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Installation Technology Transition Program (ITTP)

Standard Protocol for Protective Storage of Dormant Army Facilities

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Geoffrey D. Ray

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Abstract

The U.S. Army has an inventory of over 140,000 buildings, ranging in age from decades old to newly construction. When an Army installation experiences a mission change or force reduction, a number of the installation's buildings may become vacated; sometimes, years pass before they are re-used again. How buildings are deactivated and prepared for long term storage will determine the speed and cost of their reactivation. This work developed a protocol for deactivating, storing, and reactivating buildings to minimize maintenance costs and effort during the vacancy period, and to allow the Army to quickly bring these buildings to operational status when they are reoccupied. This work implemented and evaluated the protocol at the Kelley Hill cantonment area at Fort Benning, GA, where a significant number facilities of various types, ages, and conditions had been deactivated. The protocol prepared approximately 100 buildings vacated in the first half of 2016 to remain in a dormant state for more than 3 years, after which, when a reactivation need arises, they must be able to be made ready for occupancy within 2-4 months.

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Preface

This study was conducted for the Office of the Assistant Chief of Staff for Installation Management (OACSIM) under the Installation Technology Transition Program (ITTP) via Military Interdepartmental Purchase Request (MIPR) No. 10902914, "ITTP Ph2 Dormant Facilities." The technical monitor was Kirk W. Ticknor, Chief, Operations and Maintenance Division, Directorate of Public Works, Fort Benning, GA.

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COL Ivan P. Beckman was Commander of ERDC, and Dr. David W. Pittman was the Director.

1 Introduction

1.1 Background

The U.S. Army has an inventory of over 140,000 buildings, ranging in age from decades old to newly construction. When an Army installation experiences a mission change or force reduction, a number of the installation's buildings may become vacated; sometimes, years pass before they are re-used again. How buildings are deactivated and prepared for long term storage will determine the speed and cost of their reactivation.

Buildings that are not properly protected during their dormant phase are vulnerable to damage from water leakage and water vapor infiltration, which can cause mold and mildew growth, deterioration of interior and exterior materials, structural corrosion, pest infestations, etc. Repairing such damage can be costly, and can delay restoration to functional condition. In the worst cases, significant deterioration over time can render buildings unusable.

A protocol for deactivating, storing, and reactivating buildings will minimize maintenance costs and effort during the vacancy period and allow the Army to quickly bring these buildings to operational status when they are reoccupied. Since a force reduction often involves the closure of many types of buildings, a well-developed protocol will include many common deactivation procedures that apply to all buildings, and more specific procedures required for certain types of facilities. An installation's climatic location will also influence the procedures to be implemented.

This work implemented and evaluated a protocol at the Kelley Hill cantonment area at Fort Benning, GA, where a significant number facilities of various types, ages, and conditions had been deactivated after the 3rd Armored Brigade Combat Team (3rd ABCT) transitioned into a much smaller task force. The protocol was to prepare approximately 100 buildings that vacated in the first half of 2016 to remain in a dormant state for more than 3 years, after which, when a reactivation need arises, they must be able to be made ready for occupancy within 2-4 months.

1.2 Objectives

The objective of this project was to develop a protocol with alternatives for proper preparation and maintenance of Army facilities when they are deactivated and while they remain in layaway status. ERDC-CERL worked closely with the Fort Benning Directorate of Public Works (DPW) to develop procedures for deactivating and monitoring buildings during their dormancy so that they can be quickly and economically returned to service at a future date, when need arises.

1.3 Approach

To achieve this objective, ERDC-CERL:

- inventoried the deactivated buildings
- determined building vacancy parameters (partial vs. full vacancy, short term vs. long term dormancy, etc.)
- visually inspected facility conditions, collected data, and analyzed building environmental conditions
- developed deactivation, stabilization, and reactivation procedures
- analyzed Layaway Economic Analysis (LEA) procedures that identify best courses of action for each facility (maintain/improve, dispose, or layaway)
- worked with the ERDC-CERL BUILDER™ Sustainment Management System (SMS) team to develop recommendations for incorporating the LEA process into the BUILDER™ SMS.

1.4 Scope

The protocol covers the major tasks necessary to: vacate and deactivate a building, its contents, and the surrounding perimeter of landscaping immediately adjacent to the building footprint; safely maintain the facility during dormancy; and reactivate it into service when needed.

Each section of the protocol covers a major building system such as the building envelope, or mechanical and electrical systems. Because many of the functional parts of a building are interrelated, some material covered in one section may also be covered in a different section. This repetition is intentional to make each section complete and easy to read.

The protocol covers the major activities in deactivating buildings and monitoring them during their period of dormancy. It does not go into step-by-step processes to shut down, monitor, and perform minimally required maintenance procedures for individual pieces of equipment or building components. The buildings undergoing the protocol are not identical and will not have the same equipment and components; overly detailed procedures for extensive lists of items would result in a cumbersome document that would be difficult to use. More importantly, the protocol focuses on recommendations to address issues, and on alternatives to consider when deactivating a building, to ensure that it will remain in a condition that will enable a quick, efficiently reactivation of the building when required.

This protocol does not look at deactivation and layaway procedures for historic buildings (generally those at least 50 years old), or architecturally significant buildings. While some of the processes in the protocol may apply to historic buildings, historic preservation laws have more restrictive and unique requirements on how historic and architectural features are to be treated. For these buildings, refer to historic preservation guidelines on the most appropriate course of action to take (Park 1991, 1993, 1996).

While the development of the protocol was based on observations made of the buildings at Fort Benning's Kelley Hill, the protocol is intended to be easily adapted to suit the requirements of Army installations elsewhere in the continental United States.

2 Deactivation Considerations

Buildings can become vacant for short time periods when troops are deployed, or longer periods when excess capacity or force reductions result in buildings being unoccupied from a few to many years. Buildings that are vacant for a few months are not considered “deactivated” if they will be fully reoccupied, and no changes are made to the interior furnishings, building cooling systems and heating systems other than changes to temperature setbacks, normal interior/exterior maintenance tasks, etc. (Boiler heating systems require attention for even brief dormant periods to avoid corrosion and freezing issues and are discussed in Chapter 7.)

Buildings for which a decision has been made to vacate the premises and keep it unoccupied for more than 1 year will have some or all of the following characteristics:

- no occupants
- minimal utilities (power, water) or complete shutoff
- all interior furnishings and unused equipment removed
- building secured against access other than for periodic inspections
- mechanical systems that have been laid up or set to provide minimal conditioning
- no repairs or improvements to be made to the building other than to maintain the building envelope’s integrity against moisture and air intrusion
- landscaping around building minimized to simplify maintenance, discourage the presence of harmful pests, and increase security.
- fire protection requirements.

Once a building has been completely vacated, resources will be needed to attend to deactivated buildings, especially if it is desired to be able to reactivate in 2-4 months. There are ways to prepare a building for a deactivated state that minimize ongoing care but adopting a zero maintenance approach is appropriate only for facilities that are scheduled to be demolished or be fully renovated, where the potential future requirement of full renovation (gut and rehabilitate) before being put back into service is acceptable. Full renovations typically take 12-18 months to complete. Coordinate with the installation’s Master Planning department to identify those buildings or

areas of the installation that are slated for future demolition or redevelopment. Even abandoned buildings will need periodic inspection to ensure safety, provide security, and prevent damage to nearby facilities.

An example of the difference between the maintenance or no maintenance approaches is illustrated by two buildings at opposite ends of the condition spectrum. The first building (Figure 2-1) is an approximately 10-year old barracks building that was deactivated. Although the building's heating, ventilating, and air-conditioning (HVAC) system has been shut down, the DPW continued to conduct biweekly inspections of the building's interior and exterior. The landscaping around the building's perimeter has been carefully trimmed to enhance security checks and reduce the risk of damage from vegetation and attractiveness to pests.

For comparison, a second, much older building (Figure 2-2) is awaiting a decision on whether or not it is to be demolished. Only minimal efforts have been made to keep this building from deteriorating completely. If the building must be reactivated to acceptable conditions for occupation, a number of problems would have to be addressed.

Figure 2-1. Recently deactivated barracks with biweekly inspections.

Figure 2-2. Deactivated building with zero maintenance.

Some of the problems that can be seen in the pictures include:

- weeds that are overrunning the parking lot, causing further damage to the pavement surface as they grow through and expand existing cracks
- roof leaks that have likely damaged much of the interior materials
- windows in need of replacement
- overgrown vegetation around building
- an outside electrical panel in disrepair with weeds growing inside it
- non-functional gutters that resulting in ground erosion and eventual damage to the foundation.

2.1 Preparation requirements for deactivating facilities

Several steps are required after a decision has been made to deactivate a facility. Because the building will be unoccupied for extended time periods with no one inside to observe and report any problems that may occur, various initiatives should be completed before the actual process of deactivation begins.

2.1.1 Building stabilization planning

A building stabilization plan must be individually developed for each specific deactivation activity. This plan will account for site specific conditions, including:

- buildings' identification, including current age, condition, design and use
- all appurtenances, including installed HVAC, plumbing, lighting, fire protection, surveillance, Utility Monitoring and Control System (UMCS), and other industrial or commercial process equipment
- anticipated length of dormancy
- likelihood of reactivation
- required reactivation time
- local climate conditions
- capital development plans
- availability of funding and other resources
- economics of alternative approaches
- risks of approaches.

This protocol reviews the major considerations and alternatives for making these plans but does not provide a “cookbook” approach. Each installation's particular circumstances, objectives, priorities, constraints and preferences must be coupled with good judgment to appropriately tailor a plan.

A list of key considerations can be gleaned from the chapter headings in the table of contents and includes building grounds and security, building structure and envelope integrity, building interior finishes and furnishings, a means to avoid contamination problems, mechanical and electrical systems, fire protection systems, plumbing trap maintenance and freeze protection, a means to avoid pest infestation, and building monitoring.

The planning process is complex because building systems are interrelated and even with the best planning and execution, some unexpected deterioration is likely. The necessary thought process will incorporate both objective and subjective aspects. Depending on the size of a deactivation activity, the plan may benefit from the development of a decision tree that systematically lays out the alternatives and outcomes of stabilization. This may be useful because there are multiple stabilization decisions that dictate or constrain subsequent decision points and options.

For example, the primary decision to provide or not provide electricity to a deactivated building will impact other stabilization schemes such as the operation of the facility's HVAC system. Likewise, deciding whether or not to turn off the water supply will impact the fire protection sprinkler system, traps in the building's plumbing system, and other parts of the mechanical system. Figure 2-3 shows two examples of a simple decision tree flowchart for heating/no heating and air-conditioning/no air-conditioning decisions. These flowcharts illustrate one potential approach to integrating the many components of a plan. In practice, for expediency, flowcharting may be more of a mental activity than a written activity for knowledgeable decision makers.

Figure 2-3. Impact of providing or not providing heating and cooling.

Appendix A provides additional examples of key primary decisions and potential supplementary decisions, alternatives and considerations, and typical recommendations for component stabilization. Detailed examination of alternatives in table or flowchart form will facilitate gathering input from others on the plan and communicate the protocol to staff executing it. Installations will need to sort through their options on a case-by-case basis.

2.1.2 Building stabilization

Stabilize the building by making any necessary repairs and completing maintenance requirements for the building to prevent or minimize the possibility of further deterioration of the building's condition during the period it

is vacant. This involves sealing all penetrations to the building envelope to prevent moisture intrusion and entry of pests, removal of all nonessential interior furnishings that can be reused elsewhere, and cleaning/sweeping all interior floors. Depending on how long the building is expected to remain vacant, the electric power supply may be shut off entirely or in part (to maintain some lighting and facility monitoring through the UMCS), the HVAC system may be operated at minimally conditioned temperatures or shut off entirely and laid up, and the water supply may be shut off and all plumbing traps filled with antifreeze. Secure access to all exterior doors, windows, and any other potential points of entry, and extensively trim or entirely remove all landscaping around the building perimeter.

2.1.3 Condition assessment and documentation

Perform a condition assessment of the building's envelope, electrical and mechanical systems, and structure to document their condition at the time of deactivation. If possible, remove all unneeded furnishings before the assessment to allow the assessment to be conducted more quickly and to minimize any obstructions that can impede visual inspections. The assessment will cover the entire exterior envelope of the building, and a room-by-room inspection of all the interior rooms. Conduct and record inventory, location and condition of any furnishings, equipment, etc. that has to remain inside the building. Any critical defects or damage to the building components, such as water leaks or inoperable exterior door locks, must be identified and corrected before the completion of the deactivation process. The results of the assessment should be documented in both written and photographic form, and will serve as a baseline record of existing conditions. Subsequent inspections of the building during the layaway period can then be compared against the baseline records.

2.1.4 Fire protection

Obtain direction from the installation fire chief (or other authorized personnel) on the extent of fire protection required for buildings in layaway status. If the fire sprinkler systems are to be deactivated, determine the process to properly shut off the systems, the steps needed to minimize the combustibility of the buildings and their contents, and the maintenance efforts required over the period of vacancy. If the sprinkler systems are to be kept operational, then determine their maintenance requirements, espe-

cially in buildings in colder climates that will not be heated during the heating season. Fire alarms should be kept active. Fire extinguishers should be removed and reused elsewhere on the installation. Refer to Chapter 8, Fire Protection Systems, for more information on fire protection considerations.

For buildings outside of the installation, the local building inspector may need to be consulted.

If many buildings or a very large building is deactivated, local utility providers should be made aware of the changing needs so they can plan appropriately to better serve remaining customers.

2.2 Types of deactivation

2.2.1 Heating levels

When considering deactivation of one or more buildings, it is common to hear terms such as “warm” and “cold” deactivation. Other terms used to describe types of deactivation are “standby,” “reserve,” and “abandoned.” Circumstances vary from location to location and some installations may find that different terms work better for their particular situation. These terms generally refer to whether or not heat is left operational during the closure. In most of the United States, this decision is primarily made to avoid frozen of pipes and sewer traps. However, individual facility circumstances and requirements will determine the heating systems that get shut off and the ones that remain in an active mode during a building layaway.

Making the right decision depends on both the length of the deactivation period and the severity of the winters. It is reasonable to base most decisions of how to prepare the building for deactivation on whether the building will be needed in the next year, or whether it will be deactivated for a longer period. A common exception to the 1-year threshold is for very cold climates, where it is typically the best decision to drain all water and take other necessary steps to prepare for a no heat condition if a building will be deactivated for even one winter.

2.2.2 Maintenance levels

Manpower and funding for maintenance activities on installations are limited, and will be primarily applied to fully occupied and operational buildings. Vacant and deactivated buildings will receive much less maintenance

attention. The actual level of maintenance that can be dedicated to these buildings (Table 2-1) will depend on their expected period of vacancy, potential for re-occupancy, age, complexity, physical condition, etc. For example, a well-maintained 10-year old administration building has a higher potential for reuse than an unrenovated 1960s era “rolling pin” barracks. Power and water may still be provided to the deactivated admin building and inspection visits may be carried out on a regular basis, while the deactivated barracks may have no utilities at all, and may receive only sporadic visits to check for water leaks and signs of unauthorized access.

Table 2-1. Layaway characteristics and levels of maintenance.

		FACILITY OPERATIONAL STATUS :			
		DEACTIVATED			
		UNOCCUPIED	STANDBY - LIKELY REACTIVATION	RESERVE -POTENTIAL REACTIVATION	ABANDONED
Layaway Characteristics/ Requirements	Length of Vacancy	Less than 1 year	0 to 5 years	5 to 10 years	permanent
	Reactivation Time	60 to 90 days	2 to 4 months	12 to 18 months	none
	Level of Maintenance	A (full to partial)	B (limited)	B (limited)	C (minimal)
	Inspection Frequency	monthly/quarterly	monthly/quarterly	quarterly/semi-annual	only as needed*
Level of Maintenance Descriptions: A Maintain during unoccupied period to ensure facility readiness at reoccupation. Eliminate fire, health, and safety hazards. Frequency of maintenance is reduced the longer the building remains vacant. B Limited maintenance to ensure integrity of building envelope, structure, fire protection, and to eliminate any safety or health hazards. Discovered deficiencies are repaired, not replaced. C Maintain only to eliminate any fire, safety, and health hazards. Inspection Frequency: Can be more or less frequent based on the type of building, and local installation's preference. * “only as needed” involve only the tasks required to ensure safety, provide security, and prevent damage to nearby facilities					

The climate zone in which an installation is located is another factor when considering whether to continue paying utility costs to provide heating and air-conditioning during the vacancy period. Unheated building interiors in cold climates may suffer from peeling paint, loosening of floor tiles, cracking of walls and floor slabs, freezing of water and fire sprinkler pipes (if not drained previously), etc. Some of these will not be as much of an issue if a building will remain vacant for a number of years, since it is likely most of it will be replaced when it is reoccupied in the future.

2.3 Documentation (closure report)

A closure report documents the status and contents of the building after it has gone through the deactivation process and has arrived at a state of dormancy. Copies of the completed report should be filed in a central depository for all the dormant buildings where it can be accessed by the DPW and its service contractor. The contents of the report should include:

- location and status of water shut-off valves
- location and status of gas-operated equipment and shut-off valves
- location and status of electric distribution boxes
- operational status of fire alarms and fire protection systems
- location of still operational sump pumps and their electrical supply
- status of lighting (exterior and interior)
- inventory of any furnishings, equipment, etc. still remaining inside the building, and their location and condition
- location of any damaged exterior windows and doors
- location of any potential lead base paint or asbestos
- as observed condition of building envelope
- include and label any photographs that can help document the above.

2.4 Economics

The economics of deactivation depend on the current condition of the building and can vary based on the design of the building and the local weather. The most important variable is often the least certain – whether and when the building will ever be used again. This one factor has a large impact on how much effort should go into preparing the building for deactivation and on how much ongoing maintenance should be performed. The length of time needed to return the building to an active state is also a factor.

The decision of what to do with a given excess facility is a difficult one. Even if the facility will actually be needed at some future date, intuition says there is a point in almost every facility's life at which replacing it is a better alternative than struggling to maintain it. This is also true for active buildings but the variables are more uncertain for inactive facilities that

may no longer receive a level of attention and maintenance necessary to stem the tide of deterioration. If the facility is ultimately not needed again, valuable resources will have been devoted to maintaining a facility when those resources could have been used more effectively elsewhere.

Although economic factors are not the only consideration in deciding whether or how to deactivate a facility, they do serve as a crucial starting point since they yield results that are quantifiable, easily understood, and easily compared. Key questions to consider include:

- Should the excess facility be demolished and replaced at some future time if the need arises?
- Should the facility be mothballed and maintained in an inactive state so it can be rapidly prepared when needed again?
- What is the likely cost of each alternative? And at what point in time and under what circumstances is one alternative less expensive than the other?

Answers to these questions do not come easily. Many individual costs that vary by type of facility and location must be included. The fact that most costs will occur in the future introduces a high level of uncertainty, so that risk also must be considered. With the large number of excess facilities in the Army's current inventory, highlights the need for a method to rapidly assess the costs and risks associated with different alternatives for dealing with these facilities.

2.4.1 Approach to evaluating layaway alternative economics

The three most likely alternative strategies for excess facilities (Subick et al. 1996) are:

- *Demolish and Rebuild.* Initial demolition of the facility followed by new construction when and if a future requirement arises
- *Layaway and Renovate.* Mothballing of the facility with limited maintenance and climate control during the inactive period, and partial renovation if the facility is required in the future
- *Walk Away and Renovate.* A "walk away" strategy using minimum layaway preparation, no maintenance or climate control during the inactive period, and full renovation if the facility is reactivated.

Although the third strategy is not generally desirable, lack of near-term funds to implement one of the other two strategies may make it the only feasible alternative. The second and third alternatives represent the two extremes of the layaway possibilities. The costs and risks associated with intermediate levels of layaway preparation and maintenance were assumed to lie between those of the second and third alternatives.

Two decision points determine the possible outcomes and associated costs for the three alternatives. The first decision point occurs initially, when the decision is made to demolish, layaway, or walk away. The second decision point occurs at an undetermined time in the future when either the facility is needed again or a final decision is made that it will not be needed and must be demolished. The costs associated with each alternative depend on the length of time between the two decision points. It is recommended to consider the impact of the dormancy period varying from 1 to 10 years when deciding the option to pursue.

2.4.2 The layaway economic analysis tool and BUILDER SMS

Each installation may choose to develop its own economic analysis based on the considerations mentioned above. However, since the analysis can be quite complex, it may be worthwhile to wait for the upcoming release of the lifecycle costing module of the BUILDER SMS software.

To compare the costs of each alternative, the unique cost items associated with each alternative must be determined. To assist in this task, in 1996, CERL developed the Layaway Economic Analysis (LEA) tool (Appendix B). The LEA tool considered the costs of any energy, maintenance, layaway procedures, existing facility repairs, code and compliance upgrades, total facility replacement, and demolition for a range of alternatives. Although LEA is outdated and not currently a viable tool for the analysis it was originally intended for, the concepts, procedures, and information to be gathered for analysis remain valid. ERDC-CERL has since developed the BUILDER Sustainment Management System (SMS) to manage the lifecycle of existing facilities and model component deterioration, service life, and work cost.

The LEA tool's capabilities can be updated and modernized by leveraging the data and analysis capabilities available in BUILDER SMS. ERDC-CERL's BUILDER SMS team is currently working on incorporating the analysis features in the LEA tool into a prototype MS Excel module. The prototype LEA

module accepts facility information from BUILDER, and calculates the lifecycle cost of different facility alternatives. The prototype LEA module allows users to easily see the algorithms used to produce the lifecycle cost calculations, and to easily adjust model assumptions and costs.

Once the prototype module is tested and verified, it will serve as the requirements specifications for a new Layaway Economic Analysis capability directly in the SMS platform. It will also expand the capabilities of the SMS suite to better support strategic decisions related to the U.S. Department of Defense's (DoD's) vast facilities portfolio, and expand the capabilities for Infrastructure and Facility Life Cycle Asset Management. The result is a standardized cost model for the mothball activity to allow consistent review of failing facilities and their recommended mitigation investments across the DoD portfolio.

The Layaway Economic Analysis model considers three alternatives for an existing facility. The first option is to demolish the facility, with the option of replacing the facility with a newly constructed one in the future. Under this scenario, there is a cost for demolition and a cost if the facility is replaced, but obviously no cost for maintenance or energy in between. The second option is to layaway the facility for a period of time, with the option of reactivating the facility at a future point. Here, there may be a cost for maintenance and energy during the inactivation period, but this is typically less than under normal operations. There is also some cost for layaway procedures to prepare the facility for its inactivation period, to ensure that it will still be in sound condition if reactivation is needed. Finally, the third option is to continue to use and operate the facility under normal operations and maintenance (O&M) procedures regardless of the facility's occupancy rate. In this situation, there is no reduction in energy use, maintenance spending, or special preparations for dormancy. Table 2-2 summarizes the costs for each alternative.

In addition to the costs of each alternative, the model must also consider the changing state of the facility under each alternative. The first alternative, demolition and replacement with a new facility, will result in a high performing facility, but will also require additional lead time to construct and bring the facility on line. In second and third alternatives, the facility may undergo rehabilitation during the dormancy period, but older facilities will likely perform less efficiently than their newly constructed counterparts. In addition, if the facility is unoccupied, deterioration may actually accelerate unless the facility is active monitored.

Table 2-2. Costs for each decision alternative.

	<i>Demolish</i>	<i>Layaway/Reactivate</i>	<i>Continue to Use</i>
Layaway Activities	Layaway Pending Disposal	Initial Layaway Activities	N/A
Demolition	Demolition/Disposal	N/A	N/A
Replacement/Renovation	Facility Replacement	Planned basic Renovation	Planned basic Renovation
		Renovation add-ons for preservation	Renovation add-ons for preservation
Relocation	Relocation	Relocation of occupied portion	N/A
Operations Costs	Maintenance Pending Disposal	Maintenance During Layaway	
		Energy During Layaway	Energy at % Occupancy
	Energy for new Active Facility	Energy for Reactivated Facility	Energy Costs after Renovation
	Annual Recurring Maintenance	Annual Recurring Maintenance	Annual Recurring Maintenance
Compliance Issues	Asbestos Removal	Asbestos abatement	Asbestos abatement
	Removal of UST	Lead hazards abatement	Lead hazards abatement
		ADA upgrades	ADA upgrades
		Seismic Rehabilitation	Seismic rehabilitation
Historic Issues	Admin/coordination - Demolition	Admin/coordination - Layaway	Admin/Coordination - Renovation
	HABS/HAER Mitigation - Demolition		HABS Mitigation - Renovation
		Annual Management	Annual Management
		Historic Survey	Historic Survey

2.4.2.1 Model inputs and assumptions

The layaway Economic Analysis model forecasts the present value costs for a range of alternatives over a specified period of time. To perform the calculation, a number of assumptions are formulated that affect these cost forecasts. Global variables include cost escalation factors for work activities and energy rates, as well as assumed discount rate. Site specific variables include area cost factor, local energy rates, and the climate zone that affects energy use intensity and energy consumption forecasts. Building specific variables can be imported from BUILDER SMS, including the building type, year constructed, size, number of floors, wall, roof, and superstructure type, and condition of the individual systems of the building. Table 2-3 lists typical building level information for the model, and the location where the information resides in BUILDER. Figure 2-4 shows the BUILDER System Summary Report used as input for the building system condition levels.

The LEA model also considers a number of analysis specific factors, including:

- historic preservation considerations
- heat/cool to control climate during layaway
- remove asbestos before layaway
- remove lead hazards before layaway
- earliest year to demolish
- percent facility to be occupied during continued use
- probability that the facility will be needed in 10 years
- probability that the facility will be adequate when needed again.

Table 2-3. Building descriptive information.

Basic Info	Example Value	Builder Link
Category Code	13120	Facility Category Code
Exterior Wall Type	Brick	Wall Component Type
Roof Surface Type	Shingle - Asphalt	Roof Component Type
Superstructure Type	Unreinforced Masonry	Building Type
Construction Year	1990	Year Built
Gross Area (SF)	1000	Facility Quantity
Number Floors	1	Building Floors
Current Condition	Amber	Building Condition Index (BCI)
Percent Occupied	50%	N/A
Comments		Building Comments

Figure 2-4. Example BUILDER System Summary Report.

Final 2 - System Summary Report						
Installation Code	Installation Name	Special Area	RPUID	Bldg Num	System	System CI
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	A10 FOUNDATIONS	93
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	A20 BASEMENT CONSTRUCTION	
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	B10 SUPERSTRUCTURE	88
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	B20 EXTERIOR ENCLOSURE	84
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	B30 ROOFING	83
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	C10 INTERIOR CONSTRUCTION	85
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	C20 STAIRS	
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	C30 INTERIOR FINISHES	83
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	D10 CONVEYING	87
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	D20 PLUMBING	86
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	D30 HVAC	87
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	D40 FIRE PROTECTION	87
M60169	MCAS Beaufort	Main	NFA10000025 0104	1130	D50 ELECTRICAL	88

The LEA model then takes these inputs to compute a number of facility related costs over the analysis period (See Appendix B, Section B.5 for more detailed descriptions of these costs):

- cost of demolition
- cost of replacement
- cost of renovation
- costs of layaway procedures
- energy costs
- maintenance and repair costs

- additional costs (such as for hazardous waste removal, Americans with Disabilities Act [ADA] upgrades, seismic upgrades, etc.).

