FEMA Field Guide for Debris Estimation

Debris Estimating Team Members must ensure the accuracy and completeness of disaster debris volume and damage estimates. Recent changes in the FEMA Public Assistance Program may provide specific benefits to the “Applicant” based on the work of the Debris Estimating Team.

This guide provides the Debris Estimating Team with a ready reference and instruction manual for all phases of the disaster debris estimating process. This guide is not all-inclusive for every possible situation. When situations arise that are outside the scope of this document or in conflict with mission-specific guidance, the Debris Estimating Team should consult with their supervisors for resolution.

Throughout this Field Guide the word “estimate” is used in referring to volumetric estimation.

SAFETY ALERT

No responsibility is more important than the responsibility to work safely and implement safety policies and procedures into Debris Estimating work.

REMEMBER: *Nothing in a debris management operation is worth risking an injury or accident.*

Watch out for personal safety and the safety of team members!

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General Information

1. SAFETY

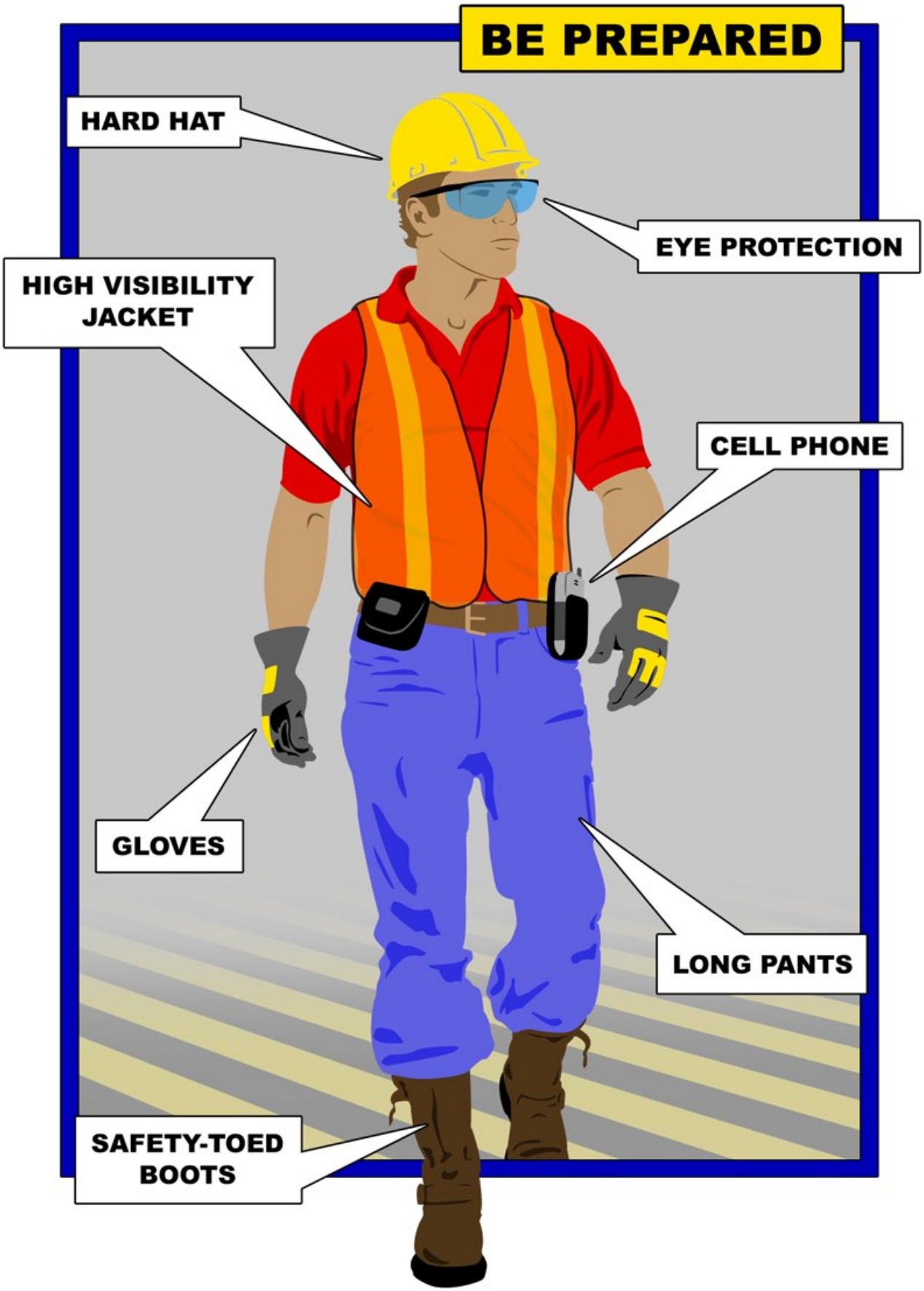
a. DEBRIS ESTIMATING HAZARD ANALYSIS

Estimating disaster debris poses a multitude of health and safety concerns. Hazards and exposures are a function of the unstable nature of the work areas, the potential presence of hazardous substances and energies, and the type of work being performed. This hazard analysis serves for general guidance only, as each area of work will have its own unique, sometimes unanticipated hazards.

The listed hazards, risks, and accompanying general recommendations represent suggested work area hazard assessment and therefore will not represent actual field hazards encountered by the Debris Estimating Team. It is incumbent upon each Team Member to perform and/or manage this work to ensure hazard analysis is performed and that appropriate actions are taken to mitigate health and safety risks.

SAFETY CHECKLIST

- Conduct a job hazard analysis to identify potential hazards before beginning work.
- Make each Team Member responsible for the Team's safety.
- Describe risks associated with each phase of the estimating process.
- Confirm that personnel are adequately trained to perform jobs.
- Describe the protective clothing and equipment to be worn by personnel during operations.
- Describe actions to be taken to mitigate existing environmental hazards.
- Does each Team Member have all the appropriate Personal Protective Equipment?


