Construction & Demolition Waste Management

pocket guide

United States Air Force

Installation C&D Waste Management Strategy

Project C&D Waste Management Plan

Construction and Demolition Waste Management

Pocket Guide

Prepared by

3D/International

For

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This publication is to be used in conjunction
with the expanded version of the
HQ AFCEE "Construction and Demolition Waste Management Guide."

Both publications are available on the HQ AFCEE
"Sustainable Development Resources" web page at

http://www.afcee.brooks.af.mil/green/resources/resources.asp.

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Contents

Introduction and Background

"'Waste' – A resource in the wrong place."
An old Chinese proverb

This proverb perhaps has no better application than to Construction and Demolition (C&D) waste. Studies show C&D waste is generated in this country at 2.8 lbs. per person per day. At this rate, a typical Air Force installation of 10,000 people produces 5,110 tons of C&D waste annually. Based on a national average C&D landfill-tipping fee of $32/ton, the cost of disposing of this waste using traditional methods is $163,520. Not only is C&D waste a resource in the wrong place, but it's also expensive to put it there.

You are reading this Pocket Guide because you have accepted the challenge of acting immediately to manage C&D waste. This Guide provides a quick reference to and summary of highlights in the "Construction and Demolition (C&D) Waste Management Guide." The purpose of both documents is to assist readers with tracking and diverting the C&D portion of the total solid waste stream. Managing C&D waste will help installations meet Air Force solid waste diversion goals.

People should use this Guide if they plan, design, contract, inspect, or execute construction and demolition activities on an installation. Each has an important role as a C&D waste manager. Users should read the "Construction and Demolition (C&D) Waste Management Guide" for a comprehensive discussion of background, tools, resources, and steps. The pocket version compliments the Guide while carried on the job or in the field.

The expanded version of the C&D Guide defines important terms in Chapter 2, page 2-1, and Appendix A, Abbreviations, Acronyms, and Definitions. Two are emphasized here:

> ***C&D waste*** *is material produced during the construction, renovation, demolition, or deconstruction of residential and commercial buildings and their infrastructure. C&D waste typically includes concrete, wood, metals, gypsum wallboard, asphalt, and roofing material. For the purposes of the Guide and pocket version, materials are C&D waste if they would normally be hauled away for disposal.*

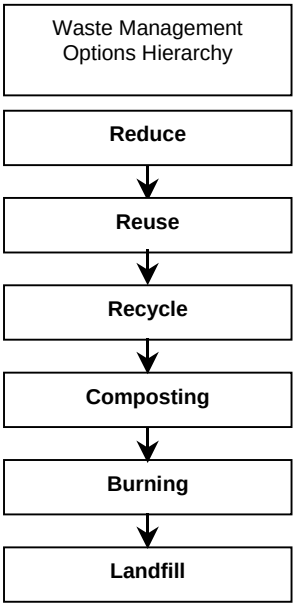
> ***Waste managers*** *refers to <u>all</u> who may be involved with the management of C&D waste, regardless of individual functional area. The term is NOT meant to refer only to the individual, usually in the Civil Engineer Squadron/Group, specifically assigned waste management responsibilities for an installation. Successful C&D waste management requires the efforts of varied team members each using their areas of expertise.*

Efficient C&D waste management has traditionally experienced five barriers. These five barriers are: the newness of doing it, limited diversion markets, limited market awareness, perceived higher cost, and perceived requirement for additional job-site space. As a result, installations have generally not been motivated to efficiently manage C&D waste because evolving markets and incentives vary greatly across installations, regions, and states.

HQ USAF/ILEV letter, 26 Jan 1999, Subject: Non-hazardous Solid Waste Diversion Rate Measure of Merit (MoM), however, has pumped new life into C&D waste management. In that letter, the Air Force has established a policy and a MoM for diverting non-hazardous solid waste from disposal in landfills and incinerators. Specifically, the MoM requires that, *"By the end of FY 2005, ensure the diversion rate for non-hazardous waste is greater than 40 percent, while ensuring integrated non-hazardous solid waste*

management programs provide an economic benefit when compared with disposal using landfilling and incineration alone."

C&D waste is now included as part of the "non-hazardous waste" to be diverted from disposal. Prior to the 1999 MoM letter, C&D waste was excluded from solid waste diversion.



C&D waste managers have a growing number of options for managing C&D wastes. The Waste Management Options Hierarchy shown is a useful guide. This hierarchy can be applied against the five phases in the life of a construction project:

1. Asset management
2. Planning
3. Design
4. Demolition
5. Construction

Overall, project planners and designers can prevent C&D waste in the asset management, design, and construction phases. In addition, C&D managers can reduce, reuse, and recycle wastes during the planning, design, demolition and construction phases of a project life. How this can be done is discussed below.

During asset management, planners assess existing buildings and properties against project needs. When possible, existing buildings are used to avoid new construction and demolition and prevent waste generation.

During planning, waste managers should develop a C&D Waste Management Strategy and establish overall waste diversion goals. These strategies and goals may be summarized and entered on the inside front cover of the Pocket Guide for reference.

During design, project designers can reduce waste generated at the source with the following techniques:

- ☐ Choosing Simple Plans - Building dimensions are in standard 2- and 4-foot increments to reduce waste from cuts.

- ☐ Using Advanced Framing - Framing details are designed to minimize unnecessary framing materials.

- ☐ Specifying Prefabricated Materials - Pre-cut and pre-fabricated materials allow scrap to be efficiently recycled at the factory.

- ☐ Specifying Recyclable Materials and Recycled-Content Material.

- ☐ Specifying Non-hazardous Materials.

- ☐ Specifying builders develop and use a Waste Management Plan for each construction project.

- ☐ Using tailored C&D waste management model specifications for each project. There are several sources for these model specifications, but the Triangle J Council of Government has produced the most comprehensive version titled WasteSpec, “Model Specifications for Construction Waste Reduction, Reuse and Recycling.” WasteSpec can be

ordered by calling 919-549-0551 or an order form is available at www.tjcog.dst.nc.us/TJCOG. The web-based Guide provides details on using WasteSpec in Chapter 3, page 3-17, and Appendix H, WasteSpec References.

During demolition and construction, waste managers can use the following methods for efficiently managing C&D waste:

- ☐ Explain Established Goals - Ensure reuse and recycling goals are clearly explained to builders and sub-contractors.

- ☐ Reduce Job Site Waste - Store and handle materials carefully and centralize material cutting operations.