2.4.2.2 Analysis

The LEA prototype model allows the comparison of the different alternatives described above against one of more building facilities. The first step in any analysis is to enter or review the basic local and global assumptions (Figures 2-5 and 2-6), and to enter the information that describes the current facility being studied. Once all of the input data is provided, the models discussed above are used to estimate the cost of several lifecycle events that may apply, including demolition, replacement, renovation, ongoing maintenance, and energy usage (Figure 2-7). The user can review and edit these cost estimates to tailor an analysis to their known circumstances.

Figure 2-5. Local analysis inputs.

Basic Info	Example Value
Category Code	13120
Exterior Wall Type	Brick
Roof Surface Type	Shingle - Asphalt
Superstructure Type	Unreinforced Masonry
Construction Year	1990
Gross Area (SF)	1000
Number Floors	1
Current Condition	60
Percent Occupied	50%
Comments	
Renovation	
Substructure	50%
Superstructure	50%
Roofing	50%
Exterior Closure	50%
Interior Construction	50%
Interior Finishes	50%
Specialties	50%
Plumbing	50%
HVAC	50%
Special Mechanical	50%
Electrical	50%
Special Electrical	50%
Equipment	50%
Conveying Systems	50%
Site and Grounds	50%
Parking	50%
Future Plans	
Heat/Cool to control climate during layaway	No
Remove asbestos before layaway	No
Remove lead hazards before layaway	No
Earliest year to demolish	2019
Percent facility to be occupied during continued use	0%
Probability facility will be needed in 10 years	100%
Probability facility will be adequate when needed again	100%

Figure 2-6. Global Inputs - Location.

Figure 2-7. Unit cost assumptions and estimates.

Layaway Activities	Demolish		Layaway/Reactivate		Continue to Use	
	Layaway Pending Disposal	0.14 \$/SF	Initial Layaway Activities	1.08 \$/SF	N/A	N/A
Demolition	Demolition/Disposal	16.62 \$/SF				
Replacement/	Facility Replacement	428.83 \$/SF				
Renovation	Relocation	1.55 \$/SF	Planned basic Renovation	244.54 \$/SF	Planned basic Renovation	244.54 \$/SF
Relocation	Maintenance Pending Disposal	0.05 \$/SF/Year	Relocation add-ons for preservation	\$/SF	Relocation add-ons for preservation	\$/SF
Operations Costs			Relocation of occupied portion	1.55 \$/SF		
			Maintenance During Layaway	0.23 \$/SF/Year		
			Energy During Layaway	0 \$/SF/Year		
	Energy for new Active Facility	3.57 \$/SF/Year	Energy for Reactivated Facility	3.88 \$/SF/Year	Energy at % Occupancy	1.68 \$/SF/Year
Compliance Issues	Annual Recurring Maintenance	1.5 \$/SF/Year	Annual Recurring Maintenance	1.78 \$/SF/Year	Energy Costs after Renovation	3.88 \$/SF/Year
	Asbestos Removal	\$/SF	Asbestos abatement	\$/SF	Annual Recurring Maintenance	1.78 \$/SF/Year
	Removal of UST	\$	Lead hazards abatement	\$/SF	Asbestos abatement	\$/SF
			ADA upgrades	\$/SF	Lead hazards abatement	\$/SF
Historic Issues			Seismic Rehabilitation	\$/SF	ADA upgrades	\$/SF
	Admin/coordination - Demolition	\$	Admin/coordination - Layaway	\$	Seismic rehabilitation	\$/SF
	HABS/HAER Mitigation - Demolition	\$			Admin/Coordination - Renovation	\$
			Annual Management	\$	HABS Mitigation - Renovation	\$
			Historic Survey	\$	Annual Management	\$
					Historic Survey	\$

Once the costs are reviewed, the user can explore the different alternatives for a facility and view analysis reports and charts that show the total cost of ownership for each. The results give facility managers a way to rapidly compare costs and facility performance (Figures 2-8 and 2-9) to inform a range of decisions regarding their excess facilities portfolio so they can choose the best alternative.

Figure 2-8. Annualized cost comparison.

Figure 2-9. Cumulative cost comparison.

3 Building Grounds and Security

Although access to most military installations is controlled, there is still potential for squatters to occupy vacant buildings. Squatters can be anyone from homeless people who have entered an installation without authorization to people on the installation seeking a location to conduct unsanctioned or illegal activities. Squatters may vandalize and steal equipment, fixtures, and fittings, and may potentially compromise installation safety and security. Vacant buildings and grounds can also be used for unwanted storage (or dumping) of excess, stolen, or broken equipment. Repair of damaged equipment and buildings and cleanup of abandoned junk will increase the cost and time required to restore buildings to fully functional condition when the time comes to reactivate them again.

3.1 Securing access

3.1.1 Doors and windows

Doors and windows must be securely locked and bolted to prevent unauthorized entry. Doors in poor physical condition or door frames not securely attached to the building structure can be easily opened or broken into even if they are locked. Depending on how long a facility will remain vacant, the level of security surveillance or local preference, consideration should be given to boarding ground level windows or installing security screens (Cosh 2012).

One concern with commercial or institutional buildings is they may be situated in scattered or isolated locations, and boarding up windows or doors will flag the buildings as vacant. Additionally, their very isolation makes them more vulnerable to vandalism or break-ins. This may not be as much of an issue on military installations, which are usually self-contained, and presumably are regularly patrolled by security staff. However, each installation will need to determine the most appropriate course of action.

Some buildings may be in such poor physical condition that reactivating them again to a condition suitable for occupation will be very costly and not practical. Only periodic security checks of these buildings may be needed to check for signs of squatting or vandalism. Boarding windows (Figure 3-1) in these situations can be considered to deter entry and prevent vandalism.

Figure 3-1. Boarded up window in dormant building.

If a decision is made to seal windows, boarding can be done using plywood or concrete masonry unit (CMU) blocks. This may require removal of the window frame, and the boarding material must be sealed tightly to prevent air infiltration and water intrusion. Doors and windows above the first floor that are still accessible from stairs or roofs above entrances should also be boarded (DCAM 2003). Additional types of boarding material are clear polycarbonate panels, stainless steel mesh, or expanded metal lath. Oriented strand board (OSB) should not be used in place of plywood. OSB may have the same structural strength as plywood, and may cost less, but its edges are very vulnerable to swelling due to moisture intrusion, and OSB takes longer to dry and will remain swollen even after it has dried.

3.1.2 Rooftops and utility corrals

For buildings with rooftop mechanical units, remove exterior access ladders if they exist, and secure roof hatches from the interior. If thieves can reach the roof, they can work relatively unobserved from ground level to strip rooftop equipment. Exterior mechanical equipment located in utility corrals or fenced in areas are often located behind buildings, or are surrounded by vegetation. Access to these areas must be secured as well (Cosh 2012).

3.1.3 Key systems

To maintain safety and to allow access/egress for security and fire department personnel, remove locksets, latches, and cipher locks from all interior doors and vaults that cannot be set in an unlocked mode. Fire doors should not be propped open unless approved by the fire chief.

When buildings are occupied, the doors to each building and rooms within the building may all have their own separate key for security reasons. This is particularly important for buildings like barracks where each barracks unit must have its own key. Once a building has become vacant and will be dormant for an extended period of time, maintaining separate, individual keys for all the buildings and rooms can become very time consuming and cumbersome if the buildings are being inspected periodically. The right photo in Figure 3-2 shows the keyset for a 4-story barracks building. The mass of keys weigh several pounds, and it can take a number of tries before the right key is found for a specific room. If permitted by the installation's security department, it would be much more efficient if a single master key can be created that can open all the rooms in the building.

Figure 3-2. Key cabinet (left) and key sets for a barracks building (right).

3.2 Monitoring and surveillance

Conduct regular daytime and nighttime drive-by surveillance by local security personnel. This should include periodic walks around the perimeter of the building for close up inspection for signs of unauthorized or attempted entry, vandalism, graffiti, and damage from weather. Repeat the same for an entire walkthrough of all the interior rooms. Promptly repair any observed damage (Oldham 2016). Monitoring alarms and cameras alone are not sufficient, but can enhance physical surveillance.

Occurrences of vandalism or break-ins should be dealt with promptly. Otherwise, these can quickly escalate if lawbreakers sense that security is not a high priority, or that vacated buildings are entirely insecured.

3.3 Security lighting

Ideally, all exterior entry doorways and stairwells should be illuminated if power is maintained at the building. Consider wiring motion sensors to entry door lights so that they turn on only when intruders are detected. This can be especially appropriate for multi-level barracks with multiple exterior access doors to reduce energy consumption in unused facilities.

If security floodlights are used, instead of illuminating the building, direct the lighting fixtures away from the building towards any area of potential intrusion. Ground level floodlights are not recommended; mount them on buildings to make them more difficult to disable (Cosh 2012).

3.4 Signs

Install signs in prominent locations stating that the buildings and grounds are under constant monitoring, and periodically “date” the signs to show that the sign was recently placed and that monitoring is ongoing (Figure 3-3). Repair or replace signs that are damaged or worn.

If the building’s fire sprinkler system has been deactivated, this should be either noted on the sign, or by some type of marking system used to make firefighters aware of this condition in the event of a fire. Figure 3-4 show two examples of signs used by fire departments to identify buildings requiring extra caution in the event of fire.

Figure 3-3. “No Trespassing” sign.

Figure 3-4. Examples of fire marking signs.

3.5 Exterior landscaping

3.5.1 Trees, bushes, and shrubbery

To allow easier visual surveillance, remove bushes, shrubbery, and trees that hide or obstruct view of the buildings, especially door and windows (Figure 3-5). Consider how bushes and shrubs will grow, especially during a deactivated state where the landscaping maintenance is likely to be reduced. Remove and prevent the growth of ivy and vines on exterior walls (Figures 3-6 to 3-8). A layer of ivy or vines can accumulate moisture that creates an environment that harbors insects, allows undissolved minerals within water droplets to leave deposits on the wall surface, and enables freeze-thaw cycles that can increase the size of any existing cracks. Some vine species climb by twining around objects such as downspouts or conduit. The diameter of the vines increase with age, and can pull objects apart. Other vines grow through tendrils or tiny suckers that embed into gaps and cracks or adhere permanently to surfaces.

Figure 3-5. Overgrown vegetation around a deactivated barracks building.

Figure 3-6. Vegetation blocking louvers to a mechanical room.

Figure 3-7. Vegetation growing on and around a chiller.

Figure 3-8. Vines growing on walls and window.

Once established, the growth can be very difficult to remove. This is particularly challenging if a building's exterior wall has an exterior insulation and finish system (EIFS) as the cladding material as the vines will be impossible to remove without damaging the surface of the EIFS. Also, be advised that certain vines, such as the Virginia Creeper (*Parthenocissus quinquefolia*), have berries that are very toxic, and sap that can cause skin rashes. Vines and ivy can be removed by cutting them off as close to their roots as possible at ground level. Allow vines to die and dry out before removing. Clean the wall surface and patch if needed (Kibbel 2018). The roots of trees growing too close to buildings (Figures 3-9 and 3-10) can damage foundations and walls. In a strong wind, untrimmed tree branches can damage windows, walls, and roofs.

Figure 3-9. Maple tree growing within 3 ft of building.

Figure 3-10. Tree roots encroaching on building foundation.

A vegetation-free zone of 5-10 ft wide (or whatever distance the installation designates) around the perimeter of the building will reduce the growth of obstructions; minimize rodent burrows, plant colonization, and insect infestation; prevent plant roots from damaging building foundations; increase air circulation; reduce moisture content along foundation walls by removing shade; and minimize fire risk from dead and dried vegetation.

Continue to maintain the building grounds during the period of dormancy. If no regular grounds maintenance is being performed, the vegetation free zone should be covered by landscape cloth with a layer of pea gravel or landscape rock on top.

3.5.2 Grading and surface drainage

Fill in any nearby depressions where stagnant water may accumulate (Figure 3-11).

Slope adjoining ground away from building if possible to prevent water from flowing into buildings during heavy rain, or from snow melt (Figure 3-12).

Figure 3-11. Standing water near building.

Figure 3-12. Sloping ground towards exterior building doors will direct rainwater inwards.

3.6 Site safety hazards

As buildings are vacated, entries may be left open, trash left unpicked up, hazardous equipment abandoned, etc. The areas around buildings should be visually examined to ensure that potential hazards are removed or otherwise resolved. Figures 3-13 and 3-14 show two examples of potential safety hazards found near buildings.

Figure 3-13. Access hatch to abandoned steam lines left open.

Figure 3-14. Concertina wire abandoned near the building.

3.7 Metal theft

Theft of metals, scrap or otherwise, seems unlikely given that entry to most bases is through checkpoints or gates. This is still possible, however, due to the large number of vehicles entering bases daily, the very light pedestrian and vehicular traffic in an inactivated and dormant part of a base, the many potential “hiding places” around buildings, and the large number of vehicles constantly leaving bases without inspection. Metal theft can continue even when prices for scrap metals decrease as thieves try to steal more metal to make up for the lowered prices being paid (Blosfield 2016).

Theft of copper (copper piping from plumbing and sprinkler systems, and wiring) makes up a majority of metal thefts. Besides potentially safety impacts (when fire protection systems are taken out of service), the economic consequences of metal theft can be significant. For example, a 5-ton air conditioner that has a scrap value of \$20-\$30 has a replacement cost of \$2,000 to \$3,000, not including the costs of replacing the connecting piping that are also likely to have been stolen. Damage to the building itself can also have occurred as walls and ceilings are torn up to get to metals, and water damage result from destroyed piping. In the meantime, the building may not be usable while the missing equipment is being replaced and restored to operating condition. Table 3-1 shows the variety and sources of metal that can be found within a building (Oldham 2016). Protective measures against metal theft include securing access to the building and performing regular surveillance.

3.8 Utilities

3.8.1 Water supply

This is also discussed in other sections, but shutting off the main water supply to the building will reduce the risk of freezing pipes during cold weather if the building is unconditioned. In dormant facilities that are not inspected on a daily basis, water damage from burst pipes or caused by stolen water or sprinkler pipes will be minimized if the water supply has been previously shut off (Cosh 2012).

Unless there is a specific need to continue watering vegetation, the water supply valve(s) for any existing lawn or landscape irrigation systems around buildings should be shut off and compressed air blown through the piping system to remove any remaining standing water.

Table 3-1. Variety and sources of pilferable metals.

	Location	Material and Equipment Stolen
Outside a Property	Roofing	Lead and copper sheet
	Guttering	Lead hoppers and downpipes (especially in older buildings)
	Lightning conductors	Copper downpipes
	Air-conditioning or process	Copper
	Cooling units	Copper cooling coils and radiators
	Drains and manhole covers	Cast iron and steel
	Signs	Aluminum
	Gates	Wrought iron
Inside a Property	Pipework	Copper water and heating system
	Heating boilers	Pipes
	Radiators	Cast iron casings and brass fittings
	Cable	Copper
	Plant	Generators and air compressors
	Sub-station components	Copper bus bars and cable

3.8.2 Electricity and gas

Shut off electric power to wall outlets to prevent usage by squatters and to reduce the risk of fire. Squatters can go to creative lengths to heat or cool a space. In one case, intruders in a barracks room tried to use a refrigerator to provide cooling by positioning it in an exterior doorway, and opening the refrigerator door to face into the room.

Shut off main gas supply to building and individual shut-offs to appliances, i.e., water heaters.

4 Building Structure and Envelope Integrity

The building “envelope” encompasses the roof, exterior walls, and floor of a building. All the elements of the envelope must be maintained in structurally sound and weather tight condition. A properly sealed envelope (i.e., one with no unintended openings such as holes, missing or broken weather stripping, etc.) will reduce unwanted moisture penetration into the building that causes damage to interior finishes, furnishings, and structural components; allows undesirable mold and mildew; and creates indoor air quality problems. Along with the prevention of moisture penetration is the need to control and maintain interior humidity conditions at a level low enough to prevent biological growths. The various components making up the building envelope must be inspected for existing damage, repaired as required, and regularly monitored during the period of dormancy. The following sections provide detailed information on specific areas of the building envelope (Volkman and Dunn 2013).

4.1 Roofing systems

The roof is the most vulnerable part of the building for water leakage that can cause severe damage to building materials from direct contact with water, and additional damage from biological growths. Maintaining weather tightness is essential. Do *not* use temporary or quick fixes to repair any found defects; these provide an illusion (and appearance) that a permanent repair has been made, even though moisture can still enter and cause continued damage to the building’s interior. Water leaks are not always immediately obvious; they can continue undetected over an extended time period. Because there are no occupants to warn of leaks, the weather tightness of a roof of a deactivated building must be maintained in as good if not better condition than an active building.

4.1.1 Low slope (flat) roofing systems

Low slope roofs typically use some type of weatherproofing layer(s) to prevent the entry of water, which can include: built-up roof (BUR) membranes, metal panel roofs, polymer-modified bitumen sheet membranes, single-ply membranes (including thermoplastic membranes (polyvinyl chloride [PVC], Thermoplastic Olefin [TPO]) and thermoset membranes

(ethylene propylene diene M-class rubber [EPDM]), and spray-applied polyurethane foam (SPF).

Inspect potential leakage points at penetrations, roof edges, and roof junctions (where the roof meets parapet walls). Flashing at these locations should be intact and undamaged. Look for spots with ponding, especially around roof drains or over roof membrane seams, and inspect and verify that all seals and joints are intact. Other signs of damage include: alligatoring and blistering of the roof's surface layer, fasteners backing out, and damage from foot traffic. If there are signs of water intrusion, identify the source and repair the damaged area around the area of leakage.

4.1.2 Steep (pitched) roofing systems

Steep roofing uses individual pieces or components for the roof material, which can include: asphalt shingles, clay and concrete tiles, metal roof systems, slate, wood shakes and shingles, and synthetic-composite units (shingles, shakes, tiles, and slates).

Look for and repair missing or worn shingles and flashing.

In colder climates, if the building is heated and the attic is not properly insulated, and heat escapes from the building's interior into the attic, this can cause the snow and ice on the roof to melt and then refreeze into ice dams at the roof's edges. The ice dam can then trap the water from melting ice and snow and allow it to leak through the roof into the building's interior causing damage to walls, floors, ceilings, insulation, and other areas. The risk of ice dams forming can be reduced by better insulating the attic and sealing it against air leakage from the space below.

4.1.3 Roofing penetrations

Inspect and verify that flashing and seals for all roof penetrations are intact and secure from water intrusion. The types of penetrations include: plumbing stacks, combustion vents, exhaust fans, (power or communications) conduits, roof drains, and supports for roof mounted equipment.

4.1.4 Gutters and drains

Inspect and verify that all gutters and downspouts discharge rainwater away from the building. Downspouts should drain at least 2 m (6.6 ft) from the building. Clogged gutters will fill with standing water, and the

overflow will eventually result in damage to exterior walls. If vegetation is located close to the building, accumulated organic debris in clogged gutters will allow seeds to take root and grow (Figure 4-1).

During winter, water from ice and snowmelt on the roof can freeze in clogged gutters and add to the damaging effects of any ice dams that may exist at the roof edge.

Inspect and verify that seals and joints for all roof drains are intact.

4.2 Exterior walls and structural and non-structural elements

Record the locations of all observed cracks and damage in exterior walls (Figure 4-2). Determine if the damage is structural and whether repair is required or can be deferred.

Entry of water into exterior walls will eventually cause damage. Inspect and repair or patch any breaks, holes, loose or missing materials in exterior wall surfaces, i.e., masonry, exterior insulation and finish system (EIFS), stucco, wood siding, etc. (Figure 4-3). Cracks in EIFS (Figure 4-4) are most likely to occur where EIFS joins with different materials such as around door and window frames.

Figure 4-1. Vegetative growth in rain gutter.

Figure 4-2. Cracked CMUs in exterior wall.

Figure 4-3. Spalled brickwork caused by moisture penetration and freeze-thaw cycles over time.

Figure 4-4. Cracks in EIFS at corners of window sill and wall surface.

Structural steel framing that is exposed to the exterior should be free of rust and corrosion, and should be painted or coated if needed to prevent deterioration.

Damaged exterior components such as brackets, signs, light fixtures, etc. that are loose and vulnerable to wind and adverse weather damage should be documented and removed, or repaired so they are securely attached. Seal any penetrations resulting from the removal or repair.

If possible, inspect buildings after major storms to ensure that no damage has occurred to the envelope that might result in water intrusion. For buildings with a previous history of flooding, provide flood mitigation measures such as sandbags if there is a strong likelihood of a severe storm occurring.

4.3 Exterior doors and windows

Secure all exterior doors and windows to prevent unauthorized entry. Boarding of doors and windows with plywood panels is often done for vacant private sector or non-DoD public buildings to prevent vandalism and squatting. The plywood panels must be painted and sealed on their edges

to prevent deterioration from exposure to the weather. Recently, clear polycarbonate panels have been increasingly used in place of plywood due to the material's better aesthetic appearance, and its better weather resistance and much greater durability. The polycarbonate panels do have a significantly higher cost than plywood, but many governmental entities are mandating their use in place of plywood due to the perception of blight associated with plywood on vacant properties.

Note that boarded up windows and doors present additional challenges to fire protection personnel in the event of fire, from the standpoint of both access and egress. Firefighters can use axes to penetrate plywood panels in seconds while electric saws are required to cut through polycarbonate panels. If polycarbonate panels are used, be sure the fire department is aware of their existence so they can be equipped and prepared to deal with them (Honig 2017).

Repair all broken glazing or window panes.

Inspect and repair all caulking around exterior doors and windows. Many exterior doors may have broken or missing seals (Figure 4-5). These must be fixed to prevent air infiltration that can bring in moist outside air or the entry of pests.

Figure 4-5. Defective or missing seals under exterior doors.

4.4 Other envelope penetrations

Buildings that have unsealed openings are very susceptible to wide variations in humidity levels. Figures 4-6 and 4-7 shows graphs of the temperature, humidity and dewpoint changes in two rooms in an unoccupied and unconditioned interior access barracks building over an early to mid-summer time period. Figure 4-6 shows temperature and humidity levels for a barracks room and Figure 4-7 shows those levels for a laundry room on the same floor. The barracks room has no openings to the building exterior except for the windows that are closed. On the other hand, the laundry room has an outside air grill and a number of vent openings for the dryers that were not capped. A comparison of the two graphs show that the humidity levels in the laundry room are higher and more variable than those for the barracks room.

Barracks and community centers with laundry facilities should be inspected for openings to the building exterior. Remove and dispose of existing clothes dryer flex ducts (Figure 4-8) and repair exterior backdraft dampers (Figure 4-9). Many of these are broken or stuck open (Figures 4-10 and 4-11). Clean and temporarily seal these dryer exhaust openings to prevent entry of water, vermin, etc.

Community centers have mailboxes that are accessible from the exterior with mail deposited into the boxes from the interior (Figures 4-12 and 4-13). These should be sealed to prevent infiltration of air and moisture.

Figure 4-6. Temperature (red), humidity (blue) and dewpoint (green) in a barracks room.

Figure 4-7. Temperature (red), humidity (blue) and dewpoint (green) in a laundry room

Figure 4-8. Dryer exhaust flex ducts.

Figure 4-9. Outside air grille and broken exhaust dampers to laundry room.

Figure 4-10. Visible light shining through unsealed dryer exhausts.

Figure 4-11. Not fully closed outside air damper to mechanical room.

Figure 4-12. Unsealed mail box openings in community center.

Figure 4-13. View to inside of community center through a mail slot.

Each space in a building that has an exterior facing wall must be inspected for unsealed openings. Figure 4-14 shows a large hole found in the air barrier wall in the attic mechanical space that allows the entry of exterior humid air into the attic.

Figure 4-14. Hole in drywall to exterior of attic mechanical room.

Older buildings may still have small air-conditioning units mounted in windows or wall openings that are poorly sealed (Figure 4-15). These should be removed for repurposing elsewhere, and the opening sealed.

Block or divert water away from all potential points for at grade or below grade water intrusion (crawlspace or foundation openings, louvers, windows, doors).

4.5 Corrosion prevention

Rust is the result of an oxidation process when iron materials are exposed to oxygen for an extended period of time. Left untreated, rusted materials will flake off the surface layers, eventually weakening the material structurally or allowing the penetration of moisture. Rust can also expand internally in embedded or covered materials such as steel rebar in concrete when moisture penetrates the covering material through cracks, thereby causing structural damage to both the steel and concrete.

Structural steel framing, metal roofs, metal chimneys, etc. that are exposed to the weather should be inspected for rust and corrosion. Remove rust and corrosion, and repaint if necessary. Do not paint over untreated rusted surfaces.

Figure 4-15. Air-conditioner unit in dormant maintenance building.

Damaged reinforced concrete that exposes underlying steel reinforcing bars must be repaired to prevent further deterioration of the steel material and spalling (fragmentation) of the surrounding concrete (Figure 4-16). Architectural metals (including iron, steel, copper, aluminum, etc.) should be coated with corrosion inhibitors to reduce corrosion.

Brown or reddish water coming from taps or stains in plumbing fixtures indicate the presence of rust in the plumbing system that may cause (or may already have resulted in) leaks (Figure 4-17).

Depending on their locations, unrepaired water leaks can eventually cause structural damage to the building or result in biological growths.

Figure 4-16. Example of deterioration of concrete.

Figure 4-17. Rust stains in water closet.

4.6 Stairways

4.6.1 Exterior stairways

Keep stairs and landings free of objects and debris to prevent trip hazards.

Tighten any loose handrails and repair damaged steps (Figure 4-18) to allow safe passage during periodic inspections.

Provide nighttime lighting for stairways (Figure 4-19). Use daylight or motion sensors to turn lights on automatically. Lights that stay on during daytime probably have defective sensors that should be replaced.

Figure 4-18. Example of damaged concrete stairs.

Figure 4-19. Stairway light on during daytime.

4.6.2 Interior stairways

Keep stairs and landings free of objects and debris to prevent tripping hazards. Tighten any loose handrails and repair damaged steps.

Fire doors to stairwells should be operational and remain closed. The fire doors serve to maintain the integrity of the building's fire barriers, and to delay the spread of fire, smoke, and toxic gases before the arrival of fire fighters.

Ensure that lighting fixtures in stairways are functional. Provide motion sensors switches with manual override at both top and bottom of stairs to turn lights on automatically.

