Demonstrating the Environmental & Economic Cost-Benefits of Reusing DoD's Pre-World War II Buildings

ESTCP Project SI-0931

April 2013

Key Findings ESTCP SI 0931

1. Modernization of DoD's Pre-War Buildings masonry buildings can be **significantly less expensive** than new construction.

2. DoD's LEED Silver standard can be met at **less cost with modernization** and Pre-War Buildings can contribute significantly to DoD's goals of lowering GHG emissions.

3. By leveraging original design features for thermal comfort ("original design intelligence") with new, energy-efficient buildings systems, DoD can modernize Pre-War Buildings to **match the energy performance of new construction**.

4. **Mission critical facility requirements can be fulfilled** through the adaptive reuse and modernization of Pre-War Buildings.

5. Historic buildings should be considered a **valuable asset** and their reuse and modernization should be integrated into installation master plans.

6. Prescriptive and rigid application of AT/FP and progressive collapse standards can result in significantly **higher modernization costs and at the same time generate higher levels of Scope 3 GHG emissions** than carefully specified AT/FP treatments.

Recommended Actions

1. Military planners should explore modernization and repurposing of Pre-War Buildings **before** considering new construction to meet installation mission requirements.

2. Military service procurement procedures should be reviewed and revised to ensure **selection and use** of contractors with experience and knowledge of historic structures.

3. DoD's MILCON and SRM funding programs should be reviewed and revised to **avoid piece-meal improvements** to historic structures and instead provide for full modernization.

4. Prescriptive and rigid application of AT/FP and progressive collapse standards should be avoided. Greater emphasis on installation-wide security measures can **lower** AT/FP compliance costs for historic, and other existing structures.

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Acknowledgments

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Projects such as this Study conduct formal demonstrations at DoD facilities and sites in operational settings to document and validate improved performance and cost savings. After selection of projects for funding in a competitive process, the ESTCP program managers assist in the formulation of a formal test and evaluation plan with periodic reporting and in-person progress reviews. Prior to commencing research or demonstration of a new technology, the awardee must submit a demonstration plan that sets forth the proposed protocol of the selected project. This Study was approved in the fall of 2010 as ESTCP Project Number SI 0931 under the title “Demonstrating the Relative Cost Benefits of Reusing Historic & Non-historic DoD Properties Using Scientifically-Derived Data (Demonstration Plan). A roster of Study Team members and their contact information is provided in Appendix A.

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[1] See ESTCP website: http://www.serdp.org/About-SERDP-and-ESTCP/About-ESTCP; accessed December 17, 2012.

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Executive Summary

Study Performance Objectives

Overall Objective

The purpose of this Study is to demonstrate how to incorporate environmental costs and benefits into traditional life-cycle cost analyses (LCCAs) and total ownership cost (TOC) analyses[2] for military construction projects, using two key metrics: life-cycle greenhouse gas (GHG) emissions and the net present value (NPV) of life-cycle costs with monetized GHG emissions. The Study focused on buildings constructed before World War II (Pre-War Buildings).

Specific Study Performance Objectives

To meet the overall objective of the Study, the Study Team worked with ESTCP staff to formulate five performance objectives, as follows:

Performance Objective #1. Demonstrate that a planning level building project can reuse existing buildings (both historic and non-historic) using sustainable design and energy-efficient building systems on a cost-effective basis compared to new construction, serving the same mission-critical use and achieving a 15 percent or more NPV cost reduction.

Performance Objective #2. Demonstrate that a planning level building project involving existing buildings (both historic and non-historic) can achieve GHG reductions exceeding GHG reductions in new construction by 15 percent or greater reduction in GHGs (broken down by Scope 1, 2, and 3 emissions).

Performance Objective #3. Develop a more complete LCCA that includes the monetary value of GHG emissions incorporated into the LCCA, demonstrating that reuse of historic or other existing building can achieve a 5 percent reduction in project NPV due to lower overall GHG emissions.

Performance Objective #4. Demonstrate that a growing installation's mission-critical needs can be met with an older (historic or non-historic) existing building.

Performance Objective #5. Demonstrate comprehensive LCCA framework that more thoroughly measures both cost and life cycle assessment of carbon footprint reduction in a manner

[2] This Study uses the term LCCA for essentially the same analysis that would also fall under the term TOC.

that can be incorporated into DoD existing MILCON approval process (DD 1391).

Study Context

Legal and Policy Context

The U.S. Congress and Executive Branch have set forth a series of legislative and policy directives that mandate that the Federal government, including DoD, take measures to achieve significant levels of reduced energy consumption and GHG emissions. At the same time DoD must fulfill its obligations to preserve and protect historic properties under the National Historic Preservation Act and adopt Anti-Terrorism Force Protection measures to protect its personnel and property assets.

DoD's Real Property Inventory

DoD is one of the world's largest property owners with a real property inventory of approximately 300,000 owned buildings as of the end of 2006. Among these properties, almost a third (approximately 32 percent) are 50 years or older. Many are either listed, or eligible for listing, on the National Register of Historic Places ("historic"), while others are considered "non-historic." DoD's building inventory would suggest that a change in energy usage can have a big total impact on reducing the agency's overall GHG emissions.

Original Design Intelligence

There has been longstanding perceived policy conflict between Federal mandates to improve energy efficiency and to preserve historic and non-historic older properties. Recent research, however, indicates that older buildings, particularly those constructed prior to the mid-1940s (prior to the widespread use of modern HVAC systems), offer opportunities to improve energy efficiency when undergoing modernization. These buildings were typically designed to maximize thermal comfort by incorporating features that provide "passive" or energy conservation through the choice of building materials and design.

Military Planning Process

As part of funding requests for military construction, military planners are required to prepare project alternatives and undertake a comprehensive economic analyses of all the costs of ownership over the life-cycle of the project. This study would introduce a new step in the process: calculating the GHG emissions associated with construction project alternatives and assigning a monetary value to GHG emissions.

Selected Installations and Buildings

The Study Team worked with DoD staff to select three active military installations and two buildings for study at each installation, as follows:

Fort Bliss – El Paso, Texas

- Buildings 1 and 115

Saint Juliens Creek Annex, Norfolk Naval Shipyard – Chesapeake, Virginia

- Buildings 61 and 168

F.E. Warren Air Force Base –Cheyenne, Wyoming

- Buildings 222 and 323

Building selected were non-residential and "typed" historic/non-historic structures that can be found at multiple military installations. Use of typed buildings allows the findings and observations from this Study to be broadly applicable.

Specification of Project Alternatives

The Study Team formulated four Project Alternatives for each selected building. The mission use for all buildings was general administrative office. The four Project Alternatives were:

- 01-Sustainment/Status Quo – used as a baseline to determine energy savings;
- 02-Demolition and New Construction –the existing building is demolished and replaced with new construction;
- 03-Modernization with HPS –a strict interpretation of the Secretary's Standards for Rehabilitation of Historic Properties is applied and AT/FP and progressive collapse standards are met with in a manner consistent with HPS, International Building Code, and ISC Security Design Criteria; and
- 04-Modernization with AT/FP –a less strict interpretation of HPS is applied and AT/FP and progressive collapse standards are met with customary treatments that reflect prescriptive and customary approached used by many installations.

All new construction and modernization Project Alternatives were specified to meet a LEED Silver level, except for one building at F.E. Warren where the Study Team specified a program to reach

LEED Gold. This exception was made early in the Study period to explore the impact of a higher level of energy efficiency on life-cycle GHG emissions and NPV costs.

Methodology

Design Standards

As part of the specification of each Project Alternative, the Study Team applied the following key design standards:

- Whole Building Design
- UFC 1-200-01 General Building Requirements
- UFC 4-610-01 Administrative Facilities
- UFC 1-900-01 Selection of Methods for the Reduction, Reuse and Recycling of Demolition Waste
- UFC 3-310-04 Seismic Design for Buildings
- DoD Minimum Antiterrorism Force Protection Standards for Buildings
- Secretary of Interior's Standards for Rehabilitation of Historic Buildings

Cost Estimation

The Study Team utilized RSMeans CostWorks as the primary source for cost data but also reviewed project cost records for recently completed projects at each installation and interviewed local contractors that have had experience at the installation or surrounding market. Demolition and typical environmental remediation (lead paint and asbestos) costs were included in the cost estimates for the Project Alternatives.

Structural Assessment

The buildings selected for this Study have experienced modifications, damage, foundation movement, aging, and exposure to moisture. The Study Team's evaluation was based on an approach intended to consider the original structural design, the condition of materials, the effects of age and past usage, hurricane and other damage, and the requirements for continued service. The Study Team made on-site observations to visually assess the condition of the structures, identify the structural system types, and obtain field measurements of primary structural elements.

Energy Consumption Estimates

After initial construction or modernization, GHG emissions are generated by energy consumed during ongoing building operations, including lighting, heating, and cooling. In order to estimate these emissions, the Study Team's mechanical engineering consultant determined the thermal insulation values (known as R- and U- values) of the door, window, roofing, sheathing, and exterior wall materials specified in each Project Alternative based on industry standards and professional judgment. These values were then input into Trane's Trace 700 Building Energy and Economic Analysis Software Version 6.2 using the TETD-TA1[3] methodology for cooling load and the U-factor by area by temperature difference and instantaneous room load calculation method for heating load.

GHG Emissions Estimation

Definition of Scopes 1, 2, & 3 GHG Emissions

Scope 1 emissions refers to emissions generated by use of energy at the building or building site, such as natural gas for a boiler. Scope 2 emissions are for purchased energy not controlled at the site, such as electricity from a utility company. Scope 3 emissions are related to the production and transport of building materials as well as transportation of waste and demolition debris to an offsite disposal site.

GHG Calculation Tools

As of the date of this Study there is not currently a single, widely-accepted, publicly-available GHG calculator that can provide estimates of Scope 1, 2, and 3 GHG emissions. To estimate GHG emissions, the Study Team reviewed off-the-shelf calculation tools and ultimately utilized the following:

- Scope 1: World Resources Institute (WRI) GHG Protocol, Emission Factors from Cross-Sector Tools, Version 1.3.
- Scope 2: EPA eGRID 2012, Version 1.0 Year 2009 GHG Annual Output Emission Rates
- Scope 3: (1) Athena Institute EcoCalculator for Assemblies, Low Rise Structures; and (2) EIO-LCA: Economic Input-Output Life Cycle Assessment, US 2002 Purchaser Price Model, adjusted to 2012 dollars.

Having gone through the demonstration process, the overall conclusion of the Project Team is that without an integrated GHG calculator (whether one model or multiple related models), the process of estimating GHG emissions by Scope 1, 2, and 3 for MILCON projects will be challenging to perform in a cost-effective manner since the process would involve multiple steps, knowledge of multiple calculators and data sources, and considerable care in cross-walking cost estimate data categories with carbon calculator categories.

CO_2e Pricing

Based on a review of fifteen available public studies, the Study Team determined that the EPA

[3] Transfer Function Method for heat gain calculations and Time Averaging Method for room load calculations.

analysis of the American Power Act ("EPA Analysis") was the best available source of per CO_2e ton pricing data study since many of the other studies referenced the EPA data as source material.

Life Cycle Cost Analysis (LCCA)

To prepare its LCCA, the Study Team adopted the standards set forth in the USACE's *Manual for Preparation of Economic Analysis for Military Construction*. Key assumptions included:

- 30-year study period, excluding project lead time;
- Current dollar analysis, all in 2012 dollars (e.g., no CPI escalations); and
- Real 30-year discount rate from OMB Circular 94-A, Appendix C.

Findings

Overall Key Findings

Based upon the data from the LCCA analyses, the Study Team can make the following overall findings:

- Pre-War Buildings can be cost effective compared to new construction on a life-cycle cost basis, both with and without factoring in the monetized value of GHG emissions;
- Leveraging existing building materials and original design intelligence, modernization of Pre-War Buildings can achieve comparable levels of energy consumption as new construction at a LEED Silver level;
- On a life-cycle cost basis, Pre-War Buildings generate less total GHG emissions compared to new construction –GHG savings from initial construction (Scope 3) is the driver of this result;
- While adding monetized GHG emissions to the project cost reflects the true economic cost, it does not have a significant impact on LLCA project NPV results. The absolute dollar values of GHG emission differences among Project Alternative was extremely low; and
- Incorporating the monetary value of GHG emissions raised the total project life-cycle costs across all Project Alternatives by approximately 2 to 3 percent.

Findings Relative to Specific Performance Objectives

The Study Team's analysis found the following with respect to the five performance objectives set forth at the commencement of the Study:

- **Performance Objective #1:** Achieve a 15 percent cost reduction with modernization relative to new construction. Five of twelve modernization Project Alternatives met this objective and two other were within ten percent of the goal. The result was the same with and without the monetized value of GHG included. Comparing only total initial construction costs, eight of twelve modernization Project Alternatives were 15 percent less than new construction.

- **Performance Objective #2:** Achieve a 15 percent cost reduction in GHG emissions with modernization relative to new construction, broken down by Scopes 1, 2, and 3 emissions. Every modernization Project Alternative achieved this goal for Scope 3 emission. Scope 1 emissions were calculated only for F.E. Warren and one modernization Project Alternative met this threshold. For Scope 2, none of the modernization Project Alternatives performed significantly better than new construction since all new construction and modernization Project Alternatives specified similar, energy-saving building systems –and this was an expected result.

- **Performance Objective #3:** As presented in Table IV-8, none of the Project Alternatives achieved Performance Objective 3 since the dollar values of GHG emissions, while material as a percent of total life-cycle costs for each Project Alternative, are not high enough to impact relative total NPV of life cycle costs among Project Alternatives.

- **Performance Objective #4:** The Study meets this Performance Objective byshowing that mission requirements can be met with historic/non-historic existing buildings. With respect to DoD standards, the Study Team relaxed strict interpretations of AT/FP and HPS standards for the purposes of comparison in Project Alternative 03 and Project Alternative 04, respectively.

- **Performance Objective #5:** The Study did not meet this objective. The replication of this Study by Military planners would be difficult for the following reasons: (i) there is no off-the-shelf, GHG emission calculation tool that integrates Scope 1, 2, and 3 emissions; (ii) existing calculators are oriented to new constructions, not historic rehabilitation or modernization; and (iii) the Study team found that it was difficult to cross-walk the cost estimation system categories with the categories of building assemblies and components found in the GHG emission calculation tools.

Other Findings

- AT/FP and progressive collapse requirements tent to be rigidly and prescriptively applied by project designers, increasing construction costs and introducing additional Scope 3 emissions.
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- The Study Team observed prior modernization treatments that result in loss of original energy saving design features (e.g., original design intelligence) in Pre-War Buildings.