- ☐ Salvage Reusable Materials - Salvage materials for reuse at this or other project sites, for resale, or for donation.

- ☐ Recycle Waste Materials - Three options include:
  1. Sort at the job site for hauling to or pick-up by a material handling facility.
  2. Commingle for delivery to a materials recovery facility.
  3. Time-phased recycling, or recycling waste materials during a specific construction stage.

Finally, during the construction phase, builders can prevent waste with the following efficient purchasing techniques:

- ☐ Tight Estimating - Ensure only the correct amount of materials are purchased and delivered to the site.

- ☐ Supplier Coordination - Require suppliers to take or buy

back substandard or rejected materials, substitute materials of lesser toxicity, and suggest ideas for reducing job site material spoilage.

- ☐ Just-in-time Delivery - Coordinate material delivery to coincide with its use to reduce material damage and waste.

- ☐ Reduce Packaging Waste - Require suppliers to reduce their packaging materials, provide reusable pallets and containers, and back-haul all shipping and packing materials.

C&D waste managers must be aware that there are five project categories in which construction and demolition can be accomplished on an installation.

1. In-house, Civil Engineer Squadron/Group workforce.

2. In-house, organizations using the installation Self-Help Store and housing residents using the U-Fix-It Store.

3. In-house, Simplified Acquisition of Base Engineering and Repair (SABER) or Military Family Housing contractors.

4. Externally, agencies like RED HORSE and National Guard forces.

5. Externally, outside contractors acquired through the installation contracting office or other Air Force organizations and tenants like AAFES, DeCA, and NAF.

Waste managers have varying degrees of control over construction and demolition accomplished under these categories. Therefore, waste managers must recognize the importance of establishing and widely communicating the installation-approved C&D Waste

Management Strategy. It becomes a team effort to ensure that builders outside the waste managers' direct control are aware of the strategy, are required to use or submit Waste Management Plans, and are required to track and report on their success with diverting C&D waste.

C&D Waste Management Project Planning

Your success in implementing plans and diverting C&D waste will depend largely on your completing the steps outlined here. C&D waste managers must complete a significant amount of research and planning before they can develop an overall C&D waste strategy. This critical research and planning lays the foundation for preparing waste management plans.

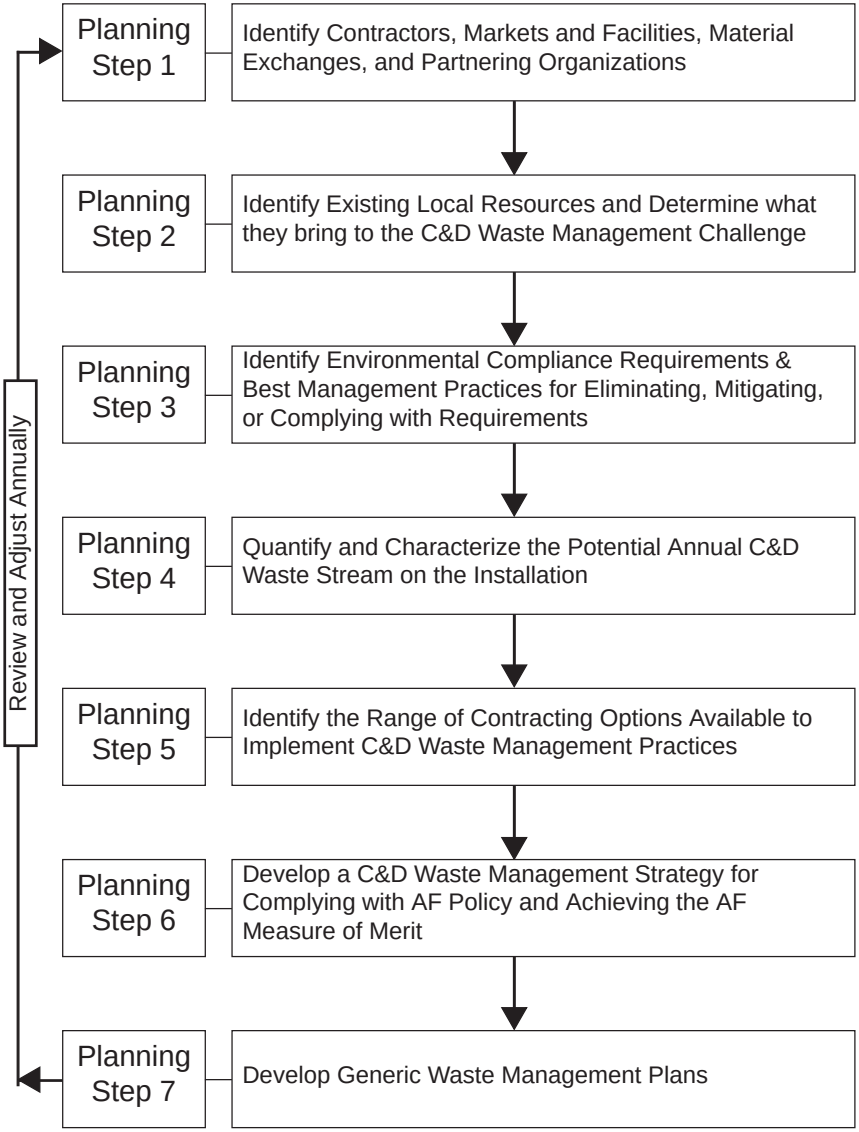
- ☐ **Planning Step 1 - Identify Contractors, Markets and Facilities, Material Exchanges, and Partnering Organizations**

First, waste managers must know exactly what can be accomplished locally and regionally in the areas of sustainable building design, recycling, and reuse. It is important to determine what the capabilities and interests of contractors are, because contractors accomplish most construction and demolition at installations.

Second, waste managers need to identify the local and regional salvage, reuse, and recycling markets and material handling contractors and facilities. Without this information, waste managers and implementing team members may spend a great deal of unproductive time asking for what can’t be accomplished.

Third, project designers, planners, and managers of in-house work forces must identify local or regional material exchanges. Material exchanges complete the diversion loop by offering reused and recycled materials for construction. Installation designers can specify procurement of reused and recycled construction materials from exchanges and installations and contractors can procure diverted materials from exchanges. For help, recommend waste managers refer to the expanded version of the C&D Guide, Appendix F. This Appendix describes how to access and use six material exhange websites.

