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Planning for Disaster Debris

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Planning for Disaster Debris

U.S. Environmental Protection Agency

Office of Solid Waste

About This Guide

This guide highlights the need for communities to plan for the cleanup of debris after a major natural disaster. Based on lessons learned from communities that have experienced such disasters, this guide contains information to help communities prepare for and recover more quickly from the increased solid waste generated by a natural disaster.

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Introduction

Every year natural disasters, such as fires, floods, earthquakes, hurricanes, and tornadoes, challenge American communities. These natural disasters have generated large amounts of debris, causing considerable disposal challenges for local public officials. If you answer yes to any of the following questions, your community could benefit from the advice and information presented in this guide.

- Is your community at risk of significant damage from a natural disaster?
- Does your emergency plan ignore disaster debris cleanup or rely on open burning or unengineered burial of the debris?
- Has your community updated its solid waste management[1] plans with recycling policies that are not included in your emergency response plan?
- Does your emergency plan need updating to reflect recent changes in the community's solid waste management practices and facilities (e.g., landfill closures, new recycling programs, or regionalization of services)?

In the past, debris from disasters was simply buried or burned in the community. As demonstrated by recent disasters, burying or burning debris as a means of waste management may not be acceptable. Citizens do not want to inhale the smoke from open burning. Municipalities do not want to risk contamination of drinking water and soil from uncontrolled burial of debris. Under normal circumstances, much municipal solid waste is recycled. The remainder is disposed of in sanitary landfills or in sophisticated combustors, both of which are equipped with devices to control pollutants. Often, however, these standard waste disposal options are not sufficient to handle the overwhelming amount of debris left after a disaster. Further adding to the disposal dilemma is the fact that many municipalities are reluctant to overburden or deplete their existing disposal capacity with disaster debris.

Any community likely to be faced with significant debris from a natural disaster should develop a debris management plan. To facilitate coordination, this plan could be a specific task under the community's general emergency plan. This guide, based on experiences of other communities, suggests some helpful planning considerations. It describes steps a community can take to prepare for dealing with the waste created by natural disasters and to speed recovery after such disasters. It also describes ways communities can reduce the burden on their municipal solid waste management systems in the event of a natural disaster.

This guide does not provide all the tools a planner will need to write a debris management plan, however. The development of a disaster debris management plan usually requires input from neighboring communities, state officials, local contractors, and a variety of local agencies. This guide is intended to help a planner begin the development process.

Hurricane Andrew

[1] In this guide, the term "solid waste management" refers to all phases of nonhazardous solid waste removal and handling, including collection, transportation, sorting, processing, recycling, reduction, combustion, and landfilling.

Natural Disasters Can Generate a Substantial Volume of Debris

Natural disasters strike with varying degrees of severity and pose both short- and long-term challenges to public service providers. The most severe natural disasters generate debris in quantities that can overwhelm existing solid waste management facilities or force communities to use disposal options that otherwise would not be acceptable. The table below gives examples of how much debris was generated in a few recent natural disasters.

Debris removal is a major component of every disaster recovery operation. Much of the debris generated from natural disasters is not hazardous. Soil, building material, and green waste, such as trees and shrubs, make up most of the volume of disaster debris. Most of this waste can be recycled into useful commodities. Debris from hurricanes, earthquakes, tornadoes, floods, and fires falls into a few major categories, as shown in the table on the facing page.

Hurricane debris

Hurricanes generate high-velocity winds, cause oceans to surge well above high tide levels, and create waves in inland waters. Hurricanes leave behind debris made up of construction materials, damaged buildings, sediments, green waste, and personal property. Hurricane debris obstructs roads and disables electrical power and communication systems over wide areas.

Most of the damage and resulting debris is in the area where the hurricane first hits land;

Disaster Debris Volume Examples

COMMUNITY	DISASTER	DATE	VOLUME OF DEBRIS
Metro-Dade County, FL	Hurricane Andrew	August 1992	43 million cubic yards of disaster debris in Metro-Dade County alone
Los Angeles, CA	Northridge Earthquake	January 1994	7 million cubic yards of disaster debris
Kauai, HI	Hurricane Iniki	September 1992	5 million cubic yards of disaster debris
Mecklenburg County, NC	Hurricane Hugo	September 1989	2 million cubic yards of green waste[2]

[2] In this guide, the term "green waste" refers to all types of organic yard and landscaping waste, including shrubs, leaves, grass, and tree materials. "Wood waste" refers to tree limbs that have been ground into mulch.

however, the destruction also can extend many miles inland. For example, in 1989, Hurricane Hugo made landfall at Charleston, South Carolina, and continued inland, causing great damage as it cut across the state and into North Carolina. The hurricane generated 400,000 tons of green waste in Mecklenburg County, North Carolina, 200 miles from Charleston. This amount of green waste would have taken up two years of landfill capacity, while only two and a half years of capacity was available in the local landfill. The county considered burning the green waste, but rejected the idea to protect the county's air quality. Instead, all the debris was ground up into mulch and given away to local citizens and businesses for use.

Earthquake debris

Earthquakes generate shock waves and displace the ground along fault lines. These seismic forces can bring down buildings and bridges in a localized area and damage buildings and other structures in a far wider area. Secondary damage from fires, explosions, and localized flooding from broken water pipes can increase the amount of debris. Earthquake debris includes building materials, personal property, and sediment from landslides.

Los Angeles is still collecting and managing debris from the Northridge earthquake that hit the city in January 1994. The amount of debris reached 3 million tons at the end of July 1995. Three months into the debris removal process, city officials decided to attempt to recycle as much of the debris as possible to conserve the remaining landfill capacity. Most of the waste was construction and demolition (C&D) debris, which could be processed by local recycling businesses. City officials worked with the Federal Emergency Management Agency (FEMA) and local businesses to expand existing recycling capacity and approve permits, thereby enhancing the ability of these businesses to meet the city's waste management needs. The city developed contracts with existing businesses, provided them with clean source-separated materials, and piloted a project to recycle mixed debris. After one year, the city had created more than 10,000 tons of new, privately operated daily processing capacity for mixed and source-separated debris.

