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Source Reduction and Resource Resilience (SR3)

Dining Facility Whole-Building Evaluation to Reduce Solid Waste

Opportunities and Best Practices for Optimization and Management of Food Waste

Angela B. Urban, Susannah C. Davidson, and
Allison R. Young

September 2023



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Dining Facility Whole-Building Evaluation to Reduce Solid Waste

Opportunities and Best Practices for Optimization and Management of Food Waste

Angela B. Urban, Susannah C. Davidson, and Allison R. Young

*US Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
2902 Newmark Drive
Champaign, IL 61824*

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Abstract

On military installations, an average of 1.2 pounds in food waste is disposed per person per day, accounting for 68% of dining facility (DFAC) refuse and 46% of the total installation refuse stream, making food waste the heaviest portion of installation solid waste. At a single installation, this can contribute up to 1.5 million dollars lost yearly from food waste alone. Department of Defense Instruction (DoDI) 4715.23 (DoD 2016) establishes policy and prescribes procedures to implement waste management through waste prevention and recycling. The US Army Installation Management Commands (IMCOM) installations have limited resources and limited personnel to study which source reduction methods are optimal to reduce food waste given their unique mission requirements. This study identifies opportunities for optimization and management of solid waste across IMCOM installations. Recycling is not enough to significantly reduce the economic or environmental costs to the DoD. Army installations pay over \$100 million annually in disposal fees. Source reduction is emphasized in regulations but not prioritized in process modifications or technology solutions. Additionally, food waste contributes to excessive global greenhouse gas emissions, which affect global warming and climate change. A multitiered approach is necessary, placing more emphasis on source reduction advances and initiatives.

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Preface

This study was conducted for the US Army Installation Management Command (IMCOM) under MIPR 11250931, “Dining Facility Whole-Building Evaluation to Reduce Solid Waste.” The technical monitor was Dr. S. Lynn Odom, IMCOM.

The work was performed by the Environmental Processes Branch of the Installations Division, US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Mr. Charles Schroeder was chief, Installation Readiness Branch; Mr. Tim Shelton was chief, Infrastructure Science and Engineering Division; and Dr. Justin Berman was the technical director for Infrastructure Science and Engineering, Office of Technical Directors. The deputy director of ERDC-CERL was Ms. Michelle Hanson, and the director was Dr. Andrew Nelson.

COL Christian Patterson was the commander of ERDC and the director was Dr. David W. Pittman.

1 Introduction

1.1 Background

On military installations, an average of 1.2 lb¹ in food waste is disposed per person per day, accounting for 46% of the total installation waste stream.² At a single installation, this can contribute up to 1.5 million dollars lost on a yearly basis from food waste alone through excess purchasing, labor costs to handle the food, and disposal costs. Researchers at the Construction Engineering Research Laboratory (CERL) have conducted solid waste characterizations at numerous military installations over the past 6 years, and dining facilities (DFACs) are consistently the top solid waste generator on a given installation with an average of 1,500 lb of food discarded per day.³ This is largely a combination of uneaten or partially eaten, postconsumer food. The excess cost to dispose of heavy, wet food waste is placing an excessive burden on military operations both at installations across the world.

Recycling is not enough to significantly reduce the economic or environmental costs to the DoD. Army installations pay over \$100 million annually in disposal fees, according to required solid waste data reports from installations (Office of Deputy Chief of Staff, G-9 2021). Source reduction is emphasized in regulations but not prioritized in process modifications or technology solutions. Additionally, food waste contributes to excessive global greenhouse gas (GHG) emissions, which effect global warming and climate change. A multitiered approach is necessary, placing more emphasis on source reduction advances and initiatives.

DoD Instruction (DoDI) 4715.23 (DoD 2016) establishes policy, assigns responsibility, and prescribes procedures to implement waste management through waste prevention and recycling. Executive Order (EO) Number 13834 (2018) mandated that federal facilities must optimize energy and environmental performance, reduce waste, and cut costs. While EO 13834

1. For a full list of the spelled-out forms of the units of measure used in this document, please refer to U.S. Government Publishing Office Style Manual, 31st ed. (Washington, DC: U.S. Government Publishing Office, 2016), 248–252, <https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

2. CERL (Construction Engineering Research Laboratory), “Modified Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste between 2014 and 2020,” unpublished Controlled Unclassified Information (CUI) data (Champaign, IL: CERL, 2020).

3. CERL, unpublished CUI data.

(2018) and the proceeding implementation instructions directed installations to continue to reduce the burden of operations and maintenance costs associated with disposal of solid waste, the required metrics of diversion of solid waste were no longer defined. Recently enacted EO 13990 (2021) revoked parts of EO 13834 (2018), stating that “it is essential that agencies capture the full costs of greenhouse gas emissions as accurately as possible, including by taking global damages into account.” In 2020, a memorandum from the Office of the Assistant Secretary of Defense (OASD) was released, providing a revision to the DoD Integrated Solid Waste Management (ISWM) metrics. This was a necessary step to demonstrate the DoD’s commitment to ISWM by instructing installations to effectively manage, reduce, divert, and dispose of solid waste while maintaining compliance with federal requirements. The revision also established targeted diversion goals with the intent to produce a shared understanding of diversion requirements.

These policies direct installations to emphasize source reduction, but solid waste management success is typically defined as high diversion and diversion rates are not meeting federal or DoD goals. Diversion refers to the waste generated that is kept out of landfills and incineration. Diversion techniques include recycling, reuse, and composting. Source reduction, reducing the generation of waste, is encouraged highly, but not captured in diversion data. Installations have struggled to meet diversion goals as standard diversion methods such as recycling have been insufficient to meet those goals. Construction and demolition waste diversion rates decreased from 51% in 2015 to 46% in 2019, and approximately 52 of 125 (41.6%) of Installation Management Command (IMCOM) installations failed to meet the 40% solid waste diversion requirement as outlined in the OASD memorandum (Office of Deputy Chief of Staff, G-9, 2021). Food waste is the heaviest component of solid waste generated at IMCOM installations and installations pay for disposal by weight. Garrisons have limited resources and limited personnel to study which source reduction methods are optimal with their unique mission requirements to reduce food waste. By optimizing DFAC operations and reducing food waste, a significant portion of solid waste can be reduced and diverted from the landfill, ultimately paving a path towards reduced operations and maintenance (O&M) costs for military installations.

1.2 Objectives

The objective of this study is to identify opportunities for optimization and management of solid waste, particularly food waste across IMCOM installations within the United States. The focus is on source reduction opportunities to improve waste management practices and to reduce food waste in DFACs in accordance with new policy and guidelines. This study compares waste generation trends and characteristics between installations in different geographical regions and with different mission types, provides recommendations for optimization of both preconsumer and postconsumer waste, and identifies new technologies.

1.3 Approach

This report aims to consider a comprehensive approach to preconsumer and postconsumer waste reduction at DFACs including interior design layout; meal planning, sourcing, and preparation; graphic design and signage usage; waste minimization technology placement; service ware options; and food donation assistance.

1.4 COVID-19 impacts

Executing field research across military installations in the United States during the COVID-19 pandemic posed tremendous challenges that significantly altered the approach to the study. Field research was planned to take place between February and May 2020; but due to the DoD travel ban in March 2020, fewer installations were able to be evaluated in-person as originally intended (Deputy Secretary of Defense, 2020). In fact, the research team was enroute to Fort Liberty to conduct the next field visit when they were immediately turned around because of the stop-movement order. In addition, a mandatory work-from-home requirement enacted across the laboratory (as well as at other DoD facilities) resulted in significant alterations adopted to conclude the study within the time specified by the sponsor. From April 2020 to August 2020, the sponsor directed that the research team pause until an extension could be granted and travel could resume. Consequently, the impact on data collection included adjusting analysis of representative installations and utilizing historical data from previous installation assessments to conclude the study (Table 1).

Table 1. Impacts of COVID-19 on project execution schedule.

Task	1Q-19	2Q-19	3Q-19	4Q-19	1Q-20	2Q-20	3Q-20	4Q-20	1Q-21	2Q-21
Funds Acceptance	—	—	—	—	—	—	—	—	—	—
Initial Site Visit	—	—	—	—	—	—	—	—	—	—
Kick-off Meeting w/ Stakeholders	—	—	—	—	—	—	—	—	—	—
Literature Review	—	—	—	—	—	—	—	—	—	—
Sites and Sampling Methodology Approved	—	—	—	—	—	—	—	—	—	—
Field Survey (and acquire data) from Selected Installations	—	—	—	—	>	>	—	—	>	>
Analysis of Selected Data	—	—	—	—	—	>	x	—	>	>
Technical Report	—	—	—	—	—	—	x	x	>	>
x	Activity Canceled		>		Activity Delayed/Modified Relative to Plan					
—	Sponsor-Directed Pause and 6-month Extension Granted									

2 Literature Review

The CERL research team conducted a literature review of relevant documentation to DFAC operations and solid waste diversion.

2.1 Army Regulation (AR) 30-22, Army Food Program

According to Army Regulation (AR) 30-22 (2019), Army Food Program, one objective of the Army Food Program is to, “implement the Army’s food service strategy to

1. Improve soldier’s readiness.
2. Improve health, weight, and physical fitness test scores.
3. Improve soldiers’ cognitive and physical performance.
4. Increase utilization of Army DFACs, satisfaction surveys, reduce total cost, decrease waste, and increase convenience.
5. Optimize DFACs to the right size and location.
6. Improve inventory and headcount management, auditability, ease of use, and increase efficiencies.”

This document further explains responsibilities and requirements for dining facility operations, which include nutritional standards and menu planning; special situations, including contracting food service functions; special programs, such as culinary arts training and energy, water and waste management; food service management boards; Army field feeding; and subsistence supply management offices and branches.

Requirements outlined in this document for energy, water and waste management related to DFACs include following AR 420-1 (2012), the guiding Army Regulation for facility management, and guidance that “each FPM [Food Program manager] will ensure that each DFAC and food service-related activity monitors the use of energy and water, the generation of solid waste, and recycling rates in accordance with the program directed by the Installation Commander.”

2.2 Department of the Army Pamphlet 30-22, Operating Procedures for the Army Food Program (HQDA 2019)

Department of the Army Pamphlet 30-22 (2019) outlines operating procedures for the Army Food Program, as opposed to AR 30-22 in section 2.1, which frames the guiding policies. It explains responsibilities, how to

establish, manage, and disestablish DFACs, discusses the Army field feeding system, and troop issue subsistence activity operations. Section II: DFAC Operation, 3-41 reviews à la carte operations (Department of the Army (HQDA) 2019). This à la carte option is supposed to provide time and menu flexibility, as well as cost savings. One of the listed benefits of this system is decreased food waste, since diners are paying for each item individually and therefore are more willing to only take what they will eat (and keep portion control in check), and menus are designed around the diners' wants (progressive cooking).

Per Chapter 3, Section II, 3-41, *h*, (1) of Army Pamphlet 30-22, "Progressive cooking improves the quality of food and helps prevent excessive waste. Food must be merchandised, and leftovers kept to a minimum. Progressive cooking ensures that food items displayed at the end of the meal are of the same quality and appearance as at the beginning of the meal. Plan food production using historical data on customer preferences and flow pattern," (Department of the Army [HQDA] 2019).

2.3 Army Policy Memo on Army Food Donation Procedures (2014)

This memorandum (Department of the Army [HQDA] 2014) encourages the voluntary donation of excess food to nonprofit organizations. The memo notes that food donation serves as sustenance to needy populations while also furthering solid waste diversion goals. Excess food is defined as food that is not required to meet Army needs and would otherwise be discarded. Excess food includes prepared foods, packaged, unopened foods nearing their sell by date, or packaged, unopened components of operational rations or field kitchens. Receiving organizations must be 501(c) nonprofits that distribute food for free to needy populations. Army food service facilities that are donating food should set up a memorandum of agreement (MOA) with the receiving organization. They also must establish procedures for excess food handling, storage, and transfer, which must be documented in the MOA. Army installations are encouraged to donate food from DFACs, field rations, Morale, Welfare, and Recreation (MWR) operations, and tenant organizations such as Defense Commissary Agency and Army and Air Force Exchange Services (AAFES). The FPM is the main person in charge of food donation operations.

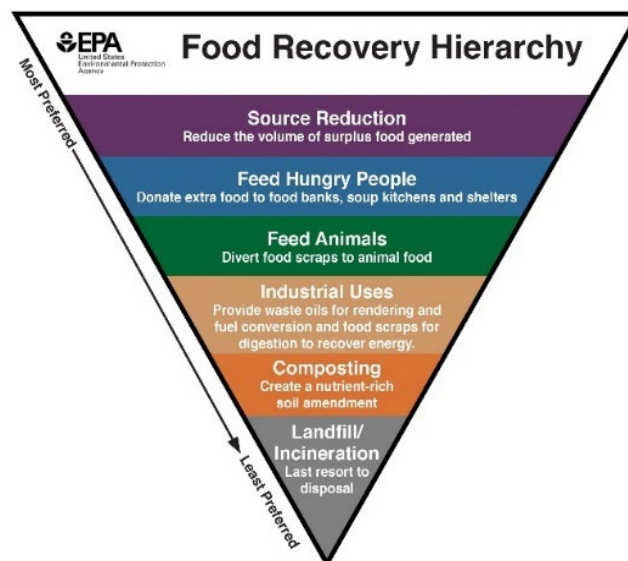
The memo suggests the following procedure for starting a food donation program. First, a survey of food service operations should be conducted to determine the types, quantities, and time frames of excess food

generation. Once it is determined that there is excess food to donate, coordination should take place with relevant internal organizations such as Directorate of Public Works (DPW), Veterinary Services (VS) and Preventative Medicine. Each organizations' role should be determined. Procedures to ensure food safety should be included. Eligible donor organizations should be contacted to find a best fit. Procedures between the donor and receiving organization should be written out in the MOA. Record keeping procedures, procedures for emergencies and nonadherence to the MOA, and staff education should be considered and planned for. Operations should be reviewed on a regular basis.