4.7 Moisture indicators

Look for the following signs of moisture intrusion and damage:

- standing water, water stains (Figure 4-20), and biological growth (mold, mildew, fungus, Figure 4-21) on surfaces (wall, floor, ceiling)
- water stains on ceiling can be due to roof leaks, pipe leaks, or condensation from uninsulated or poorly insulated pipes
- efflorescence, spalling, worn and eroded surface layers, and stains on exterior and interior surfaces
- finishes on painted surfaces that are flaking, peeling, or blistered paint (Figures 4-22 and 4-23)
- signs of rust or corrosion on metal surfaces
- condensation on interior window panes or solid surfaces
- musty or moldy smells.

Note that efflorescence occurs when the dissolved salts in moisture traveling through porous materials (concrete, brick, stone, mortar, etc.) are deposited on the surface and remain after the water has evaporated (Figure 4-24). It can be a sign of moisture intrusion that can result in structural issues or indoor air quality problems, and its cause must be diagnosed and corrected. Efflorescence can sometimes be confused with mold growth.

Figure 4-20. Examples of water stains and biological growth on ceiling tiles.

Figure 4-21. Biological growth on ceiling tile.

Figure 4-22. Peeling, blistered paint on interior bathroom wall due to excessive humidity.

Figure 4-23. Blistered paint on exterior wall caused by water intrusion.

Figure 4-24. Example of efflorescence on exterior wall.

Table 4-1 distinguishes between efflorescence and mold.

Table 4-1. Differences between efflorescence and mold.

Efflorescence	Mold
Will turn into a powder when pinched	Will not turn into a powder
Forms on inorganic building materials	Forms on organic materials
Dissolves in water	Does not dissolve in water
White, brown or yellow in color	Can be almost any color

4.8 Humidity indicators

At any given moment in time, a room or space may appear to be within acceptable humidity conditions. Over time, however, excessive humidity levels will reveal themselves through physical signs within the room or space. The following figures show some of these indicators. Ceiling fan blades (Figure 4-25) are often made of composite wood materials. They will absorb moisture in a humid environment and sag over time.

Humid conditions, combined with contact with the human body will allow the growth of mold and mildew on furniture surfaces as show in the vinyl mattress cover in Figure 4-26. Cleaning and removing all traces of this biological growth may be expensive, time consuming, and not 100% successful. Disposal of the contaminated item may be a more economical way to deal with this problem.

Dusty surfaces, as are often found on mechanical room equipment, are a food source for biological growth (Figure 4-27), which is further enhanced by humid conditions.

Figure 4-25. Sagging ceiling fan blades due to high humidity levels.

Figure 4-26. Mold on vinyl mattress cover.

Figure 4-27. Mold growth on surface of HVAC duct.

5 Building Interior, Finishes and Furnishings

5.1 Interior spaces

Remove all items of value (furniture, appliances, and office equipment) and reuse, store, or discard them as appropriate. Furniture, appliances, or office equipment that has mold growth should be discarded. Clean and remove all trash and debris off floors. Rooms should be clear of any obstructions, and floor areas should be empty of junk and refuse to improve safety, remove food sources for biological growth, and allow for easier room inspections. Figures 5-1 and 5-2 show the contrast in laundry rooms between two closed, vacated community centers.

Figure 5-1. Laundry room with washers and dryers removed and debris filled floor.

Figure 5-2. Laundry room cleaned and debris free.

Inspect for any puddles on floors, which can indicate potential roof leaks, condensation caused by excessive indoor humidity, or leaks from plumbing or fire protection systems. Flaking, peeling, or blistered paint may also be indications of moisture damage caused by water leakage or excessive humidity levels.

Keep all interior doors open to allow cross ventilation. Fire doors should be operational and remain closed. This is especially important if the fire sprinkler systems have been deactivated. Fire doors serve to maintain the integrity of the building's fire barriers, and to delay the spread of fire, smoke, and toxic gases before the arrival of fire fighters.

To enhance safety and to allow access/egress for security and fire department personnel, remove locksets, latches, and cipher locks from all interior doors and vaults that cannot be set in an unlocked mode.

Remove all suspended acoustical ceiling tiles with evidence of water damage or biological growth. Find and repair the source of the moisture causing the damage. Do not replace the damaged tiles. In the event that repairs were not successful, the open ceiling will allow puddles or water stains to show on the floor, whereas a replaced ceiling tile will provide a new source of nourishment for biological organisms. A catch basin may be desirable to protect wood floors and other flooring more easily damaged by water.

5.2 Interior finishes

Inspect wall finishes for evidence of flaking, peeling, or blistered paint, which can be indications of moisture intrusion (Figure 5-3). The source of the moisture must be detected and corrected, but it is not necessary to repaint as this is a cosmetic issue. If the building is reoccupied in the future, the new occupants will likely repaint the walls.

Exterior perimeter rooms with vinyl wallpaper should have the wallpaper removed from exterior walls. Moisture that diffuses into a building can become trapped between the inside face of the exterior wall and the wallpaper, and allow the growth of mold. Also remove whiteboards, chalkboards, bulletin boards, shelving, other mounting hardware, or similar non-permeable objects from exterior walls.

Figure 5-3. Blistered paint on exterior wall caused by water intrusion.

Inspect ceiling surfaces and acoustical tiles for signs of stains and/or biological growth, which can be symptoms of water intrusion, condensation from excessive moisture, or pipe leaks.

Cosmetic damage to finishes such as chips, gouges, marring of wall surfaces can be ignored as it is likely any future occupants will correct these defects before reoccupying the building.

5.3 Carpeting

Carpeting is a potential breeding ground for mold if conditions are ideal for mold spores. Carpeting and carpet padding can become moist or wet from excessive humidity, condensation, flooding, or water leakage (Figure 5-4). Once mold has started growing, removing it is often neither possible nor economical.

Carpeting in good condition may be left in place. Alternatively, consider removing all existing carpeting as these are likely to be replaced when a building is reactivated. The existing dust in carpeting that remains in a building will serve as a breeding ground for mold spores if the carpeting becomes wet from moisture or high indoor humidity. Since carpet containing mold growth is often not cleanable, it is often better to remove the carpeting than to allow it to remain as a continual, long term mold source (Gromicko and Ward 2018).

Figure 5-4. Water damaged and stained carpeting.

5.4 Draperies and blinds

Dirty or broken drapes and blinds should be removed and discarded since they will continue to collect dust and dirt and potentially serve as a food source for biological growth. A building that has been in layaway status for a lengthy time period likely will have new drapes or blinds installed if the building is reactivated in the future.

If a decision was made to retain the drapes or blinds, they may be left open or closed depending on local installation preferences. Opened drapes may increase light level and entry of ultraviolet (UV) rays that can help discourage mold growth. On the other hand, UV rays can accelerate fading of interior finishes and furnishings, but this would not be a problem if interior rooms will be repainted upon reoccupancy and furnishings are removed and stored elsewhere during the period of dormancy. Increased air circulation around window panes and frames will reduce condensation.

From a security standpoint, opened drapes allow easy inspection of ground level interiors from the outside. Closed drapes should not be used as a means to hide valuable items from outside observation as these items should have been removed and reused or stored elsewhere. Blinds can be used as a subtle indicator of whether anyone has entered a building or not. By closing all the blinds and flipping the slats so they are angled in the same direction, the presumption is an intruder may flip the slats or raise the blinds to allow more light and forget to return them to their original

position. Security personnel passing by can then quickly determine if unauthorized people have been in the building.

5.5 Furniture

Furniture in formerly occupied spaces should be removed as they are a potential food source for biological growth if interior humidity is at a high enough level. Besides the materials themselves, the furniture can also acquire, over time, oils and other contaminants from the previous occupants that can also become food sources. An additional advantage of moving these items out is that it minimizes dead air spaces under/behind furniture and appliances, and it promotes air movement by natural convection. The elimination of dead air spaces would promote more uniform interior surface temperatures and minimize local cold surface conditions. Furniture in good condition or that can be easily cleaned should be inventoried and stored in a climate-controlled location (Figure 5-5), or reused elsewhere on the installation. It is best to dispose of absorbent materials such as cushions or mattresses that show signs of mold growth since they cannot be easily cleaned.

Modular systems furniture (Figure 5-6) is expensive and a valuable asset that can be reused elsewhere on an installation.

As with standalone furniture, removal of systems furniture will also minimize dead air spaces. Rather than keeping the furniture in a vacant building, running the risk of exposing it to biological growth, furniture that is in good condition should be removed for reuse in other buildings. If there is no immediate need for it, the furniture should be inventoried and stored in a climate-controlled location.

Figure 5-5. Furniture stored in conditioned space.

Figure 5-6. Modular systems furniture.

5.6 Equipment

For maintenance facilities, verify that all cranes and hoists are positioned next to points of support, lower all hooks to floor level, and coat chains and cables with grease (Figure 5-7).

Tool cabinets (Figure 5-8), tools, and easily relocated equipment such as window air-conditioning units, air compressors (found in repair shops, see Figure 5-9), etc. should be targeted for reuse in other locations. For equipment that has a shorter remaining service life and for mounted or installed equipment that is more difficult to relocate such as generators, water heaters, boilers, chillers, etc., the decision to relocate equipment must be considered more carefully.

Inspect all closets and storage spaces for tools that can be reused elsewhere. For practical reasons, these are seldom bar coded so they are easily pilferable if not removed.

Figure 5-7. Crane and hoist in Tactical Equipment Maintenance Facility (TEMF).

Figure 5-8. Tool cabinets behind lift in vacant TEMF.

Figure 5-9. Air compressor unit in vacant TEMF.

6 Avoiding Contamination Problems

6.1 Avoiding mold and mildew problems

One of the most important and challenging tasks in managing dormant buildings, especially in hot, humid locations, is the prevention of mold and mildew problems. Mold and mildew require spores, food, and water to develop and grow. Since mold and mildew spores are widely present and because building materials are ideal food sources, the only practical way to prevent mold and mildew problems is to control the availability of moisture in building materials.

6.1.1 Moisture impacts on building materials

Many porous building materials absorb moisture; when they become moist, they provide an ideal environment for mold and mildew to develop since they provide the spores with both the food and the moisture needed to grow and develop. Even if exposed only to humid air, building materials can absorb enough moisture over time to come into hygrodynamic equilibrium with the moisture content of the ambient air. Water activity (A_w) is a measure of the water content within a material that is available to microorganisms. For example, the moisture content of a material exposed to ambient air at 75% Relative Humidity (RH) would, over time, come into equilibrium with the surrounding air and the material would be said to have an A_w of 0.75.

A_w levels between 0.70 and 1.0 are most conducive to growth of microorganisms; an A_w of 0.90 is ideal for mold and mildew growth. Few molds thrive at water activity levels between 0.60 and 0.70 and there is almost no possibility of mold and mildew growth at water activity levels below 0.60. As a result, conditions within building interiors should be maintained at or below 70% RH if possible.

6.1.2 Moisture sources

Moisture is primarily added to interior air spaces through occupants (breathing and sweating), occupant activities (showers, laundry, cooking, etc.), evaporation from toilets and traps, water leaks (through the roof, walls, doors and windows, leaking plumbing and piping systems, wet or damp ground surfaces), humid air infiltration, and water vapor diffusion.

Because occupant and occupant activity related moisture sources are essentially eliminated in a deactivated building, and assuming that plumbing leaks and liquid water leakage through the building envelope are controlled, the remaining means of moisture entry into the building are moist air infiltration and water vapor diffusion through the building envelope. Of these two remaining moisture sources, infiltration of humid air through the envelope is usually much more significant than diffusion of water vapor through the envelope.

6.1.2.1 Moist air infiltration through the building envelope

Unfortunately, in many parts of the country, much of the year is characterized by hot, humid outdoor ambient conditions. For buildings in these locations with leaky envelopes, humid outdoor air infiltrates the building envelope raising the moisture levels within the buildings. This is especially true for buildings such as maintenance facilities, barracks facilities with exterior entry doors, and laundry rooms with many dryer exhaust openings to the outdoors. For such leaky buildings, the indoor dew points may closely track the outdoor ambient conditions. The amount of moisture that can enter the building from infiltration of humid outdoor air can be substantial. Moisture entry by infiltration of damp outdoor air can be reduced by maintaining weather stripping on exterior doors and windows, and by sealing any unneeded or unused exterior openings in the building envelope.

6.1.2.2 Water vapor diffusion through the building envelope

To a much lesser extent, moisture in the high vapor pressure outdoor environment diffuses through permeable materials into the lower vapor pressure interior environment. As it diffuses through these building materials, it increases their moisture content and also raises the moisture content of the air within the space. Fortunately, the amount of moisture entering the building by diffusion is much smaller than that entering by bulk infiltration of moist air. Unfortunately, no building envelopes are perfectly impervious to moisture diffusion and there are few options for reducing vapor diffusion through existing building envelopes without significant alterations or repairs to the envelope.

6.1.3 Managing interior relative humidity levels

In certain climates, it is almost inevitable that environmental moisture will enter the building by one means or another. As a result, it is important to monitor building moisture levels and, if necessary, remove excess moisture.

6.1.3.1 Monitoring building moisture levels

In humid locations, periodic inspections are a valuable means of monitoring building moisture levels. Inspectors can often detect high humidity conditions just by how the room feels when they walk into it. They can also detect any musty odors that could indicate the presence of mold or mildew. A more reliable approach, however, would be to deploy a number of inexpensive temperature and relative humidity (T/RH) dataloggers (see Section 11.2.1) in representative locations throughout the building. By recording these data at regular intervals over the course of days or weeks, one can get a good picture of the moisture levels within the building.

6.1.3.2 Reducing relative humidity levels in the building

As the name implies, relative humidity within a building is “relative” to the temperature and absolute moisture content of air. If either of these factors are changed, the relative humidity of the air will change accordingly. Although it seems counterintuitive, one could lower the indoor relative humidity by raising the temperature in the building. If the heating systems remain functional, the building could be heated during periods of high outdoor dew point temperatures to lower the indoor relative humidity.

A suggested approach is to install dehumidifiers in the various building spaces to reduce the absolute moisture content of the air. Buildings such as barracks facilities with numerous isolated living units with exterior doors can have at least one dehumidifier installed in each living unit, although this would be a substantial investment. In buildings with multiple interconnected spaces, all interior doors should be left open to allow air circulation between rooms. All dehumidifiers should be set up to drain into a sink, lavatory, or floor drain to minimize or eliminate the need to drain water from the units. Depending on the size of the spaces, multiple dehumidifiers may be required. The goal should be to install sufficient dehumidification capacity to lower indoor relative humidity levels to 70% or less.

6.2 Hazardous materials

Before closure of building, walk through all rooms and identify any environmental hazards, materials (fuels, chemicals, etc.), and utilities requiring remediation or removal. Although unlikely for newer buildings, older buildings may have asbestos-containing building materials including floor tiles, various types of insulation, fireproofing products, and wall siding. As with asbestos, newer buildings will probably not have any lead painted surfaces or equipment. Older buildings should have their paint tested and documented for the presence of lead. Document the location and quantity of any waste found so they can be remediated if the building is reactivated again, or properly disposed of if the building is eventually demolished.

7 Mechanical and Electrical Systems

In a dormant facility, three major concerns related to the building's mechanical system are:

- avoiding frozen pipes, plumbing and plumbing fixtures and resulting water damage
- minimizing fire risks
- avoiding mold and mildew problems.

When a building is placed in a dormant status, a decision must be made as to how mechanical systems should be operated and maintained to minimize these risks. Mechanical systems that will not be used during the dormant period should be properly shut down so that they can be economically returned to service at a future time.

7.1 Avoiding freezing of piping, plumbing, and other systems

During frigid weather conditions water supply piping and plumbing systems, plumbing fixtures, appliances and other systems are also subject to freezing. Where freezing conditions are expected, there are several options for protecting these systems:

- draining the system
- operating the building's heating system to maintain space temperatures above freezing
- installing electric heat tracing and/or insulation.

7.1.1 Potable water supply piping and plumbing systems

If a decision is made to not heat the building, it is advised that the main water supply valve serving the building be shut and all water supply piping and plumbing systems be drained. Be aware that most water supply piping and plumbing systems will contain low points ("traps") that will prevent thorough draining of the system by gravity. It will probably be necessary to use compressed air to blow water out of these low points.

If the main water supply valve is in an unheated area inside of the building, it may be necessary to close the underground main supply valve or to provide heat tracing or other means to prevent freezing of water in the piping to the building's main water supply valve.

7.1.2 Plumbing fixtures

Hot and cold water supply valves should be cracked open to allow venting of the system for drainage and to preserve seals and O-rings inside of the valves. Fixture traps can be winterized by pouring in recreational vehicle (RV) antifreeze. After winterizing, traps can be protected from evaporation and drying out by pouring a small quantity of trap sealant such as peppermint oil into the drain (See Chapter 9 for additional information on traps).

7.1.3 Hose bibs

The water supply to exterior hose bibs should be shut off (Figure 7-1). A malicious person can turn the water on and this waste of water can potentially go undetected for a long time. Turning the water off will also protect against freezing in cold climates.

Figure 7-1. Exterior hose bib with active water supply.

7.1.4 Appliances

Domestic hot water heating systems should be valved off and drained. Appliances such as clothes washers, dish washers, refrigerators with automatic ice makers, and water coolers will often contain at least a small amount of water even when not being actively used. If possible, these units should be removed and relocated to a temperature-controlled storage area. Units that cannot be removed should be drained and protected with an antifreeze solution such as RV antifreeze.

7.1.5 Steam and hot water heating systems

If steam and hot water heating systems are expected to be dormant for at least a few months, the boiler industry recommends that the systems be laid up dry or wet, depending on the system type. Although the boiler industry's primary concern is to prevent corrosion, if a building is expected to remain unheated during freezing conditions, then dry layup is the only practical approach. See Section 7.3.1 and 7.3.2 for further discussion on layup of steam and hot water heating systems.

7.1.6 Chilled water systems

Chilled water systems in locations with cold winter conditions are typically filled with some type of antifreeze solution. If so, there is no need to drain the systems if the antifreeze concentration is sufficient to prevent freezing.

Systems susceptible to freezing that do not contain an antifreeze solution should be completely drained, taking care to use compressed air or other means to remove all liquid from any low points in the system.

7.1.7 Sump pumps and drainage systems

Buildings with basements or crawl spaces are often equipped with sump pumps installed in sump pits. For short periods of freezing temperatures, these sump pump pits may not experience freezing because of heat transfer from the earth.

Outdoor lift stations are typically installed in deep manholes so that there is no danger of freezing.

7.2 Minimizing fire risks

This section briefly discusses fire protection concerns pertaining to mechanical and electrical systems. Chapter 8 discusses fire protection systems in more detail.

7.2.1 Minimize fire sources

7.2.1.1 Shut off gas systems

It is advisable that natural gas be shut off where possible. Shutting off the gas outside the building or at building entry reduces risk of leaks and resulting explosion.

7.2.1.2 De-energize non-essential electric systems

All freestanding electrically powered equipment should be removed. In a vacant, unused building, it is unlikely there will be a need for this equipment. Shut off electric power to wall outlets to prevent usage by squatters and to minimize the risk of fire from faulty wiring. Note that these outlets may be needed for dehumidifiers.

7.2.2 Maintain fire detection and alarm systems

7.2.2.1 Fire alarm panels

Fire alarm panels should remain energized and operational. They should be inspected on a normal schedule.

7.2.2.2 Smoke detectors

Smoke detectors should be maintained and inspected on a normal schedule. Backup batteries should be replaced on an annual basis.

7.2.3 Maintain fire containment and suppression systems

7.2.3.1 Sprinkler systems and fire pumps

The National Fire Protection Association (NFPA) does not specify the protocol for vacant buildings, but the approach to handle the sprinkler systems can include either completely draining the system or using antifreeze solutions. Coordinate with and request approval from the fire department to deactivate the sprinkler system for the entire building. Do not partially

deactivate the sprinkler system if parts of the building are still being occupied. If antifreeze solutions are used, be sure to use the correct type (Section 8.6.3).

Fire pumps in locations where freezing conditions are unlikely can be maintained in a ready condition, and annual inspections conducted as normal. For locations where freezing conditions are expected, the pumps should be drained or otherwise protected, similarly to the way the remainder of the sprinkler system is treated.

7.3 Layup of mechanical systems

7.3.1 Heating systems

If heating systems are expected to be unused for several months and if it is unlikely that heating systems will be needed during the dormant period to prevent freezing or to reduce relative humidity within the building, it is advisable to lay up the systems. Boiler heating systems require attention for even brief dormant periods to avoid corrosion and freezing issues. The following sections discuss this issue in detail.

7.3.1.1 Gas and oil-fired furnaces

Power to gas-fired and oil-fired furnaces should be turned off and the main fuel supply valve should be closed. Cleaning of the burner is advised to prevent corrosion.

7.3.1.2 Hot water and steam boilers

UFC 3-240-13FN, *Industrial Water Treatment Operation and Maintenance* (NAVFAC 2005), provides an overview of industrial water treatment operations and management. “Industrial water” refers to the water used in power generation, heating, air-conditioning, refrigeration, cooling, processing, and all other equipment and systems that require water for operation. Industrial water is distinct from potable water and is never consumed or used under situations that require a high degree of sanitation. Layup of hot water and steam boiler systems that will be out of service even for relatively brief periods of time is necessary to prevent corrosion on both the fire side and the water side of these systems. Depending on the length of time that a boiler system is expected to be out of service, UFC 3-240-13FN recommends different layup methods:

- Very Short-Term Dormancy (4 to 30 days): Wet Layup Method.
This method means that the boiler is kept completely full of treated water. This method is easier to check and the boiler can be put back into service more quickly. Wet layup should not be used for boilers subject to freezing temperatures.
 - UFC 3-240-13FN, Para. 3-5.4.1: Wet Layup without Draining (Operational Boilers).
This method is used most commonly when a boiler is to be shut down for 4 to 30 calendar days. Often the boiler must be maintained in a standby condition. Corrosion will most likely occur in the boiler unless both the water level in the steam drum and the chemicals in the boiler are increased. This paragraph provides recommended procedures for wet layup of a boiler without draining or cleaning.
 - UFC 3-240-13FN, Para. 3-5.4.2: Wet Layup of Drained Boilers.
This paragraph discusses procedures for wet layup of boilers that have been emptied for cleaning or repair.
- Short-Term Dormancy (30 to 150 days): Open Dry Layup Method.
This method is described in UFC 3-240-13FN, Para. 3-5.3.1 and is recommended for short-term dormancy where the boiler room is dry, has low humidity, and is well ventilated. It is important to keep the boiler dry. Should a humid atmosphere exist, the boiler must be closed up and the procedure specified in Para. 3-5.3.2 used.
- Longer-Term Dormancy (over 150 days): Quicklime or Silica Gel Layup Method.
This dry layup method is described in UFC 3-240-13FN, Para. 3-5.3.2 and is recommended for longer-term dormancy or for shorter term dormancy where the boiler room atmosphere is quite humid and not well ventilated.

Hot water and steam boiler systems constitute a significant investment so it is important to take storage of these systems seriously. UFC 3-240-13FN is an excellent reference. Additional excellent resources include recognized expert sources such as The National Board of Boiler and Pressure Vessel Inspectors (<http://www.nationalboard.org/Default.aspx>), the boiler manufacturer or reputable boiler system contractors.

7.3.1.3 *Condensate systems*

Layup of condensate systems is much more difficult than layup of boilers. As the system cools, oxygen will be drawn in, resulting in a situation that leads to corrosion. Purging the system with dry, inert gas can be effective, but the logistics can be very difficult (nearly impossible) and the hazards include the potential for suffocating people if the system is located in an unvented area. Application of a high dosage of a filming amine before shutdown can be effective, but its use is restricted for many applications and is prohibited in military operations. Application of a high dosage of neutralizing amines (see UFC 3-240-13FN, Para. 3-2.7.3) or of a specialty volatile oxygen scavenger (see UFC 3-240-13FN, Para. 3-2.7.5) can be helpful. The application of any amine or specialty volatile oxygen scavenger can be limited where steam purity or Food and Drug Administration (FDA) restrictions exist.

7.3.1.4 *Electric and gas-fired domestic hot water heaters*

Power to electric domestic hot water heaters should be turned off and tagged out. The main gas supply valve to gas-fired units should be turned off and secured. The main water supply valve should be closed and tagged and the unit should be completely drained. Cleaning of the burner is advised to prevent corrosion.

7.3.1.5 *High temp hot water and steam to domestic hot water convertors*

High temperature hot water or steam supply valves should be closed and tagged out. The domestic hot water inlet valve should be closed and tagged out. Both the high temperature and low temperature sides of the heat exchanger should be drained, blown out with compressed air if needed, and the drain valves should be left open.

7.3.1.6 *Distribution piping, heating coils and radiant heating loops*

Hot water and steam distribution piping and heating coils must be thoroughly drained. Floor radiant heating systems must be emptied and blown out with compressed air if necessary to remove all water from the system.

7.3.2 Cooling systems

Army facilities use a variety of cooling systems. During dormant periods, there is little reason to keep these systems in an operational status. As a

result, these cooling systems should be laid up. If there is a good possibility that a building may be reoccupied within a short period of time, or periodically reoccupied during the period of dormancy, up to 10 years, consider keeping the chillers in a state of readiness where they can be cycled about once every month or two for a period of 24 hours just to keep them functional. This will minimize problems with re-starts due to the chillers sitting idle for too long.

7.3.2.1 Direct expansion (DX) cooling systems

Direct expansion (DX) cooling systems are widely used in Army facilities. They are typically air-cooled devices and are configured as split systems, rooftop units, window units, or through-the-wall units. For facilities in a dormant status, these units can be easily laid up by disconnecting and locking out power to the units. Through-the-wall units or window units should be removed, if feasible, and the wall opening or window opening should be closed and sealed. The refrigerants should be recovered if required by local environmental regulations.

7.3.2.2 Ground source heat pumps

Ground source heat pumps are an increasingly popular means of providing both cooling and heating energy to Army facilities. During the cooling season, they reject heat removed from the facility into the ground through a ground loop. Likewise, during the heating season, they extract heat from the ground loop and provide it to the facility. Since the ground loop wells and interconnecting piping are typically made of noncorrosive materials and since the working fluid in the ground loop contains glycol, there is no concern with corrosion or freezing. These systems can be easily laid up by disconnecting and locking out power to the system's water loop pumps and heat pumps.

7.3.2.3 Evaporative cooling systems

Evaporative cooling systems are widely used in dry parts of the country. The water supply to these systems should be valved off, drained, and blown out with compressed air if needed. Power to the units should be disconnected and locked out.

7.3.2.4 Vapor compression chillers

Vapor compression chillers are either air-cooled or water-cooled. Air-cooled chillers can be laid up by pumping the refrigerant into the receiver or condenser, according to the chiller specifications. The refrigerant inlet and outlet valves should be closed and the condenser and receiver should be checked for leaks. The inlet and outlet valves on the water side of the chiller's evaporator barrel should be closed and the evaporator barrel should be drained. Power to the unit should be disconnected and locked out. The refrigerants should be recovered if required by local environmental regulations.

