Chapter 8:
Constructing the Building

- *Developing a Construction Plan*
- *Writing Effective Construction Documents*
- *Safeguarding Design Goals During Construction*
- *Protecting the Site*
- *Low-Impact Construction Processes*
- *Protecting Indoor Air Quality*
- *Managing Construction Waste*

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Chapter 8

Constructing the Building

Developing a Construction Plan

A high-performance design is a great achievement, but it doesn't mean much if the building isn't then built as intended. Getting from design to a completed project happens in two stages: 1) development of construction documents and 2) actual construction. To successfully implement a sustainable design, the construction documents must accurately convey the specifics that determine building performance, and they have to set up systems for informing and training contractors and subcontractors about unfamiliar materials and methods. The task during construction is also two-fold: 1) construct the building so it will perform as intended and 2) protect the environment as much as possible throughout the process.

Ideally, the general contractor will have been an active participant in the design process, suggesting materials and construction methods to achieve the project's goals in an efficient and cost-effective manner. He or she will already be familiar with those goals, and will be well-equipped to ensure that they are promoted and supported during construction. Often, additional decisions with energy and environmental impacts are made during construction. It is essential to evaluate how these decisions can affect the ability to meet the original project design goals before implementing changes to the project design.

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The LANL Emergency Operations Center under construction.

Regardless of whether the contractor has been involved throughout the design process, the contractor and principal subcontractors should participate in setting guidelines to ensure that construction meets project design goals and that it is carried out in an energy- and environmentally sensitive manner. Creating the guidelines as a team is helpful for educating contractors about sustainability issues and getting their buy-in to the sustainability goals. Also, including the contractors in the process will ensure that the guidelines can be realistically implemented during construction. Environmental guidelines for the construction process should include construction practices, site protection, erosion control, indoor air quality, and specific measures for reducing energy and water use.

The integrated nature of high-performance buildings means that each building element may serve multiple functions. Coordinating the specifications and construction of these elements requires excellent communication throughout the process.

When developing and implementing construction documents, specification writers, general contractors, tradesmen, and others can add value by understanding the goals and intended uses of the building, and ensuring that everything they do fully supports those goals. As each person on the team is the expert within his or her profession or trade, he or she should be encouraged to suggest alternative ways to meet those goals, especially if those alternatives can improve quality, enhance performance, or reduce costs. But any changes must be reviewed by team members who are knowledgeable about all aspects of the building's performance to ensure that the proposed changes do not inadvertently undermine key performance goals.

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Reviewing construction documents for the LANL Medical Facility.

Benefits Resulting from Good Construction Guidelines

- ***Building performance*** – Attention to process issues during construction is critical to creation of a high-performance building.
- ***Reduced environmental compliance costs*** – A proactive approach to environmental issues can reduce the time and effort needed to document compliance with environmental regulations and guidelines.
- ***Safer construction site*** – Attention to environmental issues during construction leads to a safer and healthier work site.
- ***Reduced construction costs*** – Working with natural landscape features is often less expensive than clearing a site and then reestablishing landscaping and stormwater management functions.
- ***Professional development*** – Given the increasing demand for green buildings, knowledge of the skills needed to deliver these buildings will serve everyone well in the future.