2.4 Office of the Assistant Secretary of Defense Memorandum on DoD Integrated Solid Waste Management Metrics (2020)

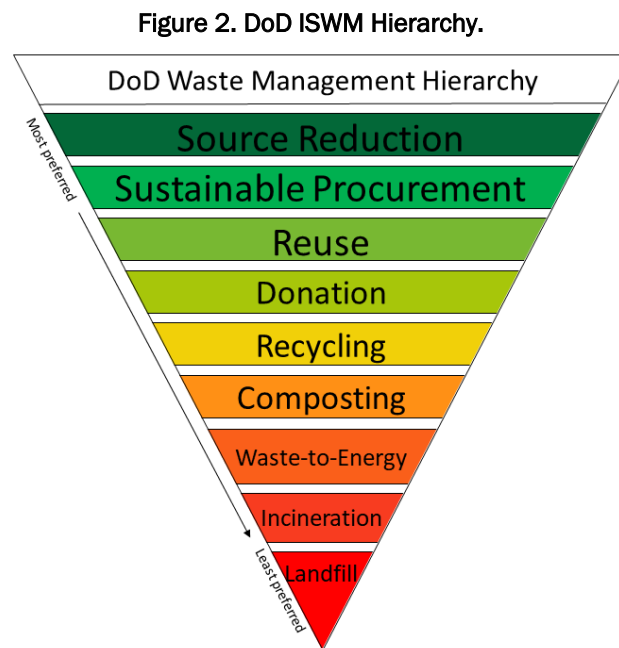
This memorandum (Office of the Assistant Secretary of Defense 2020) defines the DoD ISWM Hierarchy and the goals for solid waste diversion. In 2015, the Environmental Protection Agency (EPA) and the United States Department of Agriculture announced a goal to reduce domestic food waste by 50%, in alignment with Target 12.3 of the UN Sustainable Development Goals. As part of the program encouraging the sustainable management of food, the EPA designed the Food Recovery Hierarchy, (Figure 1). The Hierarchy organizes food waste disposal methods from most preferred to least preferred. The most preferred method is source reduction, followed by feeding hungry people, and feeding livestock. The least preferred methods are industrial uses, composting, and landfill, or incineration.

Figure 1. EPA Food Recovery Hierarchy (EPA 2022, public domain).



The DoD ISWM Hierarchy as defined in the OASD Memorandum also calls for source reduction as the most preferred method of solid waste reduction, followed by reuse, donation, recycling, and composting. The least preferred methods are waste-to-energy recovery, incineration, and land-filling. The ISWM hierarchy based on the OASD Memorandum is listed here in order of preference and is also shown in Figure 2

- a. Source reduction
- b. Sustainable procurement of goods and services
- c. Reuse of materials
- d. Donation
- e. Recycling
- f. Composting and mulching
- g. Waste-to-energy recovery
- h. Incineration
- i. Landfilling



Per the memo, the objectives were updated “to demonstrate the Department’s commitment to ISWM” and the following goals outlined:

- Divert 40% of nonhazardous solid waste from incineration and land-filling.
- Reduce total annual waste generation by 2% of total waste each year through FY 2025.

2.5 Technical Bulletin MED 530/NAVMED P-5010-1/AFMAN 48-147_IP Tri-Service Food Code (2019)

This Technical Bulletin outlines the Tri-Service Food Code (TSFC), which establishes standard military food safety standards, criteria, procedures, and roles for the sanitary control and surveillance of food to mitigate the risk of foodborne illness. The publication applies to all food activities purchased with appropriated or nonappropriated funds for the DoD and military services. The TSFC includes excerpts and modifications of the US Food and Drug Administration Food Code (2019).

Chapter 3 covers the following food handling procedures:

- Time/temperature control for safety (TCS) food; food that requires TCS to limit pathogenic microorganism growth or toxin formation, must be stored at proper low temperatures and heated to sufficient temperatures during cooking.
- Food packages shall be in good condition to avoid adulteration.
- Food that is improperly stored or contaminated cannot be served.
- Food that has been served or has been sold and is returned by the diner can only be re-served if it is dispensed so that it is protected from contamination or is in the unopened original package.
- Leftovers can be retained to re-serve if specific conditions are met.
- Expired foods are evaluated by Army VS and generally not granted shelf-life extensions at continental United States locations per Army VS Policy.
- Food establishments shall use a strict First In-First Out (FIFO) policy.

2.6 Federal Food Donation Act of 2008

The Food Donation Act of 2008, Public Law 110-247 (2008), encourages federal agencies and contractors to donate excess food to eligible nonprofit organizations to feed food-insecure people in the United States.

2.7 Bill Emerson Good Samaritan Food Donation Act of 1996

The Bill Emerson Good Samaritan Food Donation Act of 1996, Public Law 104-210 (1996), encourages donation of apparently wholesome food to nonprofit organizations for distribution to those in need and exempts those who make good faith donations from liability for injuries arising from the consumption of donated food. Food donations must be made in

compliance for food safety and food handling laws. “Apparently wholesome food” is food that meets all quality and labeling standards imposed by federal, state, and local laws and regulations even if that food may not be readily marketable because of appearance, age, freshness, grade, size, surplus, or other conditions.

2.8 Fort Jackson LeanPath Pilot Study Conducted by the EPA

The COVID-19 pandemic affected the ability to collect data in the field. Other studies that were reviewed contributed to a deeper understanding of waste generation. One such study was the *Food Waste Reduction in Military Kitchens A Tracking Technology Demonstration at Fort Jackson* (Rock and Lan 2019). This study focused on collecting data about food waste using a commercial technology called LeanPath to better understand how much and what types of foods were being wasted and to find ways to reduce food waste. Two cafeteria-style DFACs at Fort Jackson, the Advanced Individual Training, and the Drill Sergeant Academy, installed and used the LeanPath system over the course of five months. This system required contracted kitchen staff to input information about what type of food was disposed, where it originated in the process (preparation, cooking, or serving line), how it was disposed (refuse, compost, or donations), and the weight of the food. Because of the location of the LeanPath devices in the kitchen, only waste from the kitchen and the serving line were included—postconsumer plate waste was not included.

Differences between the CERL study and EPA’s LeanPath study includes the duration, the technology, the personnel for collecting data, and the scope of what was measured. The Fort Jackson study occurred over the course of five months and used the LeanPath system, where kitchen staff input data. Data were potentially lost from kitchen staff not entering data consistently or accurately. This study, on the other hand, involved outside researchers it analyzed only one meal on one day at each location. In addition, data were collected by CERL researchers manually weighing and recording data. The Fort Jackson study also analyzed only food waste, whereas this study collected data on all materials being disposed and analyzed how the design and layout of the building impacted food waste.

Ultimately, overproduction was the largest contributor to food waste at both DFACs studied at Fort Jackson, though the likely reasoning varied. The probable cause of overproduction at one DFAC was due to varied training schedules and lack of communication to the kitchen when field

training was taking place, whereas the expected cause of overproduction for the other DFAC was because of the availability of more dining choices.

Also, because plate waste was not measured, it is not clear how amounts of plate waste compare to other DFAC food waste. This study also concluded that going through the exercise of weighing the food waste helped the staff to be more aware of the waste being produced and to work on reducing it.

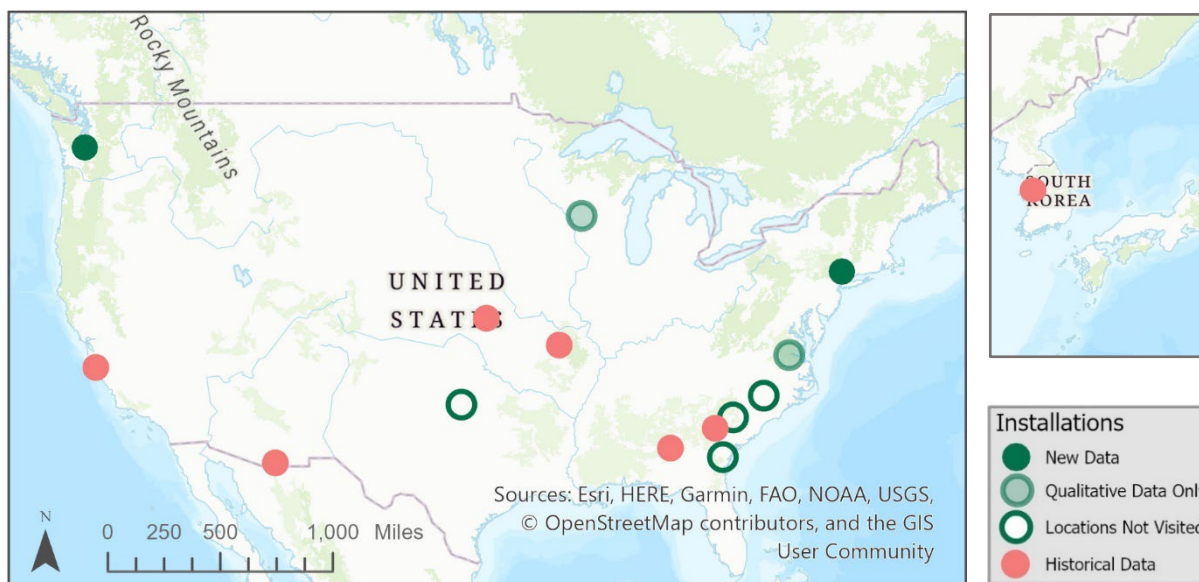
3 Selection of Representative Installations

One goal of the study was to compare DFACs at a variety of locations by mission focus (i.e., readiness, sustainment, and training), size, region, and unique approaches to food waste diversion and reduction. With these factors in mind, the following installations were initially selected: Fort Liberty, Fort Jackson, Fort McCoy, Fort Sill, Fort Stewart, and Joint Base Lewis-McChord (JBLM).

Two previsits with installation food program stakeholders were conducted in June and September of 2019. At Fort McCoy, consideration of their modified DFAC standard design was studied and informational interviews conducted. At Fort Gregg-Adams, a kickoff meeting with stakeholders from selected installations, the Joint Culinary Center of Excellence (JCCoE), and IMCOM took place. The research team also spoke with JCCoE staff about their concerns and initiatives and toured DFACs at Fort Gregg-Adams.

As the data collection phase of the project began, in February of 2020, only one installation, JBLM, was able to be studied prior to COVID-19 travel restrictions coming into effect in March of 2020. These travel restrictions, as well as changes to DFAC operations, hindered the ability of the research team to collect data at other installations within the original timeline. These travel restrictions also altered the list of locations that the research team could visit. While working to maintain a diverse collection of locations, an additional installation was selected to accommodate limitations still in place months after the shutdown began, and historical data from previous studies was included in the analysis. This historical data is from seven additional locations that were visited for previous waste characterizations and waste stream analyses by the CERL research team. Figure 3 shows the installations where data collection took place, those where only observations were completed, installations that were unable to be studied because of COVID-19 restrictions, and installations from which historical data were used.

Figure 3. Map of installation locations where data were newly collected, historical data were collected, qualitative data only was collected, and locations that were originally in the scope but were not visited because of COVID-19.



3.1 Site visits before and during COVID and historical data collection

The list of installations that were visited and studied for this project include JBLM and United States Military Academy West Point (referred to throughout this report as West Point). Historical solid waste generation data were included in this study from US Army Garrison (USAG) Humphreys, Fort Riley, Fort Eisenhower, Presidio of Monterey, Fort Leonard Wood, Fort Huachuca, and Fort Moore. The historical data comes from waste stream analyses that were performed between 2015 and 2019 to guide the recommendations of integrated solid waste management plans (ISWMPs) for the installations. All data included waste type, meal service, and designation of waste as preconsumer or postconsumer. Meal headcounts, the number of diners per meal, determined the amount of solid waste per meal.

3.2 Why originally selected installations had to be modified

As previously described, the original intent of the study was to select installations that covered a range of mission types and post population sizes. Some DFACs are run by contractors, and some are run by military personnel. The different installations were selected to show a holistic view of solid waste generation at DFACs. When COVID restrictions altered the

field study, previously selected installations were still prioritized. However, after months of setbacks and continued travel restrictions, it was clear that an adjustment to any installations designated by IMCOM to be restricted (and confirmed at the installation-level that their DFAC operations had been severely modified) would not be able to further participate in the study. This resulted in less variation than originally intended. There were not any sustainment installations, for example, and primarily, historical data from training installations were the only comprehensive data to be obtained.

One installation that was studied prior to the travel ban was JBLM in Washington. JBLM was selected in part because it is one of the few installations with a successful composting program. With their active diversion of food waste from the refuse stream, it was a case study to learn about best practices and potential opportunities that might be applicable to other installations. While at JBLM, two DFACs were evaluated—one medium and one large sized.

During the pandemic and after the total travel ban was lifted, very few installations were unrestricted. New York had stringent guidelines for quarantine and authorized personnel visiting from other states. However, after following precautionary measures, West Point, New York, was able to be field studied. All work was performed carefully using health and safety precautions, including masks for personnel at all times, social distancing, and rigorous sanitation. Because of its unique dining practices with mandatory meals and family-style service, West Point was a beneficial case study to include in the project. This was the only site visit in the COVID-19 era, and a primary focus was on their use of single-use dishware and utensils, a similar reality for multiple installations once COVID altered their operations for in-house dining.

4 Data Collection of an Installation DFAC

The study was conducted by obtaining quantitative and qualitative data from installation DFACs. While some data were retrieved during the time of the study and other data were collected from previous waste studies, all data were obtained from the same research team at CERL; and consequently, a similar protocol was adhered to on both accounts.

The solid waste stream characterization (also known as an assessment) includes a detailed analysis of the current solid waste stream, such as primary generators of each material and measured samples from representative DFACs. This information is important for determining potential diversion methods for reducing the DFAC refuse stream. Gathering this information is essential before determining potential actions.

4.1 Qualitative design

4.1.1 Preliminary surveys

The CERL research team initially collected background information from several installations to assess feasibility for being included in the study. The data were collected from previous projects, conference calls, email, and coordination with the installations. Some of the information collected included mission type, total population, an inventory of all DFACs at the installation, standard designs of associated DFACs, classification of typical diners (e.g., permanent party, training, civilian, or other), solid waste and recycling pickup schedules, meal types, hours of operation, and daily average head count.

4.1.2 On-site surveys

In the spring of 2019, an initial site visit took place at Fort McCoy, Wisconsin. Observational data were collected at the DFACs to include physically comparing a DFAC standard design to a modified version and an extensive interview with the installation food program manager and staff to better understand how these modifications to the DFAC altered their operations and solid waste generation. In coordination with the IMCOM sponsor, the summer of 2019 was selected for a kick-off visit at Fort Gregg-Adams, Virginia. The kick-off included representatives from JCCoE, FPMs, DPW Solid Waste managers, and DFAC managers from all originally selected installations. Included in the kick-off were briefings from multiple division

leads at JCCoE and tours of multiple dining facilities, including the DFAC for culinary training, permanent party, and a new, fully equipped DFAC that was not yet in operation.