BE PREPARED
HARD HAT
EYE PROTECTION
HIGH VISIBILITY JACKET
CELL PHONE
GLOVES
LONG PANTS
SAFETY-TOED BOOTS

b. WORKING SAFELY

POTENTIAL HAZARDS AND GENERAL RECOMMENDATIONS

HAZARD:

Massive piles of woody debris and other types of debris; unstable work surfaces

Risks: Slips, trips, falls, or collapsing materials can cause illnesses and traumatic, serious, or fatal injuries.

- General Recommendations:
  - Ensure that surfaces are as stable as possible.
  - Ensure scaffolding is erected on a stable surface; anchor scaffolding to a structure capable of withstanding the lateral forces generated.
  - Ensure workers have ANSI-approved safety footwear with slip-resistant soles. Consider puncture hazards and "drop and roll over" hazards.
  - Remind site personnel to watch for changes in walking surfaces.

HAZARD:

Heat stress from working in a hot, humid climate

Risks: Significant fluid loss can progress to clinical dehydration, raised core body temperature, impaired judgment, disorientation, fatigue, muscle cramping, and heat stroke.

- General Recommendations:
  - Adjust work schedules, rotate personnel, and add additional personnel if needed.
  - Replenish fluids (e.g., water, electrolytes) as needed.
  - Consider personnel and environmental monitoring plans.
  - Know the warning signs of heat-related illnesses.
  - Provide shelter for personnel in shaded areas.
  - Where possible, block out sun or other direct sources of heat from fixed work locations.
  - Prevent sun-related overexposure to skin by using a sunscreen with a significant Sun Protection Factor (SPF) of 15 or greater.

HAZARD:

Cold stress from working in a cold, wet climate

Risks: Rapid cooling of exposed skin and extremities increases the risk of frostbite and hypothermia.

- General Recommendations:
  - Get into heated shelter as necessary to maintain body temperature.
  - Replace wet clothing immediately.
  - Drink warm fluids often.
  - Wear adequate clothing to reduce the threat of cold stress.
  - Know the signs of cold stress.

HAZARD:

Power lines and gas lines

Risks: Electric shock and exposure to gas can cause illnesses and traumatic, serious, or fatal injuries.

- General Recommendations:
  - Treat all power lines and cables as energized until proven otherwise. De-energized lines can be energized by a secondary power source such as a backup generator.
  - Use appropriately grounded low voltage equipment.
  - Do not approach detected gas leaks.
  - Contact utilities (e.g., utility locate service) for buried power line location.
  - Stay at least ten feet away from live overhead power lines.
  - Get the owner or operator of the lines to de-energize and ground lines when working near them.
  - Use non-conductive wood or fiberglass ladders when working near power lines.
  - Keep area burn piles, observation areas, and areas where heavy equipment is used away from power lines and other electrical equipment.

HAZARD:

Isolated work areas and sanitation

Risks: Remote locations delay response times from emergency providers. Caution can reduce the severity of the event.

- General Recommendations:
  - Water-borne disease:
    - Always wash your hands.
    - Use hand sanitizers frequently.
    - Exercise good housekeeping.
    - Only drink from proven potable water sources.
  - Blood-borne disease:
    - Use latex or similar type of gloves when handling remains.
    - Replace gloves if punctured or torn.
    - Receive appropriate vaccinations (e.g., hepatitis A, B, tetanus, diphtheria).
    - Avoid standing water.
    - Observe universal precautions.
  - Food-borne disease:
    - Identify and dispose of food that may not be safe to eat.
    - Handle food properly.
    - Keep a supply of water and food on hand.
    - Rest when off duty.
  - Emergencies:
    - Know location and phone numbers of nearest hospital, doctor, and police.
    - Carry a first-aid kit.
    - Know the address or nearest crossroad of work site to relay to emergency responders.

HAZARD:

Insects, animals, reptiles, and plants

Risks: Insect and animal bites can cause illnesses and traumatic, serious, or fatal injuries.

- General Recommendations:
  - Protection from plants:
    - Be wary of poisonous plants.
    - Use barrier creams if available.
    - Wash affected area after contact.
  - Protection from wild or stray animals:
    - Avoid animal habitats (e.g., infested areas, rodent burrows, and nests).
    - Do not attempt to take custody of animals unless you are properly trained.
    - Avoid wild or stray animals. Assume all animals are rabid. Call local authorities to handle animals.
    - Dispose of animal carcasses according to local guidelines.
  - Protection from insects (e.g., mosquitoes, bees, spiders, fire ants):
    - Wear appropriate clothing (e.g., long pants, socks, long-sleeved shirts).
    - Avoid infested areas.
    - Use insect repellents that contain DEET or Picaridin, when necessary.
  - Protection from snakes:
    - Assume all snakes are poisonous. Be on alert for snakes that may be hiding in unusual places after flooding.
    - Seek immediate medical attention if you are bitten.
    - Try to identify the snake so that if it is poisonous you can be given the correct anti-venom.

c. REPORTING HAZARDS

The Debris Estimating Team may be one of the first official responders entering an area impacted by the disaster. This adds additional importance to detecting hazards. Any hazards posing an immediate threat to public health and safety should be reported to the appropriate authorities as soon as possible.

Example: *Downed power lines, especially if energized, should be immediately reported to the appropriate utility company and your supervisor.*

2. WHY DEBRIS VOLUME ESTIMATES ARE IMPORTANT

- FEMA now has the authority to make “grants on the basis of estimates agreed to by the Local government (or where no Local government is involved, by the State government).” These grants are paid on the basis of estimates rather than through the reimbursement of actual costs, for projects up to $500,000.

- Accurate estimates of disaster debris by type provide those responsible for managing the disaster debris with vital information for planning the debris removal and reduction operation. Good debris estimates are essential components in determining the scope of work in debris management.

- Estimates may be used to verify the need for a Request for Direct Federal Assistance.