Recommendations

Based upon the findings and observations of the Study Team, the following recommendations are offered to DoD for consideration:

- Incorporate life-cycle GHG emissions analysis into DoD MILCON and SRM programs with metrics, such as life-cycle CO2e per square foot, and report GHG metrics on D1391 forms to incent project planners to consider all options.

- Invest in formulation of an integrated GHG emission calculation carbon system of tools

- Place more emphasis on existing buildings as viable project alternatives to meet mission requirements and DoD's energy reduction targets

- Evaluate GHG tradeoffs early in the project formulation process to identify both a design and mix of building materials (or retained materials) that result in the lowest Scope 3 emission envelop.

- Identify characteristic strengths and vulnerabilities by class of building rather than apply prescriptive, "one size fits all" treatments

- Avoid modernization treatments that result in loss of original energy saving design features in Pre-War Buildings

- Improve the MILCON procurement process to ensure that construction contractors and design and engineering professionals with historic preservation experience are engaged to ensure that DoD has capacity to effectively evaluate its inventory of historic and other older, existing buildings.

Glossary

This Study utilizes the following abbreviations and acronyms:

ACHP	Advisory Council on Historic Preservation
ASCE	American Society of Civil Engineering
ASHRAE	American Society of Heating Refrigeration, and Air Conditioning Engineers
BEES	Building for Environmental and Economic Sustainability
BOMA	Building Owners and Managers Association
BOMA EER	BOMA Experience Exchange Report
BAH	Booz, Allen, & Hamilton, Inc.
BRAC	Base Realignment and Closure
BSHF	Building and Social Housing Foundation
BTU	British Thermal Unit
CCX	Chicago Climate Exchange
CFI	Carbon Financial Instruments
CERL	Construction Engineering Research Laboratory
Cf	Cubic feet
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COE	Corps of Engineers
CONUS	Continental United States
DAU	Defense Acquisition University
Demonstration Plan	Demonstration Plan for ESTCP Project Number SI 0931
DoD	Department of Defense
DoE	Department of Energy
EA	Economic Analysis
eGRID	Emissions & Generation Resource Integrated Database

EIA	U. S. Energy Information Agency
EISA 2007	Energy Independence and Security Act of 2007
EO	Executive Order
EPA	U. S. Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
EPA Analysis	EPA analysis of the American Power Act
FEW	F.E. Warren Air Force Base
FY	Fiscal Year
FTBL	Fort Bliss
GHG	Greenhouse Gas
GSF	Gross Square Feet
GSHP	Ground Source Heat Pump
HVAC	Heating, Ventilation and Air Conditioning
HPS	Historic Preservation Standards, e.g., Secretary of the Interior's Rehabilitation Guidelines and Standards for the Rehabilitation of Historic Properties
ISC	Interagency Security Committee
kBtu	1,000 British thermal units
kWh	Kilowatt hour
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design
LEED AP	LEED Accredited Professional
LEED- NC	LEED New Construction
MILCON	Military Construction
Military Services	U.S. Air Force, U.S. Army, U.S. Navy, and U.S. Marine Corps
MT	Metric Ton
MW	Mega-watt
NAVFAC	Naval Facilities Command
NIST	National Institute of Standards and Technology
NRHP	National Register of Historic Places
NHL	National Historic Landmark

NHPA	National Historic Preservation Act
NPV	Net Present Value
O&M	Operations and Maintenance
PV	Photovoltaic
Q-1	The sum of all necessary restoration and modernization costs is not greater than 10 percent of the replacement value of the facility(PRV)
Q-2	Facilities Quality Code- Sum of all restoration and modernization costs that are greater than 10 percent but not greater than 20 percent of the replacement value
Q-3	Facilities Quality Code- Sum of all restoration and modernization costs that are greater than 20 percent but not greater than 40 percent of the replacement value
Q-4	Facilities Quality Code- Sum of all restoration and modernization costs that are greater than 40 percent of the replacement value
RECs	Renewal Energy Certificates
REPI	Real Estate Property Inventory
ROI	Return on Investment
Pre-War Buildings	Existing buildings built prior to 1945
PRV	Plant Replacement Value
Project Alternatives	A set of alternative facility construction and/or improvement programs that can meet the mission requirement and applicable DoD standards
SJCA	Saint Juliens Creek Annex, Norfolk Naval Shipyard
SCF	Standard cubic foot (natural gas)
SF	Square foot
SIR	Savings-to-Investment Ratio
SRM	Sustainment, Restoration and Modernization
TOC	Total Ownership Cost
TJ	Terajoule

UFC	United Facilities Criteria
USACE	United States Army Corps of Engineers
USGBC	U.S. Green Building Council
WBCSD	World Business Council for Sustainable Development
WRI	World Resource Institute

SECTION I:
PERFORMANCE OBJECTIVES & STUDY BACKGROUND

Study Performance Objectives

This Study's overall objective is to demonstrate how DoD can reduce its carbon "bootprint" by incorporating environmental metrics, namely GHG emissions, into its life cycle cost analysis (LCCA) and economic analysis protocols, leading to economically and carbon efficient outcomes. This Study's hypothesis is that the reuse and modernization of DoD's existing buildings, particularly those constructed prior to World War II, can help DoD achieve its GHG emission goals while at the same time preserve historic and cultural resources. To test this hypothesis, the Study Team formulated five specific performance objectives (Performance Objectives) and success criteria for this Study, as presented in Table I-1:

Table I-1
Study Performance Objectives and Success Criteria

No.	Performance Objective	Success Criteria
1	Demonstrate that a planning level building project can reuse existing buildings (both historic and non-historic) using sustainable design and energy-efficiencies on a cost-effective basis compared to new construction serving the same mission-critical use.	Reuse of existing historic and non-historic buildings achieve a **15** percent or more NPV cost reduction compared to new construction.
2	Demonstrate that a planning level building project involving existing buildings (both historic and non-historic) can achieve GHG reductions exceeding GHG reductions in new construction.	Reuse of existing buildings demonstrates a **15%** or greater reduction in GHGs (broken down by Scope 1, 2, and 3 emissions) compared to new buildings in a planning level analysis.
3	Develop a more complete LCCA that includes the monetary value of carbon offsets incorporated into the LCCA.	Demonstrate a **5** percent reduction in project NPV due to carbon offset values.
4	Demonstrate that a growing installation's mission-critical needs can be met with an older (historic or non-historic) existing building.	Full documentation in a checklist format of reuse building compatibility with mission-critical use requirements.
5	Demonstrate comprehensive LCCA framework that more thoroughly measures both cost and life cycle assessment of carbon footprint reduction in a manner that can be incorporated into DoD existing MILCON approval process (DD 1391).	User survey results that measure the tool's average user satisfaction at a minimum of **60** percent, and no fatal flaws identified in the tool's application to the MILCON process.
		User survey results that measure opinions about the compatibility of the tool with LEED certification process at a minimum average of **60** percent acceptability.

Source: ESTCP Project SI 0931Demonsttration Plan.

Policy & Institutional Context

Over the past several years, Congress and the Executive Branch have set forth a series of legislative and policy initiatives that mandate that the federal government, including DoD, take measures to achieve significant levels of energy conservation and reduction in GHG emissions. As of the date of this Study, the following statutes, executive orders, OMB circulars, and DoD regulations and policies have resulted, collectively, in the need for a new approach to military construction project planning that considers the economic and environmental values and benefits of reusing the existing DoD building inventory:

Statutory Mandates:

National Historic Preservation Act of 1966

Section 106 requires Federal agencies to take into account the effects of their undertakings on historic properties that are owned or controlled by the agency. Section 110(a)(1) sets forth the duties of Federal agencies as stewards of historic properties as follows:

> *The heads of all Federal agencies shall assume responsibility for the preservation of historic properties which are owned or controlled by such agency. Prior to acquiring, constructing, or leasing buildings for purposes of carrying out agency responsibilities, each Federal agency shall use, to the maximum extent feasible, historic properties available to the agency.*

Energy Policy Act of 2005 (EPAct2005)

The EPAct2005 is the first modern Federal building energy policy. It requires that all construction projects use energy star products, fit all buildings – existing and new – with electric meters, and directs the Department of Energy (DOE) to establish Federal building performance standards. Specifically, the policy requires a 30 percent building energy consumption reduction below ASHRAE standard 90.1-2004, which would earn a new construction building seven out of ten possible points under USGBC *LEED Energy and Atmosphere credit 1 (EAc1), Optimize Energy Performance*, and would earn an existing building nine out of ten possible EAc1 points. Finally, the act requires the Federal government to set goals for renewable energy sources for all new construction and major renovation projects. This Study uses 2009 LEED for New Construction and Major Renovations.

The Energy Independence and Security Act of 2007 (EISA 2007)

This law set energy goals for Federal buildings by mandating a 30 percent reduction in energy usage by 2015 relative to base year 2005. It required agencies undertaking new construction or major rehabilitation to achieve a 55 percent reduction in fossil fuel consumption by 2010 and 100 percent by 2030; mandates LCC analyses of major equipment replacements as well as renovations or expansions of existing facilities; established high performance green building standards; and amended authorities for Energy Savings Performance Contracts.

Resource Conservation and Recovery Act (RCRA 6002)

Legislation that requires waste reduction and the use of recycled content, and increase use of bio-based products and construction materials.

2007, 2008, and 2009 Defense Authorization Acts

These laws consolidated and enhance authorities for energy conservation; increased goals for renewal energy procurement to 25 percent by 2025; mandated use of energy efficient products for new construction; amended enhanced use leasing statutes for energy related projects; and enhanced reporting requirements.

Executive Orders and OMB Circulars:

Order 13423 Strengthening Federal Environmental, Energy, and Transportation Management (January 2007)

This Executive Order (EO) requires Federal agencies to reduce their energy intensity by 3 percent per year resulting by a 30 percent reduction by 2015 relative to base year 2003 (codified by EISA 2007); mandates increasing use of renewal energy with energy production onsite to the maximum extent possible; and requires agencies to comply with the 2006 Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding, setting a goal that 15 percent of each agency’s existing building stock incorporate sustainable practices in construction, lease, operation and maintenance of buildings by 2015.

Executive Order 13514 Federal Leadership in Environmental, Energy and Economic Performance (October 2009)

This EO directs each agency within 90 days to report a percentage reduction target agency-wide decrease in direct greenhouse gas emissions from agency owned sources and to formulate a Sustainability Performance Plan. It also requires that each agency take into consideration environmental measures as well as economic and social benefits and costs in evaluating projects and activities based on lifecycle return on investment. Finally, it requires that new construction and major renovation projects implement high performance sustainable Federal building design, construction, operation and management, maintenance, and deconstruction including by: (i) beginning in 2020 and thereafter, ensuring that all new Federal buildings that enter the planning process are designed to achieve zero-net-energy by 2030; (ii) ensuring that all new construction, major renovation, or repair and alteration of Federal buildings complies with the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings.*

Executive Order 13287 Preserve America (March 2003)

EO 13287 enhances compliance with the NHPA and calls for Federal agencies to manage their historic properties in such a manner as to promote the long-term preservation and use of historic assets.

Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (January 2006)

This Memorandum of Understanding sets forth an agreement among major Federal agencies (including DoD) to adopt integrated design, energy performance, water conservation, indoor environmental quality, and materials for the purposes of reducing the total ownership cost of facilities; improving energy efficiency and water conservation; providing safe, healthy, and productive built environments; and promoting sustainable environmental stewardship.

Relevant DoD Regulations and Policies

The Deputy Undersecretary of Defense for Installations and Environment has indicated that while combat and operational activities will not be subject to emissions targets, DoD will seek to reduce emissions from non-combat areas by 34 percent. According to the Obama Administration, the average Federal-government-wide reduction target is a 28 percent emissions reduction.[4]

Office of the Secretary of Defense Instructions and Policies:

DoD Instruction 4170.11. This instruction implements energy conservation and sustainable building design requirements across all Military Services and agencies; encourages participation under the USGBC's LEED certification program. Among other items, this Instruction mandates that DoD:

> *"Develop programs that result in facility that are designed, constructed, operated, maintained, and renovated to achieve optimum performance and maximize energy*

[4] http://solveclimate.com/blog/20100129/federal-government-and-military-reduce-own-emissions-28-2020

efficiency according to sustainable principles."[5]

Unified Facilities Criteria (UFC) 3-400-01 Energy Conservation (with changes of 2008). This UFC sets minimum energy conservation standards for new construction rehabilitation, modification of facilities, including facilities offsite that are leased or otherwise acquired. This UFC focuses on the entire facility lifecycle, e.g., the planning, design, construction and sustainment, restoration, and/or modernization stages.

UFC 4-010-01 DoD Anti-Terrorism and Force Protection Requirements. This UFC requires DoD Components to adopt and adhere to common criteria and minimum construction standards to mitigate antiterrorism vulnerabilities and terrorist threats, including historic properties.

US Air Force Policy

A7C Policy Letter (August 2007). Requires one-hundred percent of MILCON projects meet LEED Silver requirements, and specifies which credits must be met. The projects need not be certified, just certifiable as determined by a LEED AP. However, the Air Force requires five to ten percent of its buildings to be certified (five percent in FY 2009, and ten percent by FY 2010). Finally, the letter creates a line item on DD 1391 for sustainable design. If the sustainable design elements cost more than two percent of the primary facility cost, the planner should justify the reason(s).

Army Policy

SPiRiT to LEED Transition (2006). Requires all new construction and major renovation projects that enter the planning process in FY 2008 to meet LEED Silver requirements. Exceptions:

- Buildings not climate controlled;
- Horizontal construction on or under- ground (e.g., airfield, roads, utilities, bridges);
- Overseas Contingency Construction and CONUS interim facilities; and
- Renovation and repair projects that are not defined as major renovation.

Office of the Assistant Secretary of the Army (OASA): Sustainable Design and Development (SDD) Policy Update – Life-Cycle Costs (2007). All new construction and major renovation projects that enter the planning process in FY 2008 are required to meet LEED Silver requirements. Housing facilities are still subject to SPiRiT Gold requirements.

[5] See page 7, DoD Instruction 4170.11.

Army Energy Security Implementation Strategy of 2009. This strategy sets forth goals to reduce energy consumption, increase energy efficiency, increase use of renewable/alternative energy, ensure access to energy, and reduce the U.S. Army's adverse impacts on the environment.

ECB 2008-27 (Sept, 2008). All projects must register with LEED and use LEED templates, even if they are not certified.

USACE. All design and construction teams must include a LEED AP.

ASHRAE 189.1 Standard. This standard adopted by the Army in December 2010. This standard is for new construction and major renovations and addresses sustainable sites, water use, and energy efficiency, and how a building impact the atmosphere, materials, and resources.f

US Navy and Marine Corps Policy

ASN "Energy and Utilities Development in MCON and Special Projects," (August 2006). Requires all new construction and major renovation projects to meet the EPAct2005 and achieve at least Silver-level rating performance.