Tornado debris

Damage from tornadoes is caused by high-velocity rotating winds. The severity of the damage depends on the size of the tornado funnel and the length of time the funnel touches the ground. Damage is generally confined to a narrow path extending up to half a mile wide and from a hundred yards to several miles long. Tornado debris includes damaged and destroyed structures, green waste, and personal property.

The city of Sandusky, Ohio, did not have a plan for managing disaster debris when a

Major Categories of Disaster Debris

	DAMAGED BUILDINGS	SEDIMENTS	GREEN WASTE	PERSONAL PROPERTY	ASH AND CHARRED WOOD
Hurricanes	✓	✓	✓	✓	
Earthquakes	✓	✓	✓	✓	✓
Tornadoes	✓		✓	✓	
Floods	✓	✓	✓	✓	
Fires	✓			✓	✓

tornado hit in July 1992. Cleanup took about two and a half months and involved approximately 600 tons of waste, most of which was green waste. City officials found that the two greatest obstacles to managing the debris were communicating instructions to residents and sorting the green waste to maximize chipping and mulching efficiency.

Flood debris

Debris from floods is caused by structural inundation and high-velocity water flow. As soon as flood waters recede, people begin to dispose of flood-damaged household items. Mud, sediment, sandbags, and other reinforcing materials also add to the volume of debris needing management, as do materials from demolished and dismantled houses.

After the Midwest flood in the summer of 1993, officials in Lincoln County, Missouri, handled the flood debris through dropoff centers as well as county collection. The debris included appliances, wood, shingles, insulation, tires, materials containing asbestos, and household hazardous waste. To comply with state solid waste regulations and county recycling goals, county staff and contractors segregated the debris by waste type. Scrap dealers picked up the appliances, and individuals salvaged the wood. Tires were cut in half for disposal in approved landfills or ground for roadside use. After the flood, the state of Missouri temporarily set aside its recycling policy, which prohibited landfilling of compostable materials, so that communities could landfill leaves and yard waste. A hazardous waste contractor collected and disposed of household hazardous waste.

Fire debris

While fires leave less debris than other types of disasters, they still generate much waste. For example, demolished houses contribute noncombustible debris. Burned out cars and other metal objects, as well as ash and charred wood waste, also must be managed. In addition, large-scale loss of plants serving as ground cover can lead to mud slides, adding debris to the waste stream.

In Malibu, California, one of the communities hit hardest in 1993 by coastal fires, 268 houses were destroyed; most of them burned to their foundations. Malibu removed fallen trees as well as dead trees that might have fallen on roads or homes, and chipped the trees for mulch. The city left other dead trees standing to help prevent erosion. The city gave property owners six weeks to remove their own debris, then began removing remaining household debris. In clearing the fire debris from about 175 properties, the city collected the same amount of solid waste normally collected in an entire year. The city recycled some concrete and asphalt and lifted daily landfill limits to accommodate the rest of the debris.

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Federal Resources Available To Help

If the President declares a community a natural disaster area, considerable federal assistance is available from FEMA. In addition to FEMA, the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) can provide federal assistance. Most natural disasters, however, do not qualify for full federal assistance.

Congress and the President

The Robert T. Stafford Disaster Relief and Emergency Assistance Act sets forth federal disaster relief responsibilities and procedures. Among many other activities, the Stafford Act authorizes debris removal in "the public interest . . . from publicly and privately owned lands and water." The President makes the final decision to declare an area a natural disaster and therefore eligible for federal assistance.

Federal Emergency Management Agency (FEMA)

The Stafford Act authorizes FEMA to respond to disasters and emergencies in order to help save lives and protect public health, safety, and property. FEMA operates under specific regulations, which are spelled out in Section 206.224 of Title 44 of the *Code of Federal Regulations* (CFR). The Stafford Act and the CFR use the term debris removal in a broad sense to encompass the entire process of removing, handling, recycling, and disposing of debris. The CFR declares debris removal to be "in the public interest," not only to protect "life, public health, and safety" but also to "ensure economic recovery of the affected community." Thus, the authorizing statements in the Stafford Act and CFR are broad and inclusive.

For communities to qualify for FEMA assistance, the effort needed to recover from the disaster must be of such magnitude as to be beyond the capabilities of the state or local government. A local government must make a declaration of natural disaster to the state emergency management agency, and the state's governor must request through FEMA that the President declare the affected area a disaster. Once the President concurs, the local government becomes eligible for reimbursement of some portion of its debris management expenses and other disaster recovery costs. FEMA also opens a Regional Operations Center and a Disaster Field Office in the affected area to coordinate efforts with local and state authorities.

Once the declaration is made by the President, FEMA negotiates the disaster relief efforts with the state emergency management agency. The state agency represents the local communities during this discussion. FEMA staff advise local government officials regarding the activities eligible for reimbursement specific to that community; FEMA also sets reasonable cost standards for these activities. Under the Stafford Act, FEMA is authorized to pay for activities to handle debris posing an immediate threat to the public, generally including debris removal, transportation, volume reduction at staging areas, and ultimate disposal. FEMA requires careful recordkeeping regarding expenditures for communities to obtain reimbursement. FEMA may fund recycling of disaster debris if the local government has in place prior to the natural disaster a policy emphasizing recycling, or if the local government can demonstrate that recycling is a cost-effective debris management option.

FEMA does not respond alone to natural disasters. Other federal agencies also have substantial roles. In particular, two agencies are involved in hazardous and nonhazardous waste management.

U.S. Army Corps of Engineers (USACE)

The Department of Defense is responsible for emergency support related to public works and engineering, and has designated USACE as its operating agent. USACE provides technical advice and evaluations, engineering services,

construction management and inspection, emergency contracting, emergency repair of wastewater and solid waste facilities, and real-estate support.

USACE assistance is arranged through FEMA. In the Miami area after Hurricane Andrew in 1992, USACE removed debris in the hardest hit areas by contracting with six large general contractors.