Writing Effective Construction Documents

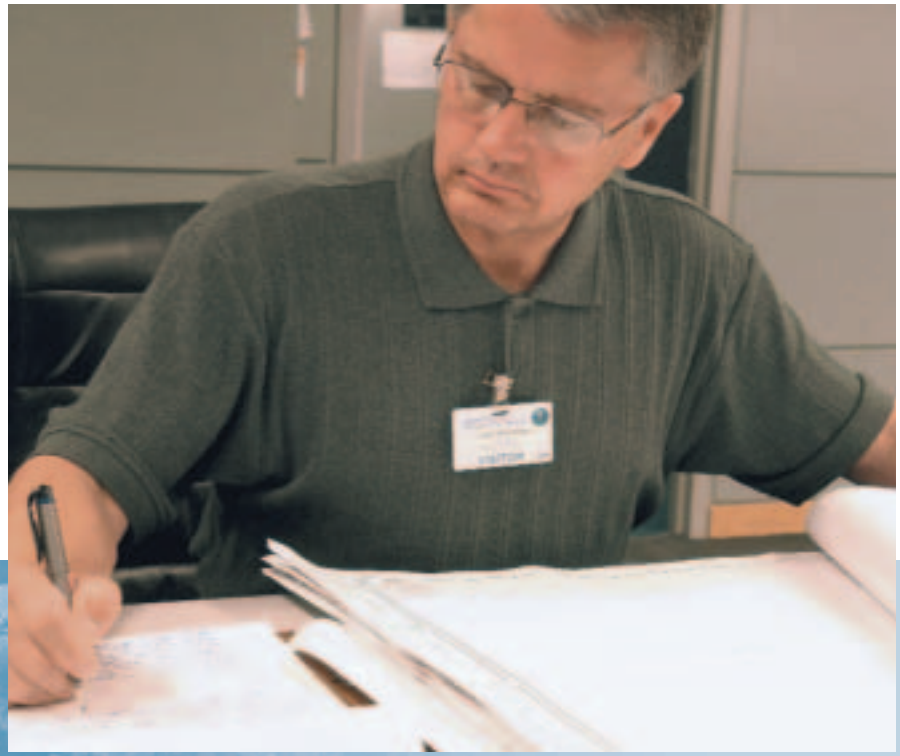
Construction documents must accurately document the design, including all features and details needed for the building's sustainable goals. They also must set up mechanisms to ensure that everyone who will participate in implementing the design is apprised of the environmental goals and knowledgeable about the materials and techniques that will be used to meet those goals. Spell out this information in Division 1 of the specifications, typically in Section 01350 – Special Procedures. Also, insert the information throughout the drawing and specifications wherever special conditions or requirements exist.

Construction documents spell out the design and make the design team informed of and accountable to the sustainability goals of the building.

Verify that the construction specifications and drawings support the design intent. Ideally, a commissioning agent will already be on-board to perform such a review at the end of the design process. The team member(s) responsible for reviewing the construction documents should follow these five steps when completing this review.

1. Verify that HVAC equipment has specified efficiencies, air-delivery volumes, and temperatures. Consult Chapter 5 to ensure that equipment has been designed for the building and sizing was not based just on rules-of-thumb.
2. Specify materials and products by name and include a performance specification to accommodate alternative products. For example,

- Specify insulation by thermal resistance (R-value), permeability, and recycled content, not by thickness.
- Specify interior paints based on durability, cleanability, aesthetics, and VOC emissions.



Warren Gretz

Accurately document the sustainable design intent in construction drawings and specifications to avoid confusion during construction.

3. Evaluate the plan's thermal integrity:

- Check for continuity of insulation to avoid thermal bridging. Potential trouble spots to focus on include: steel framing members, the building slab, door thresholds, and window frames.
- Check for potential air leakage at construction seams and joints.

4. Temporary materials purchased for construction must meet the same environmental guidelines as other materials in the project, unless other criteria have been explicitly chosen for these applications. See Chapter 6 for specifics. For example:

- Construction wood (forms, bracing, etc.) may need to be certified.
- Temporary materials should be local in origin when possible.
- Temporary materials, such as wood frames, bracing, and temporary fencing should contain recycled content when possible.

5. Create a written system for evaluating and monitoring how the contractor is meeting sustainability requirements.

- Requiring pre-installation conferences to discuss installation procedures for a product or assembly that might be unfamiliar to the local contractors or might need to be handled in a specific way. This conference allows for face-to-face communication that should clarify ambiguities and prevent costly misunderstandings.
- Clearly stating in the specifications that all substitutions shall be approved before the substitution is made. The specifications should avoid the term "or equal," and use "or approved equal" instead. That way, material or equipment selections can be considered for potential alternative products. The submission instructions must clearly explain information required to evaluate substitution requests, and the criteria to be used. In particular, it should be noted that, in addition to the usual product performance criteria (strength, durability, appearance), environmental factors will be considered.