7-Step C&D Waste Management Project Planning



Finally, waste managers must provide persistent direction and seek effective cooperation as well as financial and labor assistance through available partnerships in order to successfully implement their C&D waste management strategy and plans.

The expanded version of the Guide outlines the process for gathering this information. C&D Waste Management Planning Spreadsheet A is provided online in Appendix E for recording the data. Waste Managers should download the completed spreadsheet and use it for planning and implementing your C&D waste management program.

☐ Planning Step 2 - Identify Existing Local Resources and Determine What They Bring to the C&D Waste Management Challenge

The second planning step involves two parts. First, waste managers must obtain copies of installation plans and program documents that impact the safe and efficient management of C&D waste. At a minimum, each installation should have management plans for Solid Waste, Asbestos, and Lead-based Paint. Each installation should also have Environmental Impact Statements, Environmental Assessments, and installation building and site histories completed as part of new construction programs or the Installation Restoration Program. These documents help identify the affected environment and provide details on the miscellaneous hazardous materials buildings may contain.

Second, waste managers should establish two waste management teams. The first team is the “Steering Group for C&D Waste Management.” This team should meet at least annually and use the data gathered during planning for establishing the installation C&D waste management strategy and getting Wing Commander

approval. The second team is called the "C&D Waste Management Execution Team." The composition of this team varies widely depending on the specifics of the C&D project. The team members should be those who are directly involved with the project and can collectively influence all aspects of C&D waste management. A list of possible members of both team is provided on the inside back cover of the Pocket Guide. Space is also provided for entering names and phone numbers for quick reference.

☐ **Planning Step 3 - Identify Environmental Compliance Requirements & Best C&D Management Practices for Eliminating, Mitigating, or Complying with Requirements**

The expanded version of the C&D Guide provides the environmental impacts, the compliance requirements, and best management practices for dealing with the most common regulated materials and equipment components used on the job site. These are:

- Asbestos Containing Building Materials (ACBM).
- Lead-based Paint (LBP).
- Poly-chlorinated Biphenyls (PCB).
- Batteries containing lead and cadmium.
- Mercury.
- Chlorofluorocarbons.
- Treated Wood.
- Miscellaneous (e.g., fluorescent lights, thermostats).

Refer to Chapter 3, pages 3-7 through 3-18, of the Guide for details.

It is not the purpose of the expanded version of the C&D Guide or this pocket version to make readers experts on hazardous materials

and environmental compliance law. Waste managers must always rely first on the expertise of the installation's environmental, bioenvironmental engineering, and judge advocate offices. But the Pocket Guide does provide below a generic environmental checklist of best management practices for your use in planning and executing work involving C&D waste management.

- ☐ Review the installation management and operating plans for ACBM, LBP, and PCB prior to project design and facility inspection.
- ☐ Inspect the facility to verify the location, status, and condition of all Asbestos and PCB-containing material and identify new or suspected ACBM and PCB containing materials and equipment.
- ☐ Arrange for sampling and testing of materials and equipment suspected of containing regulated materials and ensure plans are updated accordingly.

  For LBP:
  - ☐ Segregate, if cost effective, LBP debris and LBP architectural components in the waste stream to reduce the amount of C&D waste classified as hazardous or requiring disposal in C&D landfills.
  - ☐ Use, if cost effective and not a violation of state regulations, Blastox or other LBP stabilizing products during abatement projects to render the waste non-hazardous.
  - ☐ Use, if cost effective and not otherwise affected by proposed LBP rule changes, demolition methods like grinding buildings for significantly reducing waste volumes.
- ☐ Notify the local pollution control agency of the project.
- ☐ Design the project to:
- ☐ Minimize the cost of handling and disposing of LBP debris or C&D waste containing regulated LBP.

- ☐ Remove all regulated material required to conduct the work.
- ☐ Cover compliance requirements in the specifications.
- ☐ Require a compliance plan for regulated material.
- ☐ Track compliance milestones for regulated material by inspection and periodic status meetings.

Also, project designers and waste managers should use the following best practices for achieving safe and economical hazardous waste management by contractors and in-house work forces:

- ☐ **Require waste minimization and prevention practices:**
  - ☐ Require aqueous cleaners instead of petroleum based solvents.
  - ☐ Require biodegradable cleaners instead of solvents to reduce the accumulation of waste solvent and containers and solvent-contaminated rags.
  - ☐ Require low or non-Volatile Organic Compounds (VOC) paints and coatings to reduce or eliminate VOC emissions.
  - ☐ Require water-based coatings to reduce or prevent the need for petroleum solvents and associated wastes.
  - ☐ Require low VOC water based epoxy concrete sealer to reduce VOC emissions.
- ☐ **Require reuse and recycling practices:**
  - ☐ Reuse thinner as a cleaner for painting equipment.
  - ☐ Supplement used solvents with new.
  - ☐ Recycle old and unused latex paint.
  - ☐ Use the installation Hazardous Material Pharmacy.
- ☐ **Require employee education practices:**
  - ☐ Combine waste management discussions with safety meetings.
  - ☐ Publicize waste management goals, plans, and spill prevention and counter measures.
  - ☐ Share and recognize successes with employees.

☐ **Planning Step 4 - Quantify and Characterize the Potential Annual C&D Waste Stream on the Installation**

Waste management teams must know in advance what the potential is for reducing and diverting C&D wastes because this information guides waste management planning. The team accomplishes this by measuring the C&D waste stream, identifying its components, and then matching the wastes to the reuse and recycling resources identified in Planning Step 1.

This step has been simplified by providing easy to calculate C&D waste worksheets for the following six categories of construction.

Residential	Non-residential
New Construction	New Construction
Renovation	Renovation
Demolition	Demolition

Each worksheet has three parts:

- Part 1 calculates the total tons of C&D waste for the specific project.
- Part 2 calculates the subtotal tons of C&D waste for the five primary construction materials: wood, drywall, metals, concrete, and plastics. When the C&D waste composition percentages are known for cardboard and other wastes, these may be also entered onto the worksheet for quantity calculations.
- Part 3 calculates the total tons of material diverted for the project and the C&D waste diversion rate.

The format within each part of all six worksheets is the same for clarity. Each part identifies the factors required for the calculations, the formulae, and the specific calculation. Typical examples of a

completed worksheet for each of the six construction categories are included at the end of this guide as foldouts.