7.3.2.5 Absorption chillers

Absorption chillers differ greatly from vapor compression chillers and operate with a lithium-bromide solution as the refrigerant. Proper layup of absorption chillers and reactivation after the layup period should be conducted in accordance with the manufacturer's instructions.

7.3.2.6 Evaporative cooling systems

Evaporative cooling systems are widely used in dry parts of the country. The water supply to these systems should be valved off and the units thoroughly drained. Power to the units should be disconnected and locked out.

7.3.2.7 Cooling towers

Layup of cooling tower systems is addressed in UFC 3-240-13FN, Para. 4-7.4. Cooling towers can be laid up either wet or dry. Wet layup is not advised in locations where freezing temperatures are possible or for long term (over 3 months) storage.

For long term storage of cooling towers or in locations with possible freezing temperatures, dry layup is advised. Tower basins and all exposed piping, including risers, should be drained. Drain and overflow valves should be left open to prevent accumulation of rain water, snow or melted snow and ice.

Tower fans and fan drives also must be properly prepared for storage. For example, at least one major cooling tower manufacturer recommends lu-

bricating fan motors; overfilling gear reducers with oil; removing and storing V-belts in a cool, dry dark room; and cleaning and coating sheave grooves with a rust preventative, lacquer, or paint. It is advised that reference be made to the manufacturer's specific recommendations for layup procedures and for startup procedures following layup.

Cooling tower equipment can be laid up dry, although dry layup is more appropriate for a single piece of equipment, such as a chiller's condenser tube bundle or other heat exchanger. All metal surfaces must be completely dry; residual moisture is not acceptable. In humid climates, install a desiccant such as a quicklime gel or an equivalent in as many locations as necessary, and replace as required.

Nevertheless, for wet layup, systems and system equipment such as heat exchangers, chiller tube bundles and the like first require a physical cleaning to remove all suspended materials. Corrosion inhibitors should be applied at increased dosages, usually at a level of about 4 to 5 times the normal maintenance dosage. An increased dosage (within U.S. Environmental Protection Agency [USEPA] limits) of a non-oxidizing biocide that has a long half-life, such as glutaraldehyde or isothiazolone should also be applied.

Cooling systems typically consist of direct expansion (DX) systems and Moisture is primarily added to interior air spaces through occupants (breathing and sweating), occupant activities (showers, laundry, cooking, etc.), evaporation from toilets and traps, water leaks (through the roof, walls, doors and windows, leaking plumbing and piping systems, wet or damp ground surfaces), and air leaks. Because occupant and occupant activity related moisture sources are nearly eliminated in a deactivated building, options for controlling moisture may be increased. If plumbing leaks and liquid water leakage through the building envelope are controlled, the remaining means of moisture entry into the building are moist air leakage and water vapor diffusion through the building envelope. Of these two remaining moisture sources, infiltration of humid air through the envelope is usually much more significant than diffusion of water vapor through the envelope. In either case, dehumidification could be a viable option.

7.3.2.8 Distribution piping and cooling coils

Chilled water distribution piping and cooling coils must be thoroughly drained. Floor radiant heating systems must be emptied and blown out with compressed air if necessary to remove all water from the system.

7.4 Electrical considerations

Although a vacant building will have no occupants, some amount of electrical power will still be required for security lighting, fire alarms and smoke detectors, and some amount of interior lighting. The lighting circuits to most perimeter offices that have windows can be disconnected. Any building inspections will take place in the daytime; daylighting should provide a sufficient light for inspections. Lighting should still be maintained in interior hallways, and possibly in interior offices at the discretion of the installation.

The power to most wall outlets can be shut off to prevent usage by squatters and to minimize the risk of fire from faulty wiring. Note that some outlets may be needed for dehumidifiers.

If the building has a building automation system (BAS) and the BAS is used to monitor interior environmental conditions, then power must be maintained.

8 Fire Protection Systems

8.1 Introduction

Fire protection is a major concern for dormant buildings. The NFPA has found that, in the private sector, arson is the primary factor for building fires in vacant buildings. Intentional fires were much more common in unsecured vacant properties (57%) than in those that had been secured (31%). Other leading causes of vacant building fires were exposure to other fires (8%), heating equipment (also 8%), electrical distribution or lighting equipment (7%), cooking equipment (5%), someone, typically a child, playing with a heat source (4%), and smoking materials (3%). When equipment is listed as the cause of the fire, it means that the equipment provided the heat that started the fire. It does not mean that the equipment malfunctioned or failed. (Ahrens 2009).

The codes and standards for fire protection have limited detail with regards to facilities under a layaway protocol, so the guidelines for existing systems provide the overriding principles. Codes and standards relevant to building layaway protocol for military facilities, and NFPA documents that provide specific details of fire protection protocols are:

- Unified Facilities Criteria (UFC) 3-600-01, *Fire Protection Engineering for Facilities* (NAVFAC 2016)
- International Building Code (ICC 2018a)
- International Fire Code (ICC 2018b)
- NFPA 101, *Life Safety Code* (NFPA 2018a)
- NFPA 10, *Standard for Portable Fire Extinguishers* (NFPA 2018a)
- NFPA 13, *Standard for the Installation of Sprinkler Systems* (NFPA 2016a)
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* (NFPA 2017a)
- NFPA 72, *National Fire Alarm and Signaling Code* (NFPA 2016b).

8.2 Building security

8.2.1 General security

Preventing arson is a major concern in the private sector where vacant/abandoned buildings do not have the same security protection as those on a military base. However, even military facilities are vulnerable to

arson and should review the recommended safeguards. The International Fire Code Sec. 311.2.1 states that exterior and interior openings accessible to other tenants or unauthorized persons shall be boarded, locked, blocked or otherwise protected to prevent entry by unauthorized individuals. The fire code official is authorized to placard, post signs, erect barrier tape or take similar measures as necessary to secure public safety (Section 3.4).

8.2.2 Boarding procedures

In the event that a building needs additional security, the U.S. Fire Administration has published guidance for placement of boards over doors and windows; details can be found in Appendix C.

8.2.3 Fire doors and dampers

Fire doors should be closed unless provided with an auto release mechanism activated by the fire panel. HVAC fire dampers should be maintained in their normal position.

8.3 Combustibles removal

Many of the referenced fire codes note the importance of having the vacant facility cleaned of items that could contribute to a fire. Specifically, this includes removal of all upholstered furniture, and combustible materials and trash from the building, including the basement and attic. Remove trash and trash containers and combustible furniture from exterior stairwells, porches, fire escapes and outbuildings. Remove shrubbery and vegetation that could support or spread a fire.

8.4 Utilities connections

It is advisable that natural gas be shut off where possible. Shutting off the gas outside the building or at building entry reduces risk of leaks and resulting explosion. All freestanding electrically powered equipment should be removed. In a vacant, unused building, it is unlikely there will be a need for this equipment. Dehumidifiers are an exception that must be considered. Shut off electric power to wall outlets to prevent usage by squatters and to minimize the risk of fire from faulty wiring.

8.5 Fire detection, alarm, and communication systems

Fire alarm systems shall be installed, tested, and maintained in accordance with the applicable requirements of NFPA 70, *National Electrical Code* (NFPA 2017b), and NFPA 72, *National Fire Alarm and Signaling Code* (NFPA 2016b), unless it is an approved existing installation, which shall be permitted for continued use.

8.6 Sprinkler systems

The two most common types of sprinkler systems are wet pipe and dry pipe.

8.6.1 Wet pipe sprinkler systems

In locations where freezing conditions are unlikely, maintain wet pipe fire sprinkler systems in a ready condition. The post indicator valve should remain secured in the OPEN position. Conduct annual inspections as normal.

Where freezing conditions are expected, there are several options for protecting wet pipe systems:

- Drain the system
 - Condition: No fire protection
- Operate the building's heating system to maintain space temperatures above freezing
 - Condition: Retains a freeze damage risk
- Fill the piping with an antifreeze solution
 - Condition: Allowed per UFC 3-600-01 (NAVFAC 2016) on systems connected to potable water supply if system is equipped with a reduced pressure type backflow device
- Convert wet pipe systems into dry pipe systems
 - Condition: Delays response time
- Install electric heat tracing and insulation on the piping system
 - Condition: Labor intensive modification.

If permissible, drain wet pipe sprinkler systems. Coordinate with and request approval from the fire department to deactivate the sprinkler system for the entire building. Do not partially deactivate the sprinkler system if parts of the building are still being occupied. Be aware that most sprinkler systems will contain low points ("traps") that will prevent thorough drain-

ing of the system by gravity. It will probably be necessary to use compressed air to blow water out of these low points. The post indicator valve should be secured in the CLOSED position to shut off supply of water to the building and to properly indicate the status of the system.

It is certainly possible to heat the building during frigid periods to prevent freezing of the sprinkler system, but it can be very costly and labor intensive to operate heating systems for this purpose. It is also possible to fill the system with an antifreeze solution, convert it to a dry pipe system or install heat tracing and insulation. However, these approaches, which can be expensive, are typically beyond the capabilities of most installation maintenance contractors.

8.6.2 Dry pipe sprinkler systems

In dry pipe systems, the sprinkler piping and sprinkler heads are immune to freezing conditions. However, it is still necessary to avoid freezing water in the dry pipe riser. Maintaining temperatures above freezing in the location of the dry pipe riser will be necessary. Also, it will remain necessary to maintain the air compressor that keeps the dry sprinkler piping system pressurized.

8.6.3 Use of antifreeze

NFPA 13: *Standard for the Installation of Sprinkler Systems* (2016a), Section 8.6.3 provides guidelines for the antifreeze solutions, as listed in Table 8-1 for glycerine-water and propylene glycol-water mixtures. The concentration of antifreeze solutions shall be limited to the minimum necessary for the anticipated minimum temperature.

8.7 Fire pumps

In locations where freezing conditions are unlikely, maintain fire pumps in a ready condition and conduct annual inspections as normal.

In locations where freezing conditions are expected, fire pumps should be drained or otherwise protected similarly to the way that the remainder of the sprinkler system is treated.

Table 8-1. Antifreeze solution to be used if (a) potable or (b) nonpotable water is connected to the sprinklers. Note: glycerin and propylene glycol solution concentrations will be used for either type of water.

(a)					(b)				
Material	Solution (by volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point		Material	Solution (by volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point	
			°F	°C				°F	°C
Glycerine (C.P. or U.S.P. grade)	50% water	1.145	-20.9	-29.4	Diethylene glycol	50% water	1.078	-13	-25.0
	40% water	1.171	-47.3	-44.1		45% water	1.081	-27	-32.8
	30% water	1.197	-22.2	-30.1		40% water	1.086	-42	-41.1
Hydrometer scale 1.000 to 1.200					Hydrometer scale 1.000 to 1.120 (subdivisions 0.002)				
Propylene glycol	60% water	1.034	-6	-21.1	Ethylene glycol	61% water	1.056	-10	-23.3
	50% water	1.041	-26	-32.2		56% water	1.063	-20	-28.9
	40% water	1.045	-60	-51.1		51% water	1.069	-30	-34.4
Hydrometer scale 1.000 to 1.200 (subdivisions 0.002)					Hydrometer scale 1.000 to 1.120 (subdivisions 0.002)				
C.P.: Chemically pure. U.S.P.: United States Pharmacopoeia 96.5%.									

8.8 Fire extinguishers

In general, fire extinguishers are only required where a facility or space is either occupied on a permanent, semi-permanent, or transient basis. Fire Extinguishers are intended to provide a means for occupant escape. This summarizes NFPA 101 (NFPA 2018) and NFPA 10 (NFPA 2018b), which are referenced in UFC 3 600 01 (NAVFAC 2016). For a mothballed building, there is no requirement for fire extinguishers if the building is empty on a permanent basis. If someone will visit the building on a temporary basis (maintenance personnel to check the utility rooms, etc.) a fire extinguishers must either be in that space (utility rooms), or the maintenance personnel must carry the fire extinguishers on their trucks and take them in to the utility rooms of the deactivated buildings. The only person that can waive or modify that requirement is the Authority Having Jurisdiction (AHJ). The updated UFC 3 600 01 (p 15, Para. 2-1.3) specifically states that the AHJ is now the E&C Chief at U.S. Army Corps of Engineers (USACE) Headquarters (i.e., no longer at the installations).

9 Trap Maintenance and Freeze Protection

9.1 Trap types and locations

Traps can be found in many locations in a building. They include bathtubs and showers, water closets, bathroom and kitchen sinks, utility sinks, washing machines, dishwashers, drinking fountains, and floor drains. Lay-away decisions regarding maintaining/not maintaining heat in a building or shutting off/not shutting off the water supply to a building will help determine whether to use trap seals or to periodically check traps to verify that they have not dried out. An unheated building in winter increases the risks that water in traps will freeze. A building that is not air-conditioned in summer may experience very high interior temperatures that can rapidly dry out the water in traps. Buildings that have their water supply shut off will definitely need alternatives to water to maintain the seals in traps. Developing decision trees such as those mentioned in Section 2.1.1 is a good way to develop the most appropriate trap maintenance strategy to follow based on the type of layaway process selected.

9.2 Trap maintenance

The primary parts of a building's sanitary system include the wastewater system, potable water system, and the fire protection system (Uzarski, et al. 1991). The primary concern in the wastewater system is maintaining liquid levels in traps so that sewer gases do not escape into the building and create hazardous situations, or inhibit rapid return to service when required. Possible options for trap maintenance at unoccupied facilities include using liquid sealers, using physical seals, routinely running water into traps, or capping.

9.2.1 Trap maintenance options

9.2.1.1 Liquid sealers

Liquid sealers are liquids or liquid mixtures that have low vapor pressure and that can be poured into a plumbing trap to inhibit freezing and decrease the evaporation rate of the liquid from the trap. Depending on the vapor pressure and ambient conditions, the length of time between reapplication and inspection will be increased in comparison to water-filled

traps. Liquid sealers have the benefit of being able to seal the trap and possibly prevent freezing temperatures from damaging the traps. There are four primary types of liquid sealers: propylene glycol based, poloxamer based, mineral oil based, and glycerin based.

1. Propylene glycol. Propylene glycol, otherwise known as 1,2-propanediol, has the following physical properties: melting point = -76 °F, vapor pressure = 0.08mm Hg at 68 °F, 0.13 at 77 °F, vapor density = 2.62 (air = 1), specific gravity = 1.04 at 68 °F, and water solubility (CAMEO Chemicals 2017a). The evaporation rate is 0.0157 (1 = n-butyl acetate) (The Dow Chemical Company 2003). Propylene glycol is biodegradable. The bulk price for pure propylene glycol is about \$608 per 55 gal (482 lb) (Bulk Apothecary, 2017). The use of propylene glycol may require corrosion inhibitors if exposed to metal surfaces. There are ~93-96% propylene glycol fluid in water mixtures available with inhibitors included. The method of using glycols mixtures for blocking drain traps is actually covered under a patent (Guarascio 2012). To use a propylene glycol mixture, you simply pour enough into a drain trap to displace the trap contents.

RV antifreeze is essentially a readily available propylene glycol and water mixture. The propylene glycol/water ratio can vary between brands, but is typically about 30 to 60% propylene glycol. An RV antifreeze offering a -50 °F freezing point will have about a 57/43 ratio and cost approximately \$5 per gallon. The evaporation rate will also depend greatly on the amount of water because of propylene glycol's low vapor pressure. Figures 9-1 and 9-2 show the freezing point and vapor pressure with respect to concentration. RV antifreeze will usually have corrosion inhibitors incorporated into the mixture.

2. Poloxamer. A product somewhat related to propylene glycol mixtures is named "Stinky Drain Solution" (Environmental Controls Inc. 2017), which is comprised of a polypropylene oxide (glycol)/polyethylene oxide (glycol) copolymer (Porter 2014), otherwise known as a poloxamer. A poloxamer is defined as any of a series of nonionic surfactants of the polyoxypropylene-polyoxyethylene copolymer type, used as surfactants, emulsifiers, stabilizers, and food additives (Dorland's Medical Dictionary for Health Consumers [Dorland 2007]). This proprietary solution is denser than water and is intended to fully displace the water in the trap. The expected maintenance period is 1 year. Although this product will not evaporate and could last indefinitely, the manufacturer suggests replacing it yearly due to

the accumulation of dirt in the trap. The price of this product is \$14.95 per 16 ounce bottle (one drain dose) and discounts are available for bulk purchases (Porter 2017).

3. Mineral oil. Mineral oil has the following physical properties: melting point = 0 °F (-18 °C), specific gravity = 0.822 at 68 °F (20 °C), a very high boiling point (590 °F [310 °C]), insolubility in water (CAMEO Chemicals 2017b), vapor pressure <0.01 torr (mm Hg) at 77 °F (25 °C), and evaporation rate = 0 (ARB 2017). The combination of a low specific gravity and insolubility provides mineral oil a key advantage as a liquid sealer because the product will separate and reside on top of the water on both sides of the trap when applied properly. The application method is to vigorously mix an adequate amount of both mineral oil and water then quickly pour into the trap. The two liquids should separate leaving an oil layer at the top of each side. While the oil layer prevents evaporation well, it does not prevent the water layer from freezing. Mineral oil is also biodegradable. The price of bulk mineral oil is about \$346 per 55 gal (Bulk Apothecary 2017).

Figure 9-1. Freeze points and burst points of aqueous glycol solutions.

PG = propylene glycol; Source: The Dow Chemical Company 2003

Figure 9-2. Total pressure over aqueous propylene glycol solutions vs temperature.

Source: The Dow Chemical Company 2003.

Everprime Drain Trap Liquid is a commercially available product that contains mineral oils, alcohols, and dyes (Reichardt 2017). There is An Occupational Safety and Health Administration (OSHA) Material Safety Data Sheet (MSDS) available for this product, however it does not list ingredients and the physical properties are vague but consistent with mineral oil (Waterless Co. Inc. 2017a). The Everprime promotional flier lists the freezing point at -22 °F (Waterless Co. Inc. 2017b). The price for this product is \$77.07 per gallon (per the General Services Administration [GSA]) but is also available in 55-gal barrels (with a possible 10% bulk discount) (Reichardt 2017). The recommended amount of product to use for protection on both sides of a trap is about 1 quart, or 3 to 6 fluid ounces if only protecting the building side. The application will last indefinitely unless disturbed or flushed away.

AIS Mineral Oil-Based P-Trap Primer is another commercially available product that costs about \$150 per 4 gal (AIS Specialty Products, Inc. 2017a and 2017b). It has similar application instructions as the Everprime product.

4. Glycerin/water mixtures. Pure glycerin, also known as glycerol and glycerine, has the following chemical properties: melting point = 64 °F, specific gravity = 1.261 at 68 °F, water solubility >100 mg/ml at 64 °F, vapor pressure = 0.0025 mm Hg at 122 °F (CAMEO Chemicals 2017c) and <0.001 at room temperature (Gulf Publishing Company 1967). Glycerin has an extremely low vapor pressure as a pure chemical and as a 60% solution has a relative vapor pressure 0.738 at 68 °F (20 °C), which is not as low as that of some other products, but glycerin has a high affinity for water and is used as a humectant. A glycerol and water solution will equilibrate with the humidity in the air, losing and/or gaining water to maintain this equilibrium. Glycerin is biodegradable. No commercially available glycerin based trap sealers were found. However, there is a glycerin product available for use in wet fire sprinkler systems called Glycerin 48 (Chemfast 2017).

9.2.1.2 Physical seals (floor drains)

Physical seal products vary in design, are used strictly for floor drains, and are typically constructed of plastic and silicon rubber components. They allow water flow into the drain but will prevent evaporation and escaping gases on the building side. Unfortunately, they do not prevent evaporation on the sewer side of the traps. Because of these constraints, their use may be limited. Their best application may be as an alternative to a trap primer, which is a device that periodically adds water to maintain the water seal, where an infrequently used trap is maintained in an otherwise functioning and occupied building. Five commercially available products and their approximate prices, which range from \$30 to \$60 for each 2 to 4 in. (diameter) drain are:

- a. Green Drain. The price of the Green Drain trap seal (Figure 9-3, Green Drain, Inc. 2017) is approximately \$40 per 2-in. seal, \$43 per 3-in. seal, \$45 per 3.5-in. seal, and \$50 per 4-in. seal (drain-net.com).

Figure 9-3. Application of Green Drain trap seal (image from product website, Green Drain, Inc. 2017).

- b. Sure Seal. The pricing for a Sure Seal is approximately \$34 per 2-in. seal, \$38 per 3-in. seal, \$46 per 4-in. seal (Figure 9-4, cpesupply.com)

Figure 9-4. Application of SureSeal floor drain seal (image copied from product website, RectorSeal 2017)

- c. Trap Guard. Trap Guard (Figure 9-5, ProVent Systems Inc. 2017) is a slightly different design than the other seals and is priced about \$30 per 2-in. drain, and \$34 per 3-in. drain. There are multiple variations of sizes and application available.

Figure 9-5. Image of Trap Guard seal (image from product website, ProVent Systems Inc. 2017).

- d. Quad Close Trap Seal. The Quad Close Trap Seal (Figure 9-6, Jay R. Smith Mfg, Co. 2017) is another design variation and is priced at approximately \$43 per 2-in. seal, \$50 per 3-in. seal, and \$57 per 4-in. seal.

Figure 9-6. Drawing of Quad Close Trap Seal (image from product website, Jay R. Smith MFG, Co. 2017)

- e. MI-GARD Floor Drain Trap Seal. The MI-GARD floor drain trap seal (Figure 9-7, MIFAB Inc. 2018), which is available in 2 in., 3 in., 3½ in., and 4 in. connection sizes, appears very similar to the Green Drain design, and is priced approximately \$34 per 2-in. drain, \$38 per 3-in. seal, and \$40 per 4-in. seal.

Figure 9-7. MIFAB MI-GARD floor drain trap seal display (image from product website, MIFAB Inc. 2017).

9.2.1.3 Routinely run water into traps manually.

Traps in operational buildings are usually maintained through normal use by flowing water from fixtures. This process can be mimicked in dormant buildings through routine maintenance procedures that involve the scheduled running of water through fixtures and into drains to replenish evaporated water in the traps. This process is currently employed at Fort Benning, GA (Kelley Hill), but has been found to be costly because of the labor involved with the frequent maintenance. The current protocol (June 2017) at Kelley Hill is to inspect water fixtures biweekly, run water for 5 minutes (hot and cold simultaneously for sinks and showers), and flush each toilet five times.

9.2.1.4 Capping

Another possible solution to maintaining the wastewater system is to cap off the sewer line at the building line (Park 1993). This idea would only be feasible where the potable water system is also shut off during a long term dormancy. In this scenario, the individual traps would not need to be maintained.

9.2.2 Economic comparison of trap maintenance options

The data in Table 9-1 may be used to compare the readily available solutions, which include the use of the materials: propylene glycol based sealer, poloxamer based sealer, mineral oil based sealer; and processes: routinely flowing water into traps manually, and capping the sewer line. A glycerin based liquid sealer is not considered because commercially available products were not found during this study. Using physical seals is also not considered because their application is limited to floor drains so they do not offer a complete solution.

The cost estimate of the routine manual water flow in Table 9-1 assumes that the average maintenance flow is 10 gpm/fixture. This is based on running each sink and shower fixture for 5 minutes at 2 gpm and flushing each toilet five times (2 gal/flush). The average flow per minute is based on data from the U.S. Geological Survey (USGS) (2017). The cost of water and sewage can vary widely. The average cost of water in the United States is 0.15 cents/gal (AWWA 2017). An average cost of sewage is roughly 0.5 cents/gal based on surveying numerous municipal rates across the United States.)

Based on this comparison of available options, the recommendation for trap maintenance in a dormant building is to employ a liquid sealer of some type. Any of the three options presented in Table 9-1 will be effective. Each has characteristics that may be desirable considering the actual building layaway plans and environmental conditions. For example, mineral oil based sealers may require less maintenance than propylene glycol based sealers and are less costly than the poloxamer based sealer, but they are not suitable for a mothballed building that experiences freezing temperatures like the two aforementioned sealer types. Physical seals are limited to floor drains and are not recommended as a general means for protecting all traps. However, there could be specific situations when their use may be favorable, such as to seal an infrequently used floor drain in a building that is still operational. Capping may be a good solution for a long term or permanently idle building.

Table 9-1. Trap maintenance options

Application	Propylene glycol based sealer (RV antifreeze)	Poloxamer based sealer	Mineral oil based sealer	Routine manual water flow	Capping sewer line
Time between maintenance	Monthly to yearly ¹	yearly	yearly	biweekly	indefinite
Operational in freezing temps	yes	yes	no	no	yes
Potable water system	On or Off	On or Off	On or Off	On	Off
Economics					
Materials cost/drain service visit ²	\$0.63	\$14.95 ⁵	\$4.69	\$0	\$0
Maintenance visits/yr	6	1 ³	1 ³	26	0
Maintenance ⁴ cost/yr-drain	\$21.75	\$17.95	\$7.69	\$78.00	\$0
Water Usage/ yr-drain (gal/yr) ⁶	0	0	0	260	0
Water & sewage cost/ yr – drain ⁷	\$0	\$0	\$0	\$1.69	\$0
Total cost/ yr – drain ⁸	\$21.75	\$17.95	\$7.69	\$79.69	Capping fee/ (# of drains * #yrs dormant)
¹ Depends on concentration, assume bimonthly. ² Assume full fluid replenish of 1 pint (for consistency in comparison). ³ These products can probably last indefinitely but it is recommended that an inspection take place yearly with a fluid change due to sediment. ⁴ The maintenance cost/yr-drain is equal to the cost of each maintenance visit (sum of labor and materials costs per drain) times the number of visits per year. It is assumed that one visit is approximately 2 minutes long. At an assumed \$90/hour rate it will cost \$3 for the labor cost per maintenance visit per drain. The 2 minute estimate per drain is also consistent with the routine manual water flow option because each drain requires 5 minutes flow but one to three drains could be operated simultaneously. ⁵ Volume discounts are available. ⁶ Water usage in gallons per year equals the estimated maintenance water flow per drain times the number of maintenance visits. ⁷ The water and sewage cost/yr-drain is equal to the water usage/yr-drain times the sum of the average cost of water/gallon and the average cost of sewage/gallon. Sewage costs are usually directly related to and charged on a water usage basis. These estimated costs are listed in the main text. ⁸ The total cost/yr-drain is equal to the maintenance cost/yr-drain plus the water and sewage cost/yr-drain. These estimated costs are listed in the main text.					

10 Avoiding Pest Infestations

Control of mice, rats, small animals, snakes, birds, insects, etc. is essential to prevent damage to the exterior and interior of dormant buildings. Animals can damage a building's exterior materials and finishes, and their droppings can create health hazards. Birds and animals pecking and chewing on exterior walls and roofs can create holes that then allow entry of even more pests into the building. The building envelope, consisting of the foundation, exterior walls, roof, and fenestration, separates the exterior environment from the interior of a building. Maintaining its integrity includes preventing access through it as well as protecting and preserving its physical condition.