3. DEALING WITH THE DISASTER “WOW” FACTOR

Destructive disasters, whether “man-made” or resulting from natural events, create a large volume of debris. This debris may be scattered over large areas and/or it may be concentrated into smaller geographic areas. Personnel assigned to estimate debris volumes are often amazed by the extent of the damage and may be stressed by the level of destruction, personal injury, and often death. These stressors can contribute to a sense of being overwhelmed by the volume of disaster-generated debris. An inaccurate calculation of debris volume may result if a conscious effort is not applied to remain focused on the actual debris load, as opposed to an amplified perception of the debris load. This has been described as adding the “Wow" Factor to actual debris estimates, creating an inflated estimate.

4. THE "BIG 3": CONSISTENCY, ACCURACY, and STANDARD FORMAT

1 CONSISTENCY

The importance of applying consistent methodology to the debris estimating process cannot be overemphasized. Throughout field data collection, applying formulae to field reconnaissance data and reporting estimates, consistency is a key ingredient to producing accurate estimates. This consistency requirement applies to the individual work of each team member, to each team working as a part of a larger cadre estimating debris volume for a disaster event, and to all estimates prepared for various disaster events.

2 ACCURACY

Though by definition the process of debris estimation cannot be exact, estimators must maintain a high standard of accuracy in their estimating work. When collecting field data, applying estimating formulae, compiling data, and reporting data, estimators must strive to produce the highest quality estimate possible. In most situations, estimate quality is judged by consistency, accuracy, and standard format.

3 STANDARD FORMAT

Using a standard format throughout the debris volume estimating process helps prevent errors caused by different interpretations of the data. As the volume data is collected, processed, compiled, and reported, the process must employ a format that is standard among individuals, estimating teams, and disasters to maintain consistency and accuracy.

CONCLUSION

Each level of government may have different interests and priorities in preparing an estimate of disaster debris. There are many different ways to estimate debris. Being creative with the available tools, techniques, and information will provide the best results. The one common interest is to produce consistent and accurate estimates presented in a standard format.

5. THE ESTIMATING TEAM

a. Federal, State, and Local Partners:

The potential for making “Grants on the Basis of Estimates” means that the interests and priorities of Federal, State, and Local government partners in the disaster debris estimate may vary, so agreement on disaster debris volume estimates among the government partners is essential. Each level of government with an interest in the disaster debris volume estimate should have a representative on the Debris Estimating Team. In most situations, this will be a representative of the Federal, State, and Local partners.

b. Roles and Responsibilities of Team Members

i. Federal Partner:

- Ensure debris estimates follow the FEMA eligibility guidelines for the disaster
- Instruct other team members on applicable FEMA eligibility guidelines.
- Represent Federal government interests during the disaster debris estimation and evaluation process.
- Document potential issues and concerns applicable to other Federal agencies, such as environmental issues, endangered species issues, and cultural resource issues.

ii. State Partner:

- Ensure debris estimates follow the State eligibility guidelines for the disaster.
- Represent State government interests during the disaster debris estimating and evaluation process.
- Document potential issues and concerns applicable to other State Agencies, such as environmental issues, endangered species issues, and cultural resource issues.
- Serve as a liaison to facilitate understanding and agreement between the Federal and Local interests.

iii. Local Partner:

- Represent the Local government interests during the disaster debris estimating and evaluation process.
- Document potential issues and concerns applicable to other Local government agencies, such as environmental issues, endangered species issues, and cultural resource issues.
- Facilitate the team’s access to debris volume sampling sites with local knowledge and expertise.

iv. All Team Members:

- Produce consistent, precise, and accurate estimates presented in a standard format.
- Respect the varied interests of all team members.
- Contribute and participate in the work of the team. “Pull your share of the load.”
- Be on time, and be prepared.
- Understand the policies, issues, concerns, etc., necessary to represent adequately the appropriate level of government.
- Be alert to hazards, protect the health and safety of the team, and report the hazards as appropriate.

6. ESTIMATING KNOWLEDGE, SKILLS, and ABILITIES

- Estimating debris volumes requires skill and ability in applying geometric formulae and mathematical calculations to produce accurate estimates. Team members lacking these necessary skills should inform their supervisor and ask for another assignment.

- Team members must work cooperatively to produce results that have team concurrence. If you have difficulty working in a team environment, you need to be assigned to other work.

- Each team member must be prepared to represent their level of government and have an adequate understanding of the applicable policies, laws, and regulations to facilitate recognizing potential issues and concerns.

- In order to function as a team member, each person must be able to deal with the physical and mental demands of the assignment. Twelve-hour days are the norm, weather extremes are certain, and hot meals are uncommon.

7. TEAM ESTIMATING TOOLS AND EQUIPMENT

a. MINIMUM REQUIREMENTS

- Handheld GPS
- Tape Measure (minimum 100 foot)
- Handheld Calculator
- Measuring Wheel
- Flagging Tape & Spray Marking Paint for Marking Limits of Sample
- Digital Camera
- Maps of Area
- Aerial Photographs (preferably before and after the disaster)
- Several Cans of “fix flat” for Inflating Punctured Tires
- Radio or Cell Phone for Communication with “Base”
- First-Aid Kit
- Bottled Water

b. “NICE TO HAVE ITEMS”

- Lap Top Computer
- Vehicle with 4-Wheel Drive and High Ground Clearance
- Dash-Mounted or Handheld GPS-Based Vehicle Navigation System
- Automated Data Collection and Tracking System
  (Note: *Investigation for integrating these systems into the debris estimating process is currently ongoing. See Tab 3, The Estimating Process.*)

Estimating Guidelines

1. CATEGORIES OF DISASTER-GENERATED DEBRIS

a. VEGETATIVE:

Consists of whole trees, tree stumps, tree branches, tree trunks, and other leafy material.

b. CONSTRUCTION & DEMOLITION (C&D):