All six worksheets may be downloaded and printed from the website for the expanded version of the C&D Guide for manual calcluations. However, these worksheets are designed for easy use in Excel, where the calucations are completed automatically for the user. For each construction category except residential renovation, users need only enter the square footage of the project, and the calculations for worksheet Parts 1 and 2 are completed automatically. For residential renovations, users need only enter the numbers of units (kitchens, bathrooms, and additions) for the project, and the calculations for Parts 1 and 2 are completed automatically. For Part 3 of all construction categories, users must identify and enter the estimated quantities of waste salvaged, reused, and recycled; and then the calculations for tons diverted and project C&D diversion rates are also completed automatically.

- **Planning Step 5 - Identify the Range of Contracting Options available to Implement C&D Waste Management Practices**

Building contractors are often used to execute construction and demolition projects. There are numerous contracting options available to ensure the efficient management of C&D wastes. Waste managers must contact the various contracting agencies involved, discuss the options, and select the contract vehicle best suited for this effort. The more common contracting options include:

Standard Contracts - These contracts are already in use and simply require the addition of specifications tailored to implement the C&D waste management strategy.

Standard Contracts with Bid Alternatives - These contracts have alternatives attached to the bidding process. For example, demolition project bidders may be asked to submit an alternate bid for deconstructing a building, or a construction project bidder may be asked to submit an alternate bid for reducing, reusing, and recycling just those C&D wastes for which markets exist.

Incentive Contracts - In its simplest form an incentive clause is added to a contract. For example, the contractor has a cost for traditional waste disposal but is encouraged to use diversion techniques. The contractor gets paid fully for the awarded disposal bid, but is allowed to profit from any cost reductions realized through C&D waste management.

Delivery-order Contracts - Many installations have access to delivery-order contracts where contractors respond to specific Statements of Work. Examples under this option include a delivery order for an entire deconstruction project, or one that might centralize an installation's entire C&D waste management program under one contractor.

☐ **Planning Step 6 - Develop a C&D Waste Management Strategy for Complying with AF Policy and Achieving the AF Measure of Merit (MoM)**

The waste management strategy for your installation should contain a minimum of four things:

1. The installation's annual C&D waste diversion goal.
2. The type of wastes targeted.
3. The waste generating categories covered.
4. The sustainable design and operating techniques used.

The installation's annual C&D waste diversion goal needs to support achievement of the AF MoM for solid waste diversion as outlined on page 2 and 3. An aggressive strategy might follow this course:

Fiscal Year	C&D Diversion %	Solid Waste Diversion %
2000	50%	20%
2001	55%	25%
2002	60%	30%
2003	65%	35%
2004	70%	40%
2005	75%	40%

Waste managers should include the types of waste found to be marketable from Planning Step 1. For example, the local and regional markets may only support the reuse and recycling of wood and concrete. Unless markets subsequently change, these should be the only wastes identified in the strategy.

The strategy should also include the types of installation work and projects to which the strategy will apply. The range of C&D waste generating categories includes:

- Renovation and demolition by installation in-house forces or contractors performing in-house work
  - Operations and Maintenance work
  - Self-Help Store projects
  - Military Family Housing U-Fix-It Stores
- New construction, renovation, and demolition by contractors not performing in-house work:
  - Military Construction and Family Housing projects
  - Army Air Force Exchange Service (AAFES) projects
  - Defense Commissary Agency (DeCA) projects
  - Medical and Tenant projects

- New construction, renovation, and demolition by other DOD forces
    - RED HORSE projects
    - Air National Guard and Air Force Reserve Center projects

Finally, the strategy should identify the sustainability techniques that will apply to work order and project design and operating procedures like ordering and shipping construction supplies. These techniques were outlined on pages 3-6.

Waste managers should update the strategy at least annually. They can use the strategy to test new reuse and recycling markets; expand the strategy to other waste generating categories; test the success of deconstruction versus standard demolition; and try innovative contracting options.

☐ Planning Step 7 - Develop Generic Waste Management Plans

The final step in planning for safe and effective C&D waste managements entails developing a framework for generic C&D waste management plans (WMPs). There should be a generic WMP for each of the C&D waste generating categories identified in the installation's C&D Waste Management Strategy. For example, if an installation has a multi-year program of new family housing construction and their strategy includes the reduction, reuse, salvage, and recycling of wood, metals, and concrete, then a generic WMP for these three materials should be developed for each housing project.

A WMP identifies all of the C&D diversion requirements for a specific project. The plan provides a clear picture of what is expected of the construction or demolition team. The content of a WMP includes the following five elements:

1. Analysis of the project waste.
2. A specific waste management goal.
3. Diversion methods.
4. Material handling procedures.
5. Education and promotion of the WMP.

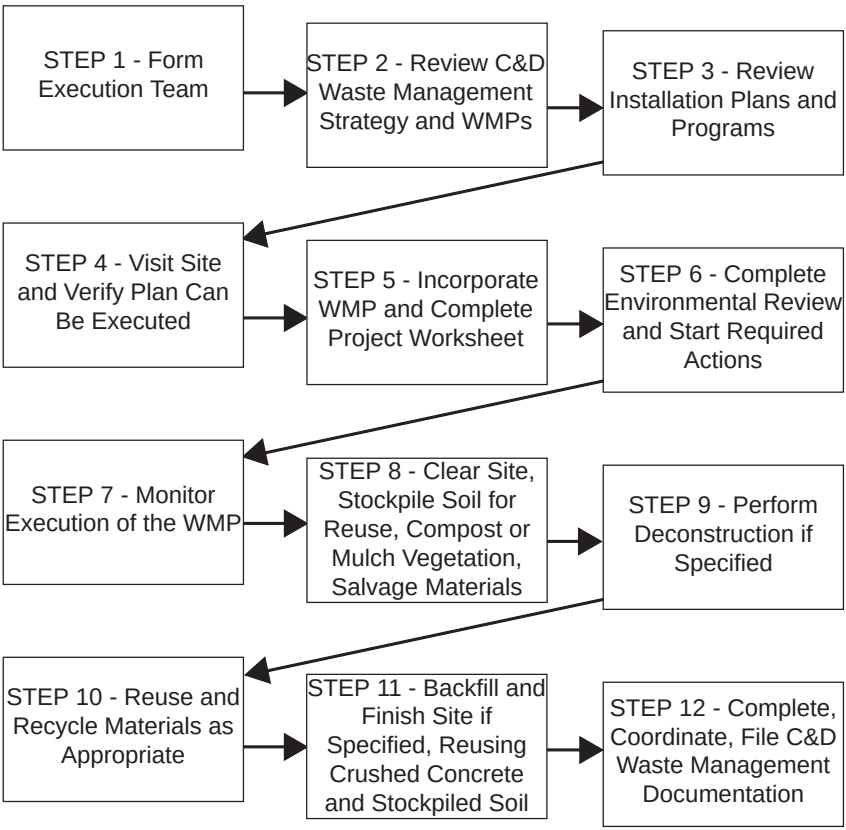
Waste Management Plans do not need to be complicated documents. By completing **Planning Steps 1**and **4**, waste managers can easily develop generic WMPs for the various C&D waste generation categories. These plans can stand alone for C&D projects accomplished by in-house workforces. They can also be provided as a resource to contractors and subcontractors who have been required by specifications to prepare draft and final WMPs. A sample WMP is provided in Appendix I of the expanded version of the C&D Guide.