U.S. Environmental Protection Agency (EPA)

EPA is the primary agency responsible for emergency support related to hazardous materials. EPA responds to releases of hazardous materials and provides technical assistance for environmental monitoring needs. EPA regional offices also can provide technical assistance on municipal solid waste issues.

State and Local Resources Available To Help

State and local governments are communities' first source of assistance in the wake of a natural disaster and in planning for disaster debris management. Such assistance is available to communities impacted by disasters, regardless of whether they receive a federal disaster declaration.

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State governments

The state emergency management agency and state waste management agency have specific roles to play in cleaning up disaster debris. The state emergency management agency serves as the local government's liaison to FEMA and can provide information for emergency planning. This state agency also can help represent the local government's interests to FEMA during a disaster and cleanup. The state waste management agency's role can be to make special accommodations for the unusual waste management needs resulting from a natural disaster. For example, this agency could temporarily lift permit requirements for solid waste facilities. In addition, specialized assistance is often available from other state agencies.

Other government assistance

Both state and local governments may enter into mutual aid agreements with other state and local governments prior to any disaster. Such an agreement could provide for either binding commitments or nonbinding intentions of support by state and local governments to assist one another in the event of a disaster. Through these agreements, communities can loan equipment and personnel with specific expertise or experience.

The Southern Regional Emergency Management Assistance Compact is an example of a mutual aid agreement originally signed by 17 states, Puerto Rico, and the Virgin Islands. The resolution supporting this pact now has been offered to all states and includes model legislation for state legislatures. The compact also contains broad language and a legal framework addressing authority, liability, licensing, reimbursement, injury or death benefits, and use of the National Guard. For more information on the Southern Regional Emergency Management Assistance Compact, contact:

The Southern Governors' Association
The Hall of the States
444 North Capitol Street, NW.
Washington, DC 20001
202 624-5897

What a Community Can Do To Speed Recovery and Reduce Costs

Preparing a disaster debris management plan in advance can pay off in the event of a natural disaster. Planning can help a community identify its debris collection, recycling, and disposal options. Although the recovery process will take a long time, perhaps even years, careful planning will prevent costly mistakes, speed recovery, and avoid creation of more waste. A plan also can save money by identifying cost-effective debris management options and sources of help, increasing control over debris management in your community, and improving administrative efficiency.

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Lessons Learned: Plan for Managing Disaster Debris

The following suggestions for disaster debris planning are based on insights from community officials who recently have experienced a major natural disaster.

Make a long-term debris management plan

Every community consulted suggested increasing existing emergency planning to include long-term debris management. Because natural disasters can generate tremendous quantities of debris, communities should plan for the worst case. Any plan should include a detailed strategy for debris collection, temporary storage and staging areas, recycling, disposal, hazardous waste identification and handling, administration, and dissemination of information to the public. Distribute the plan and work with personnel from each agency to ensure that the plan can be implemented quickly and smoothly. Review the plan at least once a year, and revise it as needed. For example, outdated forms, such as time sheets and materials tracking forms, may need to be replaced.

Consider mutual aid arrangements

Mutual aid arrangements allow communities to quickly access specialized personnel or equipment on a short-term basis. Usually the host community pays the expenses for the personnel as well as any maintenance or repair costs for equipment. These agreements can be developed for a local geographic area or can extend to communities in other states. The agreements can be formal or informal.

Implement recycling programs

Implementing a plan for recycling disaster debris is much easier if a community already has a recycling program in place. Permitting, enforcement, collection, processing, and marketing issues already will have been largely resolved. After a disaster, the community will be faced with expanding current recycling practices rather than designing and implementing new practices. It is much easier to expand existing capacities and markets than to start these endeavors in the wake of a disaster.

Update the community's solid waste management plan

It is important that a community's solid waste management plan reflect current practices and policies, especially those that apply in disaster situations. The plan is an official document that often is filed with the state, and when regional solid waste services or facilities are involved, a copy often is provided to neighboring communities as well. It also can be beneficial to share the plan with private contractors and other community agencies (e.g., fire and police) that in the event of a disaster would be involved with solid waste management services. Should a disaster occur, supporting

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agencies would find the plan useful because it describes established practices and policies, as well as the types, locations, and capacities of existing solid waste recycling and disposal facilities. Reflecting current practices and policies, the plan also would serve as a resource document in negotiating technical and financial assistance with FEMA and other agencies.

Develop a communication strategy

Prepare a communication strategy ahead of time. Government officials will need to tell the community when, where, and how trash collection will resume, as well as provide special instructions for reporting and sorting disaster debris. Many communities have prepared radio announcements and flyers as part of the emergency plan. Depending on the type and severity of the natural disaster, however, a community might lose electricity, telephone service, radio broadcasting capability, or newspaper service. Therefore, communities should prepare for more than one method of communication. Discuss with local media companies the use of free advertising time and space to communicate instructions in the event of a disaster.

Prepare for increased outreach and enforcement staffing needs

In the aftermath of a natural disaster, waste management staff must handle an increased number of telephone calls and requests concerning waste removal. Communities need more staff to train and monitor debris collection contractors, enforce disposal restrictions, and help solve implementation problems. Identify sources of temporary labor and, if your community is culturally diverse, consider the use of a multilingual telephone bank.

Obtain equipment and supplies

Identify in advance the types of equipment and supplies that your crews will need to implement the plan. Plan for quick procurement of these items through mutual aid agreements or standing contracts, or consider stockpiling this equipment. If stockpiling is too expensive for one community alone, perhaps the state could stockpile the equipment.

Types of equipment that a community might need include chain saws, portable generators, cellular phones, flashlights, batteries, vehicle repair equipment (flat tires occur more often because of glass and metal debris in roads), and extra work clothing. A local government that routinely stores drinking water (e.g., for its solid waste collection crews) might want to make sure that water supplies are well-stocked during the hurricane or flood season.

