, rust, scale, aphids, mealy bugs, pine shoot moths, snails, and rodents.

Once viewed as safe and effective for insect control, chemical pesticides and herbicides are now recognized poisons that can contaminate the soil and harm wildlife and humans — especially children. Some of this poison finds its way into lakes, streams, and groundwater supplies, where it disrupts the balance of life. Reducing the use of pesticides protects lakes and contributes to a healthier environment for fish, wildlife, and people.

Integrated pest management (IPM) is a horticultural practice that stresses the application of biological and cultural pest control techniques with selective pesticides, when necessary, to achieve acceptable control levels with the least possible harm to human health and safety, non-target organisms, and the environment.

IPM encompasses various environmentally sound strategies, including:

- Use of appropriate, adapted plant varieties
- Installation of a compatible, supportive landscape/site design (such as incorporating concrete mow strips near fencing to eliminate the need for herbicide use in these areas)
- Providing the necessary nutrients and moisture
- Following through with good maintenance practices.

## *Applicability*

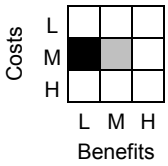
All climates.

## *Integrated Design Implications*

Planning for IPM should be integrated/coordinated with Guideline SD2: Landscaping to Provide Shade to HVAC Systems, Buildings, and Paved Areas; Guideline SD3: Landscape Design and Management; Guideline SD5: Native and Drought-Tolerant Plants; and Guideline SD6: Landscaping Soil, Amendments, and Mulch.

Landscape design that employs IPM will help limit the release of potential stormwater pollutants.

## *Cost Effectiveness*




Medium. IPM may have a higher initial cost than pesticide programs, but it is cost effective over the life of the building and produces safer school grounds, healthier vegetation, and lower spraying costs. Frequent pesticide use can result in a chemical dependent situation, where an insect comes back stronger than it was before. Increasing doses and frequency of application are then needed for attempted control of the pest. For example, pesticides that kill aphids also kill aphid predators. Since aphids reproduce more quickly than their predators, when they return to the plant, their natural enemies will be gone, and they may also become resistant to the pesticide. IPM means less pesticide/herbicide use, but may entail additional ongoing labor for maintenance as well as additional training, documentation, and policy development costs.

## *Benefits*

Decreased pesticide use means less health risk to students and staff, and lower maintenance costs associated with the purchase of pesticides.

## *Design Tools*

None.

## *Design Details*

There are four key issues for weeds, disease, and pests:

- Planting appropriate species and maintaining them in a healthy condition since most weeds and pests are more attracted to weak or over-fertilized plants than to those in good health.
- Determining what really is a weed or pest. A plant is a weed only if it is in an undesirable location or is out-competing more desired species. Many ”bugs” are essential to plant propagation and are beneficial to the health of plant.
- Maintaining weeds and pests on vegetation (grass, groundcover and shrubs, grasses and turf, gardens and perennials) within tolerable levels using the IPM approach.
- Controlling damage from water fowl, gophers, and other rodents by replacing inappropriate plants with those that are less susceptible, and by adding mechanical protection devices (cages, mesh, etc.) during the early growth period of the new plants, as needed.

Consult a landscape professional with expertise in IPM to identify landscape and site design strategies that will support ongoing IPM. Select plant species less prone to disease.

Perform weed control by hand, pulling and hoeing whenever possible. It is important to do this frequently enough so that weeds to not have a chance to go to seed. Remove weeds from pavement and all vegetative areas. If there is a persistent problem, a pre-emergent herbicide may be considered for the large or particularly troublesome areas *only* after review and approval.

IPM requires a proactive management program with a good system of monitoring and record keeping as the first line of defense. Contractors’ monthly reports shall include all weed, pest, or disease observations and actions taken for review by the management team. Mechanical and biological control measures, such as hand picking, water jets, safer soap, barriers (e.g., organic pastes or poly mesh), biological controls (e.g., *Bacillus thurengiensis*), and less toxic sprays (e.g., dormant/summer oil, sulfur fungicides,

pyrethrum, or rotenone) are first considered for use, often in combination. Less toxic chemicals will be considered before stronger chemicals.