Additionally, the research team conducted follow-on stakeholder interviews and observations at installation DFACs during field collection visits to further understanding of solid waste generation. Interviews focused on how procurement decisions are made, how food is stored, the menu planning and cooking processes, and disposal of waste. Researchers observed food storage areas, kitchen facilities, serving-line layout, the clipper room (area where the dishes are cleared and washed), DFAC loading dock, and solid waste containers. Researchers noted how much food diners took, the location of refuse and recycling containers inside the DFACs, who moved waste from interior containers to exterior containers, whether any machinery was used to lessen waste volumes, and how plate waste was cleared at the dining room or clipper room.

4.2 Quantitative design

4.2.1 Modified ASTM Standard D5231 waste characterization

The CERL research team has conducted numerous waste stream studies over the years and has amassed data on solid waste generation at different building types, including DFACs. The waste stream analyses involved the identification of each element of the refuse stream, identifying the primary sources of each element, and measuring the amounts generated for each. By utilizing a modified version of solid waste stream analysis methodology from ASTM D5231, *Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste (MSW)* (ASTM 2016), CERL conducted a thorough analysis of all nonhazardous solid waste materials generated at installation DFACs.

The solid waste stream analysis evaluated and identified materials found in refuse and recycling containers present in DFACs at the installations. The materials were organized into three main categories: compostable, recyclable, and nonrecyclable MSW. The compostable category includes organics that have the potential to be composted such as food, yard waste, wood, textiles, mixed paper, biodegradable-waxed paperboard, and soiled paper. Although not all types of food, wood, textiles, etc. may be composted depending on the compost mechanism (e.g., industrial versus backyard waste) and the level of contamination, collecting data on the available

compostable material can be informative for potential diversion of compostable waste from landfill. The recyclable category includes materials with the potential for recycling, such as plastics, aluminum, steel, white paper, and cardboard. MSW refers to materials that generally cannot be composted or recycled. Solid waste was also sorted according to which meal was served (i.e., breakfast, lunch, or dinner) and whether it was generated preconsumer or postconsumer. Preconsumer waste was mostly generated in the kitchen during the cooking process. Postconsumer waste was mostly generated from the serving line and clipper room. A small amount of postconsumer waste came from the front office and restroom.

4.2.2 DFAC whole-building evaluation

To assess the DFAC it was necessary to evaluate in more granular detail than what the standardized installation waste assessment allows. Solid waste at the DFAC was first categorized by waste type and preconsumer waste versus postconsumer waste. This includes characterizing the waste beyond the typical three major categories (compostable, recyclable, and nonrecyclable MSW) and extending the categorization beyond the 20 or more subcategories (e.g., various types of papers, metals, organics, etc.).

Since the food waste was of particular importance, subcategories were created, such as proteins, starches, produce, dairy, etc., to find any trends associate with the type of food. Additionally, the study categorized whether the food was still fully packaged and which room of the DFAC it was generated in. Preconsumer food waste refers to food that has not yet been offered to the diner. This includes any solid waste generated during the cooking process, such as vegetable peels. This also includes items that were prepared but never offered to the consumer because of being disposed of for spoilage or excess ordering. Postconsumer food waste refers to items that entered the serving line, also known as chow line. This includes food that was placed on the chow line for consumption and plate waste disposed by diners. Even if the food was not placed on a diner's tray or plate, any food that was served is considered postconsumer. This type also includes unopened packaged food, such as full chip bags or plastic-sealed muffins that are accessible to the diner. Whole produce, such as bananas and apples on the chow line also count towards postconsumer. If these items were discarded in the kitchen rather than the clipper room, these same items would be considered preconsumer.

Beyond qualitative observations and surveys, tours of physical spaces and kitchen equipment included some quantitative elements relative to potential impacts to food waste generation. These factors were included in the analysis as well. Solid waste generated at any point in the process of feeding diners was recorded and captured from the point of generation. Location of receptacles for solid waste disposal as refuse, recycling, and organic waste from all parts of the DFAC (exterior and interior) was included. How diners disposed of their discards, whether they separated parts (e.g., silverware, trays, and MSW) into multiple bins or if they simply turned in their tray was recorded. Layout of the DFAC and time the diners had to eat were also factors.

Solid waste that is generated at DFACs and disposed elsewhere, including waste from to-go meals, was not included. Food waste generated from field feeding, waste from kiosks, cafés, and other food service locations was not included.

4.2.3 EPA Waste Reduction Model (WARM) Tool

The EPA developed a modeling tool called Waste Reduction Model (WARM) to calculate GHG emissions, energy impacts, and economic impacts of solid waste generation. The tool compares baseline and alternative waste management practices. Waste management practices included in the tool are source reduction, recycling, combustion, composting, and landfilling.

The tool was used in the analysis to estimate changes in GHG emissions, energy impacts, and economic impacts with different waste management practices.

5 Results

The following sections discuss the results from the study. As the previous section explained, the initial design of the study was modified because of the pandemic. The modifications to the collection were included in the results. Qualitative factors supplemented quantitative results.

5.1 Spatial analysis

5.1.1 Standard building design

Each facility has certain spaces and equipment that allow the DFAC to function properly, and there are standards for DFAC designs (US Army Corps of Engineers 2012). Dining areas, serving lines, kitchen and preparation areas, storage spaces, clipper rooms, dishwashing, and loading docks are all among the necessary programmatic spaces within a DFAC (US Army Corps of Engineers 2012). However, not all DFAC locations are the same.

For example, the Cadet mess hall at West Point is a unique dining facility. There is enough dining space to feed 5,000 diners at once, and the kitchen space spans multiple floors of the building. The layout of Raptor's Nest at JBLM, on the other hand, is similar to the Army standard designs for an 800 people permanent party layout (U.S. Army Corps of Engineers, n.d.).

DFACs can also use different equipment to help reduce food waste. Raptor's Nest at JBLM has both a garbage disposal and a pulper, which is a device that grinds and dewateres food waste (Singer Equipment 2022). Though the pulper is used in the clipper room, they have never actually used the garbage disposal. At Lancer, they have a garbage disposal that gets used by the dishwashers, but they do not use any other technologies for food waste disposal, such as pulpers, dehydrators, or liquid digesters.

Each facility has a range of waste receptacles. At JBLM, both DFACs surveyed had between fifteen and twenty 64-gal food waste only totes, two or three actively used 96-gal recycling bins, four to five actively used 64 gal MSW bins, and smaller solid waste receptacles at handwashing stations. Lancer uses one 8 yd³ recycling container and two 10 yd³ refuse containers. Raptor's Nest uses two 8 yd³ recycling containers, and one 10 yd³ refuse container. Size estimations were derived from recorded notations in the field and information on Zero Waste Design Guidelines (Clare et al. 2017).

At West Point, it was more challenging to track all the waste receptacles because of the scale and complexity of the facility layout. However, because of the volume of waste at the breakfast meal surveyed, much of the waste was being disposed in 3 yd³ tilt hand trucks in the clipper room. There were also yellow and gray bins, yellow totes, and blue recycling totes found throughout the facility. Ultimately, most of the waste ended up in a refuse compactor, including all food waste. In addition, there were three 64-gal recycling containers near the compactor, ready for collection. One piece of recycling equipment that West Point has is a cardboard baler in the basement.

5.1.2 Facility layout

5.1.2.1 Kitchen

The back-of-house areas of DFACs must accommodate a variety of program spaces. Included are offices, food storage spaces (cold storage and dry storage), kitchen space for preparing food, dishwashing, cleaning areas, and access to the loading dock. Most of the waste being produced in the kitchen areas comes from food preparation and food spoilage. All kitchen waste is classified as preconsumer waste. To keep food waste to a minimum, and because there is limited storage space, it is important for the staff to ensure that there is no overordering, and to make sure to rotate stock when new goods arrive.

Figure 4 shows a diagram of some of the back-of-house spaces at Raptor's Nest. At DFACs such as Raptors Nest and Lancer, there are groupings of accessible waste receptacles—MSW, recycling, and food waste only—located in the back of the kitchen for food-preparation waste. These bins tend to be mobile, so that they can be brought to various workstations for food trimming and packaging disposal needs. There are also smaller MSW bins near handwashing stations, mostly used for soiled paper. Lancer had additional MSW, recycling, and food waste only bins throughout their kitchen space for disposal during prep. Field interviews mention solid waste containers are continuously taken out throughout the day. Figure 5 shows the solid waste containers at the back of the Raptor's Nest kitchen located out of the way but in a conveniently accessible to preparation and dishwashing stations.

Figure 4. Diagram of kitchen spaces and waste containers at Raptor's Nest (JBLM).

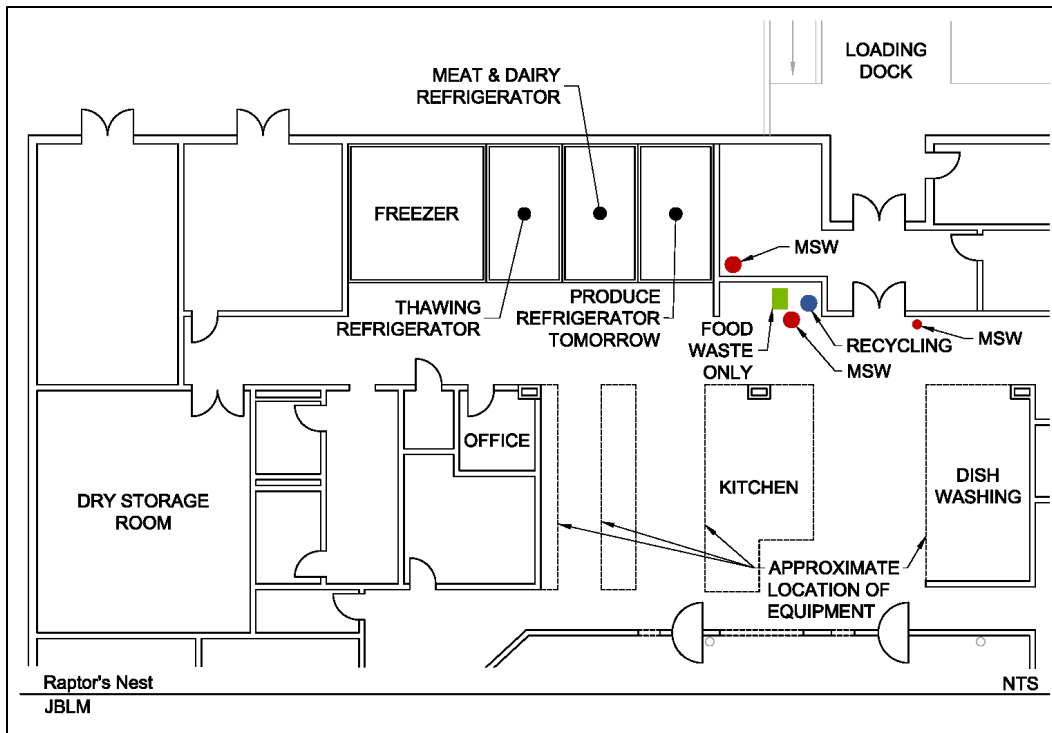


Figure 5. *Left*, image of mobile solid waste containers and a handwashing station solid waste container in the kitchen at Raptors Nest (JBLM); *right*, the food waste only (*green*) bin, recycling (*blue*) bin, and municipal solid waste (MSW; *black*) bin at Raptor's Nest (JBLM).



At West Point, there were numerous kitchen spaces that were specific to certain types of food preparation (fruit, vegetables, and meat). Most of the solid waste collected in the kitchens ended up in refuse containers. There were multiple refuse bins in each of the kitchen prep spaces. Cardboard was separated from the rest of the waste, broken down, and put into a pile.

5.1.2.1.1 Food Storage

The surveyed facilities had multiple cold storage options, as well as a large dry goods storage room. At both JBLM locations, the dry goods storage is under 700 ft² and has ration soldiers guarding the rooms. Raptor's Nest and Lancer both have three refrigerators and one large freezer.

At Raptor's Nest, all the refrigerators are the same size (approximately 125 ft² each). One refrigerator is for thawing food, one is for meat and dairy, and the last contains food for following day. This last refrigerator is the only one that remains unlocked so that staff can access it to work on preparing food for the next day. The freezer remains locked and is approximately 240 ft².

Lancer has two refrigerators that are approximately 80 ft². One is designated for thawing food, and the other is the produce refrigerator. The third refrigerator is slightly larger, at approximately 145 ft², and is the dairy fridge. The freezer is kept locked and is over 450 ft².

Both JBLM DFACs described a system of FIFO for the food. The staff rotates products as new items arrive, which helps to minimize food spoilage. Another way to minimize food spoilage is to order only what will be needed. But DFACs must also ensure that there will be enough food on hand if there is an emergency. At Lancer, they keep track of their stock, and if they have too much of an item, they will stop ordering it. They keep three days' worth of rations on hand. When their headcount goes down, so does the volume of their orders.

West Point has numerous cold storage spaces, many of which are locked. There are two large dry storage rooms, one for cans and other pantry items, and a second room specifically for bread.

5.1.2.2 *Serving-line layout*

The serving line is the waypoint for all postconsumer food waste—from what is leftover on the line at the end of a meal service to what the diner chooses to take but does not consume (Figure 6). Serving line layouts varied at the DFACs included in this study.

Figure 6. *Left*, food left on the serving line at the end of the breakfast meal service at Raptor's Nest (JBLM); *right*, postconsumer waste after the breakfast meal service at the Cadet mess hall (West Point).



5.1.2.2.1 Fort McCoy

The Food Program manager at Fort McCoy has worked to limit DFAC waste and encourage healthier eating habits. When diners enter the serving-line area, they approach the food stations in a specific order. They first pass the cold bar (with vegetables), then by the side bar, followed by the entrée bar. They can then get their drinks and sit down. Locating the desserts closer to the dining area allows diners to decide if they would like to get a dessert after they sit down and eat the rest of their meal. The location of the desserts is intentionally out of the way from the main serving line, and not all diners are guaranteed to see it, which may help to reduce the number of people who will take dessert (Figure 7).