The definition of construction and demolition debris may vary between States. C&D debris can be defined as damaged components of buildings and structures, such as lumber and wood, gypsum wallboard, glass, metal, roofing material, tile, carpeting and floor coverings, window coverings, pipe, concrete, fully cured asphalt, equipment, furnishings, and fixtures.

c. HOUSEHOLD HAZARDOUS WASTE (HHW):

HHW refers to hazardous products and materials used and disposed of by residential consumers, rather than commercial or industrial. HHW includes some paints, stains, varnishes, solvents, pesticides, and other products or materials containing volatile chemicals that catch fire, react, or explode under certain circumstances, or that are corrosive or toxic.

d. ELECTRONIC WASTE (E-waste)

E-waste refers to electronics that contain hazardous materials, such as cathode ray tubes. Examples include computer monitors and televisions.

e. WHITE GOODS

Discarded household appliances, such as refrigerators, freezers, air conditioners, heat pumps, ovens, ranges, washing machines, clothes dryers, and water heaters. Many white goods contain ozone-depleting refrigerants, mercury, or compressor oils.

f. VEHICLES OR VESSELS

Generally, a vehicle or vessel that presents a hazard or immediate threat, blocks ingress/egress within a public-use area, or is abandoned may be considered as disaster debris.

g. PUTRESCENT DEBRIS

Consists of any debris that will decompose or rot, such as animal carcasses and other fleshy organic matter.

h. OTHER

Hazardous waste, pressurized containers, commercial debris, private property debris, stream debris, wet debris, metals, etc.

2. CHARACTERISTICS OF VARIOUS DISASTER-GENERATED DEBRIS

Typical debris streams associated with various types of disasters are shown in the following table:

Table 1
Debris Stream Chart

Types of Disasters	Typical Debris Streams								
	Vegetative	Construction & Demolition (C&D)	Personal Property/ Household Items	Hazardous Waste	Household Hazardous Waste (HHW)	White Goods	Soil, Mud and Sand	Vehicles and Vessels	Putrescent
Hurricanes/Typhoons	X	X	X	X	X	X	X	X	X
Tsunami	X	X	X	X	X	X	X	X	X
Tornado	X	X	X	X	X	X		X	X
Floods	X	X	X	X	X	X	X	X	X
Earthquakes		X	X		X	X	X		
Wildfires	X		X		X	X	X		
Ice Storms	X				X				

3. DEBRIS ELIGIBILITY

The Federal government may provide grants through the Public Assistance Program to reimburse the response and recovery efforts of an applicant (State and Local governments and certain private non-profit organizations) for Presidential declared disasters. To receive supplemental disaster assistance under the Public Assistance Program, applicants must meet FEMA eligibility criteria.

Applicants may conduct debris operations in any manner they deem appropriate. However, only costs associated with applicants, facilities, and work deemed eligible according to FEMA eligibility criteria and complying with special consideration requirements are reimbursed under the Public Assistance Program. The eligibility criteria should be considered when developing estimates of disaster debris. Policy governing eligibility is subject to frequent change, even in the midst of a Debris mission. The Federal Team member should be prepared to advise the Debris Estimating Team on applicable eligibility criteria. A good reference document for this subject is FEMA Publication 325, Public Assistance Debris Management Guide. It is available on the web at the following address:

http://www.fema.gov/government/grant/pa/demagde.shtm

The Estimating Process

1. GENERAL PROCESS INFORMATION

The debris estimation process is comprised of various components and includes the following:

- Debris Estimate Sampling Methodology
- Event Specific Debris Estimate Sampling Plan
- Debris Estimating Field Guide
- GPS-Based Software/Hardware (under development for future use)
- Estimation Process Training For Field Personnel

This tab presents a discussion to help the reader understand these components and provide guidance through the process of estimating the total, eligible debris volume through on-site sampling. It contains practical information concerning eligibility, specific facilities, such as schools and parks, event type, various formulae, conversion rates, and a Standardized Data Recording Form. It also contains certain "Rules of Thumb" and "tips" for debris estimation.

Figure 3, located under *Digital Imagery*, is a general depiction of the debris estimation process described herein.

a. DEBRIS ESTIMATE SAMPLING METHODOLOGY

By separate document, a Sampling Methodology has been developed that uses Statistical Science and event physical characteristics to develop event-specific Debris Estimate Sampling Plans. The methodology prescribes sample size (number of samples) and sample locations to achieve a desired level of accuracy within specified confidence limits.

b. THE EVENT SPECIFIC DEBRIS ESTIMATE SAMPLING PLAN

A Sampling Plan is a document that describes a process for gaining an estimate of disaster debris. A good Sampling Plan will ensure that the estimate answers the right questions and communicates the strategy for obtaining the desired results. Most sampling plans will address the following topics:

- Project Goals
- Parameters to be Measured (e.g. households, road miles, city blocks)
- Sample Site(s): Designated point(s) to perform debris volume estimates, which may be identified in latitude/longitude format or street address format
- Sample Size Determination: The number of sample sites
- Sample Site Allocation: The random placement of sample sites
- Sample Unit: The surface area for which a disaster debris volume estimate is computed at an assigned sample site

- Application of the Sampling Plan: The Sampling Plan will be the Debris Estimating Team's "playbook." It should provide specific information pertaining to:
  - Where to sample within the impacted area = Sample Site(s).
  - Size of the sample area = Sample Unit. The Sample Unit is defined as the surface area for which a disaster debris volume estimate is computed at an assigned sample site. The default Sample Unit is defined as an area 100 yards along a designated public right of way with a width equal to the estimated width of the public right of way. The estimate of debris shall include all observed eligible disaster debris located on private property that is anticipated to be moved to the public right of way within the sample unit area (excluding any demolition debris). The sample site will include the volume of eligible disaster debris within, or anticipated to be brought to, the public right of way for a distance of 50 yards in both directions from the center point.
  - The Sampling Plan also should provide instructions pertaining to any specific, unique, or event-specific data collection requirements.