Select collection and storage sites

The most common suggestion from communities that have experienced natural disasters is to pre-select debris staging sites that will be used for temporary storage and processing of debris. Convenient local sites allow collection crews to reduce travel time when transferring debris to processing or disposal facilities and result in faster street clearing. Site operators can sort debris for recycling or disposal, as well as answer questions from the public. These sites can be used to store green waste before transferring it to another facility, or they can be used to chip and mulch green waste on site. Communities also can use these sites to distribute free mulch or wood to the public.

Select the sites based on planned activities, such as staging, collection, storage, sorting, recycling, landfilling, and burning of debris. Pre-selection of sites speeds the implementation of the debris management plan. Also consider access to heavy equipment, lack of impact on environmentally sensitive areas, and convenience to collection routes. Investigate possible impacts on adjacent housing, since the sites could produce noise at levels deemed unacceptable by residents or attract rodents that may carry disease. Evaluate and document the condition of these sites prior to use. The government agencies involved will be responsible for returning these sites to their original condition. Be sure to establish agreement on the schedule for return of the property to the owners and the degree of rehabilitation to the property.

If residents will be asked to bring disaster debris to collection sites, your community should include these locations in its disaster communication strategy, so that information is

immediately available to the public in the event of a disaster. Schedules and staffing plans for these sites should take into account that the busiest times for residents dropping off home-related debris are likely to be evenings and weekends.

Determine management options and goals

Any disaster debris management plan should include a disposal strategy. Communities need to set priorities for recycling wastes and determine the desired disposal options for the remaining waste.

Segregate hazardous waste

Be prepared to segregate hazardous from nonhazardous disaster debris; otherwise your community might be forced to dispose of the combined waste as hazardous waste. Monitor collected business waste to be certain it does not meet the definition of hazardous waste. Waste handlers must understand these requirements as well as have a plan for controlling and diverting the hazardous waste from the debris stream.

Prepare contracts

Determine what equipment and staff resources your community needs in the event of a disaster. Any assistance that will not be provided by state and other local governments must be obtained through contracts. If contracted work seems likely at the state or community level, consider bidding an emergency contract, as is commonly done for snow removal. The request for proposals (RFP) may include service for debris collection, storage, sorting, processing, marketing, and disposal. Investigate FEMA reimbursement policies and ensure that the terms described in the RFP are likely to meet FEMA and state requirements in the event that your community qualifies for federal or state reimbursement.

Plan for FEMA and state reimbursement

Consider staffing needs to meet the recordkeeping requirements for FEMA reimbursement of disaster debris management costs. Some states reimburse some costs even if the disaster does not qualify for federal reimbursement funds. Discuss recordkeeping requirements with your state emergency planning agency. Your community, particularly if it is small, might benefit from identifying in advance people who have experience in obtaining reimbursement.

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Case Studies

Of course, every community hopes it never has to use its disaster debris management plan, but when a disaster does hit, prepared communities can recover more quickly than other communities. Below are disaster debris case studies from an earthquake, a flood, and three hurricanes. These case studies include examples of situations in which planning paid off, as well as circumstances in which the lack of planning slowed recovery.

Los Angeles, California

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The city of Los Angeles relied heavily on recycling to manage debris from its January 1994 earthquake. In response to the earthquake, city staff negotiated with FEMA to designate recycling as the preferred method of debris management. The city developed contracts with existing businesses to recycle clean source-separated materials and worked with more than nine businesses to develop processing capacity for mixed debris. By midsummer, the city was able to recycle about 50 percent of the earthquake debris collected each week. By July 1995, the city was recycling over 86 percent of the debris collected, totaling over 1½ million tons.

Collection and recycling

The city of Los Angeles did not have a plan for debris management prior to the earthquake but quickly developed debris management procedures after the disaster. The day after the earthquake struck, the city instituted a curbside debris collection program, which did not include recycling. C&D debris under normal conditions makes up 10 to 15 percent of the Los Angeles waste stream. Prior to the 1994 earthquake, one local company processed 150 tons of C&D waste per day. After the earthquake, the city picked up as much as 10,000 tons of C&D waste per day. City officials updated an existing list of licensed, insured debris removal contractors and asked them to attend an orientation and to sign hastily drafted contracts for debris removal.

At first, contracts for debris removal were only two pages long and contracted for one week of work. These early contracts allowed the city to begin removing debris quickly, yet did not include recycling or other requirements such as subcontracting parameters. Contracts ultimately grew to 22 pages. The city assigned each contractor a grid of streets to clear. City inspectors (pulled from other assignments) monitored contractors and kept records to determine whether debris in each area was collected within seven days of being set out. When contractors expended their total contract amounts, city officials placed them at the bottom of the list of approved contractors and called them again when their turns came.

After two months of negotiation, FEMA allowed the city to include recycling as a debris removal method. This decision was based primarily on the city's local policy supporting recycling and a recycling pilot that documented a potential 82 percent recycling rate. Contractors began separate collections of wood, metal, dirt, concrete and asphalt, and red clay brick. The city required the contractors to send any debris that could not be separated to facilities that recycled at least 80 percent of the mixed debris.

Most of the materials collected were recyclable. Recyclers crushed concrete and asphalt (mixed with up to 15 percent dirt) and sold it for use as sub-base in roads. They reused dirt as landfill cover and soil amendment. They ground and screened wood, selling fine pieces

by the cubic yard for landscaping and coarse pieces for cogeneration fuel or compost. Recycling facilities either ground up brick for use on baseball infields or chipped it for use in landscaping. Scrap metal dealers recycled metal waste.

By December 1995, four facilities were capable of recycling mixed debris. Two of them used an automated process that screened out fine debris and sent the remainder along a conveyor belt where workers removed and separated wood, brick, metal, and trash by hand. A vibrating screen removed any dirt left in the remaining stream. At the end of the process, only clean concrete and asphalt were left.

City officials also ensured that debris would be recycled by providing training and incentives to haulers. For example, city officials required haulers to develop a recycling plan that included scouting for recyclables and dedicating trucks to a given type of waste, so that debris separated at the curb did not become mixed in the truck. The city also created a contract performance incentive that placed source-separated recycling higher than mixed recycling. With these efforts, the city expanded its C&D recycling capacity by a minimum of 10,300 tons per day. Immediately after the earthquake, all debris was disposed of in three landfills. Just over a year later, the city had added 18 recycling facilities and one landfill. This expansion helped to meet a long-term goal to increase recycling of routine C&D waste.