Figure 7. *Left*, entrance from Point of Sale to Salads and Greens; *right*, dessert station to the far corner of the DFAC away from the exit and main line.



In addition to the slight modifications to the serving options, signage is displayed throughout the DFAC encouraging diners to waste less food (Figure 8).

Figure 8. Signage at Fort McCoy DFAC encouraging staff and diners to waste less food.

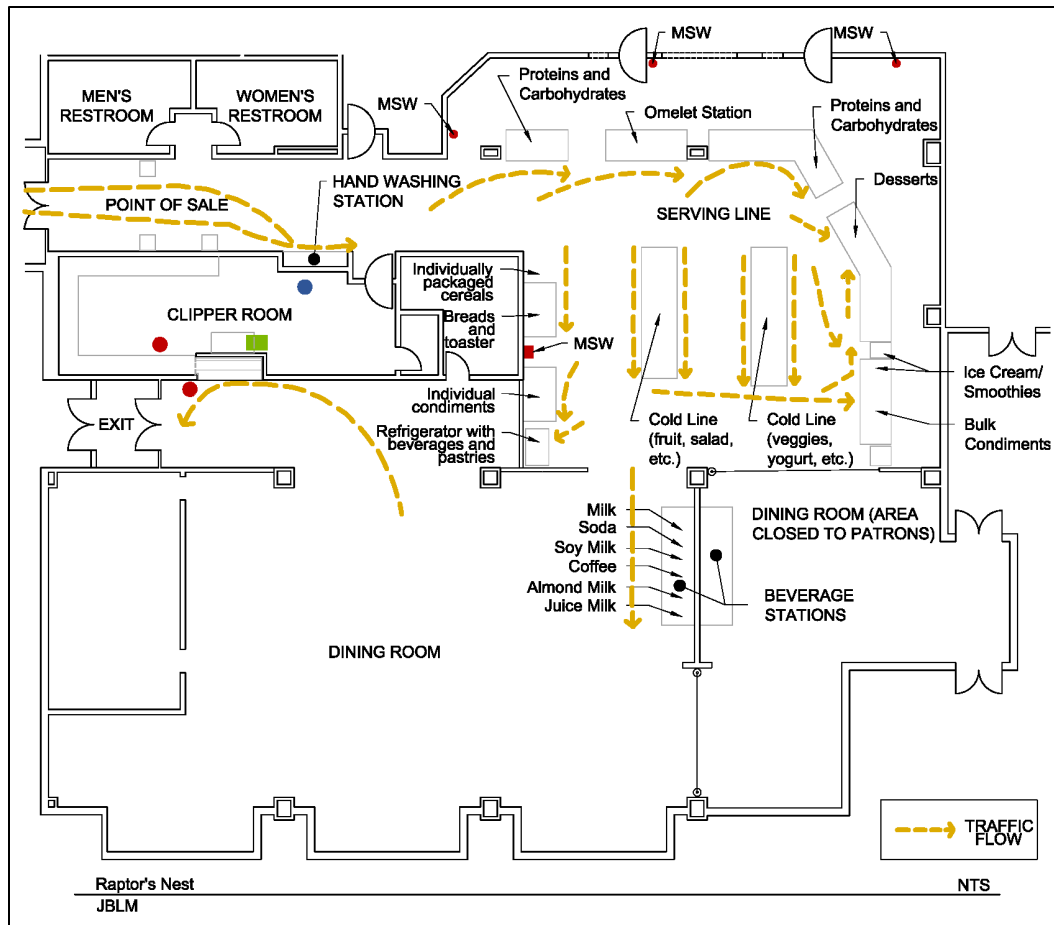


5.1.2.2.2 Joint Base Lewis-McChord (JBLM)

The DFACs studied at JBLM, Lancer and Raptor's Nest, both have serving lines with a cafeteria style layout that provides the ability to flow freely to various food stations without a direct path through the serving-line area.

Figure 9 shows that Raptor's Nest provides a natural flow around the serving-line area, where diners can visit the staff-served hot food lines (where they can get proteins, carbohydrates, and vegetable sides), the self-serve cold lines, or desserts in any order they want. Condiments, such as salad dressings, are placed along the farthest edge of the serving-line space. During field interviews, the DFAC manager mentioned that it was intentional to place the salad dressing farther away from the salad bar to "make people work for it," in the sense that when it is less convenient to pick up a certain food item, diners are more likely to take only what they will consume rather than picking it up on a whim.

Figure 9. Traffic flow patterns of diners through the Raptor's Nest DFAC (JBLM).



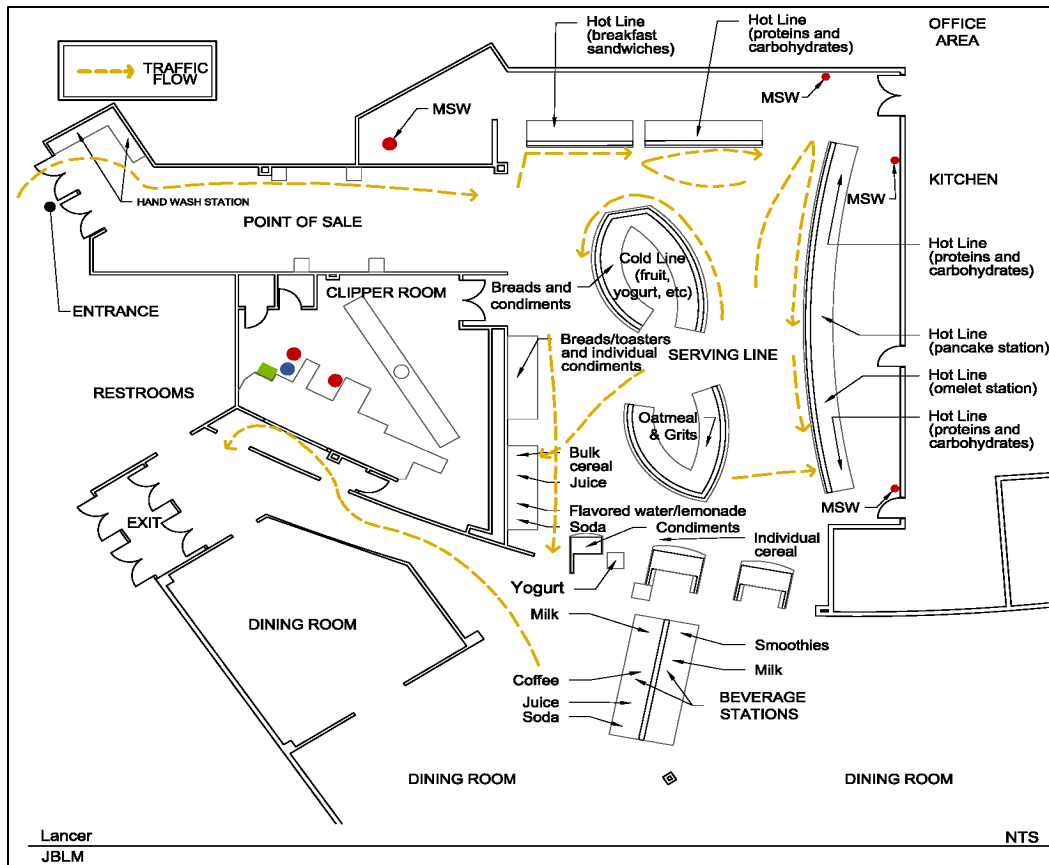
The only solid waste containers throughout the serving-line area are located behind the serving lines or where diners might need one, such as near the individually packaged items like coffee creamer.

Like the Raptor's Nest layout, the staff-served hot food stations at Lancer are along the perimeter of the serving area, self-serve cold stations are in the middle, and items such as individually packaged foods and condiments are also along the perimeter.

At Lancer, however, the food stations in the middle of the space have a unique curved V shape (Figure 10). This style of station only allows for diners to flow through one line in a single direction, instead of along two sides like a typical serving-line bar. The placement of food starts on the side opposite from the entrance to the serving-line area, forcing diners to walk to the center of the space to make their way around the cold bar putting them

back at the entrance to the serving line. If the food order is reversed, it could be a natural starting station as diners enter the serving-line area.

Figure 10. Observed customer traffic flow from the entrance, through the serving line, to the tray return, and to the exit at JBLM's Lancer DFAC.



Also, the size and configuration of these central stations takes up a considerable amount of space. These central bars occupy approximately 2.5 times as much space as the cold-line bars at Raptor's Nest. This likely adds to the congestion created by the hot food lines. During the breakfast rush, it was observed that most diners were focused on one half of the serving area—between the hot food stations and the central food stations. Figure 10 shows the general traffic patterns observed but does not convey the density or congestion of the lines. Though this serving-line area is large, the layout limits the efficient access to all food options.

5.1.2.2.3 West Point

West Point provides a unique example for food service. During the mandatory breakfast meals, diners are served family style at their tables. Still,

there are some items that are served at a cafeteria-style buffet line, which is also used as the main serving lines during other meal services. Because of the capacity needs, there are four buffet serving lines available for use. Two of these serving lines can be accessed from both sides.

For breakfast, the main hot items, bread, and a side are served at the tables family style. Bulk condiments are also located on the tables. On the buffet lines, there are items such as yogurt, fruit, salad, and individually packaged cereals. Beverages, except for water, are served on the buffet line or in small refrigerators throughout the dining area.

There are some refuse and recycling bins near the clipper room, centrally located in the dining area, but most of the solid waste is collected after the diners leave.

5.1.2.3 Clipper room

The clipper room is typically located near the exit and is where dishes are cleared and washed. The solid waste that gets disposed through the clipper room includes dinner-plate waste and prepackaged goods that the diner took off the line and did not consume. The two DFACs that were surveyed at JBLM both have tray returns that allow diners to put down their trays without having to clear their own plates. At Raptor's Nest (Figure 11), there is an MSW bin outside the tray return that diners could use if necessary. Once the trays make it into the clipper room, staff can put food waste into the pulper to reduce the volume of disposed food.

Figure 11. Diagram of the Raptor's Nest (JBLM) clipper room and surrounding areas.

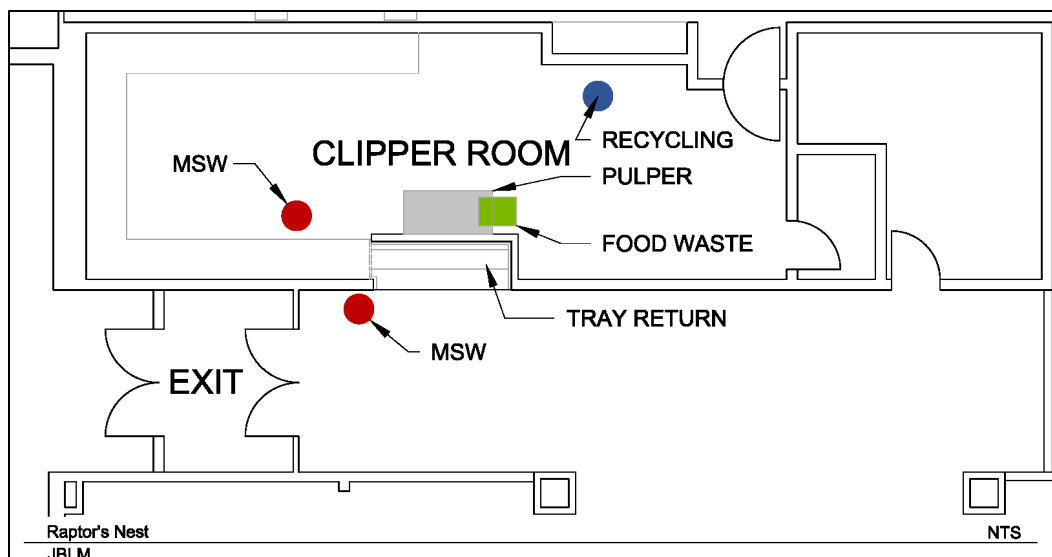


Figure 12 shows the clipper room and tray return at JBLM's Raptor's Nest. Both JBLM DFACs have MSW bins, a recycling bin, and a food waste only bin at the clipper room.

Figure 12. *Left*, tray return area from the diner's point of view; *right*, pulper and food waste only bin in the Raptor's Nest (JBLM) Clipper Room.



The situation at West Point is unique, not only because of the operation of the mess hall but also because of the COVID-19 pandemic. West Point has two clipper rooms. Typically, one clipper room is used to clean the serving trays, while the other is for cleaning items after diner use (cups, plates, utensils, trays, etc.). The clipper rooms could hold eight or nine staff members each. However, because of the pandemic, modifications were made during the time of the field study. Because of social distancing restrictions, only two people could use those rooms at a time. Since the staff had to be reduced in these areas, the entire facility switched to disposable plates and utensils. With the reduced items that needed to be washed and additional solid waste from disposable items, one of the clipper rooms was used for all washing, and the other was used to hold solid waste bins that were waiting to go onto the elevator and down to the compactor.

5.1.2.4 Solid waste containers

As mentioned previously, the JBLM DFACs surveyed use food waste only totes, recycling bins, MSW bins, and some smaller MSW receptacles. The larger totes and bins are in the kitchen and the clipper room and are taken out as necessary throughout the day. The smaller receptacles are near handwashing stations throughout the facility and throughout the serving-line spaces.

The larger containers and food waste only bins are located outside near the loading dock. The food waste only bins sit empty until brought inside and

filled up and then put back outside for collection. Food waste only bins are not used at most installations. Because of the composting facility at JBLM, it is important for the DFAC staff to separate out food waste that can be composted. Providing food waste only totes make it possible to segregate food waste where it is generated. None of the other installations in the study separated food waste or had large scale composting operations like JBLM.

As orders come in and are stocked onto shelves, cardboard containers get discarded. Cardboard is the second most common material found in DFAC waste streams after food waste. Additionally, cardboard can be bulky, so several DFACs had cardboard waste piling up in areas not designed to store cardboard waste. At Lancer, orders are delivered three times each week. Soldiers break down the boxes and sort them in a pile near the back door to the loading dock before they are taken out to the recycling container. However, the recycling container is often full, which leads to boxes being piled up, as seen in Figure 13. At West Point, although there is a cardboard baler in the basement of the kitchen, much of the cardboard waste was disposed of in the compactor.

Figure 13. *Left*, a pile of cardboard, flattened and ready for disposal on the loading dock at Lancer (JBLM); *right*, a pile of cardboard just inside the loading-dock doors at Lancer (JBLM).