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An organized, well-managed construction site promotes safety.

Safeguarding Design Goals During Construction

Building contractors are typically under a lot of pressure to meet the required schedule and budget for construction. Often, even with ample lead time, it can be difficult to ensure that specialty construction materials will be delivered when they are needed. When this happens, alternative materials and methods may be proposed to maintain the construction schedule.

Establish a plan for identifying critical design elements and component attributes that have the potential to affect other systems. Such attributes include: HVAC design, efficiency of heating and cooling equipment, glazing type (both visible and solar spectra, thermal performance of window frames, insulation R-values, and lighting layout. When changes are identified, determine alternatives with similar characteristics. Run energy simulations to determine impacts of alternatives.

David Parsons

Examining a desiccant wheel upon delivery to the construction site.

Possible Consequences of Construction Substitutions

Material substitutions can result in a building that does not perform as intended. Recovering from construction errors also can compromise the original design intent. For example:

- If window glass was specified with specific visible transmittance and solar heat gain characteristics, but is replaced with glass having different characteristics, the daylighting may not work as designed, and the building may have higher heating or cooling loads than expected. Such a change would also require redesign of the mechanical and electrical systems and the final result would be higher construction costs and much higher operational costs. Energy and environmental goals would not be met.
- If the building foundation were back-filled prior to proper installation of insulation, the consequence would be additional heat loss through the slab and higher heating costs. More important, it would adversely affect thermal comfort and require maintaining higher air temperature in the space to compensate for the reduced radiant temperature of the slab. The ripple effect is usually not acceptable from a human productivity or a long-term energy cost point-of-view.

  When such errors occur, it is important not to assume that their effect will be negligible. Instead, they should be brought to the attention of design team members who can determine what effect they might have on the project goals and how any adverse effect can be mitigated.

Protecting the Site

The final site plan for the building should minimize site disturbance zones based on the current state of the site (see Chapter 3). A plan should be written that protects as much of the site as possible, including vegetation, land contours, and drainages.

The plan should indicate areas of the site to be used, including staging areas, storage areas (for materials and excavated materials), and the building site. Consider any site clearing that may be necessary to meet fire risk reduction guidelines as described in the *Design Principles*. Elements to protect should be clearly marked. All materials entering the site should have a designated site storage destination prior to their arrival. Often, materials entering the site are "dropped" at a point that looks open. The more materials are moved, the greater the possibility for damage to the materials and the site and the potential for wasted funds.

Avoid damaging existing vegetation, especially to mature stands of trees. Damage to trees, both above and below ground, can occur during construction activities. The following guidelines help preserve existing trees:

- Install fences around trees to protect them from construction activities.
- Avoid trenching and digging near roots. (Roots can grow at distances one to three times the height of the tree.)
- If trenching cannot be avoided, then place the trench directly under the tree, as this damages the fewest roots and does not unbalance the tree. (If major roots from one side of a tree are severed, the tree could fall or blow over.)
- Avoid compacting soils containing tree roots to prevent decreasing the soil oxygen level, which inhibits root growth.

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A silt fence is used to control erosion.

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The LANL Non-Proliferation and International Security Center (NISC) was constructed on a previously distributed site.

- Avoid placing additional soil on the ground or changing the surface grade over the tree root systems, as that can smother the roots.
- Carefully choose which trees to remove, for removal of tall neighboring trees can expose remaining sun- and wind-sensitive trees to the elements and cause damage such as sunscald to trunks and branches.

Consider relocating and planting trees, shrubs, and other flora that could be restored as landscaping on this project or another project (see Chapter 7). Be sure to select plants that are able to tolerate transplanting; and become familiar with the best method for transplanting and care of the species chosen.

Preserve vegetation whenever possible, especially in low areas, to minimize runoff erosion and help water infiltrate during and after construction.