c. GPS-BASED SOFTWARE/HARDWARE

A tablet-style computer with GPS capability is being developed to record field data and position data into a GIS. The potential to pre-load the Sampling Plan into such a system, travel through the prescribed sampling area while concurrently estimating and recording data, and then upload the data to a central server for calculation of overall volume and data display is believed to be very promising. Following testing and validation, this tool will be incorporated into this Debris Estimating Guide.

d. PER-APPLICANT ESTIMATES

The Federal government may provide grants through the Public Assistance Program to reimburse the response and recovery efforts of an applicant (State and Local governments and certain non-profit organizations) for Presidential declared disasters. Each applicant's costs are independently evaluated for reimbursement eligibility under the Public Assistance Program. It is imperative that disaster debris estimates provide independent estimates for each applicant. All Sampling Plans should consider this requirement.

e. ESTIMATING PARKS

The Sampling Plan may prescribe for estimating all disaster debris in all parks, certain named parks, a single park, or specific size area(s) within one or more parks in an applicant's geographic area. It is important to capture the location and name for each park where estimates are taken. Whatever the sample size used in estimating disaster debris for park(s), some general guidelines will apply:

- Normally, only the developed and improved areas of parks are eligible for disaster debris removal work. Downed vegetation in wooded or forested areas is not eligible and should not be included in the estimate. In most situations, if an area were maintained prior to the disaster, it is considered to be an eligible area.

- The disaster debris estimate for eligible areas of parks *may* include counting the number of hanging limbs and leaning trees in maintained areas and along improved personnel trails. The Federal team member should have information to define and guide the estimating of these types of debris.
- Estimating damages to park buildings and structures should, at least initially, be limited to estimating the volume of construction and demolition (C&D) debris created by the structural damage.

f. ESTIMATING SCHOOLS

The Sampling Plan may prescribe for estimating all disaster debris in all schools, certain named schools, a single school, or specific size area(s) within one or more schools in an applicant's geographic area. It is important to capture the location and name for each school where estimates are taken. Whatever the sample size used in estimating disaster debris for schools, some general guidelines will apply:

- Normally, only the developed, improved, and maintained areas of a school campus are eligible for disaster debris removal work. Downed vegetation in wooded or forested areas is not eligible and should not be included in the estimate. In most situations, if an area were maintained prior to the disaster, it is considered to be an eligible area.
- The disaster debris estimate for eligible areas of schools *may* include counting the number of hanging limbs and leaning trees in maintained areas and along improved personnel trails. The Federal team member should have information to define and guide the estimating of these types of debris.
- Estimating damages to school buildings and structures should, at least initially, be limited to estimating the volume of construction and demolition (C&D) debris created by the structural damage.
- The Debris Estimating Team may be one of the first official government representatives visiting the site. Although it may not be needed for debris estimates, the general condition of the school buildings and campus area should be documented. If damage is not too severe, the estimator should consider what it will take to put the school back into service (e.g. clearing drives and parking areas, replacing broken windows, repair minor roof damage).

g. ESTIMATING DEBRIS VOLUME IN SPECIAL USE SITES

Areas such as cemeteries, streams, beach areas, and utility right of ways are often covered by disaster specific eligibility guidance. Event specific sampling guidance should guide the debris estimation process in these special use sites.

h. ESTIMATING ROOF DAMAGE

The Debris Estimating Team may be asked to provide initial reconnaissance for roof damage assessment. This preliminary assessment information could aid disaster managers in determining the need for assistance in providing temporary roofing. The Team may be asked to provide an assessment based on the following criteria for all the roofs within its sample area. The following criteria are used in evaluating roof damage. Residential facilities (single and multi-family) and facilities used as shelters with sloped roofs covered with composite shingles, and:

- Less than 50% of the deck is damaged.
- Less than 50% of the rafters are damaged, and
- The structure is structurally sound and can provide safe shelter once plastic sheeting is installed.
- Structures with flat, tile, or metal roofs do not qualify.

i. ESTIMATING FLOOD DAMAGE

Estimating disaster debris volumes associated with flood damage is challenging at best. The event creating the flood damage may have been a river flooding or tsunami event with no associated wind damage. It also may have been an event such as a hurricane, resulting in high winds, river flooding and/or storm surge. In catastrophic events, the flooding may have totally destroyed all structures and moved the debris significant distances from its point of origin. When flood damaged structures exist, the key to estimating the volume of debris resulting from the flood damage is to identify the height of the water intrusion into the structure. The estimator is usually not able to see inside the structure. Once the flood elevation is established for each structure, the estimator can then:

- Estimate floor covering volume using the size of the structure.
- Estimate the wall board or wall covering volume using the height of the damage to yield the estimated interior wall surface area damaged.
- Estimate additional volumes for any basement areas to include furnishings.

j. ESTIMATING EARTHQUAKES

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. For damaged structures that are still habitable, residents and businesses will usually begin soon after the main shock to clean up broken glass and ceramics, spilled foods and liquids, and broken furniture and appliances. Later, demolition material, including concrete, asphalt, bricks, gypsum wallboard, metal, and soil comprises the majority of the disaster-related waste stream. Earthquake debris includes building materials, personal property, and sediment from landslides. Considerations for estimating earthquake debris include:

- Older communities may not be constructed to earthquake building codes and so may have more serious structural damage than is obvious. This can lead to a significant under estimation of debris volume.

- Estimate “downed” debris and structures that will obviously be demolished and placed on the public right of way.
- Estimate building debris using the formula shown at Tab 4 and convert to cubic yards. To convert cubic yards of C&D to approximate tons, see Tab 4.

k. DEALING WITH ANOMALIES

Depending on the sample site(s) identified in the Sampling Plan, the Debris Estimating Team may encounter special challenges, such as mobile home parks, gated communities, and highways in the Federal Aid Road System. Proceed with producing estimates consistent with the Sampling Plan. However, record any special situations such as those mentioned above. Estimating formulae and guidelines for mobile homes are included in Tab 4.