Lancer uses one 8 yd³ recycling container and two 10 yd³ refuse containers. At the time of this study, the recycling container at Lancer was in poor condition, with a large crack down the front (Figure 14). Interviews in the

field explained that the next building over also has two refuse containers and a recycling container, which the kitchen staff often use because of the high volume of cardboard that is generated at their DFAC.

Figure 14. Recycling container at Lancer (JBLM).



Raptor's Nest uses two 8 yd³ recycling containers and one 10 yd³ refuse container. Figure 15 shows the placement of the food waste only totes and the recycling and refuse containers at Raptor's Nest.

Figure 15. *Left*, food waste only totes being emptied; *right*, the recycling and refuse containers located at the end of the dock at Raptor's Nest.



West Point has many tilt hand trucks and totes to collect solid waste. There are blue recycling totes, yellow totes, yellow bins, and gray bins. Ultimately, most of the solid waste, including recyclable materials and food waste, ended up in the compactor (Figure 16). Compactor waste is taken to the county landfill.

Figure 16. *Left*, full tilt truck ready for the compactor; *right*, Full tilt trucks about to be unloaded into the solid waste compactor at West Point's Cadet mess hall.



5.1.3 Visual cues and signage

5.1.3.1 Graphics

Graphics and signage are an important part of communicating information at a DFAC. Fort McCoy, for example, provides signage using color theory to draw attention to healthier food and beverage choices. Their signs indicate to diners where each of the various food stations are located. West Point provides digital menu boards so that diners can see what is being served at the buffet serving lines. Figure 17 shows examples of Fort McCoy and West Point signage.

Figure 17. *Left*, food-station signage at a Fort McCoy DFAC; *right*, digital menu board at West Point.



Lancer has general signage for stations around the serving-line area, but they are not applicable to all meals and are not intuitive about what is served at a given meal. For example, stations are labeled “main grille,” “hot entrée,” “pizza,” “deli,” or “grill.” This station signage is also difficult to see because of the finish material and the lighting in the space. To see what is being served, it is necessary to be close to the buffet line. There is

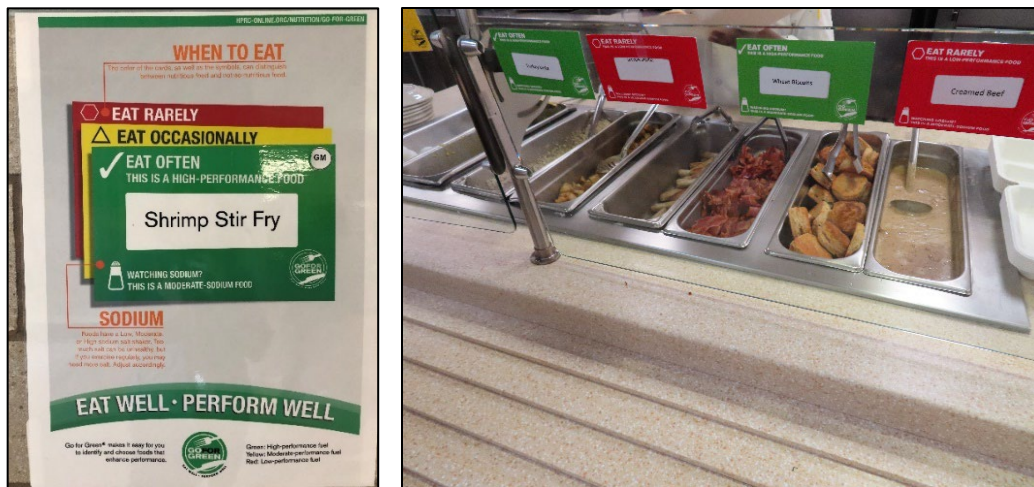
one poster that hangs high on the wall, off to the side of the entrance to the serving-line area, that does show what items are served each day of the week at the specialty bars for set menu items. It does not appear to change from week to week. Figure 18 shows Lancer signage.

Figure 18. *Left*, station signages at Lancer (JBLM); *right*, signage showing meals that are served at specialty bars on certain days of the week (*blue poster*), and other graphics at Lancer (JBLM).



Aside from general signage that assists diners in finding the type of food they desire to eat, both Raptor's Nest and Lancer have smaller signs at the buffet lines to indicate the value for each food according to the Holistic Health and Fitness (H2F) nutrition guidelines, a variation on the Go for Green® nutritional standards. JBLM is a H2F pilot location. The most prominent indication on these signs is the background color. Green, yellow, or red indicate how often foods should be eaten. However, the rest of the text on these signs is so small that it is difficult to read from more than a few feet away. When looking at the signs more closely, the food listed is described, including the sodium levels for that item. Go for Green® signage is shown in Figure 19.

Figure 19. *Left*, graphic poster explaining the Go for Green® nutritional indicators at Fort McCoy; *right*, Nutritional indicators for each food item at Lancer (JBLM).



5.2 Supply chain and staffing analysis

5.2.1 Supply chain

5.2.1.1 Meal preparation

At the Raptor's Nest DFAC at JBLM, food preparation is done the day before the food is served. Kitchen staff has flexibility to be creative in how they prepare their meals as long as they are working within the requirements of the nutritional program. At the Lancer DFAC at JBLM, most preparation is done on the day of service, and the kitchen was more frenetic than at Raptor's Nest. At West Point, on the other hand, the main food vendor supplies the installation with food that is mostly pre-cut and pre-portioned. The kitchen staff needs only to remove the food from the packaging and place it on baking pans to be put in the oven. Staff says that the time savings from limiting the amount of from scratch cooking is important when feeding almost 5,000 diners at a single meal service.

5.2.1.2 Diners per meal service (projected meal count and actual headcount)

Even within one installation, JBLM, there are different approaches to estimating the meal count for each meal service.

At Raptor's Nest, there is an estimate of what a typical headcount is for each meal service. Breakfast is the most attended meal of the day, with over 300 people. Lunch usually has over 200, and dinner can range anywhere from 100 and 200 people. On the weekends, an estimated 300–350

people eat at Raptor's Nest throughout each day. During the field visit on a weekday breakfast, Raptor's Nest planned for an estimated 350 people. The headcount for that breakfast was 303 diners.

Lancer serves a larger population and therefore deals with greater fluctuations in their headcounts from day to day. A typical day estimates 600–800 people for breakfast, 500 for lunch and dinner, and 400 for brunch and supper on weekends. The meal studied during the field visit, another weekday breakfast, was for an estimated 600 diners, with the ability to continue cooking throughout the meal to meet additional demands. In total, 744 diners were served.

At West Point, some meals are mandatory, and the estimated meal count is equal to the number of cadets. For nonmandatory meals, the staff estimates the meal count with historical data and prepares slightly more than their estimate to make sure they do not run out of food.

5.2.1.3 Grab'n'Go meals

Grab'n'Go meals are offered at many DFACs. For Grab'n'Go meals, diners take disposable clamshell containers and fill them on the line. They then take the food to go and eat it at a location of their choice. Grab'n'Go diners are included in the headcount. At JBLM, Lancer had reimplemented Grab'n'Go meals the day before our study. Prior to that, Grab'n'Go had been suspended while the container storage area had been temporarily unavailable. Despite a lack of advertising, 100 people used this meal option on the first day it was available again.

5.2.1.4 Proximity to diversion opportunities

Diversion is a waste management best practice that keeps waste out of landfill and incineration, including recycling, reuse, and composting. Diversion practices are the more preferred methods of waste management on the DoD ISWM hierarchy (Figure 2). Proximity to diversion opportunities, including composting operations, anaerobic digestors, food banks, and livestock farms, varies by installation. A small number of installations operate composting operations on-post. A few installations near farms have been able to partner with farmers to offer food waste as pig feed, including USAG-Hawai'i and Fort McCoy. Other installations are located near commercial composting operations or anaerobic digestion facilities.

Anaerobically digested food waste produces methane, which is harvested and used as an energy source.

Earthworks is the composting facility located at JBLM (Figure 20). The 200-acre facility was originally set up in the early 2000s and sits on a former transfer station with a few closed landfills on-site. Earthworks is run by one full-time staff member. Food waste and other compostable waste from DFACs, the Commissary, Child Development Centers, AAFES, and yard waste is collected by the solid waste hauling contractor, LeMay, and brought to the compost yard. The Earthworks facility is a large operation with multiple covered bays and large open spaces for piles of compost and feed stocks.

Figure 20. *Left*, recent additions to the Earthworks compost pile; *right*, fresh feed stock in front of a finished compost pile at Earthworks (JBLM).



5.2.2 Staff

One of the main differences between DFAC staff at different installations is whether they are military personnel or contractors. Regardless of whether DFAC staff are military members or contractors, turnover can be an issue. DFACs with military personnel have turnover of most of the staff at once. When units leave, they are replaced by another unit. The only contractor staff at military run DFACs are the Dining Facility Assistants (DFAs), also referred to as Kitchen Patrol. DFAs are responsible for cleaning and taking refuse and recycling to the waste bins on the loading dock. DFAC managers who work with military personnel say that they spend several months training a new unit, then they have a short time span where everyone is trained and the DFAC functions smoothly, followed by the departure of that unit. A new unit comes in and the process starts again. By contrast, DFAC managers who work with contract staff say they have regular turnover of staff but not of everyone at once. Instead, an individual will leave

and need to be replaced. Turnover rates vary by DFAC when contractor-run. Other food service operations and retail outlets on-post and nearby off-post are competing for some of the same people to work as staff. The ease of recruitment depends on the local job market.

5.2.2.1 Current responsible parties (Joint Culinary Center of Excellence [JCCoE], Logistics Readiness Center [LRC], Food Program manager [FPM])

The JCCoE is the lead organization for the development of Army Food Program doctrine. The JCCoE develops feeding concepts and menu standards and writes regulations. The JCCoE also establishes the method and principles for food safety, DFAC design, food service equipment, and food service management (US Army Quarter Master Corps 2022).

The FPM at each installation is part of the Logistics Readiness Center (LRC) Food Services Division and oversees the Food Program for the installation. FPMs work with DFAC managers to ensure their operations go smoothly and to track installation Food Program data.

5.2.2.2 Training and guidance

Leaders at JBLM understand the importance of educating DFAC staff about waste reduction practices. They have experienced the value of having managers who can communicate and form relationships with the contracted staff. In those situations, the values and processes of food waste reduction can more easily be communicated and more willingly be followed.

5.2.2.3 Roles and responsibilities related to waste disposal

At JBLM, while most of the kitchen is military run, DFA contractors are responsible for cleaning the DFAC, including taking refuse, recycling, and food waste to the bins on the loading dock. During the research visit, the same staff members were seen taking out solid waste multiple times during the meal.

At West Point, after mandatory meals, diners leave everything on the table. Contractors remove items from the tables. First, they clear the food waste, then plates, and then liquids. Unopened juice and energy drinks are returned to the refrigerators. Unopened shelf-stable foods are returned to the buffet line. Any items that are open, dairy items, and hot food items are disposed of. For nonmandatory meals, diners bring their trays to the

waste line where they pour liquids into a designated bucket, place unopened items on a tray, recycle #1 plastic bottles, throw other food and disposables into a refuse bin, and leave their trays to be washed. For every meal, refuse is put into tilt trucks. One staff member takes these tilt trucks to the compactor. The compactor is accessed using the elevator located in one of the clipper rooms. In the morning, the compactor is usually full from the meals eaten the previous day. For this reason, DPW asks the refuse hauler to take the mess hall compactor first each day. The staff member who fills the compactor watches to see when the compactor is emptied. Until the compactor is emptied and returned, waste piles up in the clipper room and at the door to the loading dock, where the compactor is located. At the time of the research visit, waste totals were higher because of COVID-19, according to DPW and DFAC staff. Because of COVID-19, cadets were not allowed to leave post, so they were eating more meals in the mess hall. Also, the mess hall had switched from reusable plates and utensils to disposable plates and utensils to facilitate social distancing for the staff in the clipper room. These adjustments led to more waste.

5.3 Diner attitudes and communication

Military personnel often live and travel from location to location. They may have lived in a location that had a rigorous composting and recycling program, or they may have come from somewhere it is nonexistent. In conversations with soldiers who have changed duty station, many expressed frustration or confusion with differing policies for what can be recycled and how to dispose of different materials.

Although units in training are required to dine at DFACs, lack of communication when plans change can lead to excessive food prepped relative to the number of diners who show up at the DFAC. Some DFAC managers discussed instances of prepping meal service for units who did not arrive to eat because of unscheduled training exercises. Without communication, the DFAC manager may not know that the schedule for units changed.

For DFACs that support units that are not in training, other dining establishments compete with those DFACs. FPMs may keep abreast of other dining establishments to structure their meal offerings accordingly. In addition, diners will not always prefer the meals or items served. Figure 21 shows a great example of communication within a DFAC. The easy-to-read sign prompts diners to consider their appetite before selecting food.

Figure 21. A sign above a DFAC serving line encouraging diners to take no more than what they will consume at Fort McCoy.



5.4 Waste diversion technology

5.4.1 Waste diversion machinery

There are many pieces of machinery used at installation DFACs to process organic waste with the goal of making waste management easier. Such machinery includes disposals, pulpers, dehydrators, anaerobic digestors and liquid digestors. Figure 22 shows a recycling bin lift in front of a liquid digester located at Fort Gregg-Adams. These machines can be beneficial when used in the right situations.

Figure 22. Recycling bin on a lift in front of a liquid digester at Fort Gregg-Adams



5.4.2 Waste monitoring software

Waste monitoring software, such as LeanPath, can help a DFAC gain a better understanding of how they are generating solid waste. Users place food on a scale with a camera above. While a picture is taken, users navigate the attached touchscreen to input how it was being disposed of (refuse, compost, or donations) and where in the process the food was coming from (prep and cooking or serving line). The input information is combined with the weight and image of the food and summaries are sent to the DFAC Manager. Having this information can help the DFAC Manager and FPM see trends and identify new issues that may emerge. One downside to a system like LeanPath is the need to pay a recurring fee. However, if LeanPath is giving the DFAC Manager the information they need to make purchasing decisions that save money, then paying for LeanPath may be worthwhile.