Implementing the C&D Waste Management Process

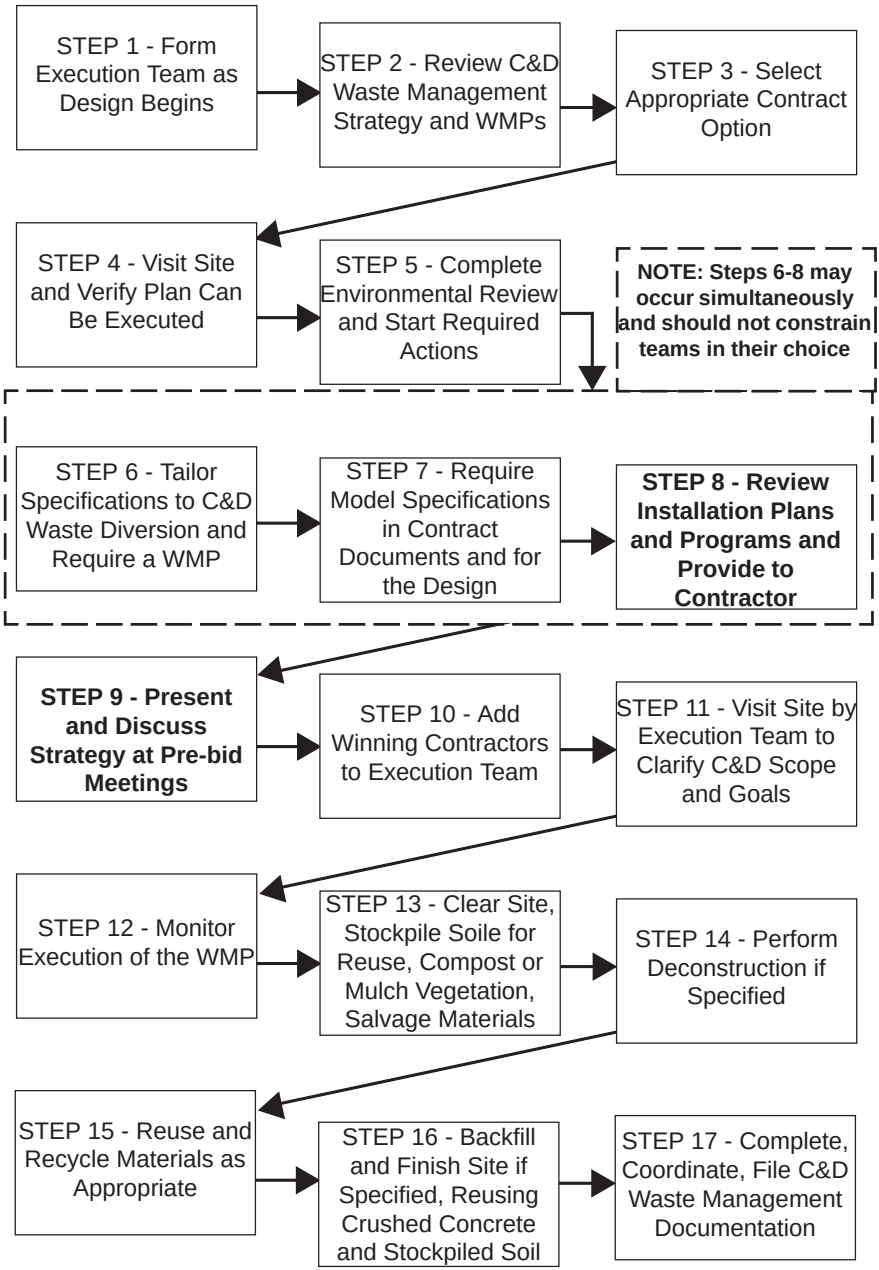
The expanded version of the C&D Guide describes and prescribes in Chapter 4 the step-by-step waste management process for incorporating, executing, monitoring and documenting the diversion of installation C&D waste.

Process flow diagrams for in-house and contract work and projects are provided here for a quick reference.

Process for In-house Work and Projects



Process for Contract Work and Projects



Summary

The safe and economic management of C&D waste has been an unrealized opportunity for many years. Despite the common sense value in diverting C&D waste, the barriers to implementing waste management techniques have been a convenient excuse to continuing the traditional practices of burning and landfilling.

The Air Force policy letter and MoM require at least a 40% diversion rate for non-hazardous solid waste by 2005 and provide renewed focus on your waste management efforts. The policy and MoM create new motivation, but they are insufficient alone to achieve the AF goals and comply with its waste management policy. Some practical “how to” guidance is also required.

The expanded version of the “C&D Waste Management Guide” was written to provide the missing guidance. The Guide is a “how to” document intended to satisfy four goals in supporting solid waste diversion. First, it explains how C&D waste management can lower disposal cost. Second, it shows design and construction project managers and other waste management team members how to manage C&D waste. Third, it identifies and explains how to comply with environmental concerns when managing C&D waste. And fourth, it identifies and provides C&D waste management tools that installation managers will need to be successful.

This Pocket Guide compliments the expanded version of the C&D Guide and provides waste managers with a convenient quick reference document for use on the job and in the field. Together the two documents provide you with what you need to act immediately on implementing your installation’s C&D waste management program.