NOTE **Estimating debris can be a daunting task. Consider the following techniques to aid in the estimating process:**

- **Collect data from previous disaster experiences as a check or means of comparison.**
- **If vegetative debris is fairly uniform, mark out a section, measure it, and calculate the volume. Use that data to extrapolate for the entire area.**
- **Look at aerial photography combined with the measured/extrapolated technique.**
- **Use computer modeling. Explore the latest techniques being developed incorporating GPS, GIS, and automated data processing.**

2. ESTIMATING DATA REPORT FORM

Figure 2
Debris Estimating Data Report Form

Debris Estimating Data Report Form

Sample Site Identifier: _____

Sample Site Descriptor:
(urban, semi urban, rural, school, park, etc.)
_____

_____

_____

Estimators Name ,Signature, Telephone
Signature indicate concurrence with Team Estimate.

_____

Month / Day / Year

Latitude: _____

Longitude: _____

Debris Removal Work Ongoing ?
If so, By whom ?
_____

Debris Volume in Sample Site:

Vegetative _____ cy

C&D _____ cy

Mixed Debris _____ cy

Total Debris Volume Estimate _____ cy

White Goods _____ unit

Household Hazardous Waste _____ 55 gal. drum

Residential Roof Damage:
(single & multifamily units)

> 50% of decking damaged _____

> 50% of rafters damaged _____

Serviceable w/ plastic sheeting _____

No Roof Damage noted _____

Flood Damage Present ? _____

Average Height of Flood Damage _____

% of Sample Area impacted by Flood Damage

_____ %

Hazardous Materials Present ? _____

Describe type & distribution _____

Comments & Observations:

_____

_____

_____

Note to estimators: Unless instructed otherwise, the sample unit shall be an area 100 yards along a designated public right of way 50 yards in both directions of the center point of the assigned sample site. The width is equal to the estimated width of the public right of way.

3. DIGITAL IMAGERY

Pre- and post-disaster aerial and ground level imagery can provide excellent intelligence in advance of the Debris Estimating Team's deployment during the field data collection process and during the actual work of preparing debris estimates.

Pre-Deployment: Reviewing pre- and post-disaster aerial imagery will assist the Team in determining available routes of travel to sampling sites, locating sampling sites, and determining the order or magnitude of the debris loading. Taking advantage of the opportunity to gain intelligence in advance of the field data collections will improve the efficiency and effectiveness of the team's fieldwork.

Data Collection: During the data collection work, imagery is a valuable tool to validate ground level observations relative to debris dispersal, types of debris, flood area coverage, storm surge area, number of impacted structures, etc. It is also valuable for geographic reference and as a tool for navigating to, from, and in the sample site(s). Ground level imagery is a tool to validate, document, and illustrate findings.

Preparing Estimates: During the work to translate field data into estimates, imagery may be used to validate recorded notes relative to debris concentration, dispersal, type, etc. The several techniques to incorporate information from aerial imagery into the debris estimating process include:

- Select an object in the photograph for which the length can be reasonably estimated (e.g., a vehicle, road width, lot size). Measure that object and estimate its length. Apply that length to the intact houses to estimate the length and width of each house. Calculate the approximate square footage by multiplying the length times the width. If there are houses of different sizes, measure several and then calculate the average square footage.
- If the approximate square footage of the homes can be determined, count the driveways and compute the estimated cubic yard of debris using the conversion tables listed in Tab 4.

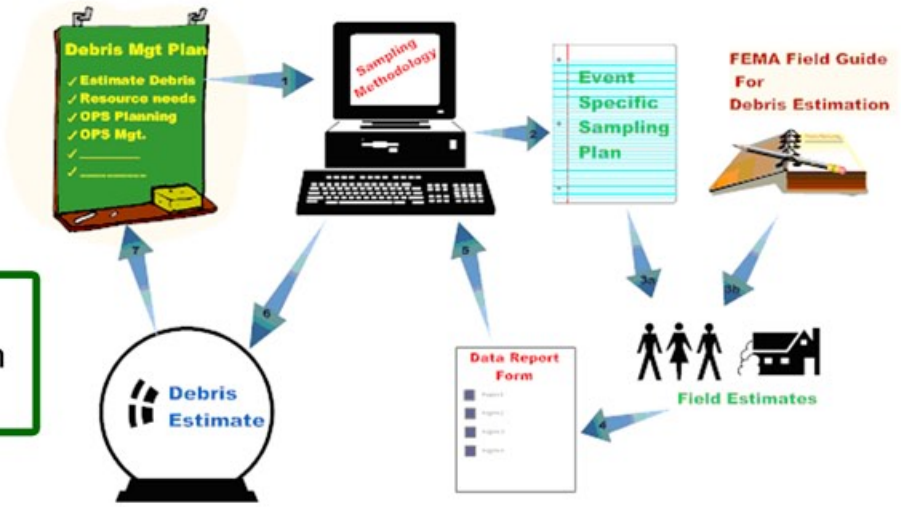


Figure 3
Debris Volume Estimation Process Chart

Estimating Formulae and Conversion Factors

1. BUILDINGS

a. RESIDENTIAL BUILDINGS:

A demolished single-family home and associated debris:
L' X W' X S X 0.2' X VCM = ___ cubic yards of debris (cy).
The square footage (L' X W') is the total living space above basement level (e.g., a two-story house with a footprint of 1200 square feet would have a living space of 2400 square feet). It also includes attached garages.

b. OUTBUILDINGS:

$$\frac{L' \times W' \times H' \times .33}{27} = _____ \text{ cy}$$

c. MOBILE HOMES:

$$\frac{L' \times W' \times H'}{27} = _____ \text{ cy}$$

- The 0.33 factor is not applied due to compact construction.