By the end of the program, the city had recycled almost 56 percent of all materials collected since the day of the earthquake for less than the cost of disposal. The city demonstrated that when sufficient recycling facility capacity exists, a recycling rate of over 86 percent can be achieved. This total would have been much higher, in fact, had the city implemented recycling in the beginning of the recovery effort. To prepare for the possibility of future disasters, Los Angeles has issued an RFP for a contingency contract for various waste management activities, including the use of sites in the event of a natural disaster.

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Communication

Soon after the earthquake, officials placed news stories and advertisements to inform the public that they could leave debris for pickup on the street in a pile as wide as a parked car. At first, the city allowed residents to leave mixed debris at the curb. Later, city officials asked residents to separate the following materials: concrete and asphalt (these could be mixed), dirt, red clay brick, wood, and all other material. Residents had been accustomed to the relaxed requirements that allowed them to set out mixed debris, however, so crews of specially hired city workers distributed doorhangers requesting residents to separate their debris. Where residents still did not separate debris into its recyclable components, work crews preceded the debris haulers and separated the debris. When residents placed yard trimmings or other non-earthquake-related debris on the curb, workers left doorhangers explaining why these materials had not been picked up and giving directions on how to dispose of the materials. In the first eight months after the earthquake, debris haulers collected 122,000 truck loads of debris.

The city relied on both residents and city staff to determine which locations needed debris pickups. A telephone bank, staffed by English-, Spanish-, and Korean-speaking operators, fielded requests for pickups from residents. Staff entered the address of each caller into a geographic information system database and regularly produced maps showing areas needing pickups. At the same time, city inspectors supervising the debris management work reported streets where debris had accumulated.

Outside assistance

Los Angeles was largely self-sufficient in managing its earthquake debris. If the quantity of debris had been greater, the city would have asked for assistance from USACE (through FEMA), the state of California, and other states. Other agencies provided some assistance. The California Office of Emergency Services provided a liaison to FEMA and issued emergency regulations expanding permit hours for solid waste facilities.

FEMA funded the debris recycling program, including paying recycling facility tipping fees, as well as the costs associated with hiring data entry staff and contracting with a consultant to manage recycling efforts. For the period of May 14, 1995, through July 15, 1995, the average tipping fee to use the recycling facilities was $21.55 per ton versus $24.92 per ton for disposal facilities, resulting in an average savings of $3.37 per ton. In addition, recycling saved the city transportation costs since recycling facilities were closer to the devastated areas and many had shorter lines. California's Integrated Waste Management Board helped Los Angeles obtain this funding by writing a letter to FEMA stating that recycling was state policy. Los Angeles, like every community in California, has been required to submit a plan for source reduction, recycling, and composting under the state's Integrated Waste Management and Litter Reduction Act. FEMA determined that since Los Angeles had a recycling policy prior to the earthquake, the city did not need to demonstrate that recycling would save money in order to obtain FEMA funding.

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Lincoln County, Missouri

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The Midwest floods in the summer of 1993 inundated 75 towns and more than 20 million acres of land in nine states. The flood damaged or destroyed an estimated 50,000 homes and ruined household belongings in thousands of other homes that were flooded. One rural county that borders the Mississippi River, Lincoln County, Missouri, developed a successful debris management program with a significant recycling component.

Collection and recycling

Lincoln County initiated separate debris cleanup programs for three types of debris:

Mud and sand deposited on roads

Crews cleared mud and sand from roads and moved it into roadside drainage ditches. Later the ditches were cleared of the dirt and sand to restore drainage. Crews delivered the dirt to farmers, who used it for topsoil.

Household debris

Soon after the flood waters began receding, county officials placed containers for household flood debris at one site in each of the county's four towns along the river. The county contracted with a private waste management firm to haul approximately 700 containers of debris, ranging in capacity from 40 to 90 tons, to a landfill.

Initially, staff operated the collection sites 10 hours per day. Officials soon increased operating time to 24 hours per day because residents dropped off more debris at night than during the day. County residents brought household flood debris to the collection sites and left it on the ground. The county used a hi-lift, a tractor with a bucket on the front, to lift heavy items into large containers. Site staff were responsible for sorting materials for recycling, as well as separating out hazardous waste. The waste management contractor provided guidance on the types of hazardous waste sorters were likely to encounter. Staff separated about 25 percent of the debris, including appliances, wood, shingles, insulation, tires, materials containing asbestos, and household hazardous waste. Scrap dealers picked up the appliances; individuals salvaged wood. Missouri's recycling policy prohibiting landfilling of compostable materials (leaves and yard waste) was temporarily lifted after the flood.

Substantial household hazardous waste accumulated at the collection sites. If sorters were unsure whether particular materials were hazardous (e.g., shingles and insulation), they set them aside as special debris. The waste hauler then determined whether these materials should be taken to a hazardous or nonhazardous waste landfill. The hauler placed leaking hazardous waste containers into sealed containers. No hazardous materials leaked onto the ground, so no soil remediation was needed at the collection sites.

Building demolition debris

Approximately 300 houses in Lincoln County sustained damage amounting to more than 50 percent of the value of the house. Most of these homeowners chose to sell their properties to the county in a buyout and demolition program. FEMA and the state Community Development Block Grant program, which is connected with a Department of Housing and Urban Development program, funded the program.

Once the county purchased the houses slated for demolition, county crews worked to remove and separate salvageable or nonburnable items from the homes. Crews removed vinyl siding, windows, asphalt shingles, insulation, cabinets, appliances, furniture, electrical cables, piping, rafters, studs, and decks. The demolition contractor then had the option to sell or give away as much of these materials as possible before disposing of what remained. The

contractor then could easily demolish the shell of each house, which consisted almost entirely of wood.

An air curtain burner combusted the demolition debris and unsalvaged items from the houses. Other debris was landfilled.