Installation Steering Group For C&D Waste Management

Position Title	Name	Phone Number
Commander, Civil Engineer		210-256-9718
Chief, Environmental Flt/Sq		
Chief, Engineering Flt/Sq		
Chief, Operations Flt/Sq		
Commander, Contracting		
Commander, Supply		
Bioenvironmental Engineer		
Environmental Lawyer		

C&D Waste Management Execution Team

Position Title	Name	Phone Number
Installation Waste Manager		
Project Manager		
Project Designer		
Project Inspector		
Contracting Representative		
Customer Representative		
Contractor Representative		
Bioengineering Representative		
Environmental Compliance		
DRMO Representative		
Local, Region, State C&D Representative		
Local, Region, State Recycling Representative		

C&D Waste Worksheet 1

New Residential Construction

Project Title: 200 Enlisted Single Family Houses (950 SF/Unit) **Project Cost:** $ 10.83 M

Part 1 - Quantity of C&D Waste

Factors
A=Project Square Footage
G_{ave}=Weighted Average Generation Rate (Refer to Table 9)
Q_p = Total Project C&D Waste
0.0005 = Conversion Factor from lbs to tons

Formula: A x G_{ave} x 0.0005 = Q_p

Calculation: Q_p = 190,000 (sf) x 4.38 (lb/sf) x 0.0005 (tons/lb) = 416.1 (tons)

Part 2 - Quantity Characterization of C&D Waste

Factors
P_χ = Rounded Average Composition of Waste χ (%) (Refer to Table 12)
Q_p = Total Project C&D Waste (tons)
Q_χ = Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_p$

Calculation:

Q_{Wood}	=	53%	x	416.1	=	220.53 tons
$Q_{Drywall}$	=	19%	x	416.1	=	79.06 tons
Q_{Metals}	=	2%	x	416.1	=	8.32 tons
$Q_{Concrete}$	=	9%	x	416.1	=	37.45 tons
$Q_{Cardboard}$ (insert %)	=		x	416.1	=	0.00 tons
$Q_{Plastics}$	=	2%	x	416.1	=	8.32 tons
Q_{Others} (insert %)				416.1	=	0.00 tons
	=		x	416.1	=	0.00 tons
	=		x	416.1	=	0.00 tons

C&D Waste Worksheet 1

New Residential Construction

Project Title: 200 Enlisted Single Family Houses (950 SF/Unit) **Project Cost:** $ 10.83 M

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)
$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)
$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)
Q_p = Total Project C&D Waste (tons)
D_p = Project C&D Waste Diversion Rate (%)
ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

Calculation:

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=		+	50	+	100	=	150.00 tons
$Q_{Drywall}$	=		+		+	60	=	60.00 tons
Q_{Metals}	=		+		+	8	=	8.00 tons
$Q_{Concrete}$	=		+	30	+		=	30.00 tons
$Q_{cardboard}$	=		+		+		=	0.00 tons
$Q_{Plastics}$	=		+		+	5	=	5.00 tons
Q_{others}								
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
	ΣQ_χ	0 (Salvaged)	+	80 (Reused)	+	173 (Recycled)		253.00 tons

Total Quantity of Material Diverted = ***253.00 tons***

C&D Waste Diversion Rate = 60.80% **%**

C&D Waste Worksheet 2

New Non-residential Construction

Project Title: Construct Administration Squadron Facility **Project Cost:** $ 1.3 M

Part 1 - Quantity of C&D Waste

Factors
A=Project Square Footage
G_{ave}=Weighted Average Generation Rate (Refer to Table 9)
Q_p = Total Project C&D Waste
0.0005 = Conversion Factor from lbs to tons

Formula: A x G_{ave} x 0.0005 = Q_p

Calculation: Q_p = 10,000 (sf) x 3.89 (lb/sf) x 0.0005 (tons/lb) = 19.45 (tons)

Part 2 - Quantity Characterization of C&D Waste

Factors
P_χ = Rounded Average Composition of Waste χ (%) (Refer to Table 12)
Q_p = Total Project C&D Waste (tons)
Q_χ = Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_p$

Q_{Wood}	=	31%	x	19.45	=	6.03 tons
$Q_{Drywall}$	=	23%	x	19.45	=	4.47 tons
Q_{Metals}	=	10%	x	19.45	=	1.95 tons
$Q_{Concrete}$	=	33%	x	19.45	=	6.42 tons
$Q_{Cardboard}$ (insert %)	=		x	19.45	=	0.00 tons
$Q_{Plastics}$	=	3%	x	19.45	=	0.58 tons
Q_{Others} (insert %)				19.45	=	0.00 tons
	=		x	19.45	=	0.00 tons
	=		x	19.45	=	0.00 tons

C&D Waste Worksheet 2

New Non-residential Construction

Project Title: Construct Administration Squadron Facility **Project Cost:** $ 1.3 M

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)

$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)

$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)

Q_p = Total Project C&D Waste (tons)

D_p = Project C&D Waste Diversion Rate (%)

ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=		+	1	+	3	=	4.00 tons
$Q_{Drywall}$	=		+		+	2.25	=	2.25 tons
Q_{Metals}	=		+		+	1.95	=	1.95 tons
$Q_{Concrete}$	=		+		+	2	=	2.00 tons
$Q_{Cardboard}$	=		+		+		=	0.00 tons
$Q_{Plastics}$	=		+		+	0.5	=	0.50 tons
Q_{Others}								
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
ΣQ_χ	=	0 (Salvaged)	+	1 (Reused)	+	9.7 (Recycled)		10.70 tons

Total Quantity of Material Diverted = ***10.70 tons***

C&D Waste Diversion Rate = 55.01% **%**

C&D Waste Worksheet 3

Residential Renovation

Project Title: Upgrade to 100 Military Family Housing units **Project Cost:** $975k

Part 1 - Quantity and Characterization of C&D Waste

a) **Quantity Calculations for Typical Scopes (Kitchen, Bathrooms, Additions)**

Factors

N_χ = Number of Units for Type χ Renovation

$G_{ave\chi}$ = Average Generation Rate for Type χ Renovation (tons/unit) (Refer to Table 10)

Q_{pa}=Total Project C&D Waste for Typical Scopes

Kitchen

N_k=Number of Units for Kitchen Renovation = 100

G_k=Ave Generation Rate for Kitchen Renovations = 4.5 tons/unit (Refer to Table 10)

Bathrooms

N_b=Number of Units for Bathroom Renovation = 200

G_b=Ave Generation Rate for type Bathroom Renovations = 1 tons/unit (Refer to Table 10)

Additions

N_a=Number of Units for Additions =

G_a=Ave Generation Rate for Additions = tons/unit (Refer to Table 10)