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Checklist for Protecting the Site:

- ☐ Protect designated areas (trees, drainages, etc.) with temporary fencing.
- ☐ Locate all construction trailers and parking areas for construction equipment and employees where they will cause the least damage to the site.
- ☐ Specify areas in which to receive materials.
- ☐ Identify locations for recycling and waste bins.
- ☐ Identify access paths for construction vehicles and general public access. If possible, these paths should correspond to areas that will eventually be paved or covered with other hard surfaces.
- ☐ Consider laying down preliminary paving in areas that will be permanently paved later. This will reduce dust and erosion from construction activities and traffic.
- ☐ When preparing the site, consider reusing site debris, including plant material, stone, gravel, and soil. Chip wood and use it on LANL grounds for mulch. Some of the material can be used as erosion and mud protection on the site. Scrape all topsoil to the construction limits and stockpile it for later use.
- ☐ Use best management practices for stormwater and silt management. Consider creating stormwater management practices, such as piping systems, retention ponds, or tanks, which can be carried over after the building is complete (see Chapter 3).

Low-Impact Construction Processes

Construction of a building uses a lot of energy, water, and other resources, beyond those that end up in the building itself. By paying attention to these resource flows, contractors can adopt procedures that are more efficient and less polluting. Here are some examples.

- Monitor energy and water use for construction. Provide incentives or place the utility and water bills in the contractor's name to encourage conservation.
- Use lighting during construction only in active areas of the site. This saves energy and protects the night sky from light pollution.
- Turn all lights off when work is at a halt. Operate security lighting on motion sensors.
- Use energy-efficient lamps, such as compact fluorescents, for temporary and permanent lighting schemes.
- Use renewable energy technologies or green power, if locally available, to power equipment.
- Consider using low-sulfur diesel or biodiesel fuel to minimize pollution from construction equipment and vehicles.
- Consider maintaining a natural-gas or electric pick-up truck on site for errands and other local use.
- Use low-flow fixtures for water siphons installed for construction.
- Use rainwater or reuse greywater from the construction site.

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Appropriate construction equipment selection reduces site environmental impacts.

Protecting Indoor Air Quality

During construction, dust, VOCs, and emissions from equipment permeate the building site and the building itself. Poor indoor air quality (IAQ) can damage the health of workers and occupants of nearby buildings. It is important to take specific measures to protect IAQ on the site during and after construction.

Create a written plan for the contractor to use in managing air quality on the construction site that includes the following:

- Put up barriers to keep noise and pollutants from migrating.
- During pollution-generating activities in enclosed spaces, ventilate those spaces directly to the outdoors whenever possible.
- Once it is installed, ventilate the building through the HVAC system with appropriate temporary filtration to prevent the system from becoming contaminated.
- Cover and seal exposed openings of any ducts or equipment during construction.
- Increase the amount of outside air coming into the building during construction to reduce pollutants.
- Create controls, such as scheduling construction activities at the end of the day, to ventilate overnight while site and surroundings are unoccupied.

- Be aware of air quality throughout the project, not just during times of activities that create high amounts of airborne pollutants and emissions.
- Monitor IAQ regularly with tests and inspections and adjust the ventilation and scheduling if necessary to improve IAQ.
- Prevent poor IAQ by selecting materials and products designed for less offgassing, such as low-VOC paints and sealants and formaldehyde-free particle board (see Chapter 6).
- Keep the site and interiors clean and free of debris to keep dust down. Store polluting materials in a specified storage area to protect the building from pollutants.
- Meet or exceed the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, 1995.
- Protect stored on-site or installed absorptive materials from moisture damage. Avoid installing any materials that might absorb moisture until they can be protected adequately.
- Replace all filtration immediately prior to occupancy. Filtration should have a Minimum Efficiency Reporting Value (MERV) of 13 as determined by ASHRAE 55-1992, Addendum-1995.
- Check for dirt and contamination in ducts and plenums, and clean them, if necessary, before occupancy.
- If an under-floor air distribution system is to be installed, keep the floors clean because they will become part of the air supply passages.
- Conduct a minimum two-week building flush-out with new filtration media at 100 percent outside air after construction ends and before occupancy.