5.4.3 Food donation search tools

Local organizations in several regions offer apps to assist with food rescue. These apps connect food donors with organizations such as food pantries that can accept donations. The national organization Feeding America also

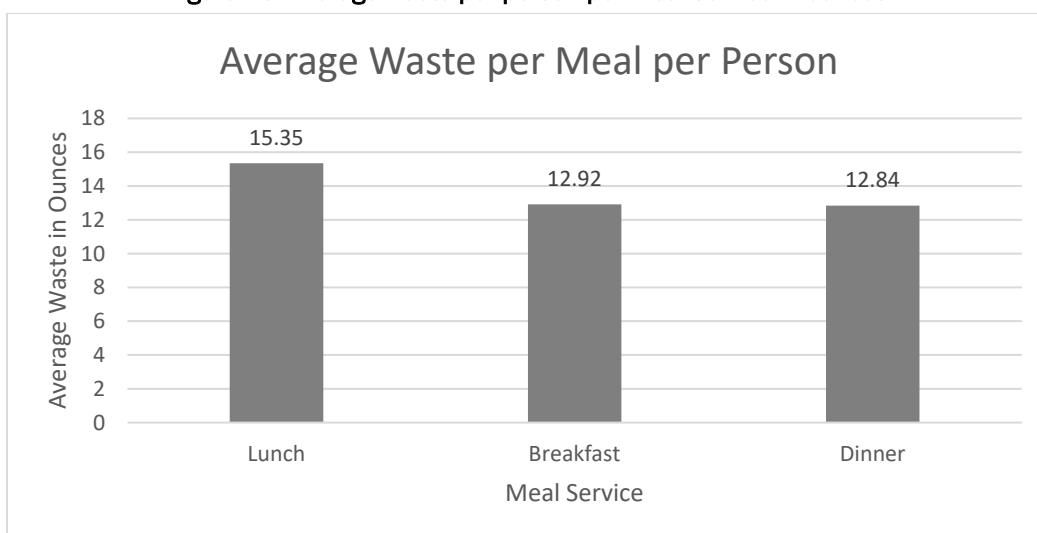
has a food rescue app called Meal Connect that connect food donors with nonprofits throughout the country (Feeding America 2016). There are also national organizations with search engines on their websites for local nonprofits that accept food donations. National organizations the EPA suggests as resources for finding local locations to donate to include Feeding America, Sustainable America, Ample Harvest, Hunger Free America, Food Recovery Network, and Food Donation Connection (United States Environmental Protection Agency, n.d.).

5.5 Solid waste generation analysis

This analysis used quantitative data from nine installations. The data includes 23 meal services: 9 breakfasts, 8 lunches, and 6 dinners.

On average, each meal included in the study generated 13.7 oz of solid waste. Lunch waste on average was higher than breakfast or dinner waste (Figure 23).

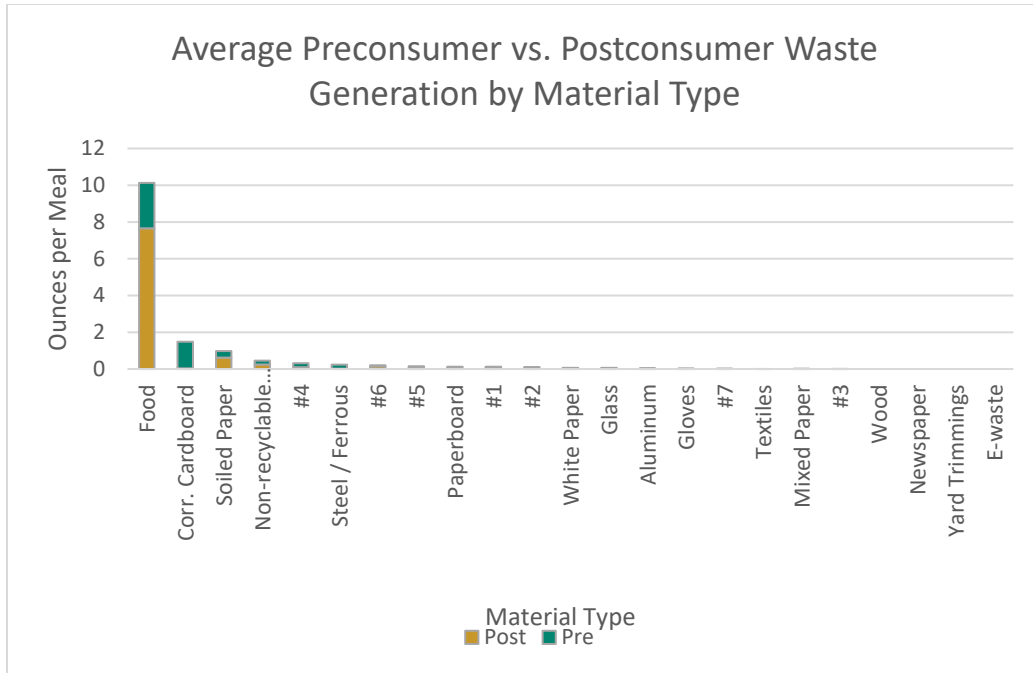
Figure 23. Average waste per person per meal service in ounces.



As shown in Figure 24, out of the average 13.7 oz of solid waste generated per meal, 70%, or just over 10 ounces, was food waste. Of those 10 oz, about 7.6 oz are generated from postconsumer waste. Postconsumer waste is either overproduction from the serving line, unopened packaged items that diners take but do not eat, or plate waste. The remaining 2.4 oz of food waste was preconsumer. Other than food waste, the next largest portion of waste generated per meal was cardboard, which represents about 1.5 oz of waste per meal. Next is soiled paper, which is slightly less than 1

oz per meal. Every other component of the waste generated per average meal was less than half an ounce each.

Figure 24. Average Preconsumer versus postconsumer waste generation by material type in ounces.



At JBLM and West Point, additional data was collected looking at what type of food waste was generated. Figure 25 shows where in the building the waste was generated: kitchen, serving line, or clipper room. The kitchen has the most waste, representing 43% of the total, followed by 35% from the clipper room and 22% from the serving line.

Figure 25. Locations of preconsumer and postconsumer waste generation.

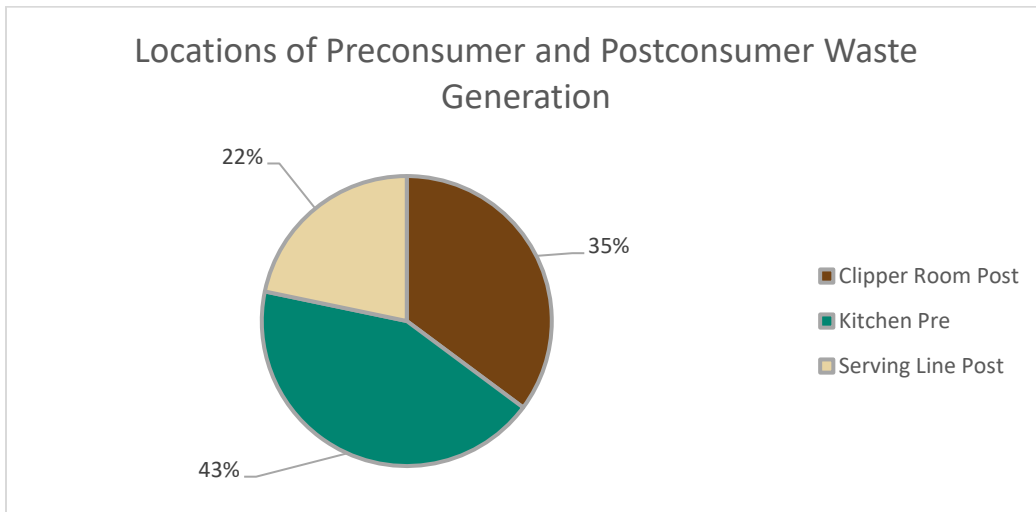


Figure 26 shows the breakdown of types of food waste. Out of the four meals in this data, 37% of the food waste was prepared food from the serving line (overproduction), 31% was plate waste, 16% was spoilage, 14% was trimmings, and 2% was packaged food. The spoilage at West Point during breakfast on the day of the field visit was significant, representing more than half of the food waste generated per meal. Most of this spoilage was a high volume of bread being disposed. Trimmings were much higher at the JBLM DFACs than at West Point's Cadet mess hall. West Point buys most of their food precut and preportioned from their food vendors, so there is less waste generated from food preparation.

Figure 26. Food waste by type.

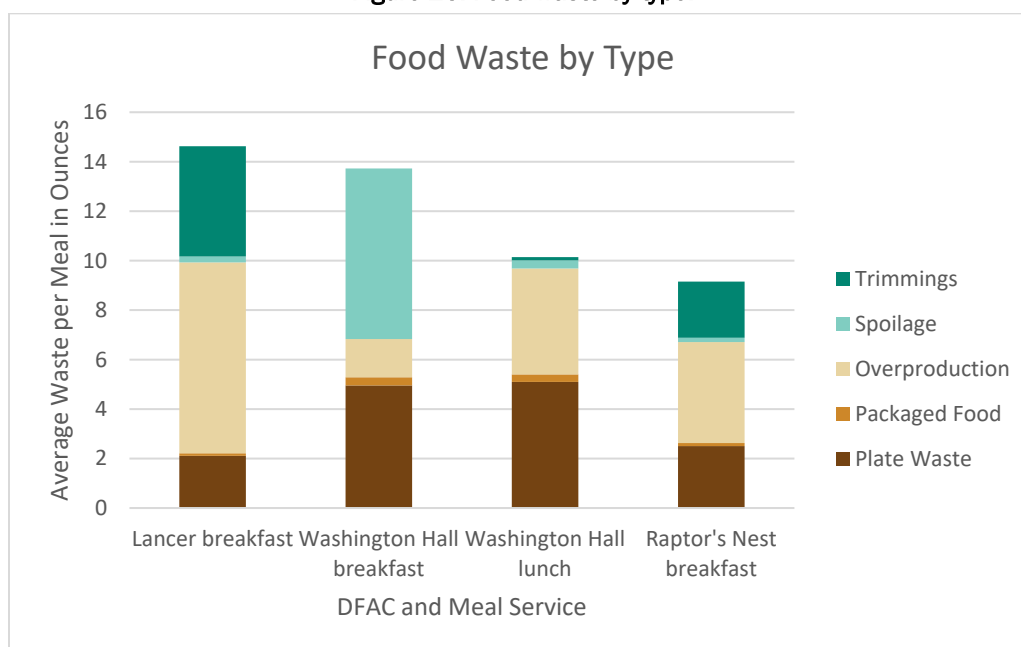
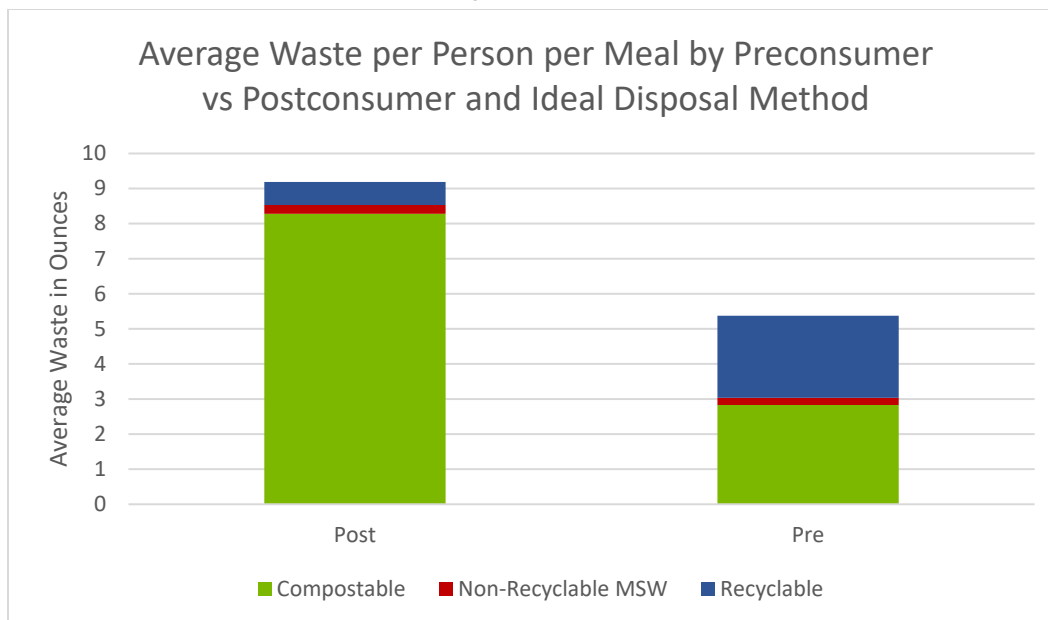


Figure 27 shows solid waste generated at DFACs by ideal disposal method and preconsumer or postconsumer waste. On average, 63% of the waste from each meal is postconsumer waste, and 37% of the waste is preconsumer waste. Of the postconsumer waste, 90% is compostable waste, 7% is recyclable, and 3% is nonrecyclable MSW. Of the preconsumer waste, 53% is compostable, 43% is recyclable, and 4% is nonrecyclable MSW. Overall, 76% of DFAC waste is compostable, 21% is recyclable, and 3% is nonrecyclable MSW.

Figure 27. Average waste per person per Meal by preconsumer versus postconsumer in ideal disposal method.



5.6 GHG emissions analysis

The EPA WARM tool was used to analyze how different waste management scenarios would affect GHG emissions, labor hours, and energy usage. The average amount of solid waste generated by 1,000 diners eating 3 meals each weekday and 2 meals each weekend day was calculated from all available data. The 1,000 diners each eat 988 meals per year, generating approximately 450 ton of solid waste, of which 313 ton is food waste. The baseline waste management scenario was assumed to be landfilling all waste. Actual waste management practices vary by installation. Landfilling was selected to represent a baseline because it is the least preferred method of waste management, as explained in Section 2.4. The baseline GHG emissions are 176.9 t of carbon dioxide. The baseline energy usage is 0.8 Btu. The baseline labor hours are 617 annual hours spent on waste management.