10.1 Rodents

Rats and mice can cause serious damage to all types and age of buildings. Vulnerable parts of the building include insulation, electrical wiring, and plumbing. Damaged electrical wiring or rodent nests in electrical panels can lead to fires. Rodents can also be carriers of various diseases that are harmful to humans. Rats and mice are resourceful creatures, and can exploit any openings leading into a building by running across electrical wires, climbing pipes or any rough vertical surface, entering via pipe or conduits, gnawing through a variety of materials including aluminum sheeting and concrete block, etc. Once the rodents have gained entry into a building, they will have access to the entire building interior.

10.2 Birds

Birds can cause damage in several ways. Many birds build nests in rain gutters, downspouts under roof overhangs, on top of wall lights, chimneys, ventilation openings, etc. Problems that can result depend on the location of the nests, and include blocked drainage systems, blocked or reduced airflow to the building's ventilation system, and increased fire hazard from the dry nesting materials. Bird droppings contain a high acid content that can damage building materials, and can provide a source of bird-borne diseases and parasites that are potentially harmful to humans. Buildings with large openings such as maintenance facilities are further susceptible to entry and habitation of birds inside the building. Mechanical means to deter birds include the placement of bird spikes or porcupine wire in potential roosting or nesting areas. Bird netting can be used inside building

spaces open to the exterior, such as warehouses or repair shops, to block off access to rafters and beams.

10.3 Bats

Bats are long lived animals that play a vital role in the ecosystem by eating many destructive pests, helping with pollination, and dispersing seeds. Bats may cause indoor nuisances and potential health risks from their droppings (urine stains, guano, and odor), and, in rare cases, as carriers of rabies. Depending on the species, some bats can enter through openings as small as 3/8-in. in diameter. Extermination is often not an option since many species of bats are protected under the Endangered Species Act. Extermination also does not prevent other bats from coming back into a building. The most effective remedy is to seal all potential entry points. This should be accomplished after the bats have left or been removed from the building. Professional pest control services can probably accomplish this faster and more safely than in-house personnel.

10.4 Insects

Buildings containing wood products are susceptible to insect damage from termites, beetles, and carpenter ants. Infected wood must be treated with insecticides to exterminate the offending pests, and with preservatives to slow the rate of deterioration while the building is dormant. Any sources of moisture that causes the material to become more attractive to these pests must be found and corrected. Although they do not usually damage buildings, flying insects like bees and wasps (Figure 10-1), may be hazardous to people with severe allergic reactions to their stings. Holes and cracks in the building envelope must be sealed, and larger openings such as vents, grilles, or louvers of deactivated HVAC or appliance systems must be sealed on the inside and covered with bug mesh or heavy duty screens on the exterior.

Figure 10-1. Wasp nest on exterior dryer vent.

10.5 Foundation, exterior walls, and roof

Cover all penetrations accessible by animals and pests. Make sure the dampers for ventilation of unconditioned buildings and unconditioned spaces such as attics are securely closed. If the louvers do not have dampers behind them, the entire face of louver should be covered. For buildings still being conditioned and receiving outside air for ventilation, fit all exterior vents with heavy gauge non-corroding wire mesh screens. Install metal screens over all chimneys and roof vents to prevent access. Floor drains should be covered with metal grates with openings not exceeding 1/4 in. to prevent entry by rats and mice through the drainage system.

Inspect building exterior surfaces and wall/roof intersections for holes, cracks, gaps and crevices, and repair, caulk or seal all openings found. Any loose or damaged areas on the walls and roofs must be repaired. Insects can gain entry through 0.02 in. (0.5 mm) cracks; bats and small rodents through openings larger than 0.2 in. (5 mm); and rats through openings larger than 0.47 in. (12 mm). While these may seem like small openings, mice and rats can gnaw and enlarge them to allow entry into the building.

Inspect and seal all openings where plumbing, electrical, communications, and similar services enter a building. Neoprene seals or spray foam will not be effective against rodents as they will be able to gnaw through these. Use Portland cement mortar or metal collars instead.

Remove debris from gutters and ensure that they drain freely. Clogged gutters increase the risk of water damage to exterior walls and of potential ice dams on roofs of buildings in colder climates.

Inspect the ground around the perimeter of the building for standing water, and ensure that gutter downspouts drain well away from the building. Standing water provides an environment for insects, and allows the growth of mold and mildew.

10.6 Doors and windows

Ensure that all exterior doors have intact door sweeps, and install new ones if the existing sweeps are worn or missing. A gap greater than 1/4 in. between the bottom of the door and the threshold is large enough to permit the entry of mice.

Verify that weather stripping along sides and tops of door frames and around window frames are intact and in place. The tight seals will prevent entry of insects and will also minimize air infiltration and leakage. While doors and windows should be serviceable for emergency exit, tape and clear plastic can be used to further reduce leakage on windows and on doors not needed for inspection and other access while deactivated.

Repair any broken window panes. Repair or remove any broken window screens and make sure they are fixed tightly in their frames.

Install wire screening, netting, or bird mesh as needed to cover bird roosting locations. Install bird spikes on locations such as beams or window ledges to discourage birds from roosting or nesting.

10.7 Landscaping and vegetation

To minimize rodent burrows, plant colonization, and insect infestation; to prevent plant roots from damaging building foundations; to increase air circulation, allow easier visual surveillance, reduce moisture content along foundation walls by removing shade; and to minimize fire risk from dead and dried vegetation, severely trim or remove all vegetation around the perimeter of the building to create a vegetation free zone 5 to 10 ft wide (or whatever distance the installation designates). Remove and prevent the growth of ivy and vines on exterior walls (Figure 10-2). A layer of ivy or vines can accumulate moisture that makes a more inviting environment for harboring insects.

Remove nearby trees and shrubbery or trim so they are at least 10 ft from the building to prevent entry by rodents and insects via overhanging branches. Branches, leaves and pine needles that drop onto roofs can accumulate in gutters and clog drain spouts, allowing water to back up and accumulate, causing water damage to the roof (Figure 10-3). Over time, unremoved vegetative debris in gutters and on roofs will rot and decay, allowing additional plant growth to grow, or providing a home and breeding ground for pests.

Continue to maintain the building grounds during the period of dormancy. If regular grounds maintenance is not being performed, the vegetation free zone should be covered by landscape cloth with a layer of pea gravel or landscape rock on top.

Figure 10-2. Intrusive vine growth around wall mounted air-conditioner unit.

Figure 10-3. Vegetative growth in rain gutter.

11 Building Monitoring

Periodic physical visits and visual inspections are essential to ensure that vacant buildings have not been broken into, building components have not been damaged by man-made or natural forces, surrounding landscaping and vegetation are not overgrown, etc.

11.1 Periodic inspections

What items to check and inspect will depend on the type and condition of the buildings, the manpower and resources available to conduct the checks, the climatic location of the installation, the frequency of the inspections, etc. Different types of facilities, i.e., a TEMF vs. a barracks, will have different things that must be examined. A barracks, for example, may need to be inspected more often than a TEMF. Depending on the number and variety of buildings involved, an installation may decide to use generic checklists applicable to all buildings, or more specific ones focused on specific building types. The installation DPW and its service contractor should coordinate their efforts and cooperatively develop a suitable checklist or set of checklists for the dormant facilities. Figure 11-1 shows an example of an inspection checklist used at Fort Benning, GA.

11.2 Remote monitoring

Often, it is not readily apparent whether the indoor environmental conditions, temperature, and relative humidity are staying within acceptable limits. The interiors of buildings in hot and humid climates can suffer from excessive and costly to remediate growth of mold and mildew if the humidity levels are too high. In cold climates, buildings that still have active water supply lines can be vulnerable to freezing pipes if the interior temperatures are too cold. Unfortunately, it is very difficult to determine what is happening inside an unoccupied building that has its heating and cooling systems shut down. It is not practical or economical to have someone go in on a regular basis to collect temperature and humidity measurements, but there are alternatives.

Figure 11-1. Example of an inspection checklist.

Kelley Hill Facility Checklist for Unoccupied Buildings					
Facility #		Floor #	Date:	(print) Inspected by:	
		(For Barracks Only)		Signature:	
TIYA Support Services		GOOD	BAD	N/A	NOTES:
COMPONENTS					
Humidity Level		☐ HVAC ON	☐ HVAC OFF	☐ N/A	TEMP: °
Ambient Temp		☐ HVAC ON	☐ HVAC OFF	☐ N/A	TEMP: °
Toilets		☐ Barracks	☐ Male	☐ Female	☐ Unisex
Sinks		☐ Barracks	☐ Male	☐ Female	☐ Unisex
Showers		☐ Barracks	☐ Male	☐ Female	☐ Unisex
Doors/Door Sweeps		☐ Broken	☐ Missing	☐ Broken Lock	☐ PICS
Window Seals		☐ Broken	☐ Missing	☐ Broken Lock	☐ PICS
Mold/Mildew		☐ Broken	☐ Missing	☐ Mold/Mildew	☐ PICS
Ceiling Tiles		☐ Broken	☐ Missing	☐ Mold/Mildew	☐ PICS
Floor Tiles		☐ Broken	☐ Missing	☐ Mold/Mildew	☐ PICS
Walls		☐ Holes	☐ Dryer Vents Closed	☐ Mold/Mildew	☐ PICS
Pest Control		☐ Roaches	☐ Rats	☐ Snakes	☐ Wasps
Foliage		☐ No	☐ Yes	☐ PICS	Ants
Bldg Envelope Cracks/Holes		☐ No	☐ Yes	☐ PICS	Within 5' of bldg, equip, enclosures of any kind?
Fire Alarms/Exit lights		☐ Fire Alarm	☐ Smoke Alarm	☐ Security Alarm	☐ Exits
Mech. Rooms		☐ Leaks	☐ Machinery Running		
Water Fountains		☐ Leaks	☐ Inoperable	☐ Dirty Water	
Security & Safety/		☐ Front Door Locked	☐ Back Door Locked		
Grounds Check		☐ Side Door(s) Locked	☐ Perimeter		
*Humidity Level -Check humidity levels and note if HVAC is ON/OFF (if applicable). *Ambient Temp -Check temperature levels in building (note if HVAC is ON/OFF)					
*Lights -Note any auto lights that are ON upon entering. Note any lights that DO NOT WORK . Make sure all lights are OFF upon leaving the building.					
*Toilets-Flush 5x and watch for leaks. Note LOCATION and WHICH toilet. (i.e. Toilet/Urinal #1, #2, on the left/right; if only one in bldg, note it on your form)					
*Sinks & Garbage Disposals -Run water in all sinks for 5 min. each; hot & cold at the same time. Check disposal. Check for leaks at both the top and underneath the sink. (Notate whether the sink is a bathroom or kitchen sink. ONLY RUN WATER IN SINKS IN THE ROOM YOU ARE CURRENTLY IN . You may forget to turn one off. Accidents happen.)					
*Showers -Run water for 5 min.; hot & cold at the same time. Check for leaks, mold, cracks in grout. Same rule to running water applies to showers as it does to sinks.					
*Doors -check for excessive gaps and security. Make sure ALL exterior doors are closed & locked before you leave assigned bldg. (if bldg is Common Access Barracks- Make sure ALL Doors Remain OPEN)					
*Windows -note damages/broken panes-close blinds &/or shades-make sure windows are closed & locked. *Mold/Mildew -Note item/area affected and location-add photos.					
*Ceiling Tiles -Note any areas of water damage-add photos. *Floor tiles -Note any areas warping due to water damage (add photos) which could lead to mold underneath floor.					
*Walls -Note paint peeling, chipping or wallpaper peeling, and water damage/stains. *Pest Control -Note any pests-roaches, bugs, wasps, ants rodents, snakes, or bees of any kind.					
*Foliage -Note any foliage within 5' of bldg, equipment, enclosures of any kind. *Mech. Rooms -Note any leaks/machinery running/Lube key access if needed.					
*Cabinets/Furniture -Note any damage/missing items. *Fire Alarms/Exits -Note any alarms making sounds, which alarm is making sounds and the area/location of the alarm . Are exit lights working?					
*Water Fountains -Check all fountains, note any fountains that are not working/leaking, and note any fountains with dirty water. *Grounds Check -Check outside perimeter for open/damaged trap doors.					
*Security -Check exterior doors for security, make sure all exterior doors are locked upon arrival and again when inspection is completed before leaving. Check perimeter for any safety hazards .					

11.2.1 Data logger monitoring

Portable battery operated data loggers (Figure 11-2) are one means to automatically measure temperature and humidity data over time inside buildings. These are typically small in size (the unit pictured is 1.44 x 3.34 x 0.6 in.), have measurement intervals ranging from 1 second to several hours, and can accumulate tens of thousands of data readings depending on the amount of memory built into the logger.

Software for the logger is often provided at no cost from the manufacturer and is used to launch and download data from the logger, and display it in graphical format. For example, Figures 11-3 and 11-4 show temperature and humidity measurements taken in a first floor room and a fourth floor room of an unoccupied, un-air-conditioned four story barracks building where the barracks room have individual exterior entry doors. The barracks is located in the southeastern United States, and data was taken from late spring to mid-summer. A comparison of the two graphs shows that, while the room temperatures for the first floor room (Figure 11-3) is lower than the fourth floor room (Figure 11-4), the humidity level is also higher for the lower floor, which increases the risk of mold growth and indicates a need to pay more attention to these rooms during hot and humid weather.

Figure 11-2. Portable, battery powered data logger.

Figure 11-3. Temperature (red), humidity (blue) and dewpoint (green) in 1st floor barracks room.

Figure 11-4. Temperature (red), humidity (blue) and dewpoint (green) in fourth floor barracks room.

Manufacturers are continuing to improve the capabilities and features of data loggers. Whereas older models use data cables connected to portable computers, newer ones (Figure 11-5) allow loggers to be launched and data downloaded wirelessly. The results can then be displayed immediately on smart phones or tablets. This can significantly reduce the amount of time and effort needed to collect and analyze building performance data. Note that the use of wireless data loggers in Army buildings will depend on the information assurance policy of the installation where the building is located.

Figure 11-5. Wireless portable data logger.

11.2.2 Using building automation controls (BAC) and UMCS to monitor layaway buildings

BAC in conjunction with UMCS can be used to monitor layaway buildings from a central point. Doing this lowers the frequency at which the buildings must be physically inspected. The primary points of interest are building temperature, humidity and dew point. While space temperatures are commonly part of BAS/UMCS systems, humidity and dew point are less common. Humidity is sometimes measured as part of an Air Handling Unit (AHU), but this is a poor point to rely on for space humidity. Space humidity sensors can be interfaced to the BAS via either an analog input on a controller or on an Input/Output (I/O) board, or via digital communications such as BACnet or LONtalk. They also come as combination temperature and humidity measurements.

11.2.2.1 Issues

A disadvantage of relying on AHU based measurements is that they are irrelevant if the AHU is not running. Since shutting off AHUs and other equipment is a common practice in layaway buildings (this is the case at Fort Benning), relying on these points for monitoring is not a reliable option. Another issue is whether or not electrical power that powers the BAS has been shut off. Without power, the BAS will not be available for monitoring. If the BAS is not connected to the UMCS, it is recommended that the cost of connecting it be investigated. Most buildings of any significant size are connected to a base-wide communications network that is used by the UMCS. It requires the installation of a Building Point of Connection (BPOC) device that connects the BAS to the base-wide network, which in turn is connected to a front end (a computer with monitoring and control software).

11.2.2.2 Costs

Of course, costs vary, but may be approximated as:

- humidity and combination humidity and temperature transmitters vary with the accuracy of the device from \$100 to \$800
- purchasing and installing a BPOC is approximately \$1,000.

Whether the costs are worth the benefits varies from case to case and depends on the length of time the building is laid away. This must be evaluated on a case-by-case basis. An alternative would be to use temporary data loggers as described above. These are less expensive than those connected to BAS. Disadvantages include that:

- They have to be accessed periodically to download data.
- They do not provide real time feedback.
- Since they are not permanently installed, they are vulnerable to theft.

11.2.2.3 Summary

In summary the recommendations for using BAS/UMCS for monitoring layaway buildings are:

- Determine key locations to monitor
- Monitor space temperature and humidity, using existing space thermostats and installing space relative humidity sensors; or install a combination relative humidity and temperature sensor
- Leave BAS systems energized even if equipment it controls is turned off.

12 Reactivation Considerations

12.1 Reactivation process

The reactivation process is not just a matter of bringing a vacant building back to its previously occupied condition. It should be considered as an opportunity to identify and implement cost efficient upgrades to existing components of the building. Various building and life safety codes may have changed during the time when the building was dormant. These must be reviewed to ensure that applicable new requirements are addressed and implemented in the reactivated building. Technology advances in HVAC, electrical, lighting, communications, etc. may also have occurred such that it may be more economical to replace existing systems with ones current at the time of reactivation. Retrieve and review all documentation created at the time the building was originally deactivated and reports and checklists created over the building's period of dormancy to ensure that deficiencies accrued over time will be corrected.

12.2 Preparation requirements for reactivating facilities

The following sections discuss key items to be addressed as part of the reactivation process.

12.2.1 Fire and life safety

Determine if the fire sprinkler system was previously deactivated and reactivate if needed. Coordinate with the fire department for inspection and testing of the sprinkler system, fire alarms, exit signs, location and status of fire extinguishers, etc. Replace backup batteries of all emergency lights.

12.2.2 Landscaping and pest control

Remove any overgrown vegetation around the building and mechanical equipment located outside the building. Inspect the building for pests that may have established themselves inside the building and remove any that are found. Repair and seal any openings that were made by pests to gain access to the building.

12.2.3 Building exterior

Inspect exterior wall surfaces, fenestration, and roofs for defects and repair to maintain or restore the integrity of the building envelop. Inspect

and repair all roof drains, gutters, and downspouts to verify that they drain properly.

12.2.4 Building interior

Inspect and remove any debris and/or animal waste that may have accumulated over the dormancy period. Inspect for any signs of water damage or intrusion and coordinate repairs with corrective work on the building exterior. Remediate any biological growth found inside the building. Repair or replace, as needed, all interior finishes after any sources of water intrusion that were found have been corrected.

Work with the installation's industrial hygienist to verify that indoor air quality is within acceptable standards. Corrective actions will be done in coordination with repairs and upgrades to the building's HVAC system.

Check inventory of any previously stored furnishings, equipment, etc. and determine if they can be reused in the building. Existing built-in equipment such as elevators or shop equipment (cranes, hoist, lifts) must be inspected for functionality, and must be recertified.

12.2.5 HVAC system

Before starting up HVAC system, inspect all components of the system for signs of biological growth. Do not operate the system if there are indications of growth as this could result in spreading the biological contaminants throughout the building.

Reactivation of the HVAC equipment will, in general, follow in reverse order the steps originally followed to deactivate and place in layaway status the equipment.

The reactivation process is an opportunity to make minor upgrades to the HVAC system. Major upgrades will be costly and delay the restoration of the building to fully operational status. The original documentation (such as maintenance logs and operation and maintenance manuals) should be reviewed to determine if repairs or upgrades are needed or possible. The HVAC system should be recommissioned to meet current operating requirements, and a new set of up to date documentation created. Training in operating the recommissioned system must be provided to O&M personnel.

12.2.6 Plumbing

If the water supply has been shut off during the period of dormancy, the valve packing and washers in plumbing fixtures should all be replaced when the building is reactivated because they will all have dried out over time.

Check the plumbing system for leaks, and repair any that are found.

12.2.7 Electrical and lighting

Determine power requirements for the reactivated building, verify that the existing electrical system is able to meet the need or upgrade if required. Verify that all receptacles and switches are functional, and if needed, replace them.

Consider replacing the existing interior and existing light fixtures and exit signs with equivalent high efficiency light emitting diode (LED) ones. LED lighting uses less energy, is more durable, has a much longer service life and therefore far fewer maintenance requirements, and provides comparable or better lighting quality. Existing sodium vapor or metal halide exterior wall lights can be replaced with LED lights. In interior rooms, existing fluorescent ceiling fixtures can be replaced with LED fixtures. As an alternative to fixture replacement and depending on the type of fixture, it may be possible to replace just the existing lamps with LED lamps.

Most buildings built or renovated within the past 30 years likely already have occupancy sensors installed in interior rooms. Verify that these are still functional, and reprogram or replace them if they are not. If there are rooms without occupancy sensors, review the functions for those rooms and determine if there is a need for new sensors to be added.

Entrance lights and lighting for stairwells are usually turned and left on during nighttime hours. Considering that most government buildings, except for barracks, are unoccupied at night, no purpose is served and energy wasted by leaving these lights on. Motion detectors can be added to these lights so they turn on only when people approach them. The detectors must be adjusted so they turn on sufficiently early when people enter their zone of detection.

13 Deactivation, Layaway, Reactivation, and Building Type Specific Checklists

Checklists are a useful tool for installation and contractor personnel to identify and select issues and activities to focus on, starting with the initial decision to deactivate buildings, through the layaway or dormancy period for the buildings, to the point when the buildings are to be reoccupied. The level of detail in checklists can be relatively basic or very detailed down to individual pieces of equipment. Some of the factors that determine how much detail to go with will depend on the type of building, how long it is anticipated to be dormant, who will be responsible to performing the tasks on the checklists, and what resources (financial and manpower to name two) are available over time to manage the checklists. This section provides examples for four types of checklists:

1. Deactivation (Figure 13-1)
2. Layaway (Figure 13-2)
3. Reactivation (Figure 13-3)
4. Building Type Specific (Figure 13-4).

Each checklist example should be considered as a starting point to be adapted to the installation's and individual building's requirements.

Figure 13-1. Deactivation checklist.

Deactivation Checklist			
	Preliminary /Stabilization	Deactivation	Responsibility (DPW, Unit, Contractor)
Deactivation Planning			
Economic analyses	X		D
Decide on type of deactivation, i.e., "warm" or "cold"	X		D, C
Building Stabilization Plan	X		D, C
Condition assessment and documentation (including photos)	X		D, C
Coordination with fire department	X		D, C
Determine monitoring and surveillance requirements	X	X	D, C
Maintenance level and resources required	X	X	D, C
Closure Report	X	X	C
Building Grounds and Security			
Secure access to buildings; verify all exterior door locks are functional and doors are secure		X	C
Lubricate lock mechanisms with graphite		X	C
Key management; tag all keys with identification and keep in a central location		X	C
Master key; to all buildings or all rooms within a building		X	D, C
Determine security lighting requirements		X	D, C
Install signs stating building is under surveillance		X	C
Remove all trash and debris around perimeter of building		X	U
Remove all shrubbery and trees within ___ feet of the building perimeter		X	U, C
Verify nearby surrounding ground is not sloped towards building allowing water flow into building during rainy weather		X	C
Fill in depressions in ground that would allow water to accumulate		X	C
Irrigation systems, shut off water and lock out master supply valve, and blow out standing water with compressed air		X	C
Sidewalks, stoops, steps, stairs, handrails; repair severely damaged sections to ensure safe access during inspections		X	C
Building Structure			
Check for signs of movement in exterior walls and interior load bearing walls (cracks, bowing or bulging)		X	C
Check for sagging trusses, girders, rafters, joists, beams; excessive amount may indicate demolition is more preferable than layaway		X	C
Columns; out of plumb, bowed or buckled		X	C
Cracking at column/slab connection		X	C
Check for signs of corrosion on structural and architectural metals		X	C

Figure 13-1. Deactivation checklist (cont.)

Building Envelope			
Inspect roof components for damage (flashing, roofing material, penetrations, equipment supports)		X	C
Check flat roofs for standing water and signs of water leakage		X	C
Check rooftop and drainage for debris and vegetation and remove if found		X	C
Repair all damaged areas on roof		X	C
Check and clean gutters and ensure downspouts are not blocked		X	C
Ice dams; check for presence of ice dams on sloped roofs during winter		X	C
Inspect building envelope for deficiencies		X	C
Repair wall damage (depending on type of construction; cracks, holes, chips, spalling, damaged expansion joints, damaged or missing mortar, missing brick or CMU units, missing siding sections)		X	C
Efflorescence, stains, peeling paint on walls; indicates potential water leakage		X	C
Close all exterior openings (grilles, louvers, dryer vents) to prevent entry of moisture, pests or animals; install wire screens as needed		X	C
Repair and make weathertight all exterior doors		X	C
Overhead doors; no holes or missing sections, securely closed. Consider sealing to reduce air and water leakage (optional). Disconnect from power (optional).		X	C
Verify all windows are closed and securely locked		X	C
Repair and make weathertight all broken windows and secure against access		X	C
Repair and secure window screens in place to deter entry of pests and animals		X	C
Seal all joints and caulk around fenestration as needed		X	C
Board all windows (optional)		X	C
Building Interior			
Remove any hazardous waste found		X	U, C
Remove any flammable material found		X	U, C
Remove all trash and debris and sweep clean or vacuum all interior floors (by leaving unit)		X	U
Check for signs of pests or vermin		X	C
Remove all contents of building, including fabric draperies. (flammables and mold food)		X	C
Inventory equipment and property and recommend for (storage/disposal)	X	X	C
Transfer/store usable equipment/property	X	X	D, C
Dispose of unusable equipment and property		X	C
Interior doors and partitions; leave open, remove or disable lockable locksets and latches		X	C
Vault doors; leave open, disable lock		X	C
Blinds; remove and dispose of if broke		X	C
Seal all joints, cracks, and holes in walls to prevent entry of water		X	C
Check for signs of moisture intrusion (ceiling, wall, floor)		X	C
Wet ceiling tiles and insulation; remove and dispose, correct source of moisture intrusion, and leave bare		X	C
If exterior facing walls have wallpaper covered surface, check for signs of biological growth on or behind the wallpaper		X	C

Figure 13-1. Deactivation checklist (cont.)

Seal all joints, cracks, and holes in floors to prevent entry of water; use appropriate methods for concrete, tile, terrazzo, wood, vinyl, carpet floors		X	C
Wet carpeting; remove and dispose, correct source of moisture intrusion, and leave bare		X	C
Refrigerators and freezers; disconnect power, clean and leave with doors open, disconnect interior lights		X	C
Walk-in refrigerators and freezers; disconnect power, clean and leave doors open, padlock latches to keep from locking		X	C
Drinking fountains; disconnect power, shut off water supply, fill drain trap with antifreeze		X	C
Elevators; lower to lowest level, block up or remove and lower counterweights to bottom of hoist way, clean interior, and deactivate		X	C
Cranes; lower hoist to rest on floor and coat all unpainted parts with corrosion-preventive compound		X	C
Building Mechanical Systems			
Water supply line to building; turn off (optional; also address fire sprinklers, sanitary lines, traps)		X	C
Gas supply line to building; turn off (optional; if decision made for unheated buildings)		X	C
HVAC; drain and dry all water supply and return lines to prevent freezing during cold weather (optional)		X	C
HVAC; provide minimal heating during cold weather to protect building components from extreme cold (optional)		X	C
HVAC; provide minimal cooling during hot and humid weather to keep relative humidity below __ % (optional)		X	C
Heating and cooling coils; clean and protect with corrosion preventive coating		X	C
Air conditioning equipment; remove and store refrigerant (optional)		X	C
Close dampers for all exterior openings to prevent entry of moisture, pests or animals		X	C
Install screens over all exterior mechanical openings		X	C
Compressors; Inspect? Remove? Run?		X	C
Pumps; Inspect? Remove? Run?		X	C
Boilers; drain and clean boiler and supply and return lines (optional)		X	C
Inspect plumbing lines (water, steam, gas, air)		X	C
Window air conditioning units; remove for reuse elsewhere and reseal window opening		X	C
Hot water heaters and other tanks containing water, drain and disconnect		X	C
Traps; for toilets, urinals, tubs, showers, lavatories, sinks, washers drained and capped (optional)		X	C
Traps; for toilets, urinals, tubs, showers, lavatories, sinks, washers filled with antifreeze (optional)		X	C
Sanitary sewer lines; drain and cap		X	C
Storm water drainage pipes for roofs and downspouts		X	C

Figure 13-1. Deactivation checklist (cont.)