National Institutes of Health

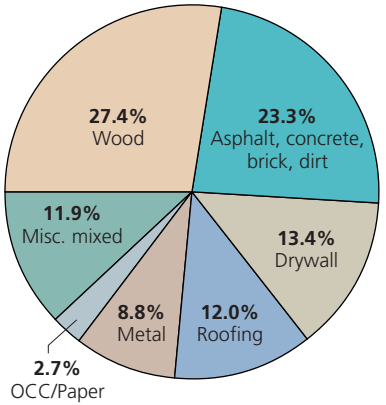
Managing Construction Waste

Construction activities generate significant quantities of solid waste. The primary intent of sustainable construction waste management practices is to conserve resources by minimizing the amount of material disposed of in landfills. Always conduct construction waste management on the basis of the three- "Rs" hierarchy: reduce, reuse, and recycle. Although recycling is an important aspect of construction waste management, it is last in the hierarchy.

- Reduce waste generation by following the waste reduction measures developed during the design phase.

Typical Construction and Demolition Waste Streams

(Waste percent by volume)



Reference: USGBC LEED Reference Guide, Version 2.0, August 2000

- Reuse materials on the project or offer materials for reuse or resale by others (e.g., return unused materials to vendors for credit or donate unused materials to organizations such as Habitat for Humanity).
- Recycle construction waste materials as the last opportunity to reduce the amount of waste destined for the landfill.

Generally, recycling construction waste also offers cost savings in the form of reduced disposal costs. However, such savings can be offset by the extra labor required to prepare the materials (e.g., source separation) and the additional hauling expense. Evaluate these factors for each project because they will vary with project size and market conditions.

Guidelines for Implementing Successful Construction Waste Management Practices

Identify recyclable materials
It is important to identify which materials can be recycled in the vicinity of LANL. Contact LANL Pollution Prevention for recycling options. The local solid waste authority or Home Builders Association may provide additional recycling options. Other sources of information include: New Mexico Environment Department, New Mexico Energy, Minerals and Natural Resources Department, waste haulers, and demolition contractors.

Determine the cost and savings of recycling
To determine if recycling is cost-effective on a construction project, compare the cost of normal waste disposal practices with the cost of recycling. Generally, recycling offers cost savings in the form of avoided disposal costs. Unfortunately, savings can sometimes be offset by the extra labor it may take to prepare materials to meet the recycler's specifications or the additional hauling expense to take the materials to the recycler.

Specifications
Develop specification language to address waste reduction, reuse, and recycling during construction. Sample specification sections are included in the references at the end of this chapter.

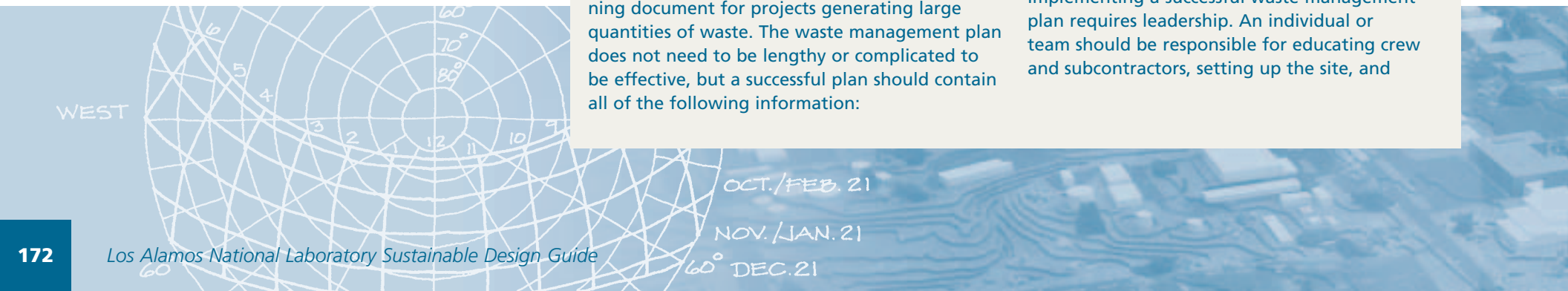
Waste Management Plan
A waste management plan is an effective planning document for projects generating large quantities of waste. The waste management plan does not need to be lengthy or complicated to be effective, but a successful plan should contain all of the following information:

- Waste management goals
- An analysis of project waste
- Identification of what materials will be recycled
- Disposal methods
- Material handling procedures
- Identification of who will be responsible for implementing and monitoring waste disposal and recycling
- Instructions for the crew and subcontractors.