Controlling pests is the subject of several research projects, particularly in grass areas. Herbicides and sprays used to eliminate broadleaf weeds or fungus have caused numerous injuries, studies, and debates. If grass areas are properly located and receive proper care, weeds and disease should not be a major problem. If problems do arise, they are to be reviewed with the consulting architect, and physical or biological solutions explored before chemicals are requested. Broadleaf weeds are to be kept to a minimum but multiple grass varieties are acceptable. The use of green dyes in particularly noticeable brown spots is an option.

## *Operation and Maintenance Issues*

IPM is a different approach and requires planning, education, and training to succeed. Each school district should develop and implement a written pest management policy.

## *Commissioning*

None.

## *References/Additional Information*

*Overview of Pest Management Policies, Programs, and Practices in Selected California Public School Districts*. This is a report of a study conducted by the Environmental Monitoring and Pest Management Branch of the Department of Pesticide Regulation (DPR) of pest management programs in California's public school districts. The study was conducted in cooperation with the California Department of Education (CDE) to: (1) obtain an overview of district pest management policies, programs, and practices, (2) identify policy and program constraints, and (3) identify ways that DPR can work cooperatively with CDE to assist school districts in implementing pest management programs based on the principles of IPM. The report is available on-line at http://www.cdpr.ca.gov/docs/dprdocs/schools/schools.htm.

*Reducing Pesticides in Schools: How Two Elementary Schools Control Common Pests Using Integrated Pest Management Strategies.* The Pesticides Reduction in Schools (PRI-School) Project explored the potential for reducing risks associated with unnecessary pesticide use by implementing IPM programs in schools throughout Santa Barbara County. The main goals of the project were to identify the local administrative, technical and social barriers to implementing effective IPM programs and to explore ways to overcome these barriers. Funding for the PRI-School Project was provided by the U.S. Environmental Protection Agency and the Santa Barbara Foundation. The project was managed jointly by the Community Environmental Council and Organic Consulting Services, both from Santa Barbara. The report is available on-line at http://www.grc.org/cec/pubs/IPM_report2.html.

University of California's Statewide Integrated Pest Management Project, web site: http://www.ipm.ucdavis.edu/default.html.

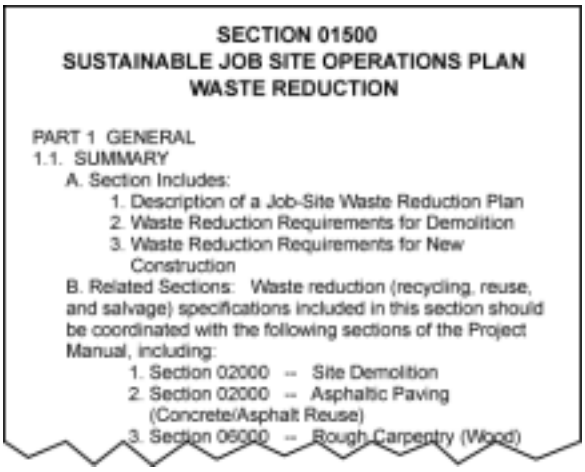
# GUIDELINE SD8: ENVIRONMENTALLY RESPONSIBLE JOB-SITE OPERATIONS PLAN

## *Recommendation*

Require a job-site operations plan that includes protocols for Job-Site Waste Reduction (Guideline RS3), IAQ (Guideline SD9), and Site Protection (Guideline SD10).

## *Description*

A job-site operations plan will describe goals, construction practices to achieve those goals, methods to train or otherwise communicate these goals to field personnel, and methods to track and assess progress towards those goals. For each component of the plan (waste reduction, IAQ, and site protection), these elements will be specified. In addition, the plan will specify the method of documenting compliance with these goals, including in the case of product substitutions.



SECTION 01500
SUSTAINABLE JOB SITE OPERATIONS PLAN
WASTE REDUCTION

PART 1 GENERAL
1.1. SUMMARY
A. Section Includes:
1. Description of a Job-Site Waste Reduction Plan
2. Waste Reduction Requirements for Demolition
3. Waste Reduction Requirements for New Construction
B. Related Sections: Waste reduction (recycling, reuse, and salvage) specifications included in this section should be coordinated with the following sections of the Project Manual, including:
1. Section 02000 -- Site Demolition
2. Section 02000 -- Asphaltic Paving (Concrete/Asphalt Reuse)
3. Section 06000 -- Rough Carpentry (Wood)

*Sample job site operations plan.*

**Applicable Climates**

**Applicable Spaces**

- Classrooms ■
- Library ■
- Multi-Purpose ■
- Gym ■
- Corridors ■
- Administration ■
- Toilets ■
- Other ■

**When to Consider**

- Programming □
- Schematic □
- Design Dev. ■
- Contract Docs. ■
- Construction ■
- Commissioning □
- Operation □

## *Applicability*

Job-site management is applicable to all spaces in schools and to all climates. While it is carried out in the construction phase, the contract documents must clearly specify the expectations of the general contractor.