HVAC Controls/UMCS (if a functioning UMCS is available)			
Schedule equipment to run a minimum amount of time		X	D, C
Monitor room temperature and humidity		X	C
Monitor occupancy		X	C
Monitor run status of equipment		X	C
Building Electrical Systems			
Remove all nonessential power consuming equipment		X	C
Verify power to fire alarms/smoke detectors	X	X	D, C
Verify power to security lighting	X	X	D, C
Disconnect electrical service to lighting except for that required for security and maintenance personnel		X	C
Disconnect lighting to all rooms with exterior windows		X	C
Remove lamps from buildings that will be vacant for greater than <u>_ONE_</u> years and reuse elsewhere		X	C
Motors, generators and control equipment; Inspect? Remove?		X	C
Remove all unused/unneeded batteries for reuse elsewhere		X	C
Verify power to sump pumps		X	C
Fire Protection Equipment			
Fire alarms/smoke detectors; keep in service	X	X	D, C
Wet-pipe sprinkler systems; drain completely and install an exterior PIV between street shut off valve and exterior face of building (optional)		X	C
Wet-pipe sprinkler systems; add antifreeze (optional, for unheated buildings)		X	C
Wet-pipe sprinkler systems; normal maintenance (optional, for buildings heated about 40F		X	C
Fire hoses inside of building; retain		X	C
Fire extinguishers; retain at main building entrances and mechanical rooms and remove all others and reuse elsewhere		X	C

Figure 13-2. Layaway checklist.

Layaway Checklist (boxes are left blank as tasks and responsibilities may vary depending on the installation's preference)							
	Initial	Monthly	6-Month	Annual	5-Year	> 5 Years	Responsibility (DPIW, Unit, Contractor)
Building Grounds and Security							
Secure access to buildings; verify all exterior door locks are functional and doors are secure							
Lubricate lock mechanisms with graphite							
Key management; tag all keys with identification and keep in a central location							
Master key; to all buildings or all rooms within a building							
Determine security lighting requirements							
Install signs stating building is under surveillance							
Remove all trash and debris around perimeter of building							
Remove all shrubbery and trees within __ feet of the building perimeter							
Verify nearby surrounding ground is not sloped towards building allowing water flow into building during rainy weather							
Fill in depressions in ground that would allow water to accumulate							
Irrigation systems, shut off water and lock out master supply valve, and blow out standing water with compressed air							
Sidewalks, stoops, steps, stairs, handrails; repair severely damaged sections to ensure safe access during inspections							
Building Structure							
Check for signs of movement in exterior walls and interior load bearing walls (cracks, bowing or bulging)							
Check for sagging trusses, girders, rafters, joists, beams; excessive amount may indicate demolition is more preferable than layaway							
Columns; out of plumb, bowed or buckled							
Cracking at column/slab connection							
Check for signs of corrosion on structural and architectural metals							
Building Envelope							
Inspect roof components for damage (flashing, roofing material, penetrations, equipment supports)							
Check flat roofs for standing water and signs of water leakage							
Check rooftop and drainage for debris and vegetation and remove if found							
Repair all damaged areas on roof							
Check and clean gutters and ensure downspouts are not blocked							
Ice dams; check for presence of ice dams on sloped roofs during winter							
Inspect building envelope for deficiencies							
Repair wall damage (depending on type of construction; cracks, holes, chips, spalling, damaged expansion joints, damaged or missing mortar, missing brick or CMU units, missing siding sections)							
Efflorescence, stains, peeling paint on walls; indicates potential water leakage							
Close all exterior openings (grilles, louvers, dryer vents) to prevent entry of moisture, pests or animals; install wire screens as needed							
Repair and make weathertight all exterior doors							
Overhead doors; no holes or missing sections, securely closed. Consider sealing to reduce air and water leakage (optional). Disconnect from power (optional).							

Figure 13-2. Layaway checklist (cont.).

Verify all windows are closed and securely locked						
Repair and make weathertight all broken windows and secure against access						
Repair and secure window screens in place to deter entry of pests and animals						
Seal all joints and caulk around fenestration as needed						
Board all windows (optional)						
Building Interior						
Remove any hazardous waste found						
Remove any flammable material found						
Remove all trash and debris and sweep clean or vacuum all interior floors (by leaving unit)						
Check for signs of pests or vermin						
Remove all contents of building, including fabric draperies. (flammables and mold food)						
Inventory equipment and property and recommend for (storage/disposal)						
Transfer/store usable equipment/property						
Dispose of unusable equipment and property						
Interior doors and partitions; leave open, remove or disable lockable locksets and latches						
Vault doors; leave open, disable lock						
Blinds; remove and dispose of if broke						
Seal all joints, cracks, and holes in walls to prevent entry of water						
Check for signs of moisture intrusion (ceiling, wall, floor)						
Wet ceiling tiles and insulation; remove and dispose, correct source of moisture intrusion, and leave bare						
If exterior facing walls have wallpaper covered surface, check for signs of biological growth on or behind the wallpaper						
Seal all joints, cracks, and holes in floors to prevent entry of water; use appropriate methods for concrete, tile, terrazzo, wood, vinyl, carpet floors						
Wet carpeting; remove and dispose, correct source of moisture intrusion, and leave bare						
Refrigerators and freezers; disconnect power, clean and leave with doors open, disconnect interior lights						
Walk-in refrigerators and freezers; disconnect power, clean and leave doors open, padlock latches to keep from locking						
Drinking fountains; disconnect power, shut off water supply, fill drain trap with antifreeze						
Elevators; lower to lowest level, block up or remove and lower counterweights to bottom of hoist way, clean interior, and deactivate						
Cranes; lower hoist to rest on floor and coat all unpainted parts with corrosion-preventive compound						
Building Mechanical Systems						
Water supply line to building; turn off (optional; also address fire sprinklers, sanitary lines, traps)						
Gas supply line to building; turn off (optional; if decision made for unheated buildings)						
HVAC; drain and dry all water supply and return lines to prevent freezing during cold weather (optional)						
HVAC; provide minimal heating during cold weather to protect building components from extreme cold (optional)						
HVAC; provide minimal cooling during hot and humid weather to keep relative humidity below ____% (optional)						
Heating and cooling coils; clean and protect with corrosion preventive coating						
Air conditioning equipment; remove and store refrigerant (optional)						
Close dampers for all exterior openings to prevent entry of moisture, pests or animals						

Figure 13-2. Layaway checklist (cont.).

[illegible]

Figure 13-3. Reactivation checklist.

Reactivation Checklist (boxes are left blank as tasks and responsibilities may vary depending on the installation's preference)			
	Pre-reactivation	Reactivation	Responsibility (DPW, Unit, Contractor)
Reactivation Planning			
Economic analyses			
Review Deactivation condition assessment documentation to identify areas requiring upgrade or replacement			
Coordination with fire department			
Determine reactivation resources required			
Fire Protection Equipment			
Fire alarms/smoke detectors; test and replace as needed			
Sprinkler systems; reactivate if needed and test			
Fire hoses inside of building; verify integrity			
Fire extinguishers; reinstall at all required locations			
Building Grounds and Security			
Verify all exterior door locks are functional and doors are secure			
Lubricate lock mechanisms with graphite			
Determine which buildings/rooms need new keys			
Determine security lighting requirements			
Remove all trash and debris around perimeter of building			
Trim all shrubbery and trees within ___ feet of the building perimeter; determine if additional landscaping needed			
Verify nearby surrounding ground is not sloped towards building allowing water flow into building during rainy weather			
Sidewalks, stoops, steps, stairs, handrails; repair severely damaged sections to ensure safe access			
Remove signs stating building is under surveillance			
Irrigation systems, turn on water and test coverage			
Building Structure			
Check for signs of movement in exterior walls and interior load bearing walls (cracks, bowing or bulging)			
Check for sagging trusses, girders, rafters, joists, beams; excessive amount may indicate demolition is more preferable than layaway			
Columns; out of plumb, bowed or buckled			

Figure 13-3. Reactivation checklist (cont.).

Cracking at column/slab connection			
Check for signs of corrosion on structural and architectural metals			
Building Envelope			
Inspect roof components for damage (flashing, roofing material, penetrations, equipment supports)			
Check flat roofs for standing water and signs of water leakage			
Check rooftop and drainage for debris and vegetation and remove if found			
Repair all damaged areas on roof			
Check and clean gutters and ensure downspouts are not blocked			
Inspect building envelope for deficiencies			
Repair wall damage (depending on type of construction; cracks, holes, chips, spalling, damaged expansion joints, damaged or missing mortar, missing brick or CMU units, missing siding sections)			
Open all exterior openings necessary to allow the proper operation of the HVAC and various exhaust systems			
Repair and make weathertight all exterior doors			
Overhead doors; no holes or missing sections, and fully operational			
Verify all windows are operational and locks are functional			
Repair and make weathertight all broken windows			
Repair and secure window screens in place to deter entry of pests and animals			
Seal all joints and caulk around fenestration as needed			
Open up boarded windows (if previously done)			
Building Interior			
Remove all trash and debris and sweep clean or vacuum all interior floors			
Check for signs of pests or vermin			
Verify operation of all Interior doors and partitions and repair and install new locksets if needed			
Vault doors; verify lock operation			
Repair broken blinds; install new blinds and drapes where required			
Seal all joints, cracks, and holes in walls to prevent entry of water			
Check for signs of moisture intrusion (ceiling, wall, floor)			
Wet ceiling tiles and insulation; correct source of moisture intrusion, and replace with new tiles and insulation			
Seal all joints, cracks, and holes in floors to prevent entry of water; use appropriate methods for concrete, tile, terrazzo, wood, vinyl, carpet floors			
Wet carpeting; remove and dispose, correct source of moisture intrusion, and install new carpeting if needed			
Refrigerators and freezers; connect power, clean and replace interior lights if burnt out			
Walk-in refrigerators and freezers; connect power, clean, and verify padlock latches are functional			
Drinking fountains; connect power, turn on water supply, and flush lines			

Figure 13-3. Reactivation checklist (cont.).

Elevators; reactivate and test			
Cranes; reactivate and test functionality			
Building Mechanical Systems			
Water supply line to building; turn on (if previously shut off; also address fire sprinklers, sanitary lines, traps)			
Gas supply line to building; turn on (if previously shut off)			
HVAC; fill all water supply and return lines (if previously drained)			
Heating and cooling coils; clean and protect with corrosion preventive coating			
Open dampers for all equipment requiring outside air or needing to exhaust building air			
Install screens over all exterior mechanical openings			
Compressors; inspect and verify operation			
Pumps; inspect and verify operation			
Boilers; follow manufacturers' operating instructions to properly restart			
Recommission heating and cooling systems after startup			
Inspect plumbing lines (water, steam, gas, air)			
Window air conditioning units; where used previous, consider installing new mini-split systems instead of window units			
Hot water heaters and other tanks containing water, refill and test for proper operation			
Traps; for toilets, urinals, tubs, showers, lavatories, sinks, washers, refill with water			
Sanitary sewer lines; if previously capped, remove cap			
Storm water drainage pipes for roofs and downspouts; verify proper draining			
HVAC Controls/UMCS (if a functioning UMCS is available)			
Determine if existing control system need to be upgraded or replaced			
Program new operating schedule			
Monitor room temperature and humidity to verify control system is working properly			
Building Electrical Systems			
Determine if electrical power supplied to the building is adequate for the new occupants			
Verify power to fire alarms/smoke detectors			
Verify power to security lighting			
Reconnect electrical service to all lighting			
Consider upgrading existing light fixtures to new energy efficient types in common use at the time of reactivation			
Motors, generators and control equipment; inspect and verify proper operation			
Verify power to sump pumps			

Figure 13-4. Building type specific checklist.

Building Type Specific Checklist (boxes are left blank as tasks and responsibilities may vary depending on the installation's preference)						
	Admin/HQ	Barracks	DFAC	Community Center	Maintenance/Shops	Responsibility (DPW, Unit, Contractor)
Deactivation Planning						
Economic analyses	X	X	X	X	X	D
Decide on type of deactivation, i.e., "warm" or "cold"	X	X	X	X	X	D, C
Building Stabilization Plan	X	X	X	X	X	D, C
Condition assessment and documentation (including photos)	X	X	X	X	X	D, C
Coordination with fire department	X	X	X	X	X	D, C
Determine monitoring and surveillance requirements	X	X	X	X	X	D, C
Maintenance level and resources required	X	X	X	X	X	D, C
Closure Report	X	X	X	X	X	C
Building Grounds and Security						
Secure access to buildings; verify all exterior door locks are functional and doors are secure	X	X	X	X	X	C
Lubricate lock mechanisms with graphite	X	X	X	X	X	C
Key management; tag all keys with identification and keep in a central location	X	X	X	X	X	X
Master key; to all buildings or all rooms within a building	X	X	X	X	X	D, C
Determine security lighting requirements	X	X	X	X	X	D, C
Install signs stating building is under surveillance	X	X	X	X	X	C
Remove all trash and debris around perimeter of building	X	X	X	X	X	U
Remove all shrubbery and trees within __ feet of the building perimeter	X	X	X	X	X	U, C
Verify nearby surrounding ground is not sloped towards building allowing water flow into building during rainy weather	X	X	X	X	X	C
Fill in depressions in ground that would allow water to accumulate	X	X	X	X	X	C
Irrigation systems, shut off water and lock out master supply valve, and blow out standing water with compressed air	X	X	X	X		C
Sidewalks, stoops, steps, stairs, handrails; repair severely damaged sections to ensure safe access during inspections	X	X	X	X	X	C
Building Structure						
Check for signs of movement in exterior walls and interior load bearing walls (cracks, bowing or bulging)	X	X	X	X	X	C
Check for sagging trusses, girders, rafters, joists, beams; excessive amount may indicate demolition is more preferable than layaway	X	X	X	X	X	C
Columns; out of plumb, bowed or buckled	X	X	X	X	X	C
Cracking at column/slab connection	X	X	X	X	X	C
Check for signs of corrosion on structural and architectural metals	X	X	X	X	X	C
Building Envelope						
Inspect roof components for damage (flashing, roofing material, penetrations, equipment supports)	X	X	X	X	X	C

Figure 13-4. Building type specific checklist (cont.).

Check flat roofs for standing water and signs of water leakage	X	X	X	X	X	C
Check rooftop and drainage for debris and vegetation and remove if found	X	X	X	X	X	C
Repair all damaged areas on roof	X	X	X	X	X	C
Check and clean gutters and ensure downspouts are not blocked	X	X	X	X	X	C
Ice dams; check for presence of ice dams on sloped roofs during winter	X	X	X	X	X	C
Inspect building envelope for deficiencies	X	X	X	X	X	C
Repair wall damage (depending on type of construction; cracks, holes, chips, spalling, damaged expansion joints, damaged or missing mortar, missing brick or CMU units, missing siding sections)	X	X	X	X	X	C
Efflorescence, stains, peeling paint on walls; indicates potential water leakage	X	X	X	X	X	C
Close all exterior openings (grilles, louvers, dryer vents) to prevent entry of moisture, pests or animals; install wire screens as needed	X	X	X	X	X	C
Repair and make weathertight all exterior doors	X	X	C	X	X	C
Overhead doors; no holes or missing sections, securely closed. Consider sealing to reduce air and water leakage (optional). Disconnect from power (optional).					X	C
Verify all windows are closed and securely locked	X	X	X	X	X	C
Repair and make weathertight all broken windows and secure against access	X	X	X	X	X	C
Repair and secure window screens in place to deter entry of pests and animals	X	X	X	X	X	C
Seal all joints and caulk around fenestration as needed	X	X	X	X	X	C
Board all windows (optional)						
After major storms, inspect for any damage to the building envelope and signs of water intrusion	X	X	X	X	X	C
Building Interior						
Remove any hazardous waste found	X				X	U, C
Remove any flammable material found	X	X	X	X	X	U, C
Remove all trash and debris and sweep clean or vacuum all interior floors (by leaving unit)	X	X	X	X	X	U
Check for signs of pests or vermin	X	X	X	X	X	C
Remove all contents of building, including fabric draperies. (flammables and mold food)	X	X	X	X	X	C
Inventory equipment and property and recommend for (storage/disposal)	X	X	X	X	X	C
Transfer/store usable equipment/property	X	X	X	X	X	D, C
Dispose of unusable equipment and property	X	X	X	X	X	C
Interior doors and partitions; leave open, remove or disable lockable locksets and latches	X	X	X	X	X	C
Vault doors; leave open, disable lock	X					C
Blinds; remove and dispose of if broke	X	X		X		C
Seal all joints, cracks, and holes in walls to prevent entry of water	X	X	X	X	X	C
Check for signs of moisture intrusion (ceiling, wall, floor)	X	X	X	X	X	C
Wet ceiling tiles and insulation; remove and dispose, correct source of moisture intrusion, and leave bare	X	X	X	X		C
If exterior facing walls have wallpaper covered surface, check for signs of biological growth on or behind the wallpaper	X	X		X		C
Seal all joints, cracks, and holes in floors to prevent entry of water; use appropriate methods for concrete, tile, terrazzo, wood, vinyl, carpet floors	X	X	X	X	X	C
Wet carpeting; remove and dispose, correct source of moisture intrusion, and leave bare	X	X		X		C
Refrigerators and freezers; disconnect power, clean and leave with doors open, disconnect interior lights		X	X	X		C
Walk-in refrigerators and freezers; disconnect power, clean and leave doors open, padlock latches to keep from locking			X			C

Figure 13-4. Building type specific checklist (cont.).

Drinking fountains; disconnect power, shut off water supply, fill drain trap with antifreeze	X	X	X	X	X	C
Elevators; lower to lowest level, block up or remove and lower counterweights to bottom of hoist way, clean interior, and deactivate	X	X		X		C
Cranes; lower hoist to rest on floor and coat all unpainted parts with corrosion-preventive compound					X	C
Building Mechanical Systems						
Water supply line to building; turn off (optional; also address fire sprinklers, sanitary lines, traps)	X	X	X	X	X	C
Gas supply line to building; turn off (optional; if decision made for unheated buildings)	X	X	X	X	X	C
HVAC; drain and dry all water supply and return lines to prevent freezing during cold weather (optional)	X	X	X	X	X	C
HVAC; provide minimal heating during cold weather to protect building components from extreme cold (optional)	X	X	X	X		C
HVAC; provide minimal cooling during hot and humid weather to keep relative humidity below __ % (optional)	X	X	X	X		C
Heating and cooling coils; clean and protect with corrosion preventive coating	X	X	X	X	X	C
Air conditioning equipment; remove and store refrigerant (optional)	X	X	X	X		C
Close dampers for all exterior openings to prevent entry of moisture, pests or animals	X	X	X	X		C
Install screens over all exterior mechanical openings	X	X	X	X		C
Compressors; Inspect? Remove? Run?	X	X	X	X	X	C
Pumps; Inspect? Remove? Run	X	X	X	X		C
Boilers; drain and clean boiler and supply and return lines (optional)	X	X	X	X		C
Inspect plumbing lines (water, steam, gas, air)	X	X	X	X	X	C
Window air conditioning units; remove for reuse elsewhere and reseal window opening		X			X	C
Hot water heaters and other tanks containing water, drain and disconnect	X	X	X	X	X	C
Traps; for toilets, urinals, tubs, showers, lavatories, sinks, washers drained and capped (optional)	X	X	X	X	X	C
Traps; for toilets, urinals, tubs, showers, lavatories, sinks, washers filled with antifreeze (optional)	X	X	X	X	X	C
Sanitary sewer lines; drain and cap	X	X	X	X	X	C
Storm water drainage pipes for roofs and downspouts	X	X	X	X	X	C
HVAC Controls/UMCS (if a functioning UMCS is available)						
Schedule equipment to run a minimum amount of time	X	X	X	X		D, C
Monitor room temperature and humidity	X	X	X	X		C
Monitor occupancy						C
Monitor run status of equipment	X	X	X	X		C
Building Electrical Systems						
Remove all nonessential power consuming equipment	X	X	X	X		C
Verify power to fire alarms/smoke detectors	X	X	X	X	X	D, C
Verify power to security lighting	X	X	X	X	X	D, C
Disconnect electrical service to lighting except for that required for security and maintenance personnel	X	X	X	X	X	C
Disconnect lighting to all rooms with exterior windows	X	X	X	X	X	C

Figure 13-4. Building type specific checklist (cont.).

Remove lamps from buildings that will be vacant for greater than _ONE_ years and reuse elsewhere	X	X	X	X	X	C
Motors, generators and control equipment; Inspect? Remove?	X	X	X	X	X	C
Remove all unused/unneeded batteries for reuse elsewhere	X	X	X	X	X	C
Verify power to sump pumps	X	X	X	X	X	C
Fire Protection Equipment						
Fire alarms/smoke detectors; keep in service	X	X	X	X	X	D, C
Wet-pipe sprinkler systems; drain completely and install an exterior PIV between street shut off valve and exterior face of building (optional)	X	X	X	X	X	C
Wet-pipe sprinkler systems; add antifreeze (optional, for unheated buildings)	X	X	X	X	X	C
Wet-pipe sprinkler systems; normal maintenance (optional, for buildings heated about 40F	X	X	X	X	X	C
Fire hoses inside of building; retain	X	X	X	X	X	C
Fire extinguishers; retain at main building entrances and mechanical rooms and remove all others and reuse elsewhere	X	X	X	X	X	C

Conclusion

This work developed a protocol with alternatives for proper preparation and maintenance of Army facilities when they are deactivated and while they remain in layaway status. The protocol was implemented and evaluated at the Kelley Hill cantonment area at Fort Benning, GA, where a significant number facilities of various types, ages, and conditions had been deactivated. The protocol prepared approximately 100 buildings vacated in the first half of 2016 to remain in a dormant state for more than 3 years, after which, when a reactivation need arises, they must be able to be made ready for occupancy within 2-4 months.

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Acronyms and Abbreviations

Term	Definition
ABCT	Armored Brigade Combat Team
ADA	Americans with Disabilities Act
AFCESA	Air Force Civil Engineer Support Agency
AHJ	Authority Having Jurisdiction
AHU	Air Handling Unit
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
Aw	Water activity
AWWA	American Water Works Association
BAC	Building Automation Controls
BAS	Building Automation System
BAS/UMCS	
BIFM	British Institute of Facilities Management
BPOC	Building Point Of Connection
BUR	Built-up Roof
CDX	Class C to D eXposed plywood
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
CERL	Construction Engineering Research Laboratory
CMU	Concrete Masonry Unit
DoD	U.S. Department of Defense
DPW	Directorate of Public Works
DX	Direct Expansion
EIFS	Exterior Insulation Finishing System
EPDM	ethylene propylene diene M-class [rubber]
ERDC	U.S. Army Engineer Research and Development Center
EUI	Energy Use Intensity
FDA	Food and Drug Administration
GSA	General Services Administration
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HVAC	Heating, Ventilating, and Air-Conditioning
I/O	Input/Output
IAAI	International Association of Arson Investigators
ICC	International Code Council
ISR	Installation Status Report
ITTP	Installation Technology Transition Program
LCCA	Life-Cycle Cost Analysis
LEA	Layaway Economic Analysis

Term	Definition
LED	Light Emitting Diode
M&R	maintenance and repair
MACOM	Major Army Command
MIPR	Military Interdepartmental Purchase Request
MRT	Major Replacement and high cost Tasks
MSDS	Material Safety Data Sheet
NAVFAC	Naval Facilities Engineering Command
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPR	National Public Radio
NPV	Net Present Value
NSN	National Supply Number
O&M	Operations and Maintenance
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OSB	Oriented Strand Board
OSHA	Occupational Safety and Health Administration
PRV	Plant Replacement Value
PVC	Polyvinyl Chloride
RH	Relative Humidity
RV	Recreational Vehicle
SF	Standard Form
SMS	Sustainment Management System
SPF	Spray-Applied Polyurethane Foam
T/RH	Temperature and Relative Humidity
TEMF	tactical equipment maintenance facilities
TPO	Thermoplastic Olefin
TR	Technical Report
UFC	Unified Facilities Criteria
UMCS	Utility Monitoring and Control System
URL	Universal Resource Locator
USACE	U.S. Army Corps of Engineers
USACERL	U.S. Army Corps of Engineers Construction Engineering Research Laboratory
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFA	U.S. Fire Administration
USGS	U.S. Geological Survey
USS	U.S. Standard
UV	Ultraviolet
WWW	World Wide Web

Appendix A: Example Decision Trees

Primary Decision	Supplementary Decision	Options (Considerations)	Typical Recommendations
1A Maintain Power to Buildings	Which Systems to Power?	Heating (freezing temperatures), Cooling (humidity), Lighting (Security, life-safety), UMCS (remote monitoring), fire protection sprinkler (wet or dry), Fire Alarms (life safety)	Maintain minimal heating if in locations w/ freezing, abandon cooling but monitor humidity (w/ UMCS), address high humidity w/ dehumidifiers, maintain lighting in doorways and hallways w/ motion sensors, maintain exit and emergency lighting if inspected regularly
1B No Power to Buildings			
2A Maintain Heat in Buildings	Cost of fuel, maintenance of heating system, failure to provide adequate or reliable heating		
2B Disable Heat in Buildings	Lay-up of system, decisions required for water, sewer and sprinkler systems		
3A Maintain air conditioning in buildings	Cost of energy, localized points of condensation, effectiveness of cooling		
3B Turn off air conditioning in buildings	Alternatives for dehumidification		
4A Set up portable dehumidifiers in select rooms	Where to locate dehumidifiers, amount of dehumidification needed	Drain water to sinks or floor drains (sanitary sewers), drain water out through windows or doors (maintain building envelop tightness)	Monitor building interiors using portable data loggers to measure humidity levels and determine if there is a need for dehumidifiers
4B No dehumidifiers			
5A Maintain potable water plumbing	Risk of leaks and freezing, requirements for maintaining sewer system		
5B Drain potable water plumbing	Cost to drain, accelerated deterioration of seals		
6A Maintain industrial water plumbing	Risk of leaks and freezing, requirements for maintaining sewer system		
6B Drain industrial water plumbing	Cost to drain, accelerated deterioration of seals		
7A Maintain active sewer lines	Maintenance of traps		
7B Close sewer lines	Must shut off water supply, labor to close up system		
8A Maintain sprinkler system	Heating is likely required		
8B Add antifreeze to system	Labor required, not recommended for occupied building		
8C Drain sprinkler	No fire protection, labor to drain		
8D Convert to dry pipe	Delayed sprinkler response		
9A Interior lighting powered	Power supply to all lighting	Entries, stairwells & hallways, interior rooms, perimeter rooms	Verify occupancy sensors and motion detectors are functional and will turn off lighting automatically
9B Partial interior lighting	Which lighting to power		Verify occupancy sensors and motion detectors are functional and will turn off lighting automatically
9C No interior lighting			
10A Exterior building lighting powered	All exterior lights or subset	Entries, stairwells, wallpacks, spotlights	Consider installing motion detectors to individual fixtures to turn on only when needed
10B Exterior building lighting shut off			

Appendix B: Overview of the Layaway Economic Analysis Tool

B.1 Approach to evaluating layaway alternative economics

As documented in USACERL TR 96/81, the Layaway Economic Analysis (LEA) tool protocol limits the number of alternative strategies for excess facilities to the three most likely to occur. This appendix is based on edited excerpts from that report. The LEA is outdated and not currently a viable tool for the analysis it was originally intended for. However the concepts, procedures, and information to be gathered for analysis remain valid, and they are therefore described here. The three alternatives are:

- initial demolition of the facility followed by new construction when and if a future requirement arises
- mothballing of the facility with maintenance and climate control during the inactive period that could be any one of numerous combinations of options, and full renovation if the facility is required in the future
- a “walk away” strategy using minimum layaway preparation, no maintenance or climate control during the inactive period, and full renovation if the facility is reactivated.