Specifications in Subcontractor Agreements
In addition to a general waste management plan, it may also be helpful to specify the waste management goals in subcontractor agreements. This ensures that expectations and procedures are clearly communicated to everyone. The following is a sample specification in a subcontractor agreement:

"The subcontractor will make a good faith effort to reduce the amount of waste generated on the job-site and recycle material per the contractor's Waste Management Plan. The subcontractor will follow the designated handling procedures for each type of waste generated on-site and provide documentation to verify material reuse, recycling, and disposal as indicated in the waste management plan."

Managing the Program
Implementing a successful waste management plan requires leadership. An individual or team should be responsible for educating crew and subcontractors, setting up the site, and



Guidelines for Implementing Successful Construction Waste Management Practices (continued)

coordinating and supervising recycling efforts to prevent contamination of recycling loads. On small-scale projects, the contractor, site supervisor, or crew chief can manage recycling activities. For larger projects, form a waste management team consisting of key people such as the owner, designer, project manager, and site supervisor.

Involving Subcontractors

Take steps to ensure that subcontractors will participate in the successful implementation of the waste management plan. Require subcontractors to use the recycling and disposal bins on-site. In doing so, be sure to provide recycling for the variety of wastes that subcontractors generate. Alternatively, the subcontractors could recycle their waste on their own, but documentation of their efforts would be required.

Source Reduction

Source reduction at the job site prevents waste generation. This includes minimizing contributors to waste such as over-packing, improper storage, ordering errors, poor planning, breakage, mishandling, and contamination.

Reuse Options

There are some new approaches to reusing materials to lower disposal costs. "Clean" wood and drywall waste can be used on site. Chipped wood can be used as mulch and pulverized drywall can be used as a soil amendment. In addition, reuse centers accept and then resell salvaged materials and misordered or slightly damaged new materials. Many reuse operations are not-for-profit organizations, such as Habitat for Humanity, the Salvation Army, and Wemagination. All reuse options considered must be coordinated through LANL.

Finding Appropriate Space

Recycling and reuse efforts require space. Set aside an area of the job site to store salvaged building materials and to house recycling bins (for either commingled or source-separated loads). The following are helpful hints for finding space on the job site:

- Use smaller bins and more frequent collection.
- Ask recycling service providers about single dumpsters with multiple compartments.
- Rent a trailer for the major portion of recyclable material generated in the first phase of construction and haul it directly to the recycler when full.
- Use smaller containers that are collected at the end of the day and dumped into a larger container for pickup.
- If self-hauling, build custom containers to fit the space requirements using scrap or damaged plywood, concrete forms, or barrier fencing.
- If space is too limited on the job site to accommodate separation of materials, seek a waste hauler who will take comingled waste and sort it off-site for recycling and disposal.

Promotion and Education

Once space for recycling and disposal activities has been designated, communicate the plan to the crew and subcontractors. Everyone will need to know how materials should be separated, where materials should go, and how often the materials will be collected and delivered to appropriate facilities. Tips for educating the project team are:

- Include waste handling requirements in all project documents. This makes it clear from the beginning that waste prevention and recycling is expected from all crew members and subcontractors.
- Let the crew and subcontractors know how effective they have been by regularly posting the volumes of material reused or recycled.
- Include everyone in the process.
- Encourage suggestions for more efficient recycling methods, or additional materials that can be recycled.