Engineering and Construction Bulletin (ECB) 2008-01 "Energy Policy Act of 2005 Implementation and USGBC LEED Certification". All new construction and major renovation Navy and Marine projects must be LEED certified, and are encouraged to be certified LEED-Silver. It also discusses the Budget Estimate Summary Sheet (BESS) that summarizes the cost premium for LEED/EPAct05 features and shows how to transfer this cost premium to DD 1391.

M I L C O N P r o g r a m O v e r v i e w

All Military Services utilize a planning and assessment process to prioritize and implement MILCON projects[6]. MILCON projects encompass:

- Construction, erection, or assembly of a new facility;
- Addition, expansion, extension, alteration, conversion, or replacement of an existing facility; and
- Relocation of a facility.

The types of projects that are excluded from the MILCON funding program include projects associated with operations, maintenance, and routine/minor repairs.

Planning, Design & Funding Process

In general, the MILCON process flows from identification of a mission-critical use and its facility requirements, conducing project planning and prioritization, formulating alternatives for economic evaluation, selecting the most cost-effective alternative, obtaining MILCON funding for the projects, and then implementation through a design and build process. Each Military Service promulgates its own instructions and guidelines for the MILCON program and has different organizational structures and terminology in some cases for components of the process. A generalized process is depicted in Figure I-1 below:

Figure I-1
Generalized MILCON Economic Evaluation Process

---- = process improvement intervention points for ESTCP 09 EB-SI6-036

[6] Military construction projects over $750,000 are typically funded through MILCON, with projects over $1.5 million requiring Congressional approval.

Determine Mission Requirements

The overall objective of the MILCON facility project planning and budget programming process is to deliver facilities critical to mission accomplishment. The first step in the planning process, typically at the Installation Commander level, is to identify the mission requirement and applicable facility standards.

Project Planning and Prioritization

The goal of project planning is to establish the most effective and economically efficient program that enables the Installation to meet its mission. After identifying the mission, the Installation commences a project planning and prioritization process.

Formulation of Alternatives

At this stage in the process, Installation staff formulates a range of alternative facility programs that can meet the mission requirement and applicable facility standards ("Project Alternatives"). Project Alternatives typically include:

- Use of existing facilities through alteration, extension, or major/minor rehabilitation;
- New construction;
- Purchase of new facility outside the Installation;
- Lease of an existing facility outside the Installation; and
- Other arrangements, including use and occupancy of other government facilities.

Installation staff then determines the initial feasibility of the Project Alternatives, indicating whether some Project Alternatives on their face are not feasible and thus do not merit further analysis. An example would be an Installation in a remote location where no private market exists to provide facilities. Hence, a lease or purchase of the required asset would not be feasible.

Evaluate Project Alternatives

For feasible Project Alternatives, the Installation performs a full evaluation of each Project. The analysis includes an evaluation of how the Project Alternative meets the applicable standards for the mission as well as a comprehensive economic analysis that indicates the life-cycle costs over the applicable time horizon. Life-cycle costs include upfront demolition and construction and/or modernization as well as ongoing costs to use and occupy the facility.

Select Project Alternative

Once a full evaluation is completed, the Project Alternative that best meets the mission requirement on an efficient and cost-effective basis is selected and advanced to the Service command headquarters for funding consideration.

MILCON Budget Request

If the selected Project Alternative involves new construction or modifying an existing asset (that meets the $750,000 dollar program threshold), the Installation initiates MILCON programming process by preparing and submitting a DD Form 1391 and other applicable forms and documentation and the project specifications. The Installation project MILCON request is reviewed internally by the Service command headquarters as well as by the Office of the Secretary of Defense. DoD MILCON requests are submitted to the U.S. Office of Management and Budget and included in the President's annual budget. Ultimately, the U.S. Congress reviews and approves MILCON projects over $1.5 million.

Design and Build

After authorization and appropriation of MILCON funding, the Installation project is funded by the Service (after first obtaining a Certificate of Compliance, which is equivalent to project entitlement in the private sector).

Strengthening the Economic Analysis of Sustainability in the MILCON Process

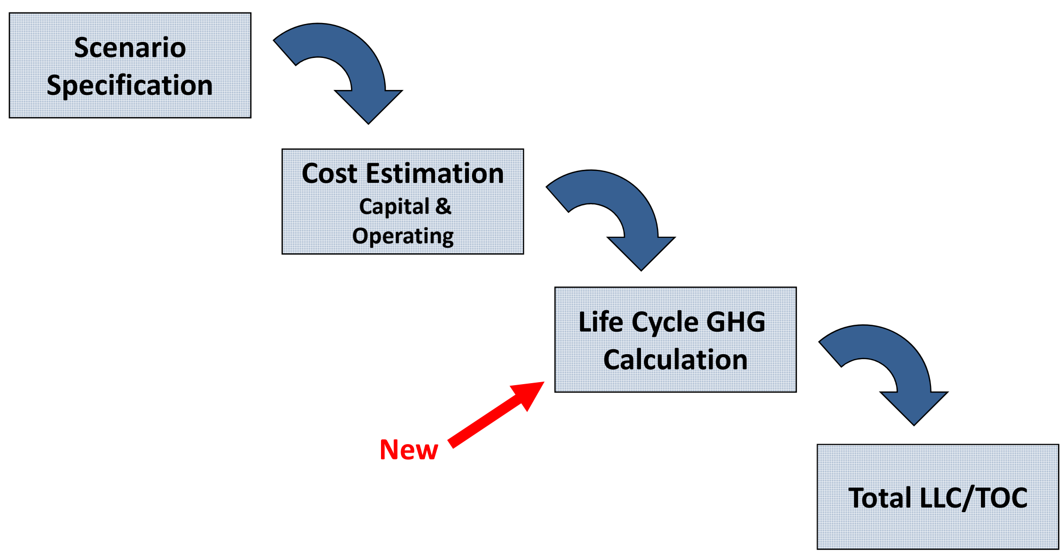
Over the past few years, the U.S. Congress and President have jointly implemented a large policy shift that mandates that DoD reduce its energy use and GHGs as described above. At present there is a need to strengthen the parametric cost estimating process and economic analysis of Project Alternatives in the MILCON planning process to reflect the full potential of existing facilities (including historic properties) to meet both mission requirements and the new mandates and standards related to energy consumption and GHGs. Analyses of restoration or modernization of existing structures should include realistic estimates of energy savings based upon replacement of relevant building systems and insulation treatments as well as embodied energy associated with new materials proposed as part of the treatment for the building.[7]

[7] Note that no value will be calculated for embodied energy of existing building materials; this is treated as a "sunk cost." The analysis will indicate the relative change in embodied energy associated with new materials introduced in each Project Alternative.

In fact, there is some evidence that alternatives for rehabilitation or adaptive reuse of existing buildings face an uphill analytic challenge compared to new construction. The Army narrowly described in its guidance document "renovation" as the renovation of the "status quo" facility and not as the restoration or modernization of other existing and available facilities.[8] The Navy is reported to use a 70 percent rule for excluding rehabilitation as a feasible alternative.[9] These operating concepts and "rules of thumb" can potentially result in suboptimal decision-making, particularly if GHG emissions are factored into consideration.

Figure 1-2 illustrates how the Study Team proposes to add a new step to the traditional economic analyses procedures.

Figure I-2
Proposed New Step for Economic Analysis



[8] See Section 9 of *Manual for Preparation of Economic Analysis for Military Construction (And Base Realignment and Closure (BRAC))*, Headquarters, U.S. Army Corps of Engineers, January 2010.
[9] Ibid. E.g. if rehabilitation of an existing structure is estimated to cost 70 percent or more of the cost of new construction.

Limitations of Existing Analytic Tools such as ECONPAK

Most economic analysis guidance documents issued by Military Services refer to ECONPAK, a software program developed and maintained by the U.S. Army Corps of Engineers, as a recommended (but not mandatory) tool to prepare economic evaluations. The ECONPAK software package enables military facility planners to generate a standardized economic analysis of Project Alternatives that can be automatically uploaded into Form 1391. This tool provides an economic impact model to compare the net present values (NPVs) of up to nine Project Alternatives, so that military planners can choose the most cost effective alternative that meets a given set of mission-critical requirements. Up to 35 life cycle cost variables can be entered in the software tool for analysis, but all data entry inputs (and underlying assumptions) are controlled by the planner.

While ECONPAK standardizes the inputs and outputs for economic analysis across Military Services and project types, the ECONPAK software program, as formulated today, has limitations that have led the Project Team to propose preparation of a new spreadsheet as a demonstration and potential use as an alternative recommended template (and/or basis for making improvements to ECONPAK). These limitations include:

- There is no ability to link inputs to the "Life Cycle Elements" module from external non-ECONPAK Excel workbooks, so values generated from other programs, models and calculators must be re-entered by hand; furthermore Life Cycle Elements can only be dollar values, preventing calculations utilizing non-dollar units within the spreadsheet;

- The cost sensitivity function is constrained by a uniform lower and upper limit of change on a percent basis that may or may not make sense for all the variables identified for cost sensitivity analysis; sensitivity analyses for variables external to the ECONPAK Life Cycle Elements cannot be accommodated;

- The internal help content offers limited guidance on data sources for operating and maintenance costs especially for historic properties;

- The internal structure does not explicitly have its users address sustainable design, historic building reuse, or greenhouse gas reduction goals of the government.

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Background and Study Relevancy

What Are Greenhouse Gases?

Greenhouse gases, abbreviated as "GHG," are gases in an atmosphere that absorb and emit radiation.[10] As GHGs concentrate in the atmosphere, a "greenhouse" effect is triggered resulting in rising average global temperatures and changes in climate. The primary GHGs in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Human activities contribute to the generation of GHGs, as do the natural physical changes that occur on Earth. People generate GHGs, primarily carbon dioxide (CO_2), from the combustion of carbon based fuels, principally wood, coal, oil, and natural gas.

Contribution of Buildings to Greenhouse Gases

The contribution of residential and commercial buildings to GHG emissions has been well documented by others. Buildings generate emissions at all points during their life-cycle: manufacture and transportation of building materials, construction and renovation of building improvements, building operations during occupancy, and demolition and transport of debris. According to a statistical summary prepared by the US Environmental Protection Agency (EPA), the built environment accounts for a major portion of energy use and CO_2 emissions in the United States[11]:

- 39 percent of total energy consumption;
- 72 percent of total electricity consumption;
- 38 percent of all carbon dioxide (CO_2) emissions;
- 40 percent of raw materials use;

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[10] Information for this section is from Wikipedia: http://en.wikipedia.org/wiki/Greenhouse_gas#Greenhouse_gases, accessed on December 13, 2012.

[11] See *Buildings and Their Impact on the Environment: A Statistical Summary*, U.S. Environmental Protection Agency, Revised April 23, 2009. The same pattern of energy use by structures has been quantified by the United Nations Environment Program in their publication *Buildings and Climate Change: Status, Challenges, and Opportunities*, 2007 and in *Buildings and Climate Change: Summary for Decision-Makers*, 2009.

- 26 percent of total non-industrial waste output (160 million tons annually); and
- 13 percent of potable water consumption.

These general statistics tell us that any national initiative to reduce energy use and GHGs must include policies that address the built environment, a point that has been incorporated into energy efficiency policies and programs at all levels of government.

DoD's Building Inventory

DoD is one of the world's largest property owners with a real property inventory of approximately 300,000 owned buildings as of the end of 2006[12]. Among these properties, almost a third (approximately 32 percent) are 50 years or older. Many are either listed, or eligible for listing, on the National Register of Historic Places ("historic"), while others are considered "non-historic.[13]" Moreover, the proportion of buildings aged 50 years or more in DoD's inventory will grow larger in the coming years. By 2025, 67 percent of DoD buildings will be 50 years or older. DoD's facilities and operations together account for approximately 80 percent of total Federal government energy consumption in 2011.[14]

This large and aging building inventory presents both an opportunity and a challenge to DoD, as the Military Services implement directives to evaluate construction projects in accordance with a series of recently enacted mandates for energy reduction, whole building design, and greenhouse gas emission (GHG) reductions. It is an opportunity since DoD's building inventory would suggest that a change in energy usage can have a big total impact on reducing GHG emissions. It is a challenge because improved energy efficiency cannot come entirely through new construction of energy-efficient buildings, but also must come through modernization and reuse of DoD's existing buildings.

[12] Data for this section taken from DoD Cultural Resources Workshop, "Prioritizing Cultural Resources Needs for a Sound Investment Strategy," November 2, 2006. It should be noted that since 2005, DoD's inventory has been reduced through demolition as well as transfer of properties subject to closure

[13] For a definition of "historic" and "non-historic" please refer to Attachment F.

[14] Table 1.11 U.S. Government Energy Consumption by Agency, Fiscal Years 1975-2011, *Annual Energy Review* 2012, US Energy Information Administration.

Original Design Intelligence

There has been longstanding perceived policy conflict between Federal mandates to improve energy efficiency and to preserve historic and non-historic older properties. Recent research, however, indicates that older buildings, particularly those constructed prior to the mid-1940s (prior to the widespread use of modern HVAC systems), offer opportunities to improve energy efficiency when undergoing modernization[15]. The U.S. Energy Information Agency published a study in 2003 that indicated that the per square foot energy consumption of buildings built before 1920 has been less than buildings built in later decades until recently when adopting energy saving building systems and operations has become widespread.[16]

These buildings were typically designed to maximize thermal comfort.[17] Van Citters (2010) and Carroon (2010) have evaluated older buildings and have identified common building features that provide "passive" or energy conservation through the choice of building materials and design, as follows:

- Natural ventilation through building siting, operable windows, transoms, and open staircases;
- Passive solar benefits obtained from building siting, thermally massive construction materials and shading devices; and
- Natural light enhancement through building siting, use of tall and wide windows, narrow floor plates, and sloped ceilings, and shading devices.[18]

While the concepts of environmental sustainability and "green" were not prevalent at the time these buildings were designed and contracted, the structural elements of these pre-war buildings act as integrated systems to provide ventilation, heating and cooling, and natural daylight. As indicated by Van Citters (2010) and Carron (2010), many of these features have been lost or compromised in

[15] See *Maintaining Elements that are Efficient by Design (or What's Already Greed About Out Historic Buildings),*" DoD Legacy Resource Management Program, Project Number 09-456, July 2010 (Van Critters 2010); and Carroon Jean, *Sustainable Preservation: Greening Existing Buildings*, John Wiley & Sons, Inc., 2010 (Caroon 2010)..