The WARM tool was used to model the following baseline and alternative waste management practices:

- Baseline: All material is landfilled⁴
- Alternate 1: 10% source reduction of each material type with remaining material landfilled⁵
- Alternate 2: 50% recycling or composting rate, depending on the material for each material type with the remaining material landfilled⁶
- Alternate 3: 10% source reduction, 40% recycling or composting, 50% landfilled for each material type⁷

The WARM tool applies negative GHG emissions to materials that are source reduced, recycled, or composted because it is assumed that source reduction and recycling both limit the need to produce new material using virgin raw material. For example, source reduction or recycling of paper products means fewer trees being cut down to produce new paper. Since trees sequester carbon, this is assumed to lead to negative emissions in the model. GHG emissions calculations are shown in metric ton carbon dioxide equivalent (MTCO₂E) values.

As shown in Table 2, the model predicts that GHG emissions are significantly lower in each alternate scenario, but the only alternate scenario that reduces labor costs is Alternate 1, where only source reduction is used. Recycling and composting efforts both increase labor hours. When all items are landfilled, there is no need to separate by material or move items separately. Recycling and composting both require additional work segregating by material type and moving items to separate areas. Composting often requires permitting and other ongoing administrative work.

4. Gloves were included with mixed plastic. Soiled paper was included with mixed compostables. Paper board and textiles were included with mixed recyclables. And nonrecyclable MSW was included with mixed MSW.

5. Source reduction was not modeled in the WARM tool for the mixed recyclables, mixed organics, or mixed MSW categories, so 100% of those items were modeled as landfilled.

6. No modeling for recycling of MSW, #3 plastics, #4 plastics, or #6 plastics, so 100% of those items were modeled as landfilled.

7. Source reduction was not modeled for the mixed recyclables, mixed organics, or mixed MSW categories. Mixed recyclables were modeled as 40% recycled, 60% landfilled. Mixed organics were modeled as 40% composted, 60% landfilled. Mixed MSW was modeled as 100% landfilled. No modeling for recycling of MSW, #3 plastics, #4 plastics, #6 plastics, so they were modeled as 10% source reduction and 90% landfill.

Table 2. Estimates of greenhouse gas (GHG) emissions and labor costs for different waste management scenarios using the Waste Reduction Model (WARM) Tool.

Scenario	GHG in MTCO ₂ E	Energy Use (million Btu)	Labor Hours	Labor Cost (GS-8 Step 1)*
Baseline	176.9027924	0.8	617	\$12,333.83
Alternate 1	10.2390852	-790.08	562	\$11,234.38
Alternate 2	-30.91194724	-854.77	1,526	\$30,504.74
Alternate 3	-156.0116871	-1,474.52	1,289	\$25,767.11

* GS-8 Step 1 hourly wages were \$19.99 in 2021, according to the Federal Office of Personnel Management.

To contextualize what these reductions in emissions and energy use mean, the WARM tool offers equivalencies. As Table 3 shows, both source reduction and recycling or composting materials help to reduce emissions and energy use, but the combination of all methods is most effective in reducing emissions and energy.

Table 3. Emissions and energy use reduction equivalencies in waste management scenarios.

Scenario	Description	Annual Emission Reduction Equivalent	Annual Energy Use Reduction Equivalent
Baseline	All materials are landfilled	N/A	N/A
Alternate 1	10% source reduction and 90% landfill	35 passenger vehicles or 18,754 gallons of gasoline	9 households or 136 barrels of oil
Alternate 2	50% recycle/compost and 50% landfill	44 passenger vehicles or 23,384 gallons of gasoline	9 households or 147 barrels of oil
Alternate 3	10% source reduction and 40% recycle/compost and 50% landfill	71 passenger vehicles or 37,461 gallons of gasoline	16 households or 254 barrels of oil

5.7 Existing solid waste and recycling plans and programs

5.7.1 Qualified recycling programs

A Qualified Recycling Program (QRP) is a recycling program that allows installations to directly sell authorized solid waste materials and retain a portion of the proceeds for installation programs related to pollution prevention, occupational health and safety, and MWR. Food waste is a QRP eligible item, so if a QRP operates on-post, the installation is able to turn the food waste into compost that benefits the QRP. Of the installations visited, JBLM has an on-site composting operation, Earthworks, which accepts DFAC food waste, other installation food waste, and installation yard waste. The finished compost is used on-post for construction, stormwater

projects, area beautification, golf course landscaping, and gardening. Unlike most QRPs, the JBLM QRP does not conduct direct sales, so selling their compost is not feasible. The compost they produce is higher in nitrogen than commercially available compost, so it may not be commercially competitive to compost that can be purchased from garden centers.

5.7.2 Integrated Solid Waste Management Plans (ISWMPs)

Integrated Solid Waste Management Plans (ISWMPs) are the guiding documents for solid waste management on installations. ISWMPs ensure the Army is maximizing efforts of solid waste source reduction, recycling, treatment, and disposal. ISWMPs also ensure environmental and economic efficiency and identify opportunities to increase solid waste diversion on installations. Because food waste is typically the heaviest type of waste by weight, reducing or diverting food waste can help Installations meet their solid waste diversion goals.

5.8 DFACs and the COVID-19 pandemic

Installation DFACs curtailed or altered operations when the pandemic hit the United States in March 2020. In March, it was unclear if transmission through respiratory droplets, aerosols, or through surfaces was most likely, so it was advised to avoid sharing common space and common surfaces. DFACs generally have many people using common surfaces and sharing the same space. Diners generally get food from the buffet line and sit to eat in close proximity.

For safety, many DFACs switched to Grab'n'Go dining only in the initial months of the pandemic. By early May, Centers for Disease Control and Prevention recommendations suggested cloth face coverings be worn when within 6 ft of other people, the DoD required cloth face coverings be worn whenever a 6 ft distance could not be maintained. The requirement to wear face coverings was a further impediment to reopening DFACs. Some installations saw fewer diners in the DFACs due to the COVID-19 pandemic as diners sought dining options that limited interactions with other people, such as take-out or cooking at home. DFACs at other installations saw an increase in diners because soldiers were restricted from leaving post and had fewer on-post dining options.

5.8.1 Fort Liberty

In March 2020, DFACs at Fort Liberty switched to Grab'n'Go options only. As of July that year, headcounts were down 35%, and roughly half of the DFACs were temporarily closed. By late August, 11 facilities were operational and 3 were still closed. Headcounts were about 25%–30% below normal levels. As of mid-October 2020, all meals were still served as Grab'n'Go meals only.

5.8.2 Fort Sill

By October 2020, Fort Sill had a system of increased field feeding and Grab'n'Go options to accommodate the decreased capacity for in-house dining. Field feeding refers to food eaten in the field rather than at DFACs or commercial dining facilities (HQDA 2015). At installations, this would often mean eating rations during field training. Advanced Individual Training DFACs were at 60% capacity, and Basic Combat Training DFACs were at 100% capacity, with distancing. Units with active COVID cases received disposable hot meal packages, with quarantined individuals receiving separate, hot, to-go meals. In terms of headcounts, the United States Army Forces Command DFAC largely stayed at historical norms. United States Army Training and Doctrine Command DFACs saw nominal headcount increase because of reduced access to off-post and other on-post dining options for officers and noncommissioned officers. Changes to feeding operations included increased sanitation, social distancing requirements, installation of plexiglass barriers at cashier stations, removing self-serve in favor of making all foods server-plated, and precleaning field feed equipment outside the DFAC before bringing inside for a second washing.

5.8.3 West Point

The mess hall at West Point was already different from DFACs at other installations. For mandatory meals, cadets are served family style at their dining tables. With new COVID-19 protocols, diners wore masks until seated at their tables. Waitstaff place food on the tables before the diners arrive, to limit interaction. All staff members always wore masks. Diners were assigned seats during mealtimes to facilitate contact tracing if any cadet tested positive for Covid-19. West Point switched to paper plates and plastic utensils, which contributed to approximately 20% of the postconsumer solid waste stream at the time of this study. Waitstaff say that this is to facilitate social distancing among staff in the clipper room.

6 Discussion

Although every effort was made to ensure that data was collected on days without situations that would cause data anomalies, because of the small data set, it is possible that the numbers were skewed more heavily in one direction or another. This could be clarified or overcome with the addition of data collected from more installations. For instance, there was a significant amount of unopened bread being thrown away the day we surveyed West Point. It is unlikely that the same quantity of bread is disposed of on a regular basis. The excess bread was likely a mistake or a one-time miscommunication. Also, because of unusual situations caused by the COVID-19 pandemic, the West Point data may not be representative of typical DFAC waste.

To comprehensively determine the best solutions for the military, more whole-building studies should be conducted. The recommendations (found in Section 7) are the result of extensive research by the CERL research team both before and during this study. However, gaps still exist and there are more opportunities for optimization.

7 Recommendations

The following are recommendations for future analysis and operational changes to Army DFACs.

7.1 DFAC solid waste management opportunity analysis

An opportunity analysis is recommended before installations make changes to their DFAC waste management processes to ensure they are making the most effective changes to their current practices. An opportunity analysis can help installations find opportunities for more effective solid waste management at DFACs. An opportunity analysis can include the following:

- A solid waste characterization
- Opportunities for source reduction
- Potential partners for food donation
- Potential partners for animal feed donation
- Diversion opportunities through composting and anaerobic digestion

The research team intended to identify much of the information that would be found in an opportunity analysis but were unable to do so because of the cancellation of site visits because of COVID-19.

7.1.1 Food recovery hierarchy for avoidance

Food waste makes up the bulk of the solid waste generated at DFACs. When considering how to reduce waste, reducing food waste will have the largest effect on total reduction. The EPA Food Recovery Hierarchy shown in Figure 1 and the DoD ISWM Hierarchy (Figure 2) can guide installations working to reduce DFAC waste.

7.1.1.1 Source reduction

Source reduction refers to reducing the amount of waste produced by eliminating excess food purchases. Source reduction is the preferred method of solid waste management under the EPA Food Recovery Hierarchy (Figure 1) and the DoD ISWM Hierarchy (Figure 2). DFACs are unlikely to reduce the amount of solid waste they produce to zero. The Army has a duty to ensure there is sufficient food for all soldiers, which means that some excess will be made just in case to accommodate higher

headcounts than usual. Each DFAC is also offering a nutritional program that requires a variety of food be offered. Nutritional programs include Go for Green® and H2F and are designed by nutritionists to ensure that soldiers get the nutrients and calories they need for daily activities.

Some DFACs may be producing much more food than is needed to meet nutritional program requirements for anticipated headcounts. Since proper nutrition is vital, it is key find the point of sufficiency between the competing needs. These needs include ensuring that each soldier is has sufficient food, offering options required by the DFAC's nutritional program, saving costs, and reducing waste. Source reduction through limiting purchasing to cover nutritional needs and limiting excess purchasing can save labor time and money, in addition to having environmental benefits.

The EPA lists the following benefits to source reduction:

- “Prevent pollution related to food production, such as fertilizers and pesticides, and save energy associated with growing, preparing, and transporting food.
- Reduce methane emissions from landfills.
- Save money by buying only what is needed and by avoiding disposal costs.
- Save labor costs through more efficient handling, preparation, and storage of food that will be used” (EPA 2022).

Because there are many competing needs that also must be met, the cooperation of FPMs, DFAC managers, and other stakeholders is important. Accurate, up-to-date information about how much food is being wasted and where in the process it is being wasted can help determine where source reduction is possible.

7.1.1.2 Food donation

Food donation also helps to feed people who lack access to the food they need. Feeding hungry people is the second most preferred method of food waste management on the EPA's Food Recovery Hierarchy (Figure 1). Food Donation has been encouraged by the Army Policy Memo on Food Donation of 2014; The Federal Food Donation Act of 2008, Public Law 110-247 (2008); and the Bill Emerson Good Samaritan Food Donation Act of 1996, Public Law 104-210 (1996). Like source reduction, food donation prevents food from going to landfill.

Stakeholders at installations mentioned in interviews the following difficulties in starting up food donation:

- Lack of storage for food to donate, especially when cold storage is needed,
- Inability to use government labor to bring the food to a donation site and the entity accepting food does not have credentials to get on-post,
- The appearance that regularly donating excess food is an inefficient use of taxpayer dollars that bought the food, and
- The need to involve VS and preventative medicine to ensure food safety.

However, food donation is encouraged through the regulations listed at the beginning of this section and should be considered. As explained above, some amount of overproduction is expected because of the need to offer each diner a variety of foods as required by the nutritional program. Also, there are situations where a one-time excess of food may appear. For example, one installation had a major training exercise that was cancelled because of wildfires. The FPM and DPW were able to work with the local Salvation Army to donate the excess food. There were about 6,000 soldiers scheduled to take part in the training, and about 20,000 pounds of food were donated.

Food donation can help those in need in the local community, which can improve relations between the installation and surrounding communities. Like source reduction, food donation keeps food waste out of landfill. If certain types of food waste are regularly generated at a DFAC or installation, having a local nonprofit organization who the installation partners with can be beneficial to make it easier to offer the waste.

7.1.1.3 Food as animal feed

Providing food waste for animal feed may be a beneficial option when an installation is located near pig farming operations. Feeding livestock is the third most preferred method of food waste management on the EPA's Food Recovery Hierarchy (Figure 1). USAG-Hawai'i has a relationship with a pig farmer, and a portion of their DFAC food waste is used for animal feed. Fort McCoy also sends food waste to local farms as pig feed. In South Korea, where the federal government has made food waste reduction a priority, much of the country's food waste is given to pig farmers as animal feed. Feeding livestock does not require the same strict food safety requirements of food donation for people. However, there are still

requirements, which vary by state. The Swine Health Protection Act regulates food waste that contains meat products that will be fed to swine (Swine Health Protection Act 1980).

Partnering with pig farmers to dispose of excess food may be easier for Installations than food donation. Donating food waste as animal feed may be possible if a partnership can be formed with a nearby farmer, as USAG-Hawai'i and Fort McCoy have done.

7.1.1.4 Composting

Composting is the creation of a nutrient-rich soil amendment through aerobic decomposition of organic material (Figure 28). Composting is the fifth most preferred method of food waste management on the EPA's Food Recovery Hierarchy (Figure 1). Compost is a byproduct that can be used throughout the installation in planting beds. Food waste is a QRP eligible item, so if a QRP operates on-post, it may be able to turn the food waste into compost that benefits the QRP.

Several installations, including JBLM and Fort Cavazos, run composting organizations. There is also the possibility to partner with nearby composting operations to have food waste composted, rather than having the installation run a composting operation.

Figure 28. *Left*, compost pile at JBLM's Earthworks; *right*, Heat byproduct from the compost process at JBLM's Earthworks.