## *Integrated Design Implications*

An environmentally responsible job-site operations plan protects the integrity of design goals to reduce waste, improve air quality, and protect the site and surrounding waterways from degradation.

## *Cost Effectiveness*

Costs for implementing the plan will include labor for overseeing and documenting compliance and should not be significant.

| Costs \ Benefits | L | M | H |
|---|---|---|---|
| L | | ■ | |
| M | | | |
| H | | | |

## *Benefits*

Having a plan in place helps minimize costs and liabilities, including delays, stoppages, and residual problems in the completed school building. Proper planning is always more cost-effective than cleaning up after a mistake.

## *Design Tools*

None.

### *Design Details*

The requirement for an environmentally responsible job-site operations plan would appear in the "Temporary Controls" section(s) of specifications. The more clearly a plan allocates responsibilities and expectations, the less likely the project will generate unpleasant surprises during and after construction. Ideally, the plan should specify a time requirement for when a plan must be submitted, such as within 14 days of Notice of Award and prior to applicable construction activities. In addition, it can include sample forms, references, or other resources for the contractor to help facilitate development of an effective plan.

### *Operation and Maintenance Issues*

The plan should specify a method of providing documentation for products substituted in the field, so that information is available to custodial staff should a replacement or repair be required. In addition, when dealing with non-conventional or innovative materials, information about how a product behaves during installation and pre-occupancy maintenance (such as during cleanup), as well as other "lessons learned" noted in a field log can be helpful.

### *Commissioning*

None.

### *References/Additional Information*

See the References listed for individual components of the plan in the following guidelines: RS3, SD9, SD10.

# GUIDELINE SD9: INDOOR AIR QUALITY DURING CONSTRUCTION

## *Recommendation*

Require indoor air quality (IAQ) planning and preventive job-site practices.

## *Description*

Preventive job-site practices can reduce residual problems with IAQ in the completed building and eliminate undue health risks for workers. "Healthy" job-site planning will adequately address problem substances, including construction dust, chemical fumes, off-gassing materials, and moisture. It will make sure these problems are not introduced during construction, or, if they must be, eliminates or reduces their impact. Areas of planning will include product substitutions and materials storage, safe installation, proper sequencing, regular monitoring, as well as safe and thorough cleanup.

*Healthy job site signage.*
*NREL/PIX 11408*

## *Applicability*

Maintaining healthy job-site conditions is important for all spaces and all climates. The activity is carried out in the construction phase, but must be planned in the design development and contract documents phases.

**Applicable Climates**

| Applicable Spaces | | When to Consider | |
|---|---|---|---|
| Classrooms | ■ | Programming | □ |
| Library | ■ | Schematic | □ |
| Multi-Purpose | ■ | Design Dev. | ■ |
| Gym | ■ | Contract Docs. | ■ |
| Corridors | ■ | Construction | ■ |
| Administration | ■ | Commissioning | □ |
| Toilets | ■ | Operation | □ |
| Other | ■ | | |

## *Integrated Design Implications*

When identifying "healthy" materials for use in buildings, the focus is generally on preventing problems during occupancy. This guideline implies that some responsibility for air quality occurs during installation, which may impact the choice of material and/or the method of installation. Also, since substitutions may happen in the field, it is important to outline the approval process for these substitutions clearly. For materials with off-gassing potential, require specific ingredient information about the product itself (as well as any adhesives, solvents, or other products that might be used during installation or maintenance). Designing to use mechanical fasteners (screws, Velcro) rather than chemical adhesives and solvents can reduce potential problems with IAQ during construction.

## *Cost Effectiveness*

| Costs \ Benefits | L | M | H |
|---|---|---|---|
| L | □ | ■ | ■ |
| M | □ | □ | □ |
| H | □ | □ | □ |

Implementing this guideline should not necessarily add cost to the project. The one area where it might add cost is in potential delays due to sequencing and ventilation requirements. However, this cost can be avoided by proper planning.