[16] See U.S. Energy Information Agency, "2003 Commercial Buildings Energy Consumption Survey Detailed Tables (Table C3, found at: ftp://ftp.eia.doe.gov/consumption/cbecs2003_ce.pdf, accessed December 13, 2012.

[17] This study will refer to buildings without modern HVAC systems that were constructed prior to the mid-1940s as 'Pre-War Buildings."

[18] These specific bulleted items are taken from Van Critters (2010).

the course of repair, sustainment or modernization.

Looking forward, when DoD faces a choice to accommodate a new mission through building a new structure or modernizing an existing building, these two studies recommend, in effect, that military planners should include restoration, to the extent possible, of these original features for any project alternative that includes modernization of an existing building. This Study identifies and incorporates these features in the specification of treatments for existing buildings to demonstrate this principal.

Prior Research

There have been few studies that have investigated and compared the life-cycle emissions of new construction with reuse of existing buildings. One of the earliest studies that addressed the GHG emissions associated with both initial building construction or rehabilitation and operation was *Assessing the Energy Conservation Benefits of Historic Preservation: Methods and Examples*, prepared by Booz, Allen, & Hamilton, Inc. (BAH) and published in 1979 by Advisory Council on Historic Preservation (ACHP 1979). This pioneering work was prepared at a point in time when energy conservation policies were driven by the 1970s oil embargoes not climate change. The study set forth key concepts, such as embodied energy, demolition energy, and operational energy, still utilized today for the study and evaluation of GHG emissions related to construction projects. BAH used a case study approach to calculate the embodied energy of materials in historic buildings and compare that to the energy used to manufacture new building materials for a replacement building. The study found that the reuse of historic buildings offer energy savings benefits when comparing rehabilitation with new construction and that rehabilitated historic buildings can achieve the same energy efficiencies on an operational basis. The study presented a set of formulas for calculating embodied and operational energy consumption of buildings, anticipating the many carbon calculators available for use today. Jackson 2005 reports that this study led to the National Trust for Historic Preservation issuing in 1981 its often-cited *New Energy from Old Buildings*, a guide to improving the energy efficiency of historic buildings.

In 2008, the Building and Social Housing Foundation (BSHF) of the United Kingdom published the results of a study, *New Tricks with Old Bricks* (BSHF 2008), that compared 50-year life-cycle emissions of new residential construction with refurbishment of existing homes. The study evaluated six homes (three new and three existing) and found that over the 50-year period of analysis, there was no significant difference in terms of total CO_2 emission generated on a square meter of space basis (this normalized the results to account for varying home sizes). However, there was a significant savings in initial CO_2 emissions with existing homes compared to new homes due to the large difference of new building materials used. Offsetting the advantage in CO_2 emissions for existing homes was the reported savings in operating CO_2 emissions for new homes which resulted in new homes essentially “catching up” with existing homes with the passage of time. The researchers for this study used Bath University’s Inventory of Carbon and Energy to calculate embodied energy for building materials and the U.K.’s National Home Energy Rating assessment to estimate CO_2 for ongoing operation of the homes. The study excluded CO_2 emissions from demolition and transport of construction debris. While this study did report construction costs, it did not provide a life-cycle cost analysis in parallel with the CO_2 emission analysis. It was uncertain from the published study if the CO_2 measured in the study was CO_2e, e.g., including all GHGs and normalizing them into a CO_2 equivalent. The study also indicated as a limitation that it did not consider the effect on CO_2 emissions of changes in the future mix of energy sources.

The Athena Institute, in association with Morrison Hershfield, Ltd., published *A Life Cycle Assessment Study of Embodied Effects for Existing Historic Buildings,* a study for Parks Canada in 2009 (Athena 2009). This study was focused on four historic buildings. Similar to this Study, Athena 2009 sought to incorporate environmental considerations and data into the decision making process for new-versus-rehabilitation development decisions. The study used Athena’s EcoCalculator to estimate embodied CO_2 related to construction of new buildings at the same location as the existing buildings. To estimate ongoing CO_2 emissions from operations, Athena used the Canadian Building Inventive Program Screening Tool sponsored by the National Resource Canada’s Office of Energy Efficiency. The study found that after renovation, the existing and new buildings performed similarly with respect to ongoing energy consumption. Similar to BSHF 2008, Athena 2009 found a significant CO_2e savings with the reuse of existing buildings compared to new construction. A drawback to the study, however, was that is excluded the CO_2e impacts of building materials for rehabilitation of the existing historic buildings. Often significant interior demolition of prior improvements is required to rehabilitate an existing building, so these impacts could be significant. The study acknowledges the “high mass envelopes typical of historic buildings” but does not provide a detailed analysis of material and design characteristics that might boost energy performance of historic buildings.

The most recent similar study to be published was released in June 2010 by the Preservation Green Lab of the National Trust for Historic Preservation (NTHP), *The Greenest Building: Quantifying the Environmental Value of Building Reuse*. This study undertakes a life-cycle analysis approach over a 75-year period of analysis. The study evaluated the comparative environmental impacts of rehabilitation versus new construction on four major impact categories: (i) climate change; (ii) human health; (iii) ecosystem quality; and (iv) resource depletion. The key study findings were that building rehabilitation “*almost always yields fewer environmental impacts that new construction when comparing buildings of similar size and functionality*.” For a new building that is 30 percent more energy-efficient than a comparable existing building it would take from 10 to 80 years to overcome the initial GHG emissions associated with building materials for the new building. Six building typologies where analyzed, including residential uses.

Overall, what distinguishes this Study from the prior studies is its attempt to be comprehensive in nature by: (i) focusing on CO_2e impacts associated with building materials for both new construction and rehabilitation (e.g., “modernization”); (ii) explicit breakdown of GHG emissions into widely recognized Scope 1, 2, and 3 categories; (iii) applying a standard energy efficiency standard, e.g., ASHRAE 90.1 and 189.1 to the rehabilitation and new construction Project Alternatives; (iv) and testing the application of a monetary value to GHG emissions in traditional LCCAs to equalize the economic aspects of construction program decision-making.

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Introduction

In this section, the Study Team presents the methodology and approach to its demonstration of incorporating GHG into LCCA economic analyses and identifies some of the general issues encountered in undertaking this demonstration study.

Selection of Installations and Buildings

As part of the Demonstration Plan, the Study Team and DoD staff selected three installations to participate in the Study and undertook an initial round of identifying specific buildings for the Study.

Installation Selection Criteria

To arrive at the three selected installations the Study Team and DoD staff formulated and applied the following criteria:

- Installations with near term growth to support additional office space for operations, training, and general administration;
- Installations representing the Military Services with buildings that are similar in design and construction;
- Installations that represent three different climatic conditions that might impact overall energy consumption;
- Installations with large numbers of buildings that have been listed or are eligible for listing on the National Register of Historic Places or are in National Historic Landmarks; and
- Installations with large numbers of non-historic buildings that have been evaluated for historic significance which are fifty years old or older.

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Installations Participating in the Demonstration

As set forth in the Demonstration Plan, the three installations that were selected for this Study are:

- Navy - Naval Support Activity, Norfolk Naval Shipyard, St. Juliens Creek Annex, Chesapeake, VA (SJCA);
- Army - Fort Bliss, El Paso, TX (FTBL); and
- Air Force - F.E. Warren AFB, Cheyenne, WY (FEW).

These three facilities and sites were selected in coordination with the Office of the Deputy Under Secretary of Defense for Installations and Environment, specifically the historic preservation function of the Environmental Management Directorate (OADUSD [ESOH]) and the facilities management functions of the Installations Requirements and Management Directorate (OADUSD [I]).

These three installations represent each of the three Military Services, are located in three different geographic areas of varying climates, represent growing installations with large numbers of historic properties listed or eligible for listing on the National Register of Historic Places and/or have numerous non-historic properties age 50 years or more. The location of these installations is shown in Figure II-1. Table II-1 shows summary climate information and Table II-2 below presents in summary form key characteristics of the selected installations.

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Figure II-1
Location of Selected Military Installations

Table II-1
Summary Climate Information for Selected Installations

Climate Metric	St. Juliens Creek Annex Norfolk, VA	Fort Bliss El Paso, TX	F.E. Warren AFB Cheyenne, WY
ASHRAE 169-2006 Climate Zone	Number 4 Subtype A	Number 3 Subtype B	Number 6 Subtype B
Avg. January Temperature (degrees Farenheit)	41	44	27
Avg. July Temperature (degrees Farenheit)	79	83	69
Avg. Annual Precipitation (inches)	44.8	8.6	14.5
Avg. Annual Evening Relative Humidity	58%	26%	38%
Days Below 32 Degrees Farenheit	53	59	175
Days of Sun per Year	105	193	106

Table II-2
Summary Characteristics of Selected Installations

Facility/Site Selection Criteria	Norfolk Naval Shipyard; St. Juliens Creek Annex	Fort Bliss	F.E. Warren AFB
Military Service	Navy	Army	Air Force
Location	Chesapeake, VA	El Paso, TX	Cheyenne, WY
Near Term Growth	Operation readiness of US Atlantic Fleet	Joint Team training and mobilization	90th Missile Wing-Home of the Missileer
Common Building Type	Masonry &/concrete warehouses	Masonry administrative buildings & barracks	Masonry barracks & warehouses
Existing Total/Historic Building Inventory	114 in St. Juliens Creek Annex	800+ Buildings NRHP eligible	220 NHL Buildings
Mission Requirement	Administrative office space	Administrative office space	Administrative office space

Building Selection Criteria

The building selection criteria were based on observations and discussions with DoD personnel, mostly facilities and cultural resource managers across service lines, with experience documenting and repurposing existing DoD buildings, including Pre-War Buildings. One of these building selection discussions took place with OSD Facilities and Environmental and ESTCP personnel. The Study Team was advised to select from the largest number of "typed" DoD buildings and focus on one category which was represented in large numbers in all of the services and through the Real Estate Property Inventory was shown to be underutilized because of functional obsolescence.

The DoD uses a condition index code to depict the capability of existing facilities known as the Facility Physical Quality Code as defined in Enclosure 4 of DoD 4245.8-H (Value Engineering). Table III-3 presents standard definitions for the classifications:

Table II-3
DoD Facility Physical Quality Codes
Summary Descriptions

Q-1	Sum of all necessary restoration and modernization costs is not greater than 10 percent of the replacement value of the facility (PRV)
Q-2	Sum of all restoration and modernization costs that are greater than 10 percent but not greater than 20 percent of the replacement value
Q-3	Sum of all restoration and modernization costs that are greater than 20 percent but not greater than 40 percent of the replacement value
Q-4	Sum of all restoration and modernization costs that are greater than 40 percent of the replacement value

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The following additional criteria were applied to select buildings for analysis in this Study:

- Non-residential buildings;
- Buildings with a Facility Physical Quality Code of Q-2, Q-3, or Q-4;
- "Typed" DoD buildings with a high level of representation nationwide such as barracks, hangars, and warehouses;
- Building with cohesive technology (avoid buildings with a series of additions);
- Buildings that are identical or similar in construction; and
- Buildings that are constructed of anchored brick veneer, concrete, reinforced masonry bearing or steel frame encased masonry.

The Study Team targeted Q2 through Q4 buildings since they are in need of modest to major repair and modernization.

Building Condition Evaluation

As part of this demonstration, the Study Team convened onsite at each of the three selected installations. At each installation, the Study Team toured the installation and inspected the selected buildings. The Study Team identified physical building layouts, materials, and physical condition issues that would be a factor in preparing specifications for Project Alternatives. This process considered both the needs of the defined mission, requiring office space, as well as the characteristics of available historic/non-historic buildings, to result in the best possible compatibility between available buildings and their use as office space. The Project Team worked with installation staff to obtain the most current floor plans, operating costs, lists of repairs, prior modernization data, maintenance logs, and mission critical use for the building based on the Installation Master Plan. Individual energy usage data for the selected buildings were not available since buildings were not separately metered. In addition, the Study Team's cost estimator worked with the installation staff to identify knowledgeable private contractors in the area with project and construction experience at the installation to inform the cost estimation process.

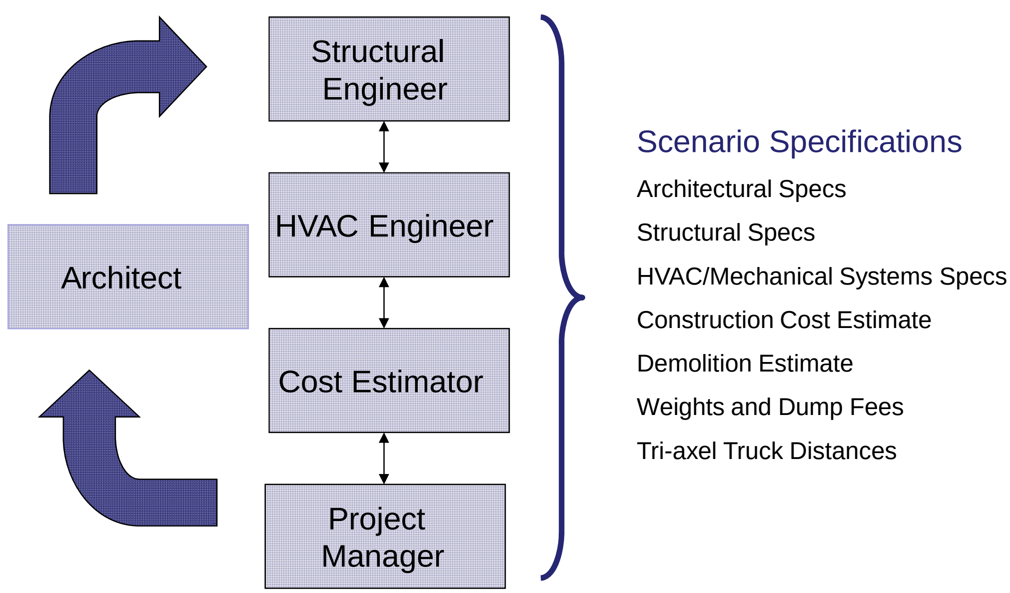
Specification of Project Alternatives

After installation and building selection, the Project Team formulated four Project Alternatives for the Study's LCCA. As described in Section I (Study Purpose, Background, and Performance Objectives), several project alternatives are typically formulated for a proposed construction project. These alternatives can sometimes include analysis of leasing space in the community or moving the mission operation to an alternative installation. This Study is limited to only Project Alternatives involving DoD's direct investment in new construction or modernization at one installation. The four Project Alternative formulated by the Study Team for this demonstration study are:

- 01-Sustainment/Status Quo;
- 02-Demolition and New Construction;
- 03-Modernization with HPS; and
- 04-Modernization with AT/FP.