- Typical quantities for mobile homes:
  - Singlewide = 290 cy.
  - Doublewide = 415 cy.

d. DEBRIS PILES:

$$\frac{L' \times W' \times H'}{27} = _____ \text{ cy}$$

e. NOTES:

L = Length of building in feet
W = Width of building in feet
S = Height of building expressed in stories
VCM = Vegetative Cover Multiplier:
- Light: (1.1 multiplier) includes new home developments where more ground is visible than trees. These areas will have sparse canopy cover.
- Medium: (1.3 multiplier) generally has a uniform pattern of open space and tree canopy cover. This is the most common description for vegetative cover.
- Heavy: (1.5 multiplier) is found in mature neighborhoods and woodlots where the ground or houses cannot be seen due to the tree canopy cover.

H = Height of building in feet
.33 = A constant to account for "air space" in the outbuilding
27 = A conversion factor from cubic feet to cubic yards
0.2 = A constant to account for "air space" in the residential building

f. REMINDERS and TIPS:

- Look beyond the curb into side and backyards and at the condition of homes. Most debris in these areas will eventually move to the curb.
- Wet storms will produce more personal property debris (e.g., household furnishings, clothing, rugs) if roofs are blown away or homes are flooded.
- Look for hanging debris, such as broken limbs, after an ice storm.
- Flood-deposited sediment may be compacted in place. Volume may increase as debris is picked up and moved.
- Using aerial photographs in combination with ground measurements will help determine if there are any voids in the middle of large debris piles.
- Treat debris piles as a cube, not a cone when estimating volume.
- 15 trees, 8 inches in diameter = 40 cubic yards (average).
- One acre of debris, 3.33 yards (10 feet) high = 16,117 cubic yards.

g. FLOODING — ESTIMATING PERSONAL PROPERTY

The amount of personal property within an average flooded single-family home has been found to be:

- Slab on grade house: 25 – 35 cy.

- House with basement: 45 – 50 cy.

- Mobile homes have less wasted space due to their construction and use. The walls are narrower, and the units contain more storage space. Therefore, the typical mobile home generates more debris by volume than a single-family home. Historically, the volume of debris from mobile homes has been found to be:

- Singlewide mobile home: 290 cy.
- Doublewide mobile home: 415 cy.

2. VEGETATION

f. REMINDERS and TIPS:

Debris Forecasting Table for Totally Destroyed Single-Family, Single-Story Homes in the Applicable Vegetative Cover Category

Table 1

Typical House (square feet)	Vegetative Cover Multiplier (yard waste)			
	None	Light (1.05)	Medium (1.15)	Heavy (1.25)
1000 sf	200 cy	210 cy	230 cy	250 cy
1200 sf	240 cy	252 cy	276 cy	300 cy
1400 sf	280 cy	294 cy	322 cy	350 cy
1600 sf	320 cy	336 cy	368 cy	400 cy
1800 sf	360 cy	378 cy	414 cy	450 cy
2000 sf	400 cy	420 cy	460 cy	500 cy
2200 sf	440 cy	462 cy	506 cy	550 cy
2400 sf	480 cy	504 cy	552 cy	600 cy
2600 sf	520 cy	546 cy	598 cy	650 cy

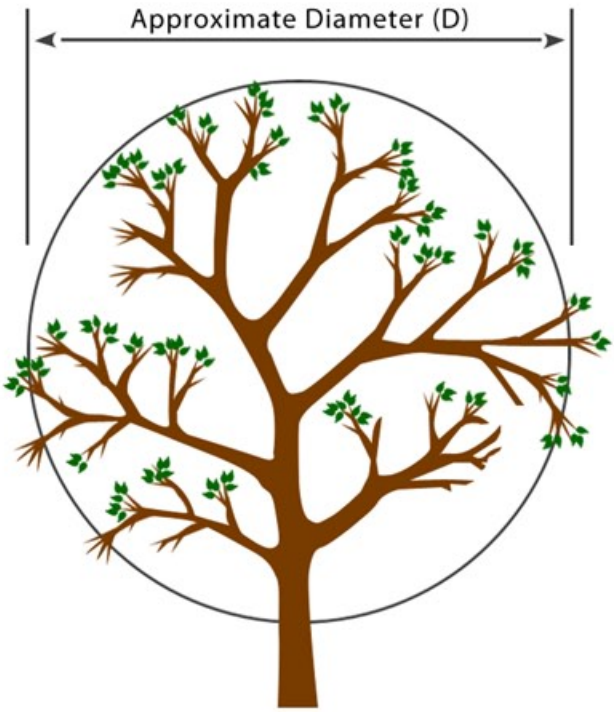
- If the structure has blown away or the square footage is unknown, measure the area of the floor slab and then use the table. Similarly, once a square footage has been generated from the floor slab, multiply by the number of floors, if that can be determined from the homes in the surrounding neighborhood.

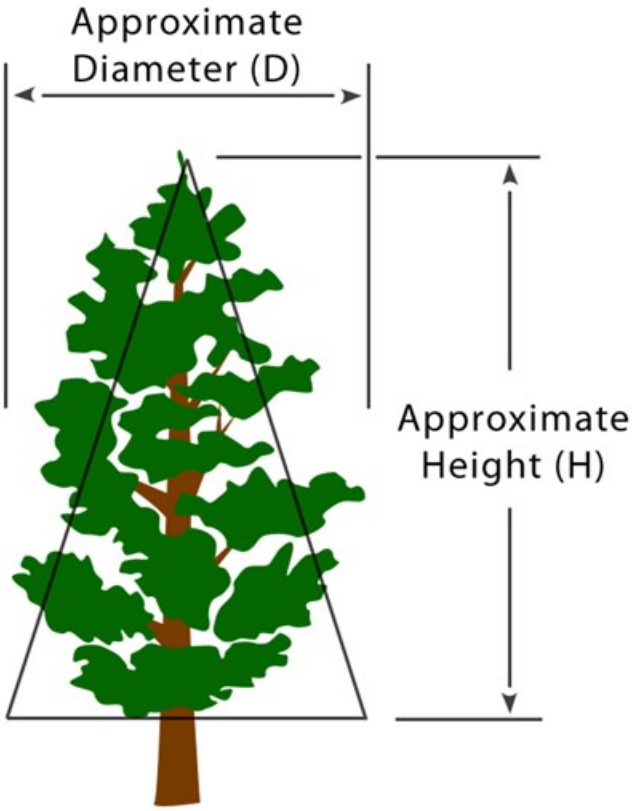
- Determining which vegetative cover multiplier to use becomes easier with experience. A new home may have had little or no vegetative cover. Older homes in densely wooded areas would be expected to have heavy vegetation.