Risk managers will be reluctant to take on the added responsibility of requiring IAQ planning and preventive job-site practices. However, school districts and project architects across the country have

experienced litigation related to poor IAQ resulting from construction activities. Addressing these issues before and during construction will reduce exposure of the district and designers to potentially expensive litigation in the future.

### *Benefits*

The costs of poor IAQ are difficult to quantify, but considerable. They include the sum of illness and decreased student productivity paid by students and teachers, along with the district's cost of equipment replacement, workers' compensation claims, and in the most severe cases, potential litigation. Unfortunately, serious health complaints have resulted from careless acts during construction projects, such as failure to clean up spilled adhesives or neglecting to properly ventilate during and after applying sealants in an occupied building. These mistakes have led to school closures, unpleasant headlines, and costly lawsuits. Good IAQ strategies during construction will help eliminate these potential liabilities.

### *Design Tools*

The U.S. Environmental Protection Agency has an online checklist available for IAQ issues at all stages and aspects of construction. Visit http://www.epa.gov/iaq/schools/tools4s2.html.

### *Design Details*

IAQ goals (as with all other resource-efficient building goals) should be outlined in the Instructions to Bidders as part of the Project Summary addition. IAQ specifications should be included in the Temporary Controls sections of General Conditions.

The specifications should describe what is included in an IAQ construction plan, outline submittal requirements, and reference the SMACNA IAQ Guidelines for Occupied Buildings Under Construction 1995, with the goals of:

- Protect the ventilation system components from contamination, or provide cleaning of the ventilation components exposed to contamination during construction prior to occupancy.
- Provide a minimum continuous ventilation rate of one air change per hour during construction, or conduct a building flush-out with new filtration media at 100% outside air after construction ends (following issuance of Occupancy Certificate) and prior to occupancy for seven days (one week). Provide a minimum of 85% filtration (as determined by ASHRAE Standard 52.1-1992) on any return air systems operational during construction, and replace filtration media prior to occupancy. Note that seven days is considered a minimum. IAQ specialists recommend flushing the building with 100% outside air for 30 days prior to substantial completion.

If the contractor is required by the specification to be responsible for protecting IAQ during construction, it is not necessary to detail methods by which the contractor can achieve it. However, it is informative for contractors to include a list of proven air quality protection strategies, such as:

- Use supplemental (temporary) ventilation when installing carpet, paints, furnishings, and other VOC-emitting products, for at least 72 hours after work is completed. Preferred HVAC system operation uses supply air fans and ducts only, with windows providing exhaust. Use exhaust fans to pull air from deep interior locations. Stair towers and other paths to the exterior can be useful during this process.
- Perform regular inspection and maintenance of IAQ measures, including ventilation system protection and ventilation rate.
- Provide VOC-safe masks for workers installing VOC-emitting products (interior and exterior), which are defined as products that emit 150 grams per liter (gpl) or more. If local jurisdiction's requirements are stricter, the strictest requirement should be followed for using VOC-safe masks.
- Provide low-toxic cleaning supplies for surfaces, equipment, and worker's personal use. Options include several soybean-based solvents and cleaning options and citrus-based cleaners.

- Wet sand gypsum board assemblies. Exceptions should be clearly defined and include full isolation of space undergoing finishing or closure of all air system devices and ductwork. Additional conditions can be set.
- Use safety meetings, signage, and subcontractor agreements to communicate the goals of the construction IAQ plan.

The IAQ construction plan is also a good opportunity to proscribe unacceptable behaviors that represent a potentially negative impact on long term IAQ such as smoking, using chew tobacco, or wearing contaminated work clothes.

## *Operation and Maintenance Issues*

Contractors should be required to provide information on product substitutions sufficient to enable operation and maintenance staff to properly maintain and repair low-emitting or otherwise “healthy” materials.

## *Commissioning*

None.

## *References/Additional Information*

U.S. Green Building Council’s *Reference Manual* for LEED Green Building Rating System (Commercial, Version 2) at http://www.usgbc.org. Also see Carpet and Rug Institute (CRI) guidelines for carpet installation. The Painting Contractors Union (New York City local) has reportedly developed guidelines for ventilation during painting.