Figure II-2 presents a general flow chart of the sequence of Study Team members in the Project Alternative specification process.

Figure II-2
Overview of Study Team Specification Process



DoD Building Treatment Definitions

The management of existing buildings owned by the DoD, is guided by a variety of treatment definitions and standards produced by the DoD. DoD has identified three treatments for physical work on existing buildings at military installations as part of its Facilities Criteria for the Sustainment, Restoration and Modernization Program (SRM Program). These three treatments- sustainment, restoration and modernization- define different approaches to the reuse of DoD property. The three treatments make no distinction between using these treatment for historic or non-historic properties.

Historic Building

An historic building for purposes of this Study is an historic property which is listed on or has been determined eligible for listing on the National Register of Historic Places.

Non-historic Building

For purposes of this Study, a non-historic building is one which has been constructed prior to World War II, and has been determined by the Department of Defense and National Park Service through application of the National Register criteria not to be eligible for listing on the National Register of Historic Places or, through alterations has lost its integrity and historic fabric causing it to no longer be eligible for listing on the National Register.

Sustainment

Sustainment means the recurring day to day periodic or scheduled work required to preserve real property in such condition that it may be used for its designated purpose.

Restoration

Restoration means the restoration of real property to such a condition that it may be used for its designated purpose. Restoration includes repair or replacement work to restore facilities damaged by inadequate sustainment, excessive age, natural disaster, fire, accident or other causes.

Modernization

Under DoD terminology, modernization means the alteration or replacement of facilities solely to implement new or higher standards to accommodate new functions or to replace a building component that typically lasts more than 50 years (such as the framework or foundation.).

01-Sustainment/Status Quo

The Study Team specified and evaluated Project Alternative 01-Sustainment/Status Quo primarily for the purpose of establishing an energy consumption benchmark against which the other three Project Alternatives could be compared for the purpose of determining LEED points for energy efficiency gains. In the Demonstration Plan, which was prepared prior to selection of the buildings, the Study Team indicated that it would estimate the energy efficiency of the existing structure prior to its demolition or modernization. However, four of the six buildings selected for the Study were used for uses other than office use (e.g., barracks, industrial shop, or warehouse), making sustainment improvements to maintain the existing use not meaningful for LCCA purposes when the ultimate mission use would be as office space. To simplify the analysis, the Study Team modeled the energy usage as if the existing building were office use with 1980s-era HVAC technology.[1] The Study Team does report LCCA cost figures for this Project Alternative but does not discuss them in the narrative.

02-Demolition and New Construction

Under this Project Alternative, the existing building is demolished and replaced by new construction in the same general footprint and total gross square feet. The demolition includes building improvements, foundation, and removing buried utilities. If an active local market for recycling existed, the Study Team included deconstruction and recycling of demolition debris and materials in its costs estimates but otherwise costs reflect demolition debris being transported to an offsite disposal site.

03-Modernization with HPS

For this Project Alternative, the Study Team applies a strict interpretation of the Secretary of Interior's Standards for Rehabilitation of Historic Properties or Historic Preservation Standards (HPS). This Project Alternative specifies building treatments to meet AT/FP and progressive collapse that are consistent with and not in conflict with HPS following the standards of the International Building Code, and ISC Security Design Criteria. For example, thick blast-proof windows are not specified under this Project Alternative even though that is a customary (but not mandatory) treatment in DoD modernization projects. Instead, AT/FP requirements are met by specifying window film for enhanced protection. Taking this approach allows one to compare the GHG and cost impacts of a modernization project with and without DoD's prescriptive and customary AT/FP and progressive collapse treatments. During periodic review sessions with DoD,

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[1] This is described in more detail in the discussion of the methodology for estimating energy consumption.

ESTCP reviewers expressed an interest in learning the additional costs associated with DoD's customary AT/FP and progressive collapse treatments (as appropriate to the selected building). This Project Alternative also generally involves a high degree of interior demolition (75 percent), in order to remove prior building renovation improvements and/or restore some of the original design intelligence of the building. For more information see the Methodology, Cost Estimation section of this Study).

04-Modernization with AT/FP

This Project Alternative relaxes the HPS standards and relies upon the prescriptive and customary DoD/USACE implementation of UFC as the basis for cost estimates, using documented structural retrofit approaches regularly used by installations. More description of this standard approach for AT/FP and progressive collapse is presented in Section II (Methodology) under the structural engineering methodology. A higher level of interior demolition (90 percent) is assumed to accommodate these standard treatments. As a result, the quantity of demolition and introduced new building materials is higher under this Project Alternative than under 03-Modernization with HPS but less than under 02-Demolition and New Construction. There is one except to the Study Team's approach to specifying Project Alternative 04. For Project Alternative FEW 323-04, the Study Team specified a modernization program that focused on maximizing the energy efficiency of the building as well as implementing customary AT/FP and progressive collapse structural approaches.

Standards Applied

Performance Objective #4 of the Demonstration Plan requires, through qualitative objectives, to show that a growing installation's mission critical needs can be met with an older (historic or non-historic) existing building. This objective requires full correspondence of the characteristics of the building and its use with the following Department of Defense United Facilities Criteria and other applicable standards:

- UFC 1-200-01 General Building Requirements;
- UFC 4-610-01 Administrative Facilities;
- UFC 1-900-01 Selection of Methods for the Reduction, Reuse and Recycling of Demolition Waste;
- UFC 3-310-04 Seismic Design for Buildings;

- UFC 4-010-01 Unified Facilities Criteria DoD Minimum Antiterrorism Standards for Buildings;
- UFC 3-400-01 Energy Conservation;
- Secretary of the Interior's Standards for the Treatment of Historic Properties; and
- 2009 LEED Silver for New Construction and Major Renovations[2].

Finally, the Study assumes that no special environmental studies for NEPA compliance will be required to implement the Project Alternatives other than to complete a NHPA Section 106 review and NEPA checklist. Further, no unique environmental conditions are assumed that would require extraordinary remediation costs beyond asbestos and lead-based paint abatement.

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[2] Use of 2009 LEED Silver was a specific requirement of DoD for this Study.

Parametric Cost Estimation at Project Planning Stage

For military construction projects at the early stages of planning and submitting funding requests, Military planners formulate parametric cost estimates that are incorporated into the project's economic analysis. Parametric cost estimation is a process of cost estimation that draws upon databases of historic costs for similar projects and like building system and components when detailed design information is limited or not available.[3] Using parametric estimating has the promise of increased efficiencies focused on speed and accuracy in producing estimates. This Study has adopted a parametric cost standard, replicating how Military Services typically would analyze the Project Alternatives at the early project planning phase.

The accuracy of parametric cost estimation model depends on the quality and homogeneity of data in the underlying cost estimation model database. For Military Planners analyzing potential adaptive reuse and modernization of existing buildings, the challenge is having the ability to work with a cost estimation model that can accommodate the many unique features and physical characteristics common to Pre-War Buildings. To estimate construction costs for the six selected buildings, the Study Team had to identify, develop, and input many special cost categories and units due to the buildings' various physical characteristics and condition. Historic and/or archaic construction systems meant developing unit costs for repairs or perhaps replacement of older components. Special considerations for installation of infrastructure required new data inputs for each new situation encountered. A few examples of unique cost items typically not found in most estimating systems include but are not limited to:

- Building new structural solid wood jambs to support masonry;
- Repair of existing doors;
- Custom manufacture of new wood flooring elements for repairs to existing flooring;
- Inserting new beams to replace damaged historic beams (such as top plates);

[3] Defense Acquisition University ("DAU") defines parametric cost estimation as follows: "[a] cost estimating methodology using statistical relationships between historic costs and other program variables such as system physical or performance characteristics, contractor output measures, or manpower loading." See DAU's ACQuipedia link: https://dap.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=36157b0b-69b4-4a0c-b16d-2e978b4c425c#, accessed December 27, 2012.

- Repair or restoration of windows;
- Energy retrofit of existing windows; and
- Repair and/or restoration of porch elements.

For an existing commercial or government-sponsored cost estimation system to be useful for modernization of existing buildings, the database would have to either have historic data related to these unique cost items, or be flexible to accommodate inputs for unique physical characteristics or system variables.

Cost Estimation Model Selection Criteria

Based upon foregoing, the Study Team established select criteria to guide our selection of a cost estimation model, as follows:

- Available, off-the-shelf estimation system and model;
- Accepted by the government for Federal agency use;
- Flexibility with customization potential;
- Ability to make preliminary budget estimates without fully detailed plans and specifications; and
- Intended for use for adaptive reuse and significant rehabilitation (or “modernization” in DoD’s nomenclature).

Survey of Existing Cost Estimation Models

The Study Team through its cost estimator, Preservation Associates, Inc., a firm specializing in cost estimation for projects involving historic properties, researched cost estimating programs pertaining to construction activities within the United States. The Study Team reviewed and evaluated for content and transparency over a dozen websites of the most promising cost estimating programs. The Study Team conducted in-depth reviews of the ten most promising programs, testing each program for versatility and accuracy and then selected four of the best systems for more detailed consideration for in this Study.[4] These four cost estimation systems were:

- CostWorks, a product of RSMeans, a division of Reed Construction Data, Inc.;
- Cost Link/AE, a product of Building Systems Design, Inc.;
- PACES, a product of AECOM, Inc.; and
- Success Estimator, a product of RIB US Cost, Inc.

RSMeans CostWorks, CostLink/AE, PACES, and US Cost Success Estimator are all available on a fee basis and all report that many Federal government agencies, including DoD, use their cost estimation systems and data. All four estimation systems are parametric cost estimation tools. CostLink/AE and US Cost Success Estimator both use the RSMeans cost database. PACES uses pre-engineered model parameters and construction criteria to accurately predict construction costs with limited design information. The PACES model had some emphasis on modernization projects, potentially an advantage for this program. Additionally, PACES incorporates area cost factors developed by the Tri-Service Cost Engineering Committee staffed by Military Service personnel.

However, even though some of these programs have been in use and development for nearly 15 years old, they still do not have enough information to account for the variables in a sensitive modernization-level program of construction to be performed on an existing building. These databases appear to be geared to smaller, remodeling level projects.[5] The Study Team determined that the Cost/Link/AE, PACES, and US Cost Success Estimator parametric modeling systems are not well advanced enough for use in the Study in which Project Alternatives include complete modernization projects.

A parametric estimating system requires a great deal of input into a database to achieve a high level of homogeneity to encompass all the special requirements associated with modernizing older existing buildings. For instance, a hypothetical set of existing wooden windows in an historic

[4] For more information pertaining to each of the top choices including a list of pros, cons and Study Team's decisions made to include or exclude certain of the top programs, see Appendix D.

[5] One of the potential findings of this study may be a recommendation to incorporate into a cost estimating program for use within DoD targeting all levels of work possible within an existing building population: full or partial modernization, or status quo sustainment. It should be noted that as of the date of this Study, AECOM is in the process of updating and restructuring its PACES system.

building needs to be brought up to an operational and energy efficient condition. Pricing existing, deteriorated historic windows for restoration and their energy retrofit usually entails a window by window survey effort. Using a hypothetical set of windows in any given building once meant that each window had to be surveyed for condition, each step in the restoration process identified and all steps bid. In a parametric model estimating system, groups of like costs are measured, averaged and arithmetically priced in an algorithm. However, to set up a parametric algorithm, a census of possible costs must be taken from 2 to 3 percent of the building population to be measured.

While parametric modeling may not be used in algorithm format during this cost estimating program effort, the basis for future study of parametric modeling can be achieved by incorporating some of the data derived from the six buildings selected for study under this program. Many other buildings would also need to be studied to increase the building cost data census within the DoD community as a basis for formulating a parametric algorithm. The older buildings and their component systems encountered in this Study were priced using the same or similar methods needed to set up a database for parametric model. Unfortunately, the six buildings selected for this Study would be too small a sample for establishing an accurate parametric model.

Selected Model: RSMeans CostWorks

After its research and evaluation, the Study Team selected RSMeans' CostWorks. The Study Team's cost estimator has had extensive experience with RSMeans cost estimating systems for projects involving modernization of existing buildings. RSMeans is a nationally recognized cost estimating database that enjoys wide recognition within the construction industry and is accepted for use by Military Services. RSMeans also indicated that the firm was undertaking a special project funded by DoD to build a useable modernization data based cost program for maintenance. RSMeans offers a high degree of transparency and flexibility and also appeared to be the most suitable for working with existing buildings as well as new construction. The RSMeans system allows for development of new, unique cost items not currently listed in the RSMeans database with the ability to store user-specific data. Based upon these considerations, the Study Team chose the RSMeans CostWorks data system as the program to be used for this Study. This choice was validated and accepted by the Director of Facility Energy and Utilities Privatization of the Office of the Deputy Under-Secretary of Defense (Installations and Environment) after discussions with the Study Team.

Cost Estimation Process

The Study's cost estimation process started with translation of architectural and engineering specifications into detailed cost categories. For the New Construction Project Alternative, the

Study Team prepared cost estimates primarily based upon assemblies (e.g., sets of building components) while for the Status Quo and two Modernization Project Alternatives, a mix of building assemblies and specific building components are used as inputs.

When the Study Team lacked RSMeans cost data for a specific building component, the Study Team conducted field research to establish the cost per unit of each unique item of work or material not provided for the cost estimation system. The Study Team identified similar construction recently completed within the installation and found, in many but not all cases, similar examples of recent costs for work performed. A second means of establishing costs was to locate general contractors who have recently successfully completed projects on the target bases who have estimating departments. In discussion with the lead estimators, the Study Team was able to obtain relevant cost data for certain missing components. A third means of establishing unique unit costs of labor and materials costs was to have the Study Team's cost estimator actually bid the work per his legacy experience with similar existing building construction situations.

Benchmarking Cost Estimates

During the onsite visit at each installation, the Study Team's cost estimator contacted the installation facility manager designated to interface with the Study Team identify similar projects that have been constructed on the base within the past five years. To the extent materials were available, the Study Team collected plans, specifications, and completed cost data for the recently completed base projects selected for establishing comparative cost data.

The installation facility manager provided the names and contact information for three or four general contractors who had recently completed projects on the base to obtain project cost experience data. It was important to locate general contractors who are familiar with construction costs at least pertaining to the base if not the surrounding region and who have been in the construction business for 10 years or more and still actively involved in the construction field. The general contractors were contacted and appointments made to discuss construction costs with their in-house cost estimators. The results of the interviews were utilized to make regional cost adjustment factors and measured against cost estimates generated using the RSMeans CostsWorks system.