Communication

A mass mailing of over 1,000 letters was sent to residents in the Lincoln County floodplain. Information also was distributed through a local newspaper. The county's communication strategy differed for each of the three types of debris generated.

Through phone calls and advertisements in local newspapers, the county found farmers interested in taking the soil debris piled by the roadside. County crews removing soil from ditches delivered some of the soil to their farms.

The county publicized the household debris collection program through public meetings, newspapers, and radio, but ultimately word of mouth was the most effective communication mechanism. Signs on the road identified each collection site. The county informed residents 30 days prior to the closing of the collection sites.

A series of public meetings was held throughout the county to inform residents of the home buyout program. County staff responsible for assessing flood damage to houses met daily for breakfast from 6 to 7 a.m. at a centrally located restaurant in the flood area and welcomed homeowners to meet with them and learn about the buyout program. The county also notified residents of the program with posters at the same restaurant and at a resort community at the northern end of the flood area. As of July 1995, Lincoln County had completed over 250 buyouts, had demolished and recycled over 200 homes, and was expecting to purchase and remove an additional 150 homes from the flood plain.

Outside assistance

The Boonslick Regional Planning Commission, a local government group, recruited staff for the collection sites and the pre-demolition salvage crews. U.S. Department of Labor funds paid for these services through the Jobs Training Partnership Act program.

Metro-Dade County, Florida

Hurricane Andrew

Hurricane Andrew, which struck the Florida coast on August 24, 1992, left an estimated 6 million tons of debris in Metro-Dade County (Greater Miami). This included downed trees and debris from 150,000 houses that were severely damaged or completely destroyed. Because of the extent of the destruction, Miami received help in collecting hurricane debris from USACE through FEMA.

Since the hurricane, to streamline the administration of hauling contracts in the event of future disasters, Metro-Dade County has issued an RFP for a contingency contract for various waste management activities. The RFP calls for two types of bids: one bid for a disposal site plus waste hauling services and one bid for a disposal site without waste hauling services.

Collection and recycling

Metro-Dade County instituted a hurricane plan prior to the disaster and followed the plan's emergency debris collection guidelines. In accordance with the plan, the county initially focused on both collection of garbage, because garbage can pose the greatest health risk, and clearing of the county's highways.

In the three weeks after the hurricane, the amount of garbage set out by residents was double the pre-disaster amount as people in houses without electricity cleaned out spoiled food from refrigerators and freezers. County garbage collection crews worked seven days a week, 18 hours per day to collect garbage and clear debris from the streets.

A small number of county solid waste management employees initially could not report to work because they needed to make emergency repairs to their homes, obtain food for their families, or provide care to children or elderly dependents. In these cases, other county employees offered assistance, thereby reducing the amount of time county employees were unable to perform their waste management duties.

Initially, the hurricane debris consisted mostly of downed trees. As citizens began their cleanup efforts, more household debris was collected (e.g., rain-damaged furniture). And as repairs began, the debris contained more C&D wastes (e.g., drywall and roofing tiles).

The county asked residents to bring wood and yard waste, appliances, and metal to any of the county's 18 existing trash and recycling dropoff centers. Wood and yard waste was chipped for mulch. Scrap dealers took appliances and metal. County officials asked residents to place other hurricane debris at the curb and to separate nonburnable waste from burnable waste.

Soon the trash and recycling centers were overwhelmed with debris. The county then opened neighborhood staging areas in parks and similar locations where residents could bring their wood waste. Approximately 500,000 tons of wood waste from the hurricane were mulched and distributed to agricultural areas, parks, and residential sites.

The county and USACE hired debris haulers to move debris from the curbs to staging areas. At each of the staging areas, personnel separated and inspected incoming loads and removed any hazardous waste. In the northern part of the county, the county government established 16 zones and assigned county resources to four zones, contracting out the work in the remaining 12 zones to qualified local contractors. The county divided up the number of contracts equally to firms owned by Whites, African Americans, and Hispanics. USACE contracted debris removal work in 13 zones to six out-of-state contractors. Metro-Dade County contracted with a private firm to haul debris from all of the staging areas to the private firm's landfills.

The Florida Department of Environmental Regulation allowed debris to be burned under an emergency 30-day order. USACE used air-curtain burners that met all federal and state requirements. Some other local burn sites, however, did not use state-of-the-art technology. Burning at these sites led to many public complaints and

protests by environmental activists. As a result, county commissioners shut down all burning three weeks after it began. The major problem that arose during burning operations was commingled debris that did not burn efficiently. At USACE burn sites, the resultant ash was tested to determine if it was hazardous and disposed of accordingly. After debris collection and staging areas were cleared of all debris, the county conducted soil and water testing for hazardous waste contamination.

Communication

Metro-Dade County used different communications strategies for each stage of the debris management effort. In the days following the hurricane, city officials gave about 10 television and radio interviews each day, in which they asked residents to carry their garbage to the nearest cleared street. Later, the county used television, radio, and direct mail advertisements. Newspaper advertisements were not an option since the hurricane had temporarily halted publication of Miami's daily newspaper. Because most access into the hurricane zone was by highway, the county also distributed flyers at highway toll plazas. Through all of these communication vehicles, the county told residents and building contractors how to set out debris, the status of debris collection in each zone, and the sanctions against illegal dumping. The county also added new telephone lines and work stations and hired and trained new staff to handle thousands of calls each month about debris. Every call complaining about debris piles or illegal dumping was recorded, routed to the appropriate agency for action, and mapped on a geographic information system to help identify problem areas.

Outside assistance

Metro-Dade County received extensive assistance from USACE in managing its hurricane debris. Within three days, two general contractors had been awarded debris removal contracts for $3 million and had begun removal efforts. USACE took responsibility for the harder hit southern half of the county, while the county crews concentrated on the northern half. USACE debris removal work went on for over two years and totaled over $375 million.

Hurricane Andrew

Mecklenburg County, North Carolina

Hurricane Hugo

In September 1989, Hurricane Hugo created a solid waste crisis for Charlotte, North Carolina. In Mecklenburg County, North Carolina, alone, the equivalent of 10 years' worth of green waste was generated in just over three hours.