U.S. Environmental Protection Agency. www.epa.gov/iaq/schools/tfs/renovate.html. A checklist for IAQ issues at all stages of construction.

# GUIDELINE SD10: SITE PROTECTION DURING CONSTRUCTION

## *Recommendation*

Require best management practices for site protection during construction.

## *Description*

An effective job-site protection plan will describe construction practices that eliminate unnecessary site disturbance, minimize impact on the site's natural (soil and water) functions, and eliminate water pollution and water quality degradation.

Primarily it will include protocols for:

- Construction equipment operation and parking
- Topsoil and vegetation protection and reuse
- Hazardous materials management
- Installation and maintenance of erosion control and stormwater management measures.

*Silt fencing helps to avoid construction delays and work stoppages due to erosion. NREL/PIX 11409*

**Applicable Climates**

## *Applicability*

This guideline applies to all climates and spaces.

**Applicable Spaces**

- Classrooms ■
- Library ■
- Multi-Purpose ■
- Gym ■
- Corridors ■
- Administration ■
- Toilets ■
- Other ■

**When to Consider**

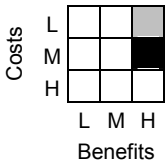
- Programming □
- Schematic □
- Design Dev. ■
- Contract Docs. ■
- Construction ■
- Commissioning □
- Operation □

## *Integrated Design Implications*

The plan should be integrated with stormwater management and erosion control measures. In addition, a requirement to submit ingredient information about in-field product substitutions to avoid degradation of water quality on the site is important.

## *Cost Effectiveness*

This guideline recommends going beyond typical site practices. The project architect needs to evaluate the risk of erosion problems to determine whether redundant erosion control measures are cost effective. Least-toxic pest and weed control is quite cost effective, as it can provide savings and an increased level of safety for students who will be using the school grounds.




## *Benefits*

Construction delays and work stoppages due to erosion control failure are avoided. Water quality in surrounding waterways and groundwater supplies are protected. Health risks to students due to residual toxicity on the site can be reduced.

## *Design Tools*

None.

## *Design Details*

Site protection (as with all other resource-efficient building goals) should be referenced in the Instructions to Bidders as part of the Project Summary. In addition, site protection specifications should be included in the Temporary Controls sections of General Conditions. The specifications should describe what is included in a site protection plan, outline submittal requirements, and recommend strategies, including:

- Regular inspection and maintenance of site protection measures. At a minimum, inspection of all erosion and sedimentation measures after a heavy rainfall, which is defined as 0.5 in. in less than 24 hours.
- Redundant mechanisms for site protection of any critical or sensitive areas, as identified in the site plan. Silt fencing fabric and other temporary site protection measures should be selected to last for the life of the project.
- Measures to ensure that detergent does not get into soil and sediment separators.
- Posted protocol for construction vehicles regarding parking and access on the site.
- Rocked heavy construction vehicle entrance and tire wash.
- Posted clean-up procedures for spills to prevent illicit discharges.
- Measures to minimize risk of the toxic release of hazardous wastes, including paints and other finish products, solvents, adhesives, and oils as follows:
  - Avoid overstocking.
  - Adopt a first-in, first-out policy.
  - Label containers properly.
  - Control access to storage areas and routinely inspect containers.
  - Inspect all containers upon receipt. Reject leaking or damaged containers.
- Topsoil preparation, planting, and maintenance using Integrated Pest Management (least-toxic) protocol. Least-toxic products for controlling pests and insects in detention ponds and for soil prep. No chemical weed eradication.
- Safety meetings, signage, and subcontractor agreements that communicate the goals of the site protection plan.

## *Operation and Maintenance Issues*

Operation and maintenance staff should be informed so that least-toxic products have been used for soil preparation and for controlling pests and insects in detention ponds. Also, contractors should be required to provide information on product substitutions sufficient to enable operation and maintenance staff to properly maintain site protection measures.

## *Commissioning*

None.

## *References/Additional Information*

Ross Middle School. Ross School District, CA. Completed in 1999. For more information contact Dana Papke, DPapke@CIWMB.ca.gov.

U.S. Green Building Council's *Reference Manual* for LEED Green Building Rating System (Commercial, Version 2) at http://www.usgbc.org. Also see the Environmental Protection Agency (EPA) publication: *Stormwater Management for Construction Activities, Chapter 3*