Although the third strategy is not generally desirable, lack of near-term funds to implement one of the other two strategies may make it the only feasible alternative. The second and third alternatives represent the two extremes of the layaway possibilities. The costs and risks associated with intermediate levels of layaway preparation and maintenance were assumed to lie between those of the second and third alternatives.

Two decision points determine the possible outcomes and associated costs for the three alternatives. The first decision point occurs initially, when the decision is made to demolish, mothball, or walk away. The second decision point occurs at an undetermined time in the future either when the facility is needed again, or when a final decision is made that it will not be needed and must be demolished. The costs associated with each alternative depend on the length of time between the two decision points. It is recommended that the length of time for the facility to be in an inactive status be allowed to vary from 1 to 10 years in deciding the option to pursue.

To compare the costs of each alternative, the unique cost items associated with each alternative must be determined. The tool accumulates costs over a 20-year period, including operation and maintenance of the active facility, to account for the advantages of the less expensive maintenance, repair, and utility costs for the newly constructed facility under the first alternative vs. those of the renovated facility of the second and third alternatives.

The risk factors considered in the tool are:

- the possibility that the facility might not be needed again
- the possibility that the facility will not be able to meet the Army's standards at the time of reactivation
- the possibility that environmental problems within the facility will be considerably more expensive to remedy in the future.

To account for these uncertainties, probabilities for each of the risk factors are used in the cost calculations to produce comparable Net Present Values (NPVs) of expected costs for each alternative. To analyze the risks of these uncertainties, a separate risk analysis model was constructed to link dynamically with the Microsoft Excel® 5.0 workbook.

There are five scenarios to be considered:

- a baseline comparison of costs for the three alternatives when the need for and adequacy of the excess facility is certain and environmental problems are not involved
- a comparison of costs for the three alternatives when the excess facility may never be needed again
- a sensitivity analysis to determine the least expensive alternative as a function of the probability that the facility will be needed and the probability that it will be adequate when no environmental problems are involved
- a sensitivity analysis to determine the least expensive alternative as a function of the probability that the facility will be needed and the probability that it will be adequate, when environmental problems are involved
- a sensitivity analysis to determine the least expensive alternative as a function of the level of possible increase in environmental costs and the probability that such an increase will occur.

The analysis should consider the total expected cost of each strategy over a 20-year period, beginning with the initial decision to layaway, walk away, or demolish, through the reactivation or reconstruction of the facility within 10 years of the initial action, and continuing with the operation and maintenance of the facility in the 10 or more years following its reactivation or reconstruction.

B.1.1 LEA costs

Every cost that could be counted as an expense under a given alternative does not need to be considered. Rather, the intent should be to identify the major cost differences. Also, the costs that are different in amount or time of occurrence from one alternative to another are considered. Because the operation and maintenance of a new facility is generally less expensive than that of an older structure, the time period over which costs are accumulated includes some portion of time after the facility is reactivated or rebuilt. The prime question is: “How long can the facility be inactive under layaway or walk away before the cost of that alternative equals the cost of demolishing the facility and rebuilding it?” Therefore, the number of years between the decision to layaway/walk away/demolish and the need to reactivate/rebuild is considered an independent variable.

With these considerations in mind, the costs associated with each of the alternatives are accumulated for a 20-year period. The time between the initial decision and the reactivating/rebuilding was allowed to vary from 1 to 10 years, with 10 or more years remaining in the cycle for the operation and maintenance of the new or reactivated facility.

B.1.2 LEA scenarios

LEA contains a spreadsheet for each alternative and for each cost type. Each alternative contains 10 “scenarios,” one for each of the possible years in which reactivating/rebuilding was to occur. Within a particular scenario (i.e., for a given year of reactivation), a row is entered for each possible type of cost for that alternative, and the actual line-item cost is entered under a column representing the year from 1 to 20 in which the cost is incurred. Each cost is expressed as a current year cost increased by an escalation factor and discounted to the present time. Escalation rates and discount rates are among the variables that may be changed by the LEA user. Unless there is a reason to use other rates, the latest National Institute of

Standards and Technology (NIST) (formerly National Bureau of Standards) guidance on Life Cycle Cost Analysis (LCCA), handbook 135 should be used. Totals for each of the column years indicated the NPV of the cost of the alternative during that year, and the sum of these yearly totals over the 20-year period yielded the discounted cost of the alternative for the given year of reactivation. The study analyzed the 20-year NPV of each alternative for different years of reactivation.

B.1.3 LEA uncertainty input

The uncertainty of future events is handled by computing the expected value of costs from probabilities of occurrence assigned through user input. In addition, a separate risk analysis model was built on top of LEA using the software package called DATA. LEA considers only two sets of uncertain complimentary events: that the facility may or may not actually be needed at some future date and that the original facility, if needed later, may or may not be able to meet the existing standards for a facility of its type. Each cost associated with the occurrence of one of these events is multiplied by the appropriate probability. It is expected that the new tool tied to Builder SMS currently being developed will incorporate this without the need for an additional software package like DATA.

B.1.4 LEA facility attributes, probabilities, and uncertainty inputs

The inputs to the LEA model consist of a brief list of facility attributes, probabilities associated with the uncertainty factors, and a brief description of the presence of hazardous materials. The facility attributes include: facility category group, geographic location, age of facility, net square footage, type of exterior wall, and current condition as measured by the Army's Installation Status Report (ISR) standards using the red/amber/green designation. The probabilities required for LEA are: the facility will be needed again and the facility will be able to meet the standards for its type. The inputs for hazardous materials include whether lead-based paint is present on more than 30% of the surface areas of the facility, and whether asbestos is present in the roofing material, siding, flooring, or insulation. Figures B-1 through B-4 show screenshots from the LEA tool used to enter this data.

Figure B-1. Basic building information.

The screenshot shows the 'Layaway Economic Analysis' software interface. The 'Basic data' tab is selected, displaying various input fields for building information. The 'Select a facility' section includes buttons for 'Add new facility', 'Select from database', 'Delete this facility', 'Copy this facility', 'Open saved scenario', and 'Delete all facilities'. The 'Basic data' section contains the following fields:

- Closest category code in database: 14182 Brigade Headquarters Building
- Type of exterior wall: Slag or Concrete Block
- Type of roof surface: Corrugated Aluminum
- Number of floors: 3
- Year of construction: 1967
- Current ISR condition rating: Amber
- Gross area (sq ft): 30000
- Percent of facility currently occupied: 0%

A red note at the bottom right states: 'NOTE: This building may be eligible for the historic register. Be sure to check the information on the Preservation tab.'

Figure B-2 shows a screenshot that requires basic information on the building such as building category or use type, construction type of walls and roof, and year of construction.

Figure B-2. Anticipated renovation needs.

The screenshot shows the 'Layaway Economic Analysis' software interface with the 'Renovation' tab selected. The 'Renovation' section contains a table for indicating the percent of each building system that currently requires repair or replacement. The table is as follows:

Substructure	0%	Plumbing	40%	Site and grounds	25%
Superstructure	0%	HVAC	25%	Parking	10%
Roofing	25%	Special mechanical	0%		
Exterior closure	10%	Electrical	25%		
Interior construction	50%	Special electrical	0%		
Interior finishes	25%	Equipment	0%		
Specialties	0%	Conveying systems	0%		

Below the table is a 'Comments' field and an 'Apply to all facilities' button.

The screenshot shown in Figure B-2 requires information on anticipated renovation needs. Information requirements for asbestos abatement and lead hazards are shown in Figures B-3 and B-4, respectively.

Figure B-3. Asbestos abatement requirements.

The screenshot shows the 'Asbestos' tab in the 'Layaway Economic Analysis' software. The interface includes a menu bar (File, Actions, Help) and a toolbar with buttons for 'Set location', 'Set economic environment', 'Describe facilities', 'Review cost factors', 'Define alternatives', and 'View reports'. Below the toolbar, there is a 'Select a facility:' section with a dropdown menu set to 'Test Facility' and buttons for 'Add new facility', 'Select from database', 'Delete this facility', 'Copy this facility', 'Open saved scenario', and 'Delete all facilities'. The main content area is divided into three columns of checkboxes for different building components, each with a header 'R E M' (Removal, Encapsulation, Monitoring). The first column is 'Exterior/Structure' with items: Beam Insulation, Column Insulation, Wall-Asbestos Cement, Wall-Other, and Roofing. The second column is 'Interior Finishes' with items: Ceiling, Wall-Concrete Block, Wall-Other, Floor-Vinyl Asbestos Tile, and Carpet. The third column is 'HVAC/Plumbing' with items: Ductwork-Asbestos Cement, Ductwork Insulation, Boiler Breaching, Boiler Insulation, HVAC Pipe Insulation, HVAC Radiator Backing, Plumbing Pipe-Asbestos Cement, and Plumbing Pipe Insulation. At the bottom, there is a 'Comments:' text area and an 'Apply to all facilities' button.

Figure B-4. Lead hazards.

The screenshot shows the 'Lead hazards' tab in the 'Layaway Economic Analysis' software. The interface is similar to Figure B-3, with the same menu bar and toolbar. The 'Select a facility:' section is also present. The main content area is divided into three columns of checkboxes for different building components, each with a header 'R E' (Removal, Encapsulation). The first column is 'HVAC/Plumbing' with items: HVAC Radiators and Plumbing Pipes. The second column is 'Exterior/Structure' with items: Wall Siding, Wall-Concrete/Masonry, Window Frames, and Soffits. The third column is 'Interior Finishes' with items: Interior Wall-Wood, Interior Wall-Other, Ceilings-Other, Ceilings-Wood, Stairs, Interior trim < 6", Interior trim > 6", Doors, and Cabinets. At the bottom, there is a 'Comments:' text area and an 'Apply to all facilities' button.

B.1.5 LEA costs for layaway/reactivate and walk away/reactivate

The costs uniquely associated with keeping the facility for later reuse include: initial layaway costs, caretaker costs (maintenance, repair, climate control), restoration and renovation costs, O&M costs (maintenance, repair, climate control) for the active facility, and any costs for required remediation of environmental problems (e.g., lead-based paint and asbestos). The differences between the layaway and walk away strategies were in the initial layaway and caretaker costs (which are minimal for walk away), and in restoration/renovation costs (which vary according to the type and

initial condition of the facility), the level of maintenance during the inactive period, and the length of the inactive period. The costs to restore and operate the facility after its inactive period were affected by the probability that the facility may not be needed again and by the probability that, if needed, the facility will be able to meet the standards existing at the time of reactivation. In these two instances, the cost to demolish the facility and the cost to construct a new facility if the facility is needed but inadequate were added to the costs in proportion to the probabilities of the two events. The restoration/renovation costs and active O&M costs are adjusted to account for the diminished probability of their being incurred, or for the reduced costs associated with operating a new vs. an older building.

B.1.6 LEA demolish/rebuild costs

The costs uniquely associated with demolishing the facility, then, if such a facility is required again, with constructing a new facility included: the cost of demolition and disposal, new construction costs, O&M costs (maintenance, repair, climate control) for the active facility, and any required cleanup and disposal costs for lead-based paint and asbestos. The probability that the facility may not be needed again reduced the new construction costs and O&M costs proportionately.

B.1.7 LEA data sources

The cost calculations for each strategy are based on the net floor space of the facility and a per square foot cost factor adjusted for the year of occurrence by a 3% per year escalation rate. The individual cost factors are taken from the sources discussed in the following subsections.

B.1.7.1 Maintenance and repair costs for initial layaway and caretaker activities

The maintenance and repair (M&R) costs for the initial layaway and caretaker activities were taken from a USACERL special report (Cork et al. February 1995).

B.1.7.2 Restoration/renovation costs

The costs for the layaway and walk away strategies were the sum of the total major replacement and high cost tasks (MRT) that would have arisen during the years the facility was inactive, and the renovation costs determined by a study algorithm using the Army's ISR renovation factors. The

MRT costs were taken from a report by Neely and Neathammer (1991). Updated ISR renovation factors were provided electronically by the point of contact at the U.S. Army Cost and Economic Analysis Center (USACEAC 1995).

The assumption for the layaway strategy was that a facility in caretaker status would decline from a green condition to an amber condition in 10 years, and from an amber condition to a red condition in 6 years. A linear growth in the renovation cost was assumed, beginning with the cost associated with the initial condition of the facility. For the layaway strategy, this meant an additional $1/10$ of the amber renovation factor for each year in the period from green to amber, and an additional $1/6$ of the red renovation factor for each year from amber to red. It also was assumed that a facility in red condition at the beginning of the inactive period would require an additional 1% of the red renovation factor for each inactive year.

For the walk away strategy, the assumption was that a facility in an abandoned state would decline from a green condition to an amber condition in 6 years and from an amber condition to a red condition in 4 years. A linear growth in the renovation cost is assumed, beginning with the cost associated with the initial condition of the facility. That is, an additional $1/6$ of the amber renovation factor for each year in the period from green to amber and an additional $1/4$ of the red renovation factor for each year from amber to red. Also it was assumed that a facility in red condition at the beginning of the inactive period would require an additional 2% of the red renovation factor for each inactive year.

The derived renovation rates for specific locations were adjusted in the same manner as the construction costs for the geographic region by the method outlined in Area Cost Factor Indexes, in the PAX Newsletter' No. 3.2.1, 15 June 1995.

B.1.7.3 Annual M&R of the reactivated/rebuilt facility

Costs for the annual M&R of reactivated or rebuilt facilities were taken from a USACERL report (Neely and Neathammer 1991).

B.1.7.4 Annual fuel costs for active and inactive facilities

Data from the U.S. Department of Energy (USDOE 1992 and 1993) provided the annual fuel costs for active and inactive facilities were provide

from the. The government utility rate was assumed to be half of the commercial rate. For specific locations, the workbook calculations included an adjustment for the climatic zone of the region determined by the average yearly heating and cooling degree days.

B.1.7.5 Facility demolition costs

Cost estimates for facility demolition were taken from the Cost Estimates - Military Construction, in the PAX Newsletter No. 3.2.2, 15 June 1995.

B.1.7.6 Cost of new construction

ISR new construction rates were provided electronically by the ISR point of contact at the U.S. Army Cost and Economic Analysis Center (USACEAC 1995). These rates were adjusted for geographic location by the method outlined in Area Cost Factor Indexes, in the Pax Newsletter No. 3.2.1, 15 June 1995.

B.1.7.7 Lead-based paint removal/disposal

The cost to remove lead-based paint was based on the amount of materials in a standard building as outlined by Lufkin and Pepitone (1994), and on removal and disposal costs from the Means Company (1994). Paint can be easily analyzed in the field with test kits like the one shown in Figure B-5. The surface must be clean. The only other preparation involved is when multiple layers of paint are involved, which requires a small area to be cut and peeled back to expose the multiple layers. The user simply breaks two small capsules in the tube and then dabs some liquid on the exposed area. If it turns red this indicates the presence of lead. In the case of red paint, the product describes a slightly different procedure.

B.1.7.8 Asbestos removal

Cost to remove asbestos was based on using the amount of materials in a standard building as outlined by Lufkin and Pepitone (1994), and asbestos removal and disposal costs from the Means Company (1994).

Figure B-5. Lead paint test kit.

B.1.8 LEA uncertainties

If the decision maker knows with certainty whether a specific facility is going to be needed or not and, if so, when it will be needed again, the decision of whether to lay a facility away or to demolish it is straightforward and can be supported by cost-effectiveness analysis. Simply total the costs in present dollars for each alternative and choose the alternative with the least total cost.

Unfortunately, certainty about future requirements is a rare event. If the decision maker does not know the installation's facility requirements with certainty, a layaway decision becomes a risky one. In this case, the cost (c) of building a new facility if the need arises is not a certain cost, and a straightforward comparison of alternatives is not possible. If the decision maker knows the probability (p) of needing the facility in the future, he/she can compute the expected cost as the product of c and p . Choosing the alternative with the least expected cost will be the most cost-effective strategy over the long run if the decision maker makes many such decisions for a large number of independent facilities. The 1996 study's LEA

model computes this type of expected net present value for each alternative. However, a given individual facility may have costs for the three alternatives that differ substantially from the expected costs. So the study developed a decision analysis tool to explore how sensitive a given decision is to the uncertainties and to establish bounds for the risks involved.

The future facility requirement is not the only uncertainty for the three alternatives. The LEA tool does not consider other uncertain events that can have a significant impact on the final cost of each alternative, namely: accidental destruction of the mothballed facility, future cost of environmental restoration, and changes in the functional requirements of the facility. In addition, the cost and effectiveness of deactivation actions and maintenance is uncertain. The accuracy of the deterioration rate is crude at best and has no basis other than best guess. The cost to rehabilitate a deteriorated building in red or yellow condition is uncertain.

The uncertainty in the future cost of environmental restoration is due to the continuous change in environmental regulations and technologies. For instance, removing asbestos from a building is more expensive now than it was 10 years ago. But, future technological improvements may reduce the cost of cleaning up some contaminants, making the future cost of environmental restoration less expensive than current costs.

Over time, the functional requirements for buildings often change. One good example is that of barracks that were changed from open barracks with gang latrines and showers to shared rooms, to private rooms with shared baths. There is little doubt that functional requirements for headquarters, housing, or other building uses will change in the future in ways that cannot be predicted.

The cost and effectiveness of deactivation actions and maintenance is uncertain. The accuracy of the deterioration rate is crude at best and has no basis other than best guess. The cost to rehabilitate a deteriorated building in red or yellow condition is uncertain.

In the 1996 model, the decision maker has three alternatives: demolish the facility, lay it away, or walk away from it. After one of the three alternatives is chosen by the decision maker, “nature” takes over and chooses the path to follow and, hence, which final outcome results. There are a total of 32

possible paths in this tree, and each one has a different probability of happening and a different cost.

The DATA model estimates the cost associated with each path. The exogenous variables of the model are: facility type, size, age of facility, location, type of hazardous materials present in the facility, and number of years until the facility is needed again. In addition, the probabilities associated with each chance node of the tree: probability of change in environmental regulations, probability of accidental destruction, probability of actually needing the facility, and probability of the facility becoming obsolete

This decision model is made up of two parts, each one running in a different software package. All data inputs to the model as well as the economic model itself reside in the Microsoft Excel® 5.0 workbook LEA. The decision tree part of the model is done in DATA, which works with LEA through dynamic links.

The optimal policy to follow for making this decision depends on the amount of information the decision maker has at the time and on the decision maker's attitude toward risk. If the decision maker knows the probabilities associated with the chance nodes, the model can compute the total cost and the probability of each "leaf." The risk associated with each alternative is described by the probability distribution of all the paths following that alternative, and different decision makers may react differently to it. If the decision maker is making this decision with several buildings of similar characteristics, the risk of the actual cost being different in the long run from the expected cost is minimum, and the least expected cost policy rule is the best policy. However, if the decision maker cannot bear the risk associated with the probability of the worst case scenario happening, the best policy rule is to choose the alternative with the minimum maximum cost.

The two extremes described here may well be the case for decision makers at the Army Major Command (MACOM) level and at the installation level. At the MACOM level, the decision maker is faced with large numbers of similar buildings scattered around different installations. As a consequence of the large number of buildings, the total average cost of the policy will be close to the expected total cost. However, at the installation level, the decision maker faces a smaller number of buildings and, as a consequence, the actual cost may differ significantly from the expected cost.

Hence, minimum expected cost may not be the optimal rule at the installation level. If the decision maker does not know the probabilities associated with the chance nodes of the tree (Figure 2), or is not able to estimate them satisfactorily, it would not be possible to compute expected cost and, hence, not be possible to choose the alternative with the least expected cost. This situation is called “decision making under uncertainty” by decision theorists, and the optimal policy rule is more abstract. The most popular decision rules are: Laplace Rule, Mini-max Rule, Mini-min Rule, Hurwicz Rule, and Mini-max Regret Rule. Each decision rule makes a different assumption regarding the probability of each outcome and, as a consequence, the recommended alternative may be different.

The Laplace Rule assumes that each possible state of nature is as likely to occur as any other. The rationale is that there is no stated basis for one state of nature to be more likely than any other. In other words, nature is assumed to be indifferent between outcomes. Under this assumption, the optimal policy rule is to choose the alternative with the least average cost.

The Mini-max Rule assumes an extremely pessimistic view of the outcome of nature. This rule assumes that nature will do her worst. The optimal policy rule under this assumption is to choose the alternative with the smallest maximum cost. However, the Mini-min Rule is based on an extremely optimistic view of the outcome of nature. This rule assumes that nature will do her best. The optimal policy rule under this assumption is to choose the alternative with the least minimum cost

In between these two extremes is the Hurwicz Rule, which assumes that the outcome will be something in between the optimistic and pessimistic ones and allows the decision maker to select an index of optimism, a , between 0 and 1. If the decision maker is optimistic, then $a=1$, and if the decision maker is pessimistic then $a=0$. The expected outcome for each alternative is assumed to be a times the optimistic outcome plus $(1-a)$ times the pessimistic outcome. The optimal policy rule then is to select the alternative with the least expected cost.

The Mini-max Regret Rule assumes that a decision maker regrets the selection of one alternative if another alternative ultimately yields a better result. This rule is based on the premise that a decision maker wishes to minimize the maximum regret.

Each rule has a different objective and recommends a different alternative as optimal. In other words, there is no unique optimal alternative, and the recommended alternative depends on the personality of the decision maker and the decision maker's perception of the natural events. Therefore, there is a need for both a qualitative and quantitative understanding of the uncertainties involved in this decision.

B.2 LEA input template

To assist in evaluating the inputs to the LEA tool, sheets were created with the various inputs and possible values were created (Table B-1).

Table B-1. Inputs to the LEA tool.

<u>BASIC DATA</u>		# Floors
Building #		ISR Cond
Cat Code From RPD		% Occ
<u>Wall Type - Select One</u>		<u>Roof Type - Select One</u>
ACF Board	Hollow Tile & Asbestos Board	Aluminum, copper or lead
Adobe	Metal	Asbestos Produced Material
Aluminum	Plywood	Asphalt
Asbestos Protected		Built-Up Roofing without gravel
Metal	Railroad Ties	Cement Asbestos
Brick	Reinforced Columns	Concrete
Brick, Tile	Sheet Metal	Corrugated Al, Asbestos, SM
Cast Iron	Slag or Concrete Block	Dirt covered Glass, Glass Fiber, Plastic
Cement Asbestos	Split Logs	No surface
Clay or Concrete Block	Steel	Roll-Building Paper
Concrete	Stone	Roll Composition
Concrete & Metal	Tile, Steel, Wood	Rubberoid
Concrete & Stone	Tile, Structural	Shingle-
Concrete, Corrugated		Asb,Asph,Comp,Slate,Wood
Asbestos	Wood	Steel, Gal
Concrete Reinforced	Wood & Aluminum	
Concrete, Wood Asbestos	Wood & Steel	Strip Shingles
Corrugated Iron	Wood - Corrugated Asbestos	Tar or Silicone
Glass, Plastic, Transparent		Tile or Transite

<u>Asbestos R E or M</u>	
<u>Exterior</u>	Removal, Encapsulate, or Monitor
Beam	<u>HVAC/PLUMBING</u>
Column	Ductwork - Asb Cement
Wall	Ductwork - Insulation
Roof	Boiler Breeching
<u>Interior Finishes</u>	Boiler
Ceiling	HVAC pipe
Wall -Concrete Block	HVAC radiator
Wall - Other	Plumbing Pipe cement
Floor	Plumbing Pipe Insulation
Carpet	
<u>ADA (Y/N)</u>	
Install new ramp	Mod elevator
modify ramp	Enlarge entrance
Install new lift	Install emerg comm
Install new elevator	Restroom remodel
	Seismic Rehab
<u>LEAD (R or E)</u>	
<u>HVAC/Plumbing</u>	<u>Interior Finishes</u>
HVAC radiators	Interior Wall-Wood
Pipes	Interior Wall-Other
<u>Exterior/Structure</u>	Ceiling-Other
Wall Siding	Ceiling-Wood
Wall-Concrete/Masonry	Stairs
Window frames	Interior trim < 6 in.
Soffits	Interior trim > 6 in.
	Doors
	Cabinets
<u>Other</u>	
Type superstructure - select one	<u>RENOVATION NEEDS - Enter %</u>
Unreinforced Masonry	
Wood Light frame	Substructure

Wood (comm or industrial)	Superstructure
Precast Concrete Tilt up wall	Roofing
Reinforced Masonry	Exterior closure
Concrete Moment	
Frame	Interior construct
Conc Frame w infill	
walls	Interior finishes
Steel Moment Frame	Specialties
Steel Braced Frame	Plumbing
Steel Light frame	HVAC
Steel frame infill walls	Special mechanical
Concrete shear wall	Electrical
Precast Concrete Tilt up wall	Special electrical
Precast concrete Frame	Equipment
Reinforced masonry	Conveying systems
Steel frame w concrete walls	Site and grounds
	Parking
<u>Future Plans</u>	
Heat/Cool during layaway (Y/N)	<u>Seismic Rehab Req Y/N</u>
Remove asbestos before layaway (Y/N)	
Remove lead paint before layaway (Y/N)	<u>#, Size underground Tanks</u>
When can be demolished	
% facility occupied initial continued use	
Probability of Need for 10 years (%)	
Probability facility adequate (%)	
<u>Historic Status Y or N</u>	
Inventory Complete Hist Sig?	
Listed or Eligible for National Reg?	