Collection and recycling

The Charlotte/Mecklenburg Emergency Management Office was well prepared to handle the variety of medical, housing, and communication needs presented by this disaster. Mecklenburg County did not, however, have a plan to deal with the enormous quantity of debris generated by the storm. When Hugo hit, the county was down to its last municipal solid waste landfill, which had only 2½ years of capacity remaining. The county did not want to use up its remaining landfill capacity. Because of existing air pollution problems, burning was not a viable option either. County officials determined the best option would be to collect and shred the green waste—by far the largest category of waste—and distribute the resulting product for use as mulch and boiler fuel.

Hurricane Hugo

The city of Charlotte and six other municipalities in Mecklenburg County were responsible for collecting the hurricane debris. Working together, these communities spread collection and storage locations throughout the county. Eleven public properties were designated as green-waste dropoff sites, including former, present, and future landfill sites and a parcel of land at the Charlotte airport. Private citizens also volunteered land for collection sites.

More than 175,000 vehicle loads dumped a total of 400,000 tons of green waste at the collection sites over a 10-month period. Officials feared that such a large quantity of green waste would be accompanied by a high level of nonorganic contaminants. The contaminant level was very low, however, due primarily to three factors:

- During the three weeks immediately following the storm, the county landfill accepted all storm-related, non-green-waste debris free of charge. This debris totaled 6,300 tons and consisted primarily of C&D waste.
- All entrances to green-waste sites were staffed during operating hours, and staff strictly enforced the prohibition of other types of waste.
- The city of Charlotte resumed weekly curbside trash collection two days after the storm, providing convenient disposal of other types of waste for all residents.

While awaiting shredding, wood was piled 10 to 15 feet high over 100 acres of land. One problem with storing this much wood was the fire hazard.

Green-waste mulch also was piled 10 feet high. When piled that high for more than a

month, this mulch tends to heat up and can spontaneously combust. One mulch fire at a storage site took a week to extinguish.

The county initially hired a local contractor to shred the green waste into mulch using high-speed shredding equipment. One month after the hurricane, with four shredding systems working 12 hours per day, seven days a week, the county decided to contract for more grinders. Shredding was finally completed in February 1991 (16 months after the storm) at a cost of $7 million.

Communication

As the green-waste mulch was created, the county had yet another challenge on its hands: what to do with 400,000 tons of shredded green waste.

In October 1989, the county launched its "Take-a-Ton" mulch give-away program. The media was very supportive in getting the word out. The Charlotte newspaper published maps of the give-away locations, and radio and television stations ran announcements.

Initially, the product was too coarse to be used as mulch. But once the county reduced the shredder's screen size and provided loaders on site, citizens took home the mulch as fast as it could be produced. County officials also granted permits to contractors to haul away as much mulch as they could to sell to their customers. One company hauled away thousands of cubic yards to sell as boiler fuel to local paper mills.

Outside assistance

State and federal sources, including FEMA, provided funding to Mecklenburg County. FEMA required the county to maintain data on all incoming debris and equipment operations. Five full-time staff kept detailed records of the county's recovery expenses. At the site, county personnel recorded information on each vehicle, including delivery date, time, truck type, and user. The county hired temporary staff to record similar information for contracted grinding operations. As a result of its diligent record-keeping efforts, the county was reimbursed fully (75 percent from FEMA, 25 percent from the state of North Carolina) for its debris management costs, totaling over $7 million. The accounting also has proved helpful in planning for future natural disasters in the region.

Kauai, Hawaii

Hurricane Iniki

Hurricane Iniki struck the Hawaiian island of Kauai in September 1992. The storm generated more than 5 million cubic yards of debris—seven years' worth of Kauai's normal refuse—for a landfill with less than four years of remaining capacity. Kauai needed the four years to plan and design a new landfill, and shipping the debris off the island for disposal was not economically feasible. Island officials therefore chose to develop an efficient collection and recycling plan that saved both money and the dwindling landfill space.

Collection and recycling

Within days of the storm, island officials, with the cooperation of local landowners, established five temporary hurricane debris receiving sites. Officials trained temporary site operators to separate recoverable materials on site, but encountered many problems during the early stages of the cleanup effort. Hauling contracts had been written quickly and did not include incentives to keep materials free of contaminants. Consequently, some reusable materials became unusable. Haulers mixed clean loads of green waste with other trash and combined hazardous materials with recyclable debris. Stores and household refrigerators generated tons of food waste, which was mixed with recyclable materials. In the absence of instruction to do otherwise, residents began creating spontaneous dumps and at some sites burned or buried debris. In addition, the initial collection contractors were construction crews with little or no experience in handling and recovering solid waste.

Because Kauai is an island, officials could not easily spread the burden by transporting hurricane debris to unaffected communities. Without an adequate management plan, the collection sites were overwhelmed until December, when officials implemented a debris management plan and contracted with professional solid waste personnel to manage the sites and the collection process.

The island's solid waste management plan focused on recycling. From the beginning, local and state officials made a firm commitment to divert the massive amounts of debris from Kauai's landfill. A response team that included local, state, and federal government staff, contractors, and the county's solid waste consultants developed the plan. Team members agreed that materials recovery was the most environmentally sound and economical method of managing the hurricane debris.

The plan aimed to divert debris in a cost-effective manner by separating materials at the point of generation. It also proposed methods to maintain separation through the collection, transportation, storage, and processing stages. The plan required residents to separate materials into five piles at the curb: green waste; metals and appliances; wood debris; aggregate materials, including toilets, tile roofing, and concrete; and mixed debris. The plan also banned the burning of debris and instituted curbside collection across the island to accommodate those unable to haul the debris themselves. The plan ensured that processed debris was usable and met market specifications. Officials decided to hold off grinding any materials until a processing and end-use plan was developed. While this delay increased stockpiles of materials, it was essential to cost-effective diversion.