Preventing Contamination

Project recycling efforts may be in vain if recycling loads get mixed or become contaminated with non-recyclable garbage. Haulers and recyclers generally won't take contaminated materials, which can then cost extra disposal fees. The following tips can help prevent contamination of recyclables:

- Post information describing the recycling program in visible locations.
- Clearly label recycling bins. Post lists of materials that are and are not recyclable.
- Place recycling and trash bins near each other so that trash is not thrown into the recycling bins.
- Conduct regular site visits to verify that bins are not contaminated. Give feedback to subcontractors and the crew on the results of their efforts.
- Consider locating bins in a locked or supervised area.

	✓ *Standard Practice/ Code-Compliant*	✓ *Better Performance*	✓ *High Performance for Sustainability*
Specifications	◯ Standard specs based on office master or generic master specifications, modified to fit project	◯ Specifications with green goals and requirements spelled out in Division 1 and all relevant technical sections	◯ Preinstallation conferences with contractors and subcontractors to ensure good communication
Changes During Construction	◯ Accepted with minimal review in most cases	◯ Reviewed by generalist who is supervising construction	◯ Reviewed by design team members who are qualified to determine the effect of the change on the project goals
Sitework	◯ Staging areas and traffic flows not well coordinated	◯ Areas designated for staging and traffic with consideration for protection of environmentally sensitive areas	◯ Any areas not specifically designated for staging or traffic protected with temporary fencing and penalties for damage
	◯ Existing vegetation scraped off for convenience of construction activities	◯ Areas to be protected fenced off and irrigated as appropriate	◯ Existing vegetation protected during construction, including relocating existing plants for reuse
Construction Processes	◯ Minimal attention to energy and water usage	◯ Efforts made to improve efficiency of the most energy- and water-intensive processes	◯ Comprehensive effort to document energy and water usage and avoid waste
Construction Waste	◯ Segregation and disposal	◯ Recycling	◯ Comprehensive plan implemented for material and waste reduction
Construction IAQ	◯ No special attention to indoor air quality effects of construction	◯ Increased ventilation during polluting activities	◯ Comprehensive plan implemented for protecting IAQ during construction and preventing actions that could jeopardize IAQ afterwards

Additional Resources

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ***www.ashrae.org***

"Construction IAQ Management: Job-site Strategies for Ensuring a Healthy Building" *Environmental Building News,* Vol. 11, No. 5 (May 2002).

EPA Comprehensive Procurement Guidelines, ***www.epa.gov/epaoswer/non-hw/procure/products.htm***

"Greening Your Business" *Environmental Building News,* Vol. 9, No. 10 (October 2000)

Green Seal, ***www.greenseal.org***

"Getting from Design to Construction: Writing Specifications for Green Projects" *Environmental Building News,* Vol. 11, No. 7 (July-August 2002)

Green Building Materials: A Guide to Product Selection and Specification, Ross Spiegel and Dru Meadows, John Wiley & Sons, 1999.

"Construction Specifications" by Donald Baerman, in *Time-Saver Standards for Architectural Design Data*, 7th edition (McGraw-Hill, 1997)

Reference Specifications for Energy and Resource Efficiency, California Energy Commission: ***www.eley.com/specs/***

GreenSpec Product Directory with Guideline Specifications, BuildingGreen, Inc., 2002

International Society of Arborculture, ***www.isa-arbor.com***

Sheet Metal and Air Conditioning National Contractors Association (SMACNA), ***www.smacna.org***

"Transplanting Trees and Shrubs," North Dakota State University, NDSU Extension Service, ***www.ext.nodak.edu/extpubs/plantsci/trees/f1147w.htm***

WasteSpec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling, Triangle J Council of Governments, ***www.tjcog.dst.nc.us/cdwaste.htm***

Habitat for Humanity, Espanola, New Mexico: Phone: (505)747-2690

LANL Pollution Prevention, ***http://emeso.lanl.gov***

New Mexico Environment Department, ***www.nmenv.state.nm.us***

New Mexico Energy, Minerals, and Natural Resources Department, ***www.emnrd. state.nm.us***

Home Builder's Association for Central New Mexico, ***www.hbacnm.com***