Most information, such as that pertaining to construction material type, can be best gathered during an on-site inspection of the buildings.

B.3 LEA scenarios

B.3.1 Scenario 1: The base case

The first step in the analysis is to determine the point at which the expenses of keeping and reactivating an inactive facility are equivalent to demolishing and rebuilding it. For this base case, all uncertainties and environmental problems were removed. That is, the probability that the facility

will actually be needed in the future is 100%; the probability that the facility will be able to meet future standards when reactivated is 100%; and the facility does not, nor will it, have any environmental problems that will increase costs.

The results of this analysis are reported for each facility in the appendix under the titles “Comparison of 20-Year Costs by Initial Condition” and “Layaway/Walk Away as Percentage of Demolish/Rebuild.” These results show that the demolish/rebuild alternative is always the most expensive alternative for an inactive period of 10 years or less, i.e., there is no point at which the layaway or walk away alternative and the demolish alternative are equally attractive options because of the high cost of new construction.

When the excess facility is in green condition, the results show that the layaway/ reactivate alternative is the least expensive. That is, if the facility is in good condition, keep it and take care of it.

When the excess facility is in amber condition, the NPV of the costs for both the layaway and the walk away alternatives increases substantially as the inactive period lengthens until the facility reaches a red condition (year 5 for walk away and year 7 for layaway). For inactive periods of 7 years or longer, both alternatives parallel the costs of a facility initially in red condition. This is primarily a result of the study’s assumed deterioration rates and the dominance of the restoration/renovation costs in the overall expense of the alternative.

When the excess facility is in red condition, the layaway and walk away alternatives are almost identical in NPV costs. Essentially, the facility cannot deteriorate much more than its initial condition, so there is little advantage to maintaining it at any level during the inactive period. As a percentage of the NPV cost of the demolish/ rebuild alternative, both the layaway and the walk away alternative have NPV costs that are within 65 to 90+ percent for all facilities considered.

The dominant cost in all of the alternatives is the rebuilding/reactivating costs, which were taken from the ISR data. As the data in Table 2 indicates, renovation costs vary substantially relative to the rebuild costs for facilities.

B.3.2 Scenario 2: Facility not needed in the future

Scenario 2 considers that the facility ultimately may not be needed. For the demolish/rebuild alternative, the NPV of accumulated costs is simply the initial cost to demolish the facility, regardless of the length of the inactive period. However, for the layaway and walk away alternatives, the NPV of costs includes all of the expense of caring for the facility during the inactive period as well as the ultimate demolition of the facility at the end of the inactive period.

The results of this analysis are reported for each facility in the appendix under the title “Comparison of Costs if Facility Is Never Reactivated.” Except for 14185 and 17120, all of the other facilities have the same predictable pattern: the demolish/rebuild alternative has the least NPV cost, followed by the walk away alternative, with the layaway alternative being the most expensive and growing as the length of the inactive period increases. For facilities of type 14185 and 17120, the cost of the walk away alternative during the inactive period increases at a rate smaller than the discounting. Discounting at the 7% annual rate means that postponed costs are smaller than current costs. Thus, for facilities of type 14185 and 17120, the walk away alternative is the least expensive.

B.3.3 Scenario 3: Sensitivity to need and adequacy - without environmental problems

In Scenario 3, the LEA model was configured with the same parameters as the base case for each facility, although only an initial condition of green with reactivation in the sixth year was considered. The DATA risk analysis model used this data to test the sensitivity of the decision node in Figure 2 against the probability that the facility will be needed and the probability that the facility will be adequate. The DATA model varied these two probabilities from 0 to 1 and identified regions of values for the probabilities in which a particular alternative would have the least expected NPV of costs.

The results of this analysis are reported for each facility in the appendix under the title “Least Cost Alternative-Without Environmental Problems.” These graphs in Appendixes B through H fall into one of three categories. For 21110, 60000, 71110, and 72100, all three alternatives appear as the least cost alternative for some region. The layaway alternative is chosen for the region in which both probabilities are high. The demolish alternative is chosen in the region in which both probabilities are low. And the walk

away alternative is chosen in the region between the two extremes. For 14185, 17120, and 22600, only the layaway and walk away alternatives appear as the least cost alternative for some region. In this case, taking a “wait-and-see” attitude appears to be justified because of the significantly higher cost of replacing the facility and the discounting that favors postponing expenses.

B.3.4 Scenario 4: Sensitivity to need and adequacy-with environmental problems

Scenario 4 is similar to Scenario 3, except that the cost of restoration/renovation or future demolition is increased to five times over the current costs to account for a radical increase in the expense of cleaning up hazardous materials. The future costs of removal or remediation of hazardous materials are extremely difficult to predict. Costs might increase because of more restrictive regulations, increased disposal costs, increases in the amount or type of contamination, or a combination of all three. Currently two events trigger costs for hazardous materials: demolition and renovation. This scenario was designed to test the baseline case by adding a large future environmental cleanup expense to the layaway and walk away alternatives.

The results of this analysis are reported for each facility in the appendix under the title “Least Cost Alternative-With Environmental Problems.” Five of the seven facility types (14185, 17120, 22600, 60000, 71110) have similar results. When the probabilities that the facility will be needed and that the facility will be adequate are both high, the least cost alternative is demolish/rebuild. The expected cost of renovating the original facility exceeds the cost of disposing of the facility now and rebuilding it when needed. As the certainty of need and adequacy diminishes, the walk away alternative becomes the least cost alternative. The other two facility types (21110, 72100) have only the walk away alternative as their least cost alternative, regardless of the probability of need or adequacy. These two facility types have a small amber renovation cost relative to the new construction cost. So the 5-fold increase in renovation still does not exceed the cost of a new building.

In this scenario, the layaway alternative is never the least cost alternative. This is due to the parameters of the scenario. The original condition of the facility is green, and the year of reactivation is the sixth year. The first group of facilities (14185, 17120, 22600, 60000, 71110) has relatively high amber renovation costs; the second group (21110, 72100) has relatively low amber renovation costs. For both groups, when the probabilities of

need and/or adequacy are low, the best strategy is “wait and see” with no upfront expenses-hence walk away. When the probabilities of need and adequacy are both high, the two groups have different least cost alternatives. For the first group, both layaway and walk away surpass demolish/rebuild. For the second group, the layaway and walk away alternatives have almost identical expected costs when the inactive period is less than 7 years. Though the sensitivity analysis identifies the least cost alternative for the decision node, it does not indicate how close or far apart the expected costs are for each alternative. For the second group in this scenario, the baseline scenarios indicate that the expected costs of the layaway and walk away alternative are almost equal.

B.3.5 Scenario 5: Sensitivity to increases in environmental costs

In Scenario 5, the LEA model was configured with the same parameters as the base case for each facility, although only an initial condition of green with reactivation in the sixth year was considered. The DATA risk analysis model used this data to test the sensitivity of the decision node in Figure 2 against the probability that the cost of environmental problems will increase, and against the level of that increase. The method by which the DATA model was structured was to assume that either the demolition cost or the renovation cost (including present known costs for lead-based paint and asbestos) would be increased. The DATA model tested the decision node to determine the values for the probability and the increase for which a particular alternative would be chosen for having the least expected NPV cost.

The results of this analysis are reported for each facility in the appendix under the title “Least Cost Alternative-Environmental Problems Increase.” This scenario assumed that the facility is in green condition and that reactivation of the facility occurs in the sixth year. As in Scenario 4, the same two groups of facilities emerge, probably for the same reasons described in the earlier scenario.

Facilities of type 14185, 17120, 22600, 71110, and 60000 each favor the demolish/rebuild alternative after a 3- to 4-fold increment in cost when the probability that the environmental costs will increase is high. They also favor the layaway alternative when the probability of an increase is low. When the probability of an increase is high but the increase is less than 4-fold, the walk away alternative has the least expected NPV cost.

Facilities of type 21110 and 72100 have different sensitivities. Facility type 21110 requires a 6.5-fold increase in environmental costs before the option to demolish and rebuild is the least cost alternative. Facility type 72100 requires an 8-fold increase.

B.4 General observations, conclusions, and recommendations

- The LEA model provides a quick estimate of the costs and risks of each of the three alternatives. The distribution of this updated version of this Microsoft Excel® 5.0 workbook to decision makers considering facility layaway options would ease much of the effort required to gather and process cost data so a “first-cut” decision could be made quickly.
- The updated LEA tool should be flexible enough to produce expected cost estimates for a wide variety of facilities, locations, and economic environments.
- A cost that the old LEA tool does not consider is furniture repair and replacement. At Fort Benning, mattresses would need to be replaced due to mold. To prevent this in the future, the procedure is currently to remove them and store in a facility that is maintained. Related to this are the costs of moving furniture and equipment such as washers and dryers. It is suggested that new tools include this cost.
- The analyses are based on macro-level planning data. The costs for the alternatives are expressed in net present value and do not include all of the costs of each alternative, but only the costs that are uniquely different for that alternative.
- The cost of replacing a facility in good condition and with no environmental problems is always considerably higher than the cost of keeping it for later use. If it is known that the facility will be needed later, the best option is to keep it and take care of it.
- Sensitivity analysis typically shows that the least cost alternative is extremely dependent on the probabilities that the facility will be needed and adequate. The results show that the order of preference for the alternatives reverses as these probabilities decline. Layaway decisions should be made with careful consideration of these two probabilities.
- When environmental problems are introduced, the least cost alternative depends on the probability that cleanup costs will increase and on how much that increase will be. In this situation, there is a point at which demolishing a facility that will be needed later and then rebuilding it is a less expensive alternative than keeping it for later use.
- The quality of the analysis tools depends on the data used. Although the Army has well established cost databases for most of its activities,

layaway actions are relatively new and the costs associated with preparing a facility for layaway and taking care of it while it is in layaway are not well established. In addition, little consensus exists about the factors that determine the level of deterioration of a building while it is in layaway or the factors that determine the costs of restoring the facility for active use. In the current analysis, the results were strongly influenced by the study's assumptions regarding deterioration rates and the associated restoration costs. Although a portion of the current study was devoted to collecting data regarding both the cost of layaway and the deterioration rates of buildings in layaway, this is an area that would benefit from a continued effort to collect data and to develop accurate databases to test and validate the model.

B.5 Facility related costs in the LEA model

B.5.1 Cost of demolition

Demolition involves activities that result in the deconstruction and removal of an entire existing facility, and only apply for Alternative 1. The cost of demolition is modeled as a cost per square foot, which varies based on the construction type of the building. For example, the unit cost to demolish a light frame wood construction will be less than that of reinforced masonry construction. The demolition unit costs are based on **PAX Newsletter No. 3.2.2, 15 June 1995**, and escalated to current year of analysis. Demolition costs are typically incurred in the first year of the analysis unless the user specifies a later date. Demolition costs do not include the removal of asbestos, lead paint, and other hazardous materials, which are accounted for separately in the model:

$$\begin{aligned} \text{Demolition Cost} \\ &= \text{Demo Unit Cost} * \text{SF Area} * \text{Area Cost Factor} \\ &\quad * \text{Escalation factor} \end{aligned}$$

B.5.2 Cost of replacement

Facility replacement includes all activities necessary to replace the facility with a newly constructed building of the same function and square footage but with up-to-date building standards. Replacement only applies in Alternative 1 after a previously existing facility has been demolished. The facility replacement cost is modeled based on the facility size and unit cost per square foot, which varies based on the facility type. Facility replacement unit costs

are based on data listed in Table 3 of UFC 3-701-01 (NAVFAC 2018c) and escalated to the current year when the replacement activity occurs:

$$\begin{aligned} \text{Replacement Cost} \\ &= \text{Replace Unit Cost} * \text{SF Area} * \text{Area Cost Factor} \\ &\quad * \text{Escalation factor} \end{aligned}$$

B.5.3 Cost of renovation

The facility renovation activity upgrades an existing facility in a substandard condition to one in good condition. Facility renovation activities apply in Alternatives 2 and 3, when a facility may be renovated before reactivation to improve its level of performance. Facility renovation costs are parametrically calculated based on the individual condition index of each building system, as well as the value of each system. For example, the condition index determines the percent of each system requiring repair or replacement. This is then multiplied by the system replacement value, which is derived by apportioning the facility plant replacement value (PRV) to each system. The renovation cost is escalated to the year that the activity is schedule to occur, which can be specified by the user:

$$\begin{aligned} \text{Renovation Cost} \\ &= \left(\sum \text{System Repair\%} * \text{System Replacment Cost} \right) \\ &\quad * \text{Area Cost Factor} * \text{Escalation Factor} \end{aligned}$$

B.5.4 Costs of Layaway procedures

Layaway activities ready the facility for a prolonged period of inactivity and vacancy, and are necessary to ensure that a condition is adequately prepared for dormancy and eventual reactivation. This may involve relocation of tenants, as well as a number of facility actions such as the removal and storage of furniture, draining of water lines, boarding of windows, etc. Relocation and layaway preparation costs are based on facility size and unit cost that varies based on facility type. These unit costs are based on the previously developed LEA software version, and escalated to current value dollars. However, since layaway procedures can vary widely, it is important for users to review and edit these costs as needed. These layaway costs typically occur in the first year of the analysis when the facility is first put in a layaway status:

$$\begin{aligned} \text{Relocation Cost} &= \text{Reloc Unit Cost} * \text{SF Area} * \text{Area Cost Factor} \\ &\quad * \text{Percent occupied} * \text{Escalation factor} \\ \text{Initial layaway Cost} \\ &= \text{Initial layaway Unit Cost} * \text{SF Area} * \text{Area Cost Factor} \\ &\quad * \text{Escalation factor} \end{aligned}$$

B.5.5 Energy costs

Energy Costs are used to model the annual expenses of operating a facility. These costs will vary based on a number of factors such as facility location, size, type, age, condition, and occupancy rate. In the LEA model, there are four types of energy costs that depend on the status of the facility. These are: (1) Energy during layaway, (2) Energy for reduced occupancy, (3) Energy for a new facility, and (4) Energy for a reactivated facility. Energy costs during layaway primarily include heating and cooling for climate control. Reduced occupancy energy costs include operation of equipment still necessary even if the facility is less than fully occupied. Energy for a new or a reactivated facility include the costs of normal operation once the facility is back in use at fully occupancy. Energy costs in new facilities are typically lower due to newer and more efficient equipment when compared to existing or renovated facilities.

All energy calculations described above, are based on the Energy Use Intensity (EUI) of the facility and its energy rate. EUI values for the facility are based on facility type and climate zone, taken from U.S. Army Sustainable Design and Development Policy Update of January 2017 (ASA(IE&E) 2017). Energy rates for consumption (\$/kWh) are based on facility type and location, provided by U.S. Energy Information Administration (USEIA 2017). For these calculations, it is important to know facility's location and climate zone from Table B-1, "U.S. Climate Zones," from the ASHRAE Standard 90.1-2004 (ASHRAE 2004). For the model, energy prices and consumption were based on reference values for a fully occupied new facility, but adjusted as appropriate to account for older renovated, or partially occupied/unoccupied facilities:

$$\begin{aligned} \text{Annual Energy Cost (New Facility)} \\ &= \text{EnergyRate} * \text{EUI} * \text{SF Area} * \text{Area Cost Factor} \\ &\quad * \text{Escalation Factor} \end{aligned}$$

$$\begin{aligned} \text{Annual Energy Cost (Renovated Facility)} \\ &= \text{Energy for new facility} * 1.2 \end{aligned}$$

$$\text{Reduced Occupancy Energy Cost (0\%)} = \text{Energy for new facility} * 0.5$$

$$\text{Energy Cost during Layaway} = \text{Energy at 0\% occupancy}$$

B.5.6 Maintenance and repair costs

Maintenance and repair (M&R) activities are necessary to keep a facility in good condition and to ensure that the facility and its components can realize their full service life without premature failure. M&R costs are continuous costs that appear annually in the model. The model does distinguish between various types of M&R costs, including M&R for a new facility, M&R for a renovated facility, or M&R during the layaway period. This Caretaker M&R is the costs of maintenance, repairs and climate control to preserve the facility at a condition similar to its condition when it was closed and secure.

M&R costs are calculated based on the size of the facility and the unit cost of maintenance sustainment as provided in Table 3, “Unit Costs for DoD Facility Cost Models” in UFC 3-701-01 (NAVFAC 2018c). This source contains the sustainment unit costs and expected facility service life based on facility type (Facility Analysis Category). The sustainment cost provided in this table are an average over the life of the facility, and are assumed to be less for a new facility and more for a facility near the end of its service life. As a result, facility age is used as an adjustment factor when calculating M&R costs for the LEA model:

Annual M&R Cost

$$\begin{aligned} &= \text{Sustainment Unit Cost} * \text{Age Adjustment factor} \\ &* \text{SF Area} * \text{Area Cost Factor} * \text{Escalation factor} \end{aligned}$$

B.5.7 Additional costs

In some cases, there are some additional costs related to upgrades for compliance and preservation for historic buildings. In the presence of asbestos and/or lead hazards in a building component, a plan must be developed to remove, encapsulate, or monitor these hazards. Depending on the facility’s historic significance, there might also be some preservation costs to be added. Additionally, new safety measurements and current laws may require upgrades that bring the buildings to code according to the American with Disabilities Act (ADA), and the Seismic Rehabilitation of Existing Buildings. The need to remove underground storage tanks may also incur additional costs. These costs were not included in the model, since more specifics details are needed on the facility to make a more accurate cost estimate. It is the responsibility of the user to account for these additional costs.

Appendix C – USFA National Arson Prevention Initiative Board-Up Procedures

C.1 Materials list and specifications

This content is from the U.S. Fire Administration (USFA) documentation (IAAI/USFA 2001), reformatted into this report for reading ease.

C.2 Security measures

1. All openings in the basement, first floor doors and windows, and any point of entry accessible from a porch, fire escape or other potential climbing point shall be barricaded with plywood, 2x4 braces, carriage bolt sets, and nails. Particle board, wafer board, Masonite, or other similar material shall not be used for purposes of boarding-up a building.
2. Openings that are at least 10 ft from ground level that are not accessible from a porch, fire escape, roof, or other climbing point can be secured with nails in each brace, and every 12 in. around the perimeter. For all openings, the plywood should be fitted so that it rests snugly against the exterior frame, butting up to the siding on wood frame buildings and up to the brick molding edge on brick buildings. It may be necessary to remove the staff bead so this fit can be flush and tight.
3. The structure shall be posted with a NO TRESPASSING sign at the completion of the board-up.

C.3 Materials

1. Plywood, 1/2-in. (4 ply) exterior grade CDX (Class **C** to **D** eXposed plywood)
2. Braces, 2 in. x 4-in. x 8 ft construction grade lumber
3. 3/8 in. (coarse thread) by 12 in. carriage bolts (rounded head on weather side)
4. 3/8 in. (coarse thread) construction grade nuts
5. 1/2 in. (U.S. Standard [USS]) flat washers with an inside diameter large enough to bypass the wrench neck inside the carriage bolt head so no lift edge is available beneath an installed carriage bolt head.
6. 3/8 in. (USS) diameter flat washers for installation beneath the nut inside the building
7. 1 5/8 in. (6d) galvanized or stainless steel ring-shank nails or comparable deck nails. Figure C-1 shows a Materials list.

C.4 Barrier assembly

1. Applying barriers is accomplished with an inside and outside carpenter with appropriate tools and supplies. The inside carpenter will need a light. Exit is made over a ladder when the last window is boarded.
2. Plywood shall be cut to fit over the window and door openings, flush with outside of the molding/trimmer stud. Application of barriers shall be completed so that all lift or pry points are avoided.
3. The 2x4 braces shall be cut to fit the horizontal dimension of the plywood. Two exterior and two interior 2x4 braces shall be provided for each window and three sets for each door.
4. Window Assembly. Braces are located horizontally approximately $\frac{1}{3}$ of the distance from the top and the bottom of the window. Bolt holes are located $\frac{1}{3}$ of the length of the brace from the outside edge of the window jams. Before installation, the assembly should be pre-assembled and $\frac{3}{8}$ -in. holes drilled through all of the components. Figure C-2 shows window details.
5. Door Assembly – Door braces will be placed horizontally; one in the center of the doorway and one $\frac{1}{2}$ the distance from the center to the top and one $\frac{1}{2}$ distance from the center to the bottom of the doorway. Bolt holes are located $\frac{1}{3}$ of the length of the brace from the outside edge of the door frame. Before installation, the assembly should be pre-assembled and $\frac{3}{8}$ -in. holes drilled through all of the components.
6. Plywood used to cover exterior openings shall be nailed every 12 in. along the perimeter to the window or door frame. Figure C-3 shows board up procedures.
7. The 2x4 braces on the interior and exterior of the assemblies shall be secured using $\frac{3}{8}$ in. by 12 in. carriage bolt assemblies. Bolts shall be inserted through the predrilled holes from the exterior with a $\frac{1}{2}$ -in. washer place against the exterior brace; a $\frac{3}{8}$ in. washer is placed against the interior brace. The bolt is tightened from the inside so that it slightly compresses the interior brace.
8. The exterior surfaces of barriers shall be painted or stained the same color as the structure to minimize the appearance.
 - a. Should the through-bolt compression method be impossible due to the size or condition of the opening, the opening shall be covered with plywood and secured with a minimum of 3-in. long deck or wood screws installed on 4-in. centers around the circumference of the opening. Figure C-4 shows bolt assembly detail.
 - b. For buildings that require access by authorized personnel, a single door that is visible from the street may be secured using a solid core wood or steel door. There shall be no windows or other openings in this door.

The door shall be securely locked using a padlock and hasp assembly that is bolted through the door. The lock loop portion of the hasp is attached to the door frame using a minimum of 3-in. long wood screws.

Figure C-1. Materials list.

WINDOW ASSEMBLY MATERIALS REQUIRED PER WINDOW		
1	1/2" CDX PLYWOOD SHEET - CUT TO DIMENSIONS OF WINDOW FRAME (WEATHER SIDE)	NUMBER OF WINDOWS TO BE SECURED (N_w): _____
4	2X4 BRACES - CUT TO WIDTH OF PLYWOOD	NUMBER OF WINDOWS BRACES REQUIRED: ($N_w \times 4$) _____
4	CARRIAGE BOLT ASSEMBLIES	CARRIAGE BOLT ASSEMBLIES REQUIRED (B_w): ($N_w \times 4$) _____
DOOR ASSEMBLIES MATERIALS REQUIRED PER DOOR		
1	1/2" CDX PLYWOOD SHEET - CUT TO DIMENSIONS OF DOOR FRAME (WEATHER SIDE)	NUMBER OF DOORS TO BE SECURED (N_b): _____
1	1/2" CDX PLYWOOD SHEET - CUT TO OUTSIDE DIMENSIONS OF DOOR FRAME TRIM (INSIDE)	NUMBER OF DOOR BRACES REQUIRED: ($N_b \times 6$) _____
6	2X4 BRACES - 3 CUT TO WIDTH OF OUTSIDE PLYWOOD, 3 CUT TO WIDTH OF INSIDE PLYWOOD	NUMBER OF BOTTOM BRACES REQUIRED: (N_b) _____
1	2X4 BOTTOM BRACE - CUT TO WIDTH OF DOOR TRIM (OPTIONAL)	CARRIAGE BOLT ASSEMBLIES REQUIRED (B_d): ($N_b \times 6$) _____
6	CARRIAGE BOLT ASSEMBLIES	
CARRIAGE BOLT ASSEMBLY		
1	12' X 3/8" CARRIAGE BOLT - COURSE THREAD	
1	1/2" USS STANDARD FLAT WASHER (WEATHER SIDE)	TOTAL CARRIAGE BOLT ASSEMBLIES REQUIRED: ($B_w + B_d$) _____
1	3/8" USS STANDARD FLAT WASHER (INSIDE)	
1	3/8" CONSTRUCTION GRADE NUT - COURSE THREAD

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Figure C-1. Materials list. (Cont'd.).

WINDOW ASSEMBLY MATERIALS REQUIRED PER WINDOW		
1	1/2" CDX PLYWOOD SHEET - CUT TO DIMENSIONS OF WINDOW FRAME (WEATHER SIDE)	NUMBER OF WINDOWS TO BE SECURED (N_w): _____
4	2X4 BRACES - CUT TO WIDTH OF PLYWOOD	NUMBER OF WINDOWS BRACES REQUIRED: ($N_w \times 4$) _____
4	CARRIAGE BOLT ASSEMBLIES	CARRIAGE BOLT ASSEMBLIES REQUIRED (B_w): ($N_w \times 4$) _____
DOOR ASSEMBLIES MATERIALS REQUIRED PER DOOR		
1	1/2" CDX PLYWOOD SHEET - CUT TO DIMENSIONS OF DOOR FRAME (WEATHER SIDE)	NUMBER OF DOORS TO BE SECURED (N_d): _____
1	1/2" CDX PLYWOOD SHEET - CUT TO OUTSIDE DIMENSIONS OF DOOR FRAME TRIM (INSIDE)	NUMBER OF DOOR BRACES REQUIRED: ($N_d \times 6$) _____
6	2X4 BRACES - 3 CUT TO WIDTH OF OUTSIDE PLYWOOD, 3 CUT TO WIDTH OF INSIDE PLYWOOD	NUMBER OF BOTTOM BRACES REQUIRED: (N_d) _____
1	2X4 BOTTOM BRACE - CUT TO WIDTH OF DOOR TRIM (OPTIONAL)	CARRIAGE BOLT ASSEMBLIES REQUIRED (B_d): ($N_d \times 6$) _____
6	CARRIAGE BOLT ASSEMBLIES	
CARRIAGE BOLT ASSEMBLY		
1	12' X 3/8" CARRIAGE BOLT - COURSE THREAD	
1	1/2" USS STANDARD FLAT WASHER (WEATHER SIDE)	TOTAL CARRIAGE BOLT ASSEMBLIES REQUIRED: ($B_w + B_d$) _____
1	3/8" USS STANDARD FLAT WASHER (INSIDE)	
1	3/8" CONSTRUCTION GRADE NUT - COURSE THREAD	

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Figure C-2. Window detail.

Figure C-3. Window detail.

Figure C-4. Board up procedures.

Figure C-5. Bolt assembly detail.

NOTES:

1. USE 3/8" X 12" CARRIAGE BOLTS - ROUNDED HEAD ON OUTSIDE OF BUILDING
2. TIGHTEN NUTS FROM INSIDE ENOUGH TO SLIGHTLY COMPRESS WASHER INTO 2X4 BRACE.
3. USE 1/2" WASHER ON WEATHER SIDE TO ACCOMMODATE THE WRENCH NECK OF BOLT AND ELIMINATE PRY POINTS.

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Bolt Assembly Detail

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