- For multiple story buildings, multiply the debris from one story by the number of stories. Vegetative cover should still be determined by using the multiplier from a one-story home.

- To obtain rough estimates of the debris volume contained in trees, consider the formula used by some companies in the tree removal industry:
  - For oak and most hardwood trees the diameter of the stump 2 feet above the ground in inches changed to cubic yards equals the approximate debris volume. *Example*: an oak tree with a 24 inch diameter stump (measured 2 feet above the ground) will contain approximately 24 cubic yards of vegetative debris.
  - For pine trees the diameter of the stump 2 feet above the ground in inches multiplied by 75% (.75) and changed to cubic yards equals the approximate debris volume. *Example*: a 24 inch diameter (measured stump 2 feet above the ground) will contain approximately 18 cubic yards of vegetative debris (24 X .75 = 18).
  - For magnolia, pecan, and other nut trees with heavy limb & leaf growth the diameter of the stump 2 feet above the ground in inches multiplied by 125% (1.25) and changed to cubic yards equals the approximate debris volume. *Example*: a 24 inch diameter stump (measured stump 2 feet above the ground) will contain approximately 30 cubic yards of vegetative debris (24 X 1.25 = 30).

For estimating purposes, the tree's canopy (limbs, branches, leaves, etc., above the trunk) can be approximated by either a sphere (defined simply by its approximate diameter) or a cone (defined by an approximate height and base diameter). Since the volume of the canopy is not perfectly solid, the computed volume should be adjusted by a factor that reflects the amount of air space that exists between limbs, branches, leaves, etc. For example, in the figure illustrating a tree with a canopy approximated by a sphere of diameter D, only 15 or 20 percent of the volume appears to be actual solid material. Therefore, estimating with a percentage factor will compute a volume of debris reflecting only the solid material (limb, branches, leaves, etc.). The volume of the tree trunk itself can be thought of as being included in the approximate volume of the canopy.





Tree with Cone Shaped Canopy

Adjustment Factor	30 percent solid material
Diameter (D)	12 feet
Height (H)	22 feet
Volume of Debris	9 cubic yards

Tree with Sphere Shaped Canopy

Adjustment Factor	15 percent solid material
Diameter (D)	18 feet
Volume of Debris	17 cubic yards

3. CONVERSION INFORMATION, FORMULA, & "RULES OF THUMB"

Table 2 Material Conversion Rates and Typical Densities for Construction Material

Typical densities for construction material.

Materials & Description	Density (lb per cu ft)
Gypsum or plaster board	50
Plywood	34
Sheathing, fiberboard	18-25
Particleboard	40
Blanket and Batt Insulation mineral wool, fibrous form	0.3-2.0
Boards and Slabs Insulation Cellular glass	8.5
Glass fiber	4-9
Expanded rubber (rigid)	4.5
Expanded polyurethane (R-11 blown)	1.5
Acoustical tile	18-23
Cement mortar	116
Sand & gravel or stone aggregate	140
Stucco	116
Brick, common	120
Brick, face	130
Granite, marble	150-175
Aluminum	171
Brass	524-542
Copper	550-555
Iron, gray cast	438-445
Iron, pure	474-493
Lead	704
Steel	490
Cement plaster, sand aggregate	116
Gypsum plaster	45
1-ply membrane roofing	83
Asphalt roll roofing	70
Asphalt shingles	70
Built-up roofing	70

* Source: Hoke (1988).

Material Conversion Rates:

Wood
300 lb/cu yd. ➡ 6.7 cu yd./ton

Cardboard
30-100 lb/cu yd. ➡ 20-50 cu yd./ton

Drywall
400 lb/cu yd. ➡ 5 cu yd./ton

Concrete Rubble
1400 lb/cu yd. ➡ 1.4 cu yd./ton

Mixed waste
350 lb/cu yd. ➡ 5.7 cu yd./ton

*Source: Yost and Lund (1997).

Approximate Conversions

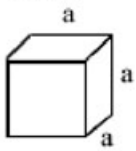
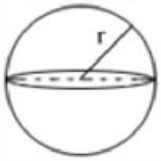
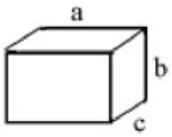
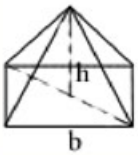
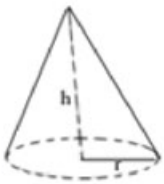
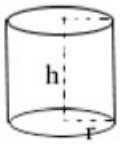
Construction & Demolition (C&D)

- CY of C&D debris to tons – divide by 2
- Tons of C&D to CY – multiply by 2
- ½ in. gypsum wallboard = 2lb/sf.

Woody Debris

- CY of hardwoods to tons – divide by 4
- Tons of hardwoods to CY – multiply by 4
- Tons of softwoods to CY – multiply by 6
- Fifteen – 8 inch diameter trees = 40 cy (average)

Table 3
Volume Formulae

• **Cube:**  Volume = a^3	• **Sphere:**  Volume = $(4/3) \times pi \times r^3$
• **Rectangular Prism:**  Volume = $a \times b \times c$	• **Pyramid:**  Volume = $(1/3) \times b \times h$
• **Cone:**  Volume = $(1/3) \times pi \times r^2 \times h$	• **Cylinder:**  Volume = $pi \times r^2 \times h$

4. REFERENCES

- *Debris Operations Job Aid, FEMA 9580.1, August 2000*
- *Public Assistance Debris Management Guide, FEMA 325, July 2007*