All of the metals, appliances, tires, and aggregate materials were reused. The aggregate was used to make revetment walls to shore up county shore-front property. A local company processed more than half of the 100,000 tons of green waste created by the storm into compost, thereby saving the county millions of dollars and precious landfill space. As a result of delays, the recycling plans for the remainder of the green waste and mixed debris fell through, and the waste was buried or landfilled.

Although the plan took three months to prepare, it resulted in much higher debris diversion rates, minimized environmental impacts, reduced waste management costs,

minimized threats to health and safety, and significantly shortened the duration of the cleanup effort. In addition, the plan instituted specific controls at collection sites across the island to monitor incoming debris, contain odors, and minimize water runoff.

Communication

One of the first orders of business after the storm was to inform residents about what to do with hurricane debris scattered across their property. With all communication systems down for several weeks, however, it was nearly impossible to reach all island residents to instruct them on how to separate materials. Kauai had only a fledgling recycling program, and source separation was not a household practice. As the communication systems recovered, island officials posted signs, ran articles in the newspaper, and broadcast radio announcements to inform citizens of upcoming collection efforts. After several weeks of intense outreach, the public caught on and began separating materials before pickup or dropoff. Discrete piles of green waste, metals, wood, and mixed debris soon lined the streets of Kauai. During this process, island officials realized that mobilization for recovery would have occurred more rapidly and effectively if they had planned ahead. By developing a clearly defined organizational structure and public information materials in advance, officials could have saved time and money and streamlined cleanup efforts in the chaotic aftermath of the storm.

Outside assistance

Most of the funding for the cleanup efforts came from a FEMA grant. Shortly after the storm, more than 2,000 military and National Guard personnel arrived to help in the cleanup effort, and the aid of 27 private contractors was secured. Together with county and state road crews, military units and contractors systematically swept the entire island to collect source-separated debris placed curbside by residents. With FEMA's assistance, officials are preparing for future disasters by establishing a permanent collection and storage site with proper environmental controls.

Hurricane Iniki

For More Information

The following references and contacts can help your community plan for disaster debris cleanup.

Federal Emergency Management Agency (FEMA)

For more information about FEMA requirements, contact:

Infrastructure Support Division, Room 714
Response and Recovery Directorate
Federal Emergency Management Agency
500 C Street, SW.
Washington, DC 20472
Phone: 202 646-4240

EPA regional offices

EPA's local offices can help provide information on solid waste management and regulations. Contact the EPA office in your region:

Region 1
U.S. EPA
Mail Code: HER-CAN6
90 Canal Street
Boston, MA 02203
Phone: 617 573-9670
Fax: 617 573-9662

Region 2
U.S. EPA
Mail Code: 2AWM
290 Broadway
New York, NY 10007-1866
Phone: 212 637-4099
Fax: 212 637-4437

Region 3
U.S. EPA
Mail Code: 3HW53
841 Chestnut Building
Philadelphia, PA 19107
Phone: 215 597-9636
Fax: 215 580-2013

Region 4
U.S. EPA
Mail Code: 4WD-OSW
345 Courtland Street, NE.
Atlanta, GA 30365
Phone: 404 347-2091 ext. 6425
Fax: 404 347-0076

Region 5
U.S. EPA
Mail Code: HRP-8J
77 West Jackson Boulevard
Chicago, IL 60604-3590
Phone: 312 886-0976
Fax: 312 353-4788

Region 6
U.S. EPA
Mail Code: 6H-H
1445 Ross Avenue
Dallas, TX 75202-2733
Phone: 214 665-6656
Fax: 214 665-6762

The Northridge Earthquake

Region 7
U.S. EPA
Mail Code: STPG
726 Minnesota Avenue
Kansas City, KS 66101
Phone: 913 551-7666
Fax: 913 551-7947

Region 8
U.S. EPA
Mail Code: 8HWM-WM
999 18th Street, Suite 500
Denver, CO 80202-2466
Phone: 303 293-1667
Fax: 303 293-1488

Region 9
U.S. EPA
Mail Code: H-W-3
75 Hawthorne Street
San Francisco, CA 94105
Phone: 415 744-2106
Fax: 415 744-1044

Region 10
U.S. EPA
Mail Code: HW107
1200 Sixth Avenue
Seattle, WA 98101
Phone: 206 553-2857
Fax: 206 553-8509

Resource Conservation and Recovery Act (RCRA) Hotline

For general information on solid waste management and regulations, contact the RCRA Hotline Monday through Friday, 9 a.m. to 6 p.m. EST, at:

- **800 424-9346**.
- **800 553-7672**—TDD (for hearing impaired).
- **703 412-9810**—in the Washington, DC, metropolitan area.
- **703 412-3323**—TDD (for hearing impaired in the Washington, DC, metropolitan area).

RCRA Information Center

To order EPA publications on solid waste management and regulations, write to:

RCRA Information Center (5305W)
U.S. EPA
401 M Street, SW.
Washington, DC 20460

Publications disaster debris planners might find useful include:

Criteria for Solid Waste Disposal Facilities: A Guide for Owners/Operators (530/SW-91-089)

Environmental Fact Sheet: Yard Waste Composting (530/SW-91-009)

Household Hazardous Waste Management: A Manual for One-Day Community Collection Programs (530-R-92-026)

Joining Forces on Solid Waste Management: Regionalization Is Working in Rural and Small Communities (530-K-93-001)

Recycling Works! State and Local Success Stories (530/SW-89-014)

Safer Disposal for Solid Waste: The Federal Regulation for Landfills (530/SW-91-092)

Summary of Markets for Compost (530/SW-90-0736)

Magazine articles

Below are a few articles that served as resources in writing this guide and might be of use to disaster debris planners:

Brickner, R. 1994. *How To Manage Disaster Debris.* C&D Debris Recycling. April, p. 8.

Friesen, G., J. Harder, and W. Rifer. 1994. *Closing the Loop After the Storm. Resource Recycling*. October, p. 37.

Sheehan, K., and C. Thoresen. 1993. *Des Moines, Iowa: A River Ran Through It, and Over It.* Waste Age. November, p. 39.

Steuteville, R. 1992. *Recycling After the Storm.* BioCycle. October, p. 30.