Formula: $Q_{pa}=\Sigma(N_\chi \times G_{ave\chi})$

Calculation							
	Kitchen	100	x	4.50	=	450.00	
	Bathrooms	200	x	1.00	=	200.00	
	Additions	0	x	0.00	=	0.00	
						650.00	(tons)

b) **Quantity Characterization of C&D Waste for Typical Scopes (kitchen, bathrooms, additions**

Factors

P_χ=Rounded Average Composition of Waste χ (%) (Refer to Table 12)

Q_{pa}=Total Project C&D Waste for Typical Scopes (tons)

Q_χ=Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_{pa}$

Calculation

Q_{Wood}	=	37%	x	650	=	240.50	tons
$Q_{Drywall}$	=	31%	x	650	=	201.50	tons
Q_{Metals}	=	3%	x	650	=	19.50	tons
$Q_{Concrete}$	=	5%	x	650	=	32.50	tons
$Q_{Cardboard}$ (insert %)	=		x	650	=	0.00	tons
$Q_{Plastics}$	=	1%	x	650	=	6.50	tons
Q_{Others} (insert %)				650	=	0.00	tons
	=		x	650	=	0.00	tons
	=		x	650	=	0.00	tons
	=		x	650	=	0.00	tons
	=		x	650	=	0.00	tons

C&D Waste Worksheet 3

Residential Renovation

Project Title: Upgrade to 100 Military Family Housing units **Project Cost:** $975k

Part 2 - Quantity and Characterization of C&D Waste for Additional Scopes (Driveway, Roof and HVAC Equipment Replacements)

Factors

N_χ = Number of Units for Type χ Renovation

$G_{ave\chi}$ = Average Generation Rate for Type χ Renovation (tons/unit) (Refer to Table 11)

Q_{pa}=Total Project C&D Waste for Typical Scopes

Q_{pb} = Total Quantity of Waste from Additional Scopes (tons)

Q_p = Total Quantity of Project C&D Waste (tons)

Q_χ = Quantity of Waste χ (tons)

Driveway

N_d=Number of Units for Driveway Renovation =

G_d=Ave Generation Rate for Driveway Renovations = tons/unit (Refer to Table 11)

Roof - Wood

N_{rw}=Number of Units for Wood Roof Renovation =

G_{rw}=Ave Generation Rate for Wood Roof Renovations = tons/unit (Refer to Table 11)

Roof - Asphalt

N_{ra}=Number of Units for Asphalt Roof Renovation = 100

G_{ra}=Ave Generation Rate for Asphalt Roof Renovations = 1.68 tons/unit (Refer to Table 11)

HVAC Equipment Replacements

N_h=Number of Units for HVAC Equipment Replacement =

G_h=Ave Generation Rate for HVAC Equipment Replacement = tons/unit (Refer to Table 11)

Formula: $Q_\chi = (N_\chi \times G_{ave\chi})$

$Q_{pb} = \Sigma(N_\chi \times G_{ave\chi}) = \Sigma Q_\chi$

$Q_p = Q_{pa} + Q_{pb}$

				tons/unit		
$Q_{Concreteb}$	= 0	x	8.91	=	0.00	tons
$Q_{Wood\ Roofing}$	= 0	x	1.68	=	0.00	tons
$Q_{Asphalt\ Roofing}$	= 100	x	1.38	=	138.00	tons
$Q_{HVAC\ Equipment}$ (from Table 11)	= 0	x		=	0.00	tons
			$Q_{pb} = \Sigma Q_\chi$	=	138.00	tons

Qp = 650.000 + 138.000 = 788.00 tons

C&D Waste Worksheet 3

Residential Renovation

Project Title: Upgrade to 100 Military Family Housing units **Project Cost:** $975k

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)
$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)
$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)
Q_p = Total Project C&D Waste (tons)
D_p = Project C&D Waste Diversion Rate (%)
ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

Calculation

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=		+		+	100	=	100.00 tons
$Q_{Drywall}$	=		+		+	50	=	50.00 tons
Q_{Metals}	=	15	+		+		=	15.00 tons
$Q_{Concretea}$	=		+		+		=	0.00 tons
$Q_{Concreteb}$	=							0.00 tons
$Q_{Cardboard}$	=		+		+		=	0.00 tons
$Q_{Plastic}$	=		+		+		=	0.00 tons
$Q_{Asphalt\ Roofing}$	=	100	+		+	25	=	125.00 tons
$Q_{Wood\ Roofing}$	=		+		+		=	0.00 tons
$Q_{HVAC\ Equipment}$	=		+		+		=	0.00 tons
Q_{Other}	=							
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
ΣQ_χ		115 (Salvaged)		0 (Reused)		175 (Recycled)		290.00 tons

Total Quantity of Material Diverted = ***290.00 tons***

Project C&D Waste Diversion Rate = 44.62% **%**

C&D Waste Worksheet 4

Non-residential Renovation

Project Title: Alter Headquarters Office Building **Project Cost:** $ 1.9 M

Part 1 - Quantity of C&D Waste

Factors
A = Project Square Footage
G_{ave} = Weighted Average Generation Rate (lb/sf) (Refer to Table 9)
Q_p = Total Project C&D Waste (tons)
0.0005 = Conversion Factor from lbs to tons

Formula: $A \times G_{ave} \times 0.0005 = Q_p$

Calculation: Q_p = 25,000 (sf) x 17.67 (lb/sf) x 0.0005 (tons/lb) = 220.88 (tons)

Part 2 - Quantity Characterization of C&D Waste

Factors
P_χ = Rounded Average Composition of Waste χ (%) (Refer to Table 12)
Q_p = Total Project C&D Waste (tons)
Q_χ = Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_p$

Q_{Wood}	=	28%	x	220.875	=	61.85	tons
$Q_{Drywall}$	=	22%	x	220.875	=	48.59	tons
Q_{Metals}	=	19%	x	220.875	=	41.97	tons
$Q_{Concrete}$	=	22%	x	220.875	=	48.59	tons
$Q_{Cardboard}$ (insert %)	=	6%	x	220.875	=	13.25	tons
$Q_{Plastics}$	=	3%	x	220.875	=	6.63	tons
Q_{Others} (insert %)				220.875	=	0.00	tons
	=		x	220.875	=	0.00	tons
	=		x	220.875	=	0.00	tons

C&D Waste Worksheet 4

Non-residential Renovation

Project Title: Alter Headquarters Office Building **Project Cost:** $ 1.9 M

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)

$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)

$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)

Q_p = Total Project C&D Waste (tons)

D_p = Project C&D Waste Diversion Rate (%)

ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=	10	+	5.5	+	13.75	=	29.25 tons
$Q_{Drywall}$	=		+		+	20	=	20.00 tons
Q_{Metals}	=	17	+		+	11	=	28.00 tons
$Q_{Concrete}$	=		+		+		=	0.00 tons
$Q_{Cardboard}$	=		+		+	13.25	=	13.25 tons
$Q_{Plastics}$	=		+		+		=	0.00 tons
Q_{Others}								
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
ΣQ_χ	=	27	+	5.5	+	58		90.50 tons
		(Salvaged)		(Reused)		(Recycled)		

Total Quantity of Material Diverted = ***90.50 tons***

C&D Waste Diversion Rate = 40.97% **%**

C&D Waste Worksheet 5

Residential Demolition

Project Title: Demolish 180 Military Family Housing Units (1000SF/Unit) **Project Cost:** $ 2.7 M

Part 1 - Quantity of C&D Waste

Factors
A = Project Square Footage
G_{ave} = Weighted Average Generation Rate (lb/sf) (Refer to Table 9)
Q_p = Total Project C&D Waste (tons)
0.0005 = Conversion Factor from lbs to tons

Formula: $A \times G_{ave} \times 0.0005 = Q_p$

Calculation: Q_p = 180,000 (sf) x 115 (lb/sf) x 0.0005 (tons/lb) = 10350 (tons)

Part 2 - Quantity Characterization of C&D Waste

Factors
P_χ = Rounded Average Composition of Waste χ (%) (Refer to Table 12)
Q_p = Total Project C&D Waste (tons)
Q_χ = Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_p$

Q_{Wood}	=	33%	x	10350	=	3415.50	tons
$Q_{Drywall}$	=	10%	x	10350	=	1035.00	tons
Q_{Metals}	=	4%	x	10350	=	414.00	tons
$Q_{Concrete}$	=	27%	x	10350	=	2794.50	tons
$Q_{Cardboard}$ (insert %)	=		x	10350	=	0.00	tons
$Q_{Plastics}$	=	1%	x	10350	=	103.50	tons
Q_{Others} (insert %)				10350	=	0.00	tons
Bricks	=	15%	x	10350	=	1552.50	tons
	=		x	10350	=	0.00	tons

C&D Waste Worksheet 5

Residential Demolition

Project Title: Demolish 180 Military Family Housing Units (1000SF/Unit) **Project Cost:** $ 2.7 M

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)
$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)
$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)
Q_p = Total Project C&D Waste (tons)
D_p = Project C&D Waste Diversion Rate (%)
ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=	475	+		+	1000	=	1475.00 tons
$Q_{Drywall}$	=		+		+	50	=	50.00 tons
Q_{Metals}	=	300	+		+	50	=	350.00 tons
$Q_{Concrete}$	=		+	500	+	1525	=	2025.00 tons
$Q_{Cardboard}$	=		+		+		=	0.00 tons
$Q_{Plastics}$	=		+		+	15	=	15.00 tons
Q_{Others}								
Bricks	=	750	+	750	+		=	1500.00 tons
	=		+		+		=	0.00 tons
ΣQ_χ	=	1525 (Salvaged)	+	1250 (Reused)	+	2640 (Recycled)		5415.00 tons

Total Quantity of Material Diverted = ***5415.00 tons***

C&D Waste Diversion Rate = 52.32% **%**

C&D Waste Worksheet 6

Non-residential Demolition

Project Title: Demolish Supply Warehouse **Project Cost:** $1.9 M

Part 1 - Quantity of C&D Waste

Factors
A = Project Square Footage
G_{ave} = Weighted Average Generation Rate (lb/sf) (Table 9)
Q_p = Total Project C&D Waste (tons)
0.0005 = Conversion Factor from lbs to tons

Formula: $A \times G_{ave} \times 0.0005 = Q_p$

Calculation: Q_p = 90,000 (sf) x 155 (lb/sf) x 0.0005 (tons/lb) = 6975 (tons)

Part 2 - Quantity Characterization of C&D Waste

Factors
P_χ = Rounded Average Composition of Waste χ (%) (Refer to Table 12)
Q_p = Total Project C&D Waste (tons)
Q_χ = Quantity of C&D Waste χ (tons)

Formula: $Q_\chi = P_\chi \times Q_p$

Q_{Wood}	=	21%	x	6975	=	1464.75	tons
$Q_{Drywall}$	=	10%	x	6975	=	697.50	tons
Q_{Metals}	=	7%	x	6975	=	488.25	tons
$Q_{Concrete}$	=	53%	x	6975	=	3696.75	tons
$Q_{Cardboard}$ (insert %)	=		x	6975	=	0.00	tons
$Q_{Plastics}$	=	3%	x	6975	=	209.25	tons
Q_{Others} (insert %)				6975	=	0.00	tons
	=		x	6975	=	0.00	tons
	=		x	6975	=	0.00	tons

C&D Waste Worksheet 6

Non-residential Demolition

Project Title: Demolish Supply Warehouse **Project Cost:** $1.9 M

Part 3 - Project Diversion Rate

Factors

$Q_{sal\chi}$ = Quantity of Waste χ Salvaged (tons)

$Q_{reu\chi}$ = Quantity of Waste χ Reused (tons)

$Q_{rcy\chi}$ = Quantity of Waste χ Recycled (tons)

Q_p = Total Project C&D Waste (tons)

D_p = Project C&D Waste Diversion Rate (%)

ΣQ_χ = Total Quantity of Material Diverted (tons)

Formula: $D_p = (\Sigma Q_{sal\chi} + \Sigma Q_{reu\chi} + \Sigma Q_{rcy\chi}) \div Q_p$

		SALVAGE	+	REUSE	+	RECYCLE	=	
Q_{Wood}	=	250	+		+	740	=	990.00 tons
$Q_{Drywall}$	=		+		+		=	0.00 tons
Q_{Metals}	=	375	+		+	105	=	480.00 tons
$Q_{Concrete}$	=		+		+		=	0.00 tons
$Q_{Cardboard}$	=		+		+		=	0.00 tons
$Q_{Plastics}$	=		+		+		=	0.00 tons
Q_{Others}								
	=		+		+		=	0.00 tons
	=		+		+		=	0.00 tons
ΣQ_χ	=	625 (Salvaged)	+	0 (Reused)	+	845 (Recycled)		1470.00 tons

Total Quantity of Material Diverted = ***1470.00 tons***

C&D Waste Diversion Rate = 21.08% **%**