Pricing of LEED Silver Building Features

The Study Team's cost estimates for the Project Alternatives include costs associated with meeting DoD's minimum LEED standard of Silver. While many of the items that generated points to reach the Silver LEED level do not have costs associated with them, such as site selection and regional priority, certain items, such as geothermal systems as a component of HVAC, do have cost impacts which are reflected in the cost estimates. The general conditions costs reported for each Project

Alternative include engagement of a LEED Accredited Professional on the planning and design team. The Study Team's cost estimates do not include the costs to apply for and obtain actual LEED certification.

Pricing of Anti-terrorism Force Protection Requirements

The Study Team's approach to estimating the costs of meeting ATFP requirements consisted of pricing specific building specifications, including but not limited to additional steel and concrete as well as fortified doors, thicker windows, and structural modifications to the doors and window frames. When additional quantities of steel and concrete were required, the Study Team simply estimated the additional quantity and applied the per-unit cost to that quantity. For doors and windows, the Study Team estimated a per-unit cost to that reflected the design specifications for the item and applied that per-unit cost for the quantity indicated. For exterior ATFP improvements, the Study Team estimated these costs (e.g., items such as bollards, reconfigured parking areas, and lighting) as two percent (2%) of total construction costs for each Project Alternative based upon the experience of the Study Team engineer and cost estimator.

Pricing of Services

At the earliest stages of project planning, before detailed designs are available, costs for electrical and plumbing services are typically expressed as a percent of total costs. The Study Team followed this protocol and identified typical range of electrical and plumbing costs. For electrical, the industry-accepted range is ten to fifteen percent (10% to 15%) and eight to twelve percent (8% to 12%) for plumbing. Based upon the its own collective project experience, the Study Team has assumed that the Project Alternative 02 Demolition and New Construction would be at the low end of these identified ranges since there would be no retrofitting of systems and that Project Alternative 03 Modernization with HPS would be at the high end of the range since greater labor effort is typically required to install replacement electrical and plumbing systems without compromising contributing features of the building (requiring fishing and chasing wires and pipe). For Project Alternative 04 Modernization with ATFP, which has a greater level of interior demolition and new materials, the Study Team assumed that electrical and plumbing system costs would fall in the middle of the indicated ranges.

Furniture and Fixtures

The Study did not estimate costs for equipment and furnishings since this would generally be a wash across the Project Alternatives.

Demolition and Remediation

Scope of Demolition. The Study Team prepared detailed demolition costs for three of the four Project Alternatives: 02 Demolition and New Construction, 03 Modernization with HPS, and 04

Modernization with ATFP. Project Alternative 02 was figured as a total demolition and site clearing of the entire building including footers and underground utility connections. For calculating the size and cost of new construction, the Study Team used one hundred percent of the gross square foot footprint multiplied by the number of floors. For Project Alternatives 03 and 04, the total square footage used for calculating the demolition costs depended on the existing condition of the six selected buildings and the treatment specified under each Project Alternative. However, for Project Alternatives 03 and 04, demolition costs were based upon the net square footage and the percent of interior improvements to be removed. The percent of interior demolition also depended on previous interior changes to the building under consideration (e.g., a building with substantial interior changes such as barracks Building 222 at FEW or one with few interior changes such as warehouse Building 61 at SUCA. Project Alternative 04 specified a greater level of removal of interior improvements than Project Alternative 03 to accommodate customary ATFP treatments.

Estimated Demolition and Remediation Costs

The Study Team formulated three related sets of demolition costs applicable to all Project Alternatives; demolition cost per square foot, lead based paint abatement per square foot and asbestos abatement per square foot:

- Building Interior Demolition: A very good per square foot cost for interior demolition at FEW was calculated as $10.69/net useable square foot. The number was derived from studying a small portion of a 2,000 square foot office rehabilitation done in Building 232 in 1998 and updated in 2007 at that installation. The Study Team’s project cost estimator was able to procure detailed plans for the office renovation of a small portion of the total size of adjacent barracks converted to offices at an earlier date. The original walls, internal structural members such as posts, floor framing and flooring as well as all original window and exterior door openings of the barrack were left in original condition. There was no structural work in that renovation. This prior renovation provided the opportunity to study a sizable portion of an office “inserted” into a standing structure and to undertake a detailed take-off of all the materials needed for the new office complex. The materials added to the original structure formed the new office, hall, bathroom and storage walls, insulation, ceilings, floor finishes, interior doors, trims, paints, and mechanical systems as it applied to that specific renovated space. Armed with a detailed and accurate list of the materials, sizes and components used for the renovation of the new office space, the project cost estimator was able to calculate the demolition costs for the entire space. The estimator then divided the total demolition figure by the square footage of the space demolished and arrived at a per square foot price of $9.71 per square foot for interior demolition. The original structural components were left in place and were not figured in the demolition cost figure. Ten percent (10%) was added to the raw demolition per square foot figure to allow for inflation, continuing cost increases in the short term and cost differences between the base locations of FEW, SJCA and FTBH. Hence, the final number used for a per-square-foot demolition cost at all three installations is $10.69 per square foot.

To double check its demolition cost number, the Study Team referred to the Reed Industries RSMeans 2010 Building Construction Cost Data manual and the 2010 Repair and Remodeling Manual by Means for comparison data. A square foot listing found for Selective Demolition, minimum interior demolition, was 0241 19.21 1000 as called for by the architect in his specification. The cost per square foot listed was set by RSMeans at $6.85 per square foot total. Add to that an upcharge of fifty percent (50%) for selective nature of the interior demolition called for by the architect and the cost per square foot came to $10.28 per square foot. The RSMeans and architect upcharge is within four percent (4%) of the actual cost calculated per square foot. The project cost estimator selected the higher cost per square foot to cover regional differences between locations and any costs missed in the calculation.

- Lead-based Paint Removal: The Study Team's demolition number did not include the costs to remove and dispose of any hazardous materials such as asbestos or for lead based paint abatement. The lead based paint abatement and disposal cost per square foot was taken from a pricing award sheet for the contract let to modernize Building 236 at FEW. A reliable number was taken from the Contract Award Pricing Schedule directly from the contract awarded for the renovation of Building 236 at FEW. Ten percent (10%) was added to cover for inflation, regional price variations between bases and for short term future cost increases. The per-square-foot cost was calculated as $7.98 per square foot with ten percent (10%) added equaling an eighty cent ($0.80) per square foot increase to the base number. The unit price cost for lead based paint abatement is $8.78 per square foot.

- Asbestos Abatement: The Study Team's demolition number did not include asbestos abatement. All costs for asbestos abatement and disposal for Building 222 were calculated, including costs for containerizing, loading, and hauling to the dump. The cost per square foot was averaged from actual asbestos abatement and removal costs per square foot for FEW modernizations of Buildings 220, 228, and 236. The averaged cost to abate the asbestos between the three building renovations was $11.49 per gross square foot. Ten percent (10%) was added to cover any short term price increases, regional cost variations between the three bases and inflation. The total per square foot to be used for all three bases is $12.64 per net useable square foot.

Structural Assessment

The buildings selected for this Study have experienced modifications, damage, foundation movement, aging, and exposure to moisture. The Study Team's evaluation was based on an approach intended to consider the original structural design, the condition of materials, the effects of age and past usage, hurricane and other damage, and the requirements for continued service. In assessing older existing structures, the Study Team's interpretation of the observations, available data, and analysis was necessarily based upon professional experience with similar projects and the judgment of the engineers on the Study Team.

Document Review

The Study Team reviewed the following documents, when available for each installation and the selected buildings:

- DoD Master Site Files and Site Inventory Forms;
- Original architectural and structural drawings; and
- Historical reports and photos.

Condition Assessment

The Study Team made on-site observations to visually assess the condition of the structures, identify the structural system types, and obtain field measurements of primary structural elements. In all cases, the Study Team had access to most areas of the buildings, either in the specific targeted building or in a similar building undergoing renovations at the time. The Study Team did not typically have an opportunity to assess hidden conditions, such as beam or joist ends in masonry. But generally, our assessment of each building type and condition was comprehensive.

Past Modifications

The Study Team noted significant past modifications that have affected the structural integrity of the buildings. For the most part, the original building walls and interior framing were still intact, but had undergone some past modifications. For example, at Building 323 at F.E. Warren, the most significant structural modifications have been the removal of the horse stalls, and the replacement of the bottom half of the interior timber columns with steel pipes. The original stalls probably provided most of the lateral resistance of the building, as the frame has no other transverse bracing. It is likely that the timber columns required repair due to decay, which led to the installation of the steel pipe columns, but this change left them somewhat weaker than the original timber columns.

Soils

Specific geotechnical information was not typically available for the building sites. The Study Team made use of historical soil surveys for the general vicinity from the United States Geological Survey reports. The Study Team also, in some cases, found good original documentation of the foundation types.

Load Capacity Evaluation

The Study Team analyzed the load capacity of the floor systems for the purpose of determining appropriate occupancies. The analysis was based on preliminary structural calculations using information obtained from the available documents, field observations, and our experience with similar construction. For allowable strength values, the Study Team used the notional material strengths from team members' previous experience with similar construction and historic data from various published sources, as well as the permitted strengths published in the 2006 International Existing Building Code.

Hazards Analysis

The Study Team also evaluated the buildings for the identified risk categories below:

Seismic

The Study Team performed a preliminary seismic evaluation in accordance with the provisions of the Handbook for the Seismic Evaluation of Buildings (ASCE 31). The Tier 1 evaluation identifies components of the building that may require strengthening pending further investigation and analysis.

DoD Anti-Terrorism and Force Protection

The Study Team analyzed each building for compliance with UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings. Under current policy, where any DoD building undergoes renovations, modifications, repairs, and restorations and the costs exceed 50-percent of the replacement cost of the building, implementation of UFC 4-010-01 standards to bring an entire building into compliance is mandatory. The 50-percent cost threshold is exclusive of the costs required to meet the ATFP standards. Where the 50-percent threshold is not met, compliance with these standards is recommended.

Wind, Hurricane and Flood

Wind analysis of the buildings was based on the ASCE 7-05 wind loads, assuming a regularly-shaped masonry building. Using building dimensions and site conditions, an average net shear force (pounds/foot and pounds/square inch) and average uplift was calculated, and compared against the general resistance of the building. The Study Team assessed the buildings for vulnerability to hurricane and flood hazard, in accordance with FEMA guidelines. Recommendations for rehabilitation are based on the FEMA 55 Coastal Construction Manual and the team members' experience with hurricane retrofit of existing structures.

Standoff Distance

For all of the buildings in the study, the Study Team concluded that operational controls are feasible. In some cases, greatly improved security conditions can be obtained through comprehensive site planning, rather than building-by-building ad hoc controls. Note that the UFC does not require a controlled perimeter around each building in order to establish control of parking areas and access roads (Webster et al ERDC/LAB TR-06-23).

Progressive Collapse

Regardless of standoff distance, where the building is three stories or more, the progressive collapse provisions of Standard 6 in the UFC must be applied. As such, the Study Team considered Progressive Collapse mitigation for F.E. Warren Building 222 and Ft. Bliss Building 1 because they have three-stories of occupied space. For Project Alternative 04, we assumed a major retrofit consistent with customary DoD practice which is based on more-or-less standard details used by the USACE. This retrofit concept involves a steel frame embedded in the historic masonry and application of the Tie-Force method (UFC 4-023-03).

The customary Tie-Force approach with embedded steel frame is difficult and expensive to implement in existing buildings. The UFC does allow for use of the Alternative Load Path and Enhanced Local Resistance options, which take advantage of the natural redundancy of load-bearing masonry, and have a much lower cost and are less intrusive than the Tie-Force method[6]. So for Project Alternative 03, we developed a retrofit approach that, in contrast, uses the Alternative Path and Enhanced Local Resistance options[7]. We used the ISC for alternative window upgrades, by allowing film for an improvement in blast performance.

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[6] UFC 4-023-03 Commentary.

[7] Applied to the perimeter corner and penultimate columns and load-bearing walls of the first story above grade

Energy Consumption Estimation

After initial construction or modernization, GHG emissions are generated by energy consumed during ongoing building operations, including lighting, heating, and cooling. In order to estimate these emissions, the Study Team's mechanical engineering consultant determined the thermal insulation values (known as R- and U- values) of the door, window, roofing, sheathing, and exterior wall materials specified in each Project Alternative based on industry standards and professional judgment. These values were then input into Trane's Trace 700 Building Energy and Economic Analysis Software Version 6.2 using the TETD-TA1[8] methodology for cooling load and the UTAD[9] method for heating load.

The Study Team selected the Trane Trace 700 Building Energy and Economic Analysis Software since it is widely used in industry and is approved by the U.S. Green Building Council for LEED energy modeling. This software accounts for the climate region, size, and orientation of each building to generate site-specific outputs. Finally, the mechanical engineer inputted the HVAC system type as specified for each alternative in order to generate an annual energy consumption total for each Project Alternative. It should be noted that analysis of building energy consumption at FTBL and SJCA does not include natural gas used to power building water-heaters, as water heating demands are not materially affected by a building's composition and were thus not included in this Study's analysis. This study parameter also resulted in low Scope 1 emissions estimates, if any, because water heating is not the primary or only source of on-site fuel combustion in most buildings. The Study Team had made such estimates for FEW and determined that the impact of Scope 1 was negligible and required a high level of effort to specify for parametric LCCA purposes and was dropped from the analysis of Project Alternatives at FTBL and SJCA.

For the one new construction and two modernization Project Alternatives, the HVAC system selected was a ground source heat pump (GSHP) geothermal system. Unlike traditional geothermal energy, which relies on geologic convection of heat from the Earth's core to certain locations on the Earth's surface to produce electricity, contemporary GSHP Geothermal HVAC systems can be used in nearly any location. For the system selected by the Study Team, a loop of refrigerant is continually cycled through a system of copper tubing underground and up to the HVAC system's heat pump above ground. The Study Team assumed that vertical bores, between 200 to 400 feet, would be used for the geothermal loop field and heat transfer water would be

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[8] Transfer Function Method for heat gain calculations and Time Averaging Method for room load calculations.
[9] U-Factor by Area by Temperature Difference and instantaneous room load calculations.

pumped through high density polyethylene piping to transfer heat to and from the ground as required for heating and cooling. Because the Earth's surface maintains more stable temperature throughout the year relative to the air temperature, this system uses the ground temperature to absorb excess heat from the refrigerant loop in warmer months and to provide additional heat to the loop in cooler months.

These systems require substantially less energy to provide heating and cooling services than a conventional above-ground system and have been used at many DoD installations, including F.E. Warren. In Project Alternative 01 Sustainment – Status Quo, an energy consumption total was estimated using the same software and methodology, but assuming a conventional 1980's era HVAC system in each building using the insulation values of existing materials. This system type was chosen by the Study Team to reflect the older HVAC systems present in most existing DoD office buildings with a Q2 through Q4 Facilities Quality Code.