In the past 10 years, several states have announced food waste bans for landfill. While installations may not be directly affected as federal facilities, it is also possible that local landfills begin to refuse to take large quantities of food waste. Composting may be one way that installations can dispose of food waste and avoid sending food waste to landfills.

7.1.2 Including waste tracking technology (LeanPath, etc.) in contracts and budgets

A consistent source of data on waste generation allows the DFAC Manager and FPM to see any issues soon after they arise, potentially allowing them to make quick changes to solve those issues. The Fort Jackson study participants who used LeanPath found the system useful and wanted to continue using it. However, they could not because of lack of funding. If LeanPath could be included in the DFAC budget and added to the contract, then they could continue to use the tool and make changes to their Food Program as solid waste generation trends of concern emerged in the data.

In addition to software, there are more low-tech options for monitoring waste. Some food service establishments have tracking systems like LeanPath, but instead of software, a clipboard and a scale are used to track the same information. The downsides are that paper can get dirty and the information needs to be manually input into a computer spreadsheet and converted into charts to allow staff to see solid waste generation trends.

7.2 Focus on sustainable procurement

The preferred method of solid waste management is source reduction, according to the DoD ISWM Hierarchy. Source reduction means buying less to reduce the amount of waste generated. To accomplish source reduction, opportunities for source reduction must be identified and those charge of procurement encouraged to procure fewer of any items they are purchasing in excess. To measure source reduction, installations need a baseline value of waste generation that future values can be compared against. If source reduction is measured, a standard procedure for calculating baseline waste values and for calculating source reduction should be implemented.

7.3 Provide clear guidance and easily understood signage

Disposal procedures vary across installations. A material that can be recycled at one installation cannot necessarily be recycled at another depending on what local authorities accept. Some installations require recyclables to be brought to a recycle center. Others provide recycling containers at each building. Since post populations change frequently, it can be confusing for people who arrive at a new installation. Installations have tried various means of providing information to the post population about Installation recycling policies.

Many installation QRP managers noted that direct outreach was effective in increasing compliance with recycling policies, but it was also labor intensive. Staffing levels for installation recycling programs vary, and capacity to perform outreach activities similarly varies. A handful of installations offer smartphone applications that allow the post population to search by material type to learn how to dispose of each item. If an item is not on the list, application users can request that it be added. Through the addition of this information, the application improves over time. Although application maintenance may be less labor intensive than direct outreach activities, it limits the information flow to those individuals who take time to seek out information.

7.4 Decrease excess food at the serving line and reduce plate waste

According to Department of the Army Pamphlet 30-22, “the menu planner should develop and produce the menus by balancing the following factors: nutrition standards; food safety considerations; plate presentation, complementary food items, and sensory appeal; catalog and seasonal availability of items; diner and regional food preferences; budget, equipment, labor, and time constraints; and special themes” (2019). This calls for providing multiple, appealing choices for diners, which means there will always be some food waste generated from the serving line. Limiting the amount of food on the line and monitoring when more food is needed will decrease the overall amount of excess food that must be thrown out at the end of the meal service. By using smaller serving trays, staff can help reduce how much food needs to be disposed since food on the serving line can no longer be donated. At the same time, the staff must provide a variety of choices, keep prepared food fresh, and make enough food to feed a fluctuating number of diners.

Both staff and diners play a role in decreasing excess food. In some cases, diners are served well above a prescribed serving size. when it comes to how much the diners are served (by staff) or how much they choose to take. Plate waste and the number of packaged goods diners choose to take. If diners can limit what they take to what they will eat, there will be less waste sent to the clipper room. Deciding against single-use or individually packaged items, such as cereal or condiments, and choosing from bulk options are ways that the diners can also help to reduce the amount of non-food waste.

7.5 Make proper disposal accessible

Solid waste containers and storage areas should be accessible where waste is generated. As seen at JBLM, having refuse, recycling, and food waste only containers located nearby in the kitchen allows staff to properly dispose of every material. At one DFAC in the study, bulky wastes such as cardboard blocked walkways as they piled up. Planning space for cardboard storage before it can be moved to the loading dock for disposal is important for maintaining safe walkways a DFAC.

7.6 Incentivize diversion

Several installations use recycling incentive programs to encourage the on-post population to recycle. In exchange for bringing recyclables to the on-post recycling center, units receive funds or vouchers for MWR-run facilities. Recycling program managers have found that having units bring the presorted recyclables to them can more than offset the cost of the vouchers, if priced appropriately. Offering MWR vouchers can be a win-win for the recycling program and for MWR. Diversion rates increase while MWR facilities get more business. Units also benefit because they have funds to use for morale activities. Recycling incentive programs were successfully implemented at Fort Liberty, Fort Johnson, and Fort Sill.

7.7 Consider waste diversion technologies and alternatives

There is no one technology that will work for every DFACs' waste issues. To help stakeholders and decision makers decide how to how best to handle waste management technologies for their DFAC, a previous CERL study compared waste management technologies. A Microsoft Excel interactive flowchart for organic waste diversion was prepared based on their research and can be downloaded online from ERDC Knowledge Core (Fey et al. 2016).⁸

In addition to the flowchart for waste management diversion, the following questions are worth asking before purchasing a new piece of machinery to determine if it is a good fit for the DFAC:

8. ERDC Knowledge Core link: <https://hdl.handle.net/11681/22154>

- How much space is needed to store the machinery and where can it be placed in the DFAC?
 - Would there be any difficulty for staff to access that location?
- What are the recurring costs of operation?
 - Possible costs include electricity use, water use, and additional inputs such as proprietary enzymes.
- Is there a need for heating and ventilation improvements?
 - Some of these machines get very hot.
- Is the electric capacity of the DFAC sufficient to handle additional energy use?
 - Some machines use significant electricity.
- What will be done with any by-products?
 - Some installations have tried to offer dehydrated material for composting, but it may or may not meet the needs of composting operations.
 - The byproduct of Liquid Digestors enters the wastewater stream, so it may be necessary to work with installation DPW to understand if the current wastewater system can handle this byproduct.
- What training is required to operate the machinery and who will conduct the training?
 - How many people will be operating the machinery and how frequent is turnover in that group? At a minimum, training should be offered to each new staff member who will use the machinery.
 - Will refresher training be needed?

- Who will be responsible for machinery maintenance and parts replacement?
 - Who will spend the labor time making calls to maintenance workers and parts providers?
 - Who will provide the labor for maintenance and repair?
- If DFAC is contractor-run, does the contract allow for additional labor time to operate the machinery? If not, can the contract be updated?

Deciding which piece of machinery to buy should be carefully considered. Technological solutions can be expensive to procure, operate, and maintain. Once it has been purchased, it takes up valuable DFAC space and may require labor that can no longer be used for other tasks. For those reasons, the decision should be made with the input of all relevant stakeholders.

8 Conclusions

Food waste is a poor use of resources from water, land, energy, labor, and capital. It also contributes to higher emissions of GHG globally. The further within the food system the waste occurs, the higher in carbon emissions since it would have already passed through harvesting, processing, and transportation. The complete reduction of solid waste from DFACs is an unlikely goal, but any reduction can be beneficial. There will always be some waste because of the need to ensure that all soldiers have adequate and nutritious food available at the DFAC. However, to the extent that it is feasible, solid waste reduction can be beneficial financially and environmentally. The best methods for solid waste reduction will vary depending on the situation at each installation and DFAC. A combination of methods may offer the best solution.

Bibliography

- ASTM. 2016. *Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*. ASTM D5231 West Conshohocken, PA: ASTM. <https://www.astm.org/d5231-92r16.html>.
- Bill Emerson Good Samaritan Food Donation Act of 1996. 1 October 1996. Public Law 104-210. <https://www.congress.gov/congressional-report/104th-congress/house-report/661/1>.
- Clare, Mifflin, Juliette Spertus, Benjamin Miller, and Christina Grace. 2017. *Zero Waste Design Guidelines*. New York: Center for Architecture, Inc. https://www.zerowastedesign.org/wp-content/uploads/2017/10/ZeroWasteDesignGuidelines2017_Web.pdf.
- Department of the Army (HQDA). 2012. *Army Facilities Management*. Army Regulation 420-1. Washington, DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN15517_R420_1_admin_FINAL.pdf.
- Department of the Army (HQDA). 2014. Memorandum. *Army Food Donation Procedures*. Washington, DC, HQDA. https://quartermaster.army.mil/jccoe/operations_directorate/CSPD/Army_Food_Donation_Procedures_Memo_2014-07-31.pdf.
- Department of the Army (HQDA). 2015. *Army Field Feeding and Class I Operations*. ATP 4-41. Washington, DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/atp4_41.pdf.
- Department of the Army (HQDA). 2019. *Army Food Program*. Army Regulation 30-22. Washington, DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN7458_R30_22_FINAL.pdf.
- Department of the Army (HQDA). 2019. *Operating Procedures for the Army Food Program*. Pamphlet 30-22. Washington, DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN18456_P30_22_FINAL.pdf.
- Department of the Army (HQDA). 2019. *Tri-Service Food Code*. TB MED 530/NAVMED P-5010-1/AFMAN 48-147_IP. Washington, DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN15052_TB_MED_530_FINAL.pdf.
- Department of the Army (HQDA), Assistant Chief of Staff for Installation Management. 2012. *Revised Army Standard for Permanent Party Enlisted Personnel Dining Facilities (EPDF)*. Memorandum. Washington, DC: Assistant Chief of Staff for Installation Management. <https://rfpwizard.mrsi.erd.c.dren.mil/MRSI/content/cos/nao/epdf/Library/Archives/EPDF%20Army%20Standard%2020120215.pdf>.
- Deputy Secretary of Defense. 2020. Memorandum. *Stop Movement for all Domestic Travel for DoD Components in Response to Coronavirus Disease 2019*. Washington, DC: DoD. <https://media.defense.gov/2020/Mar/13/2002264686/-1/-1/1/STOP-MOVEMENT-FOR-ALL-DOMESTIC-TRAVEL-FOR-DOD-COMPONENTS-IN-RESPONSE-TO-CORONAVIRUS-2019.PDF>.

- DoD. 2016. *Integrated Recycling and Solid Waste Management*. DoD Instruction 4715.23. Wahsington, DC: DOD. <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/471523.pdf?ver=2018-11-13-140624-277>.
- EPA. 2022. How to Prevent Wasted Food Through Source Reduction. *Sustainable Management of Food*. <https://www.epa.gov/sustainable-management-food/how-prevent-wasted-food-through-source-reduction>.
- EPA. n.d. *Sustainable Management of Food*. Accessed 20 May 2021. <https://www.epa.gov/sustainable-management-food>.
- Federal Food Donation Act of 2008, June 20, 2008, Pub. L. No. 110-247. <https://www.congress.gov/110/plaws/publ247/PLAW-110publ247.pdf>.
- Feeding America. 2016. "Nourishing Healthy Futures: 2016 Annual Report." *Feeding America*. <https://www.feedingamerica.org/sites/default/files/about-us/financials/2016-feeding-america-annual-report.pdf>.
- Fey, C., C. Chadderton, G. Rodriguez, D. S. Gilbert, A. Urban, and C. M. Foran. 2016. *Interactive Flowchart for U.S. Army Installation's Organic Waste Diversion: Dataset*. ERDC/EL TR-16-17. Vicksburg, MS: ERDC/EL. <http://hdl.handle.net/11681/22154>.
- Office of the Assistan Secretary of Defense. 2020. Memorandum. *Revision to the Department of Defense Integrated Solid Waste Management Metrics*. Washington, DC: DoD. https://www.usar.army.mil/Portals/98/OSD_Integrated%20Solid%20Waste%20Metrics%202020.pdf.
- Office of Deputy Chief of Staff, G-9. 2021. *Solid Waste Annual Reporting (SWAR) Web*. Limited access Army database. Retrieved 30 September 2021. <https://aewrs.army.mil/swarweb>.
- Rock, S., and A. Lan. 2019. *Food Waste Reduction in Military Kitchens A Tracking Technology Demonstration at Fort Jackson: Report*. EPA/600/R-19/095. Washington, DC: US Environmental Protection Agency. https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=346767&Lab=NRMRL.
- Singer Equipment. 2022. *Meiko AZP 80 Waste Pulper*. Singer Equipment. <https://www.singerequipment.com/products/meiko-us-azp-80/10022614/>.
- Swine Health Protection Act of 1980. 17 October 1980. Public Law 96-468, Ch. 94, Stat. 2229. <https://www.congress.gov/96/statute/STATUTE-94/STATUTE-94-Pg2229.pdf>.
- US Army Corps of Engineers. n.d. MRSI. *Enlisted Personnel Dining Facility (EPDF)*. <https://mrsi.erdcdren.mil/cos/nao/epdf/>.
- US Army Quartermaster Corps. 2022. *Joint Culinary Center of Excellence*. Last modified 25 February 2022. https://quartermaster.army.mil/jccoe/jccoe_main.html.
- White House, The. 2018. *Efficient Federal Operations*. EO 13834. Federal Register 83, no. (99): 23771–23774. <https://www.govinfo.gov/content/pkg/FR-2018-05-22/pdf/2018-11101.pdf>.

White House, The. 2021. *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis*. EO 13990. Federal Register 86 (no. 14): 7037–7043. <https://www.govinfo.gov/content/pkg/FR-2021-01-25/pdf/2021-01765.pdf>.

Abbreviations

AAFES	Army and Air Force Exchange Service
AR	Army regulation
CERL	Construction Engineering Research Laboratory
DFA	Dining Facility Assistant
DFAC	Dining facility
DoDI	Department of Defense Instruction
DPW	Directorate of Public Works
EO	Executive order
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
FIFO	First in-first out
FPM	Food Program manager
GHG	Greenhouse gas
H2F	Holistic Health and Fitness
IMCOM	Installation Management Command
ISWM	Integrated solid waste management
ISWMP	Integrated solid waste management plan
JBLM	Joint Base Lewis-McChord
JCCoE	Joint Culinary Center of Excellence
LRC	Logistics Readiness Center
MOA	Memorandum of agreement
MSW	Municipal solid waste
MTCO ₂ E	Metric ton carbon dioxide equivalent
MWR	Morale, welfare, and recreation
OASD	Office of the Assistant Secretary of Defense
QRP	Qualified recycling program
TCS	Time/Temperature control for safety
TSFC	Tri-Service Food Code
VS	Veterinary Services
WARM	Waste reduction model

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