The energy savings reported in the Study for calculating LEED points to reach the Silver Standard under 2009 LEED for New Construction and Major Renovations were then calculated as the difference between this hypothetical consumption baseline and the estimated consumption for each non-sustainment Project Alternative. All Project Alternatives yielded a substantial energy savings from the status quo due to the superior energy efficiency of GSHP HVAC systems compared to conventional systems, while Project Alternatives that called for the preservation of historic exterior wall materials yielded even greater savings.[10]

This approach (comparing the difference between the hypothetical consumption baseline Project Alternative 01 Sustainment- Status Quo and estimated consumption for the new construction and modernization Project Alternatives) achieved a fine-grained, site specific output that was appropriate for the analysis in this Study. However, the approach also presented drawbacks. First, the software used is proprietary and a cost would be incurred to use it. Second, the mechanical engineer had to specify thermal zones within each building alternative to produce accurate results. This can be a challenge when planning projects at a conceptual level since it is not always known what the ultimate interior layout will be. The Study Team had to make generic assumptions regarding interior zones in order to utilize the tool effectively. Finally, the use of a GSHP geothermal system requires very precise sizing and installation in order to function efficiently, meaning that the0 estimates generated based on this technology are more vulnerable to being compromised in construction than a conventional system.

[10] See discussion of Scope 2 GHG emissions for each of the six selected buildings for more information.

GHG Emission Estimation

Overall Approach

The Study Team has treated the embodied energy in the selected existing historic and non-historic buildings at the three installations as "sunk" energy expenditures. Sunk energy expenditures refer to energy that was used in the past to produce materials, transport them, and construct existing buildings from which energy cannot be recovered. Following the economic concept of sunk costs, the Study Team only quantified the prospective energy expenditures associated with each treatment formulated in the Project Alternatives. Hence, the Study Team did not attempt to calculate the embodied energy contained in the six selected existing structures. The Study Team's fundamental approach is to identify, specify, and quantify the new energy expenditures over the life-cycle of the six buildings over the 30-year period of analysis. Prospective, new expenditures of energy will be triggered by the construction or modernization of the buildings under each Project Alternative. With respect to Scope 1 and 2 emissions, the approach of the Study is to measure the reduction from a baseline and identify any differences in Scope 1 and 2 emissions among the new construction and modernization Project Alternatives.

Greenhouse Gas Protocol

The Project Team has calculated GHG emissions by Scope 1, Scope 2, and Scope 3 emissions following the Greenhouse Gas (GHG) Protocol formulated by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). The GHG Protocol is widely utilized, serving as the foundation for nearly every GHG standard and program undertaken by both business and government.[11] The three scope levels are defined as follows for this Study:

- Scope 1: all direct GHG emissions (i.e., emissions by or for the building from sources that the base owns or controls);

- Scope 2: indirect GHG emissions from purchased energy (primarily electricity) to service the building; and

- Scope 3: Other indirect emissions not included in Scope 2, including emissions related to

[11] For more information regarding the Greenhouse Gas Protocol, see: http://www.ghgprotocol.org/standards, accessed December 13, 2012. Note that the International Organization for Standardization (ISO) adopted the GHG Protocol, Corporate Standard as the basis for its ISO 14064-I: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals.

the supply chain for purchased materials, construction, demolition and debris removal and transportation of building components.[12]

GHG Calculators

As of the date of this Study there is not currently a single widely-accepted, publicly-available GHG calculator that can provide estimates of Scope 1, 2, and 3 GHG emissions. One requirement of this Study was that any data source be available free to the general public. Available calculators with widely-accepted protocols and methodologies typically focus on one aspect of GHG accounting and do not take into account the life cycle impacts of a building: design, construction, use, maintenance, and end-of-life phases. Some calculators focus on GHG emissions generated from building operations while others calculate the embedded emissions contained within building materials. Therefore, to calculate the life cycle emissions from the six selected buildings, the Study Team designed an interface that allowed the use of a mix of existing data sources to make GHG emission estimates on a life cycle basis by Scope 1, 2, and 3. At the outset of the Study, the Study Team had identified several GHG data sources that could be utilized as shown in Table II-4. During the course of the Study Team's work, it was necessary to change the mix of data sources for the Scope 3 calculations.

It was known at the outset of the Study that multiple data sources would have to be utilized to cover all components under the Project Alternatives to ensure that GHG emissions are captured fully. Only one GHG data source was used per type of assembly or material and detailed reporting of which data source was used for which component is provided in Appendix B of the Study for one of the Project Alternatives. The Project Team endeavored to make the application of GHG data sources transparent for the purposes of verifying accuracy of the estimates and avoiding inadvertent omissions or double counting of GHG emissions. GHG emissions have been calculated and reported by scope (e.g., Scope 1, 2, and 3) in the LCCA summary and supporting detailed spreadsheets.

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[12] Note that Scope 3 emissions are broader than we present here and can also include emissions from, say, the operation of military aircraft, vessels, and other equipment.

Table II-4
Identification and Actual Use of GHG Calculators By Scope of GHG

	Carbon Calculator Sources	
Scope of GHG Emissions	Demonstration Plan	Actual Use
Scope 1: Direct energy onsite	WRI GHG Protocol	WRI GHG Protocol, Emission Factors from Cross-Sector Tools, Version 1.3
Scope 2: Purchased energy not controlled onsite	WRI GHG Protocal	EPA eGRID2012 Version 1.0 Year 2009 GHG Annual Output Emission Rates
Scope 3: New building materials	Building for Environmental and Economic Sustainability (BEES)	Not used
	Athena Institute, EcoCalculator	F.E. Warren: Athena EcoCalculator for Assemblies, Version 3.5.2 US Average, ASHRAE Climate Zone 6, Low-rise Structures (up to 4 stories); for St. Julien's and Fort Bliss: Version 3.71 US Average, ASHRAE Climate Zone 3, Low-rise Structures (up to 4 stories)
	Carnegie Mellon University's Economic Input-Output Life Cycle Assessment Model (EIO-LCA)	EIO-LCA: Economic Input-Output Life Cycle Assessment (EIO-LCA), US 2002 Purchaser Price Model
Scope 3: Transportation for demolition and waste disposal	WRI GHG Protocol	WRI GHG Protocol Mobile Combustion GHG Emissions Calculation Tool, Version 2.3

Sources: Center for Resource Solutions; BAE, 2012.

Having gone through the demonstration process, the overall conclusion of the Project Team is that without an integrated GHG calculator (whether one model or multiple related models), the process of estimating GHG emissions by Scope 1, 2, and 3 for MILCON projects will be challenging to perform in a cost-effective manner since the process would involve multiple steps, knowledge of multiple calculators and data sources, and considerable care in cross-walking cost estimate data with carbon calculator categories. A more detailed discussion of these issues follows for each of the three GHG emission scopes.

Detailed Approach to Scopes 1, 2, and 3 GHG Estimation

For all GHG emission calculations, the Study Team has expressed results in kilograms and metric tons of carbon dioxide equivalent (CO_2e), a common unit for different GHGs.[13]

Scope 1

Based upon its estimate of building energy usage, the Study Team estimated Scope 1 emissions by utilizing the World Resources Institute, GHG Protocol, Emission Factors from Cross-Sector Tools, Version 1.3 (Aug 2012).[14] The Study Team's Scope 1 analysis included only the six primary GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) and used the follow equivalencies:

- 1 Therm = 100,000 British thermal units ("BTU");
- 1 Standard cubic foot ("SCF") natural gas = 1.02 kBTU;
- 1 Metric ton = 2,204.62 pounds; and
- 1 Terajoule ("TJ") = 947,816.98 kBtu.

Scope 2

Following the WRI GHG Protocol and using estimates of building energy usage for the Project Alternatives, the Study Team estimated Scope 2 emissions in the first year in the analysis period by utilizing the U.S. Environmental Protection Agency (EPA)'s Emissions & Generation Resource Integrated Database ("eGRID"). eGRID is a database providing information regarding the environmental characteristics of electrical power generated in the United States. Data reported include air emissions rates; net generation; resource mix; and other attributes.[15] The estimates are calculated using the emissions data provided for the eGRID subregion in which each installation is located. Different regions of the country have a cleaner or dirtier mix for their electrical grid. Hence, for eGRID regions with a high emissions factor, Scope 2 savings can be very important. The eGRID database is the best available data source for subregional average emission rates/emissions factors for electricity generation and use of these emissions factors in Scope 2 GHG calculations is considered standard practice. It is consistent with WRI guidance and WRI calculation tools also utilize eGRID emissions factors for U.S. Scope 2 calculations.[16]

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[13] Note that one metric ton is equivalent to one tonne or one short ton (it does not equal a long ton).
[14] This is available online: http://www.ghgprotocol.org/calculation-tools/all-tools
[15] See: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf
[16] See "Indirect CO2 Emissions from the Consumption of Purchased Electricity, Heat, and/or Steam, Guide to

The Study Team used the average emissions factor for the applicable eGRID subregion for each installation. Local electric service providers, such as the Western Area Power Administration for F.E. Warren, were contacted for a utility specific emissions factor, but the Study Team was told that they have not yet calculated emission factors. Hence, actual utility emissions factors may be higher or lower than what the Study Team has estimated. For example, considering that WAPA's fuel mix is nearly all hydropower, its emissions factor may be significantly lower than the eGRID regional average used for F.E. Warren.[17]

Since the Study's period of analysis is thirty years, the Study Team had to make projections of Scope 2 emissions factors over time to reflect the expectation that the mix of emissions would change. To make these estimates, the Study Team first obtained forecasted changes in national emissions for electricity from U.S. Energy Information Agency (EIA) and then applied that trend to the eGRID subregion for each installation.[18]

Overall, the Study Team's Scope 2 calculations assumed that the data provided is for electricity consumption for the building, as opposed to district-wide or base-wide meter data. Metered energy usage data at the building level were not available, although the Study Team notes that DoD is implementing a building metering program across the Military Services to better control its energy usage. Although some of the bases have on-site renewable energy, such as wind at F.E. Warren, it covers a small portion of the base's electric load and cannot be all attributed to one building and it is unclear in some cases whether they keep associated renewal energy certificates (RECs) since these are typically owned and operated by private third parties under a long-term lease agreement with the Military Service owner.

Scope 3

In its Demonstration Plan, the Study Team indicated that it would use the Athena Institute's EcoCalculator for as many items as possible and use the BEES and EIO-LCA calculators for any remaining construction materials that were not included in EcoCalculator, as shown in Table II-3.[19]

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calculation worksheets (January 2007) v 1.2, A WRI/WBCSD GHG Protocol Initiative calculation tool:" http://www.ghgprotocol.org/files/ghgp/tools/ElectricityHeatSteamPurchase_guidance1.2.pdf

[17] What this means is that Scope 2 emissions may be overstated across all Scenarios for F.E. Warren and as a consequence, the impact of Scope 3 emissions on the LCCA analysis would be less than if Scope 2 emissions reflected an energy mix dominated by hydroelectric power with a lower level of emissions over the 30-year study period.

[18] EIA data sources can be found at http://www.eia.gov/analysis/projection-data.cfm#annualproj and http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf

[19] There is an inherent problem with mixing carbon calculators since the two calculators do not give the same estimate for any given material since each calculator uses different algorithms to estimate GHG emissions. The

For the first installation, F.E. Warren, the Study Team used Athena's EcoCalculator for Assemblies, Version 3.5.2 US Average, ASHRAE Climate Zone 6, Low-rise Structures (up to 4 stories). For St. Juliens and Fort Bliss, the Study Team used the same Athena calculator but Version 3.71, ASHRAE Climate Zone 3, Low-rise Structures (up to 4 stories). It should be noted that St. Juliens was not located within the exact footprint of the publically available Athena calculator but was very close to Climate Zone 3 and so Climate Zone 3 was used for both St. Juliens and Fort Bliss. For filling specific Project Alternative components not included in the Athena calculator, the Study Team used Carnegie Mellon University's EIO-LCA: Economic Input-Output Life Cycle Assessment (EIO-LCA), US 2002 Purchaser Price model. The WRI GHG Protocol Mobile Combustion GHG Emissions Calculation Tool, Version 2.3 was used for Scope 3 demolition and transport of waste.[20] Cost estimates for each project alternative were used as inputs.

The Study Team started its estimation work following the layout of the Athena calculator. Athena's publically available calculator is an excellent tool for new buildings, particularly since it is quantity-based instead of cost-based. However, it is more challenging to use Athena when dealing with rehabilitating existing structures, mainly because one is often replacing a portion of a given material. For example, for roofs, Athena includes many components within one line/calculation, but the user/planner may want to only replace one of the components in Athena's line item. As the project progressed, more items were identified that needed to be calculated using the EIO-LCA calculator tool.

When EIO-LCA calculations were made, the Study Team used the closest sector available for each material and the estimated cost in dollars was the model input. The 2002 version of the EIO-LCA Purchaser model was the latest model available, the Study Team formulated an adjustment factor to account for inflation between 2002 and 2012. When material cost data was available and given, we used the material data as the input to EIO-LCA. Based upon the cost estimator's experience with historic and older, non-historic buildings, the Study Team assumed 25 percent material cost for existing buildings and 33 percent material cost for new buildings to reflect an anticipated higher labor cost associated with Pre-War Buildings if material cost data were not available or given. This particular assumption may introduce a bias into the analysis when construction specifications are similar for new construction and the two modernization Project Alternatives since a greater proportion of the cost of a building component, such as HVAC system, is allocated to materials that generate GHG emissions or when construction cost components are calculated as percents to total costs as is often done for electrical and plumbing systems. At the

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Study Team applied the same calculator to the same Project Alternative components at each installation to ensure that the effect would be a wash across the Project Alternatives. Formulation of a new carbon calculator to resolve these issues was beyond the scope of this Study.

[20] The Study Team assumed a heavy duty vehicle articulated diesel from "Year 1960 to present" category in the calculation tool.

early project planning stage that is typical for completing economic analysis of proposed MILCON projects, project design is at a very basic level and electrical and plumbing specification detail is not always provided. More work needs to be done to investigate this potential bias and pursuing it further was beyond the scope of this Study. This issue can be avoided by using quantity based inputs, rather than price-based inputs, in Scope 3 calculator tools.

The Study Team encountered inconsistent building material category definitions between RS Means and the carbon calculators. RS Means is a common tool used by estimators and, for the reasons presented earlier in this Study, the Study utilized RS Means for estimating, status quo, new construction and modernization costs for the Project Alternatives. However, none of the existing carbon calculators have input categories defined to match RS Means. There are many categories that are not available in the versions of the Athena EcoCalculator that we used. Based upon its experience, the Study Team recommends that developers and sponsors of carbon calculators formulate and provide tools that are organized in categories similar to RS Means or other prevalent cost estimation software packages.

It should be noted that the carbon results (see Appendix B for a representative analysis) for the Project Alternatives are from existing calculators and the spreadsheet used by the Study Team is not meant to serve as a replacement for the Athena EcoCalculator or EIO-LCA calculators. The Study Team recommends that either a new, free carbon calculator is developed and/or the DoD considers using available calculators that are provided on a fee basis.

Finally, the Study Team notes that a number of factors were not included in the Scope 3 analysis, including but not limited to:

- Construction equipment other than trucks used for demolition materials;[21]
- Transit access;
- Covered parking;
- Water consumption;
- Neighborhood development impacts; and
- Traffic flow impacts.

[21] Costs for non-truck construction equipment are included in the cost estimates but not Scope 3 GHG emission estimates due to the parametric level of analysis.

The omission of these items is appropriate since either they do not apply due to (i) the generally small scale of the Project Alternatives as measured by square feet; (ii) location at a closed military installation; or (iii) the item would constitute a wash (e.g., no material difference) across the Project Alternatives for any of the six buildings analyzed in the Study.

Carbon Pricing

To incorporate the monetary value of GHG emissions into the LCCA, the Study Team had to formulate a value assumption and approach to pricing over time. In the Demonstration Plan, the Study Team proposed using data drawn from trading of Carbon Financial Instruments from the Chicago Climate Exchange ("CCX")[22] or other sources to be identified during the Study. The Study Team conducted a review of carbon pricing sources and projections for carbon pricing, and investigated the source material for the projections. Based on a review of fifteen available public studies, the Study Team determined that the EPA Analysis of the American Power Act ("EPA Analysis") was the best available study since many of the other studies referenced the EPA data as source material.[23]

The EPA analysis modeled the multi-sector cap-and-trade program, the alternative compliance program for the transportation fuels and refined petroleum products sectors, the competitiveness provisions, and many of the energy efficiency provisions of the proposed but un-adopted American Power Act. It also includes a lengthy comparison to the modeled impacts for legislation proposed in 2009.[24] The EPA Analysis set forth several scenarios that were utilized by the Study Team for low, medium, and high pricing assumptions.[25] Projections for the medium and high cases were given in 5-year increments, and we interpolated between these numbers to give a year-by-year projection. This Study used EPA's medium price scenario in its LCCA. Interpolated prices were applied to the corresponding CO_2e estimate on an annual basis. More detailed information regarding the assumptions for the Study's carbon pricing may be found in Appendix C.

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[22] Although there is not currently a U.S.-wide compliance market for carbon, there was an existing, established national voluntary market and regional compliance markets in the U.S. The CCX market closed in 2010.

[23] See Source: www.epa.gov/climatechange/economics/economicanalyses.html, accessed December 26, 2012.

[24] The legislation was the American Clean Energy and Security Act of 2009, an energy bill in the 111th United States Congress (H.R. 2454) that would have established an emissions trading plan similar to one operated by the European Union. The House of Representatives approved the bill June 26, 2009 but the legislation was defeated in the Senate.

[25] The low scenario is based upon the IGEM model Scenario 4 in the EPA Analysis. The medium scenario is based upon the Core Policy Case (ADAGE model Scenario 2 in the EPA Analysis. The high scenario is based upon the EPS's ADAGE model Scenario 7.

Life Cycle Cost Estimation

Definition of Life Cycle Cost Analysis (LCCA) and Standards Applied

LCCA is an analytic tool that takes into account all costs related to the planning, design, construction, operation, and disposal of a building or building system over the course of its useful life.[26] As formulated in this Study, LCCA is essentially the same as a total ownership cost (TOC) analysis. LCCA is an appropriate tool when a project has a performance requirement that can be met through different project alternatives with varying initial investment and operating costs. A LCCA is part of the economics analysis (EA) required for MILCON projects. To prepare its LCCA, the Study Team adopted the standards set forth in the USACE's Manual for Preparation of Economic Analysis for Military Construction.[27]

Inputs to LCCA

For each Project Alternative, the Study Team prepared a LCCA analysis that followed the ACOE standard but included reporting of GHG emissions by Scope and incorporated the monetary value of GHG into the LCCA initial and ongoing cost estimates. Key inputs and assumptions included:

- 30-year study period, excluding project lead time;
- Current dollar analysis, all in 2012 dollars (e.g., no CPI escalations);
- Real 30-year discount rate from OMB Circular 94-A, Appendix C;
- 55-year building life for new construction and modernization Project Alternatives;[28]

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[26] This definition is consistent with the Whole Building Design Guide; see http://www.wbdg.org/resources/lcca.php for further information. Note that the LCCA tool can be applied to many types of projects, not just construction of facilities.

[27] Smigel, Donna, lead MILCON Economist, Headquarters US Army Corps of Engineers, Manual for Preparation of Economic Analysis for Military Construction (And Base Realignment and Closure (BRAC)), January 4, 2010.

[28] To simplify the analysis, the Study Team assumed that the overall durability of new construction and modernized Pre-War Buildings would be the same. Evaluating the durability of new building materials introduced compared to existing materials in historic and non-historic Pre-War Buildings was beyond the scope of this Study but merits further research.

- One-time Expenses associated with each Project Alternative as prepared per the Construction Cost Estimation:

    - Sustainment costs for 01: Sustainment/Status Quo
    - Construction costs for 02 Demolition and New Construction
    - Construction costs for 03 Modernization with HPS and 04 Modernization with AF/TP
    - Demolition and debris transportation costs

- Recurring Expenses:

    - Maintenance and repairs
    - Utilities
    - Grounds and parking
    - Cleaning services
    - Maintenance and operations personnel

- Residual Value, based on straight-line depreciation of building investment over a 55-year life of building for new construction and modernization; 15 to 20 years for improvements made under Project Alternative 01 Sustainment – Status Quo;

- Scope 1, 2, and 3 GHG emissions, calculated per GHG Emission Estimation; and

- Initial and Future Carbon Credit Price, per GHG Emission Estimation.

Building Maintenance and Other Operating Expenses

For building operating costs other than utilities, the Study Team used building operating expense data from the Building Owners Managers Association International's Experience Exchange Report database (BOMA EER).[29] BOMA EER reports actual operating costs for office buildings for most metropolitan areas in the United States. Data is supplied by BOMA EER members, including owners and managers of office buildings occupied by government agencies. BOMA EER is prepared annually and the Study Team used 2012 BOMA EER Report data for this Study. The Study Team adjusted the 2012 BOMA EER data, which is actually based upon 2011 BOMA EER participant submittals to account for inflation. These adjustments were made on a regional basis using the US All Consumers Consumer Price Index.

[29] For further information, see: https://www.bomaeer.com/Boma/main_landing.aspx, accessed December 28, 2012.

BOMA ERR's online interface permits the user to select metropolitan areas and apply a number of screens, including size, number of stories, and age of structure. In formulating selection criteria, the Study Team had to balance narrowing BOMA ERR selection criteria to most reflect the characteristics of the selected DoD buildings and proposed treatments under the Project Alternatives with applying a similar selection criteria across all three installations and yielding at least five reporting buildings which is a data confidentiality requirement of BOMA.

The Study applied a size cap of 50,000 square feet per reporting building for FTBL and SJCA and a 100,000 square feet cap for FEW. In the case of FEW, an insufficient number of buildings were reported for Cheyenne, WY so Denver, CO had to be added to expand the pool of reporting buildings to meet the five-building minimum. The Study Team applied an age screen to pull reporting buildings less than 30-years old to reflect the new construction and modernization treatments in the Project Alternatives. In both new construction and modernization, treatments included new building systems, such as HVAC, electrical, and plumbing, that drive maintenance costs. HVAC is a particular major repair and maintenance cost component. Hence, the overall maintenance profile for the new construction and modernization Project Alternatives will be closer to a pool of buildings constructed more recently than for an older stock of buildings.

In the end, the Study Team used BOMA ERR data for six buildings (totaling 248,000 square feet; average of 41,333 square feet per reporting building) in the Norfolk/Virginia Beach, VA metropolitan area for SJCA; eleven (11) buildings (totaling 258,000 square feet; average of 23,500 square feet per reporting building) in the El Paso TX/Las Cruces, NM metropolitan area for FTBL; and fifteen (15) buildings (totaling 735,800 square feet; average of 49,000 square feet per reporting building) for FEW from the Denver CO and Cheyenne WY combined metropolitan areas. This represented the best data available to estimate building operating costs. By using these standardized ERR data, the Study Team effectively assumed that the maintenance cost profile between new construction and modernization Project Alternatives would be equivalent.[30]

Utility Expense

Water and sewer utility costs were taken from the BOMA EER sample for each installation. Electrical costs did not use BOMA EER dataset. Instead, the Study Team applied the average per KWh rate charged by the local electric power provider to the installation to the total KWh consumed annually by the building as estimated for the GHG Scope 2 analysis. The Study Team shows the effective electric utility rate per square foot in the full LCCA analyses presented in Appendix F.

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[30] The Study Team contacted a knowledgeable official at the National Park Service, Golden Gate National Recreation Area who has facilitated numerous high dollar value modernization projects with both historic and non-historic structures to confirm the reasonableness of this assumption.

Model Outputs

Based upon these assumptions and inputs, the Study calculated for each Project Alternative:

- Net Present Value of all costs to be incurred over the 30-year period of analysis with and without GHG emission monetary values;

- Total GHG emissions generated by Scope over the 30-year period of analysis expressed in total CO_2e metric tons, CO_2e kilograms, and CO_2e per square foot.

The LCCA involved running 24 different LCCAs, four for each of the six buildings. The full analyses are provided in Appendix F.

SECTION III:
PROJECT ALTERNATIVE ANALYSES

Ft Bliss | El Paso, TX

Installation Description

Fort Bliss is a 1.1 million acre United States Army installation located adjacent to the city of El Paso, TX with land holdings in both Texas and New Mexico. (See Figure III-1). The base is currently home to the Army's 1st Armored Division, 32nd Army Air and Missile Defense Command, and the El Paso Intelligence Center. The base has grown from 10,000 to some 34,000 soldiers since 2005 due to BRAC realignment and contains approximately 20.7 million gross square feet of non-housing permanent building space. This total is projected to grow to roughly 31,000,000 GSF by 2016.[1]

Environment and Energy Sources

Fort Bliss' location is in the arid southwest, where monthly temperatures range from an average low of 33 degrees Fahrenheit (0.5 C) in January to an average high of 96 degrees (35.5 C) in July. Average annual precipitation at the site is less than nine inches and annual evening relative humidity averages at 26 percent. In fiscal year 2010, Fort Bliss purchased and consumed 312,582 MWh of electricity and this total is expected to increase to up to 500,000 MWh by 2015. The electricity provider serving Fort Bliss is El Paso Electric, an investor-owned utility serving approximately 380,000 retail and wholesale customers over a 10,000 square mile service area in both Texas and New Mexico. El Paso Electric owns three natural gas power stations in Texas featuring steam-electric and combined-cycle units for a combined capacity of 569 MW and two wind turbines with a capacity of roughly 1.5 MW. The electricity provider also owns a 15 percent interest (or 633 MW) in the Palo Verde nuclear plant in Arizona and a seven percent interest (or 108 MW) in the Four Corners coal plant in New Mexico. Thus, roughly half of the fuel mix providing electricity to Fort Bliss is comprised of nuclear generation, with another 45 percent coming from natural gas, and eight percent and less than one percent from coal and wind power, respectively. Fort Bliss purchased and consumed 900,824 MMBtu of natural gas in fiscal year 2010, the equivalent of roughly 264,000 MWh for comparison. Fort Bliss purchases its natural gas from Texas Gas Service, a large natural gas distributor serving some 600,000 customers statewide. In 2011, Fort Bliss was designated a Pilot Integrated Net Zero Installation. This means that the installation has adopted a target of net zero energy by 2015.[2]

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[1] Fort Bliss Garrison, Directorate of Public works. Fort Bliss, TX – Fact Sheet. August 8, 2011.

[2] Even though the installation is designated as a Pilot Integrated Net Zero Installation, the Study Team did not specify the Project Alternatives to achieve net zero in order to allow comparisons across installations.

Figure III-1
Location of Fort Bliss
El Paso, Texas

Historic Significance

Fort Bliss was originally established as an infantry post in the 1850s following the Mexican-American War and played a key role in the US involvement in the Mexican Revolution in the early 20th century, when US troops engaged Pancho Villa's cross-border raiders in 1916 and again in 1919. During World War I, Fort Bliss served as a major training site for US troops and became home to the 1st Cavalry Division after the war. During this time, dozens of stout masonry buildings were constructed. Most remain at Fort Bliss and are listed on or eligible for the National Register of Historic Places. The base remained an important training facility throughout US involvement in World War II and the Cold War and continues to serve as an important missile defense and intelligence installation.

In consultation with installation managers, the Study Team selected Building 1 and Building 115 for study. (See Figures 2 and 3.) Building 1 was constructed in 1904 as the base hospital and is one of six buildings that are part of the Fort Bliss Main Post Historic District built during the Interim Period (1900-1912). Building 115 was constructed in 1915 and is one of fifty buildings constructed during the First Expansion Period (1913-1917), which is part of the Fort Bliss Main Post Historic District. It is one of the buildings constructed at the time when Fort Bliss transitioned from serving as an infantry post into a cavalry installation. Building 115 is an example of Army standardized plans for common building types such as barracks, quarters, hospitals, storehouses, offices and guardhouses. Standardized plans began to be used at Fort Bliss in 1910 and Building 115 is an example of a standardized plan for Enlisted Men's Barracks CQM-341 represented by Buildings 11, 12, and 112-118 at Fort Bliss. This standardized plan has hundreds of examples nationwide at DoD installations. The installation's Master Plan identified a need to use these structures as office space.

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Figure III-2
Photos of Building 1
Fort Bliss, El Paso TX

Building 1- Typical Entry

Building 1 - Exterior

Building 1- Typical Window

Building 1 – Site Context

Figure III-3
Photos of Building 115
Fort Bliss, El Paso TX

Building 115 – Front on Pershing Road

Building 115 – Site Context

Building 115 – Window & Eave

Building 115 – Basement Entry

Fort Bliss Building 1 Analysis

Existing Conditions

Building Description. Fort Bliss Building 1 (FTBL 001) is a three-story (two stories with partial basement) cross-plan building constructed in 1904 as the base hospital. It occupies a footprint of 15,256 square feet and contains a total of 22,842 gross square feet). Floor-to-ceiling heights are 9 feet for the basement, 11 feet on the ground floor, and 12 feet 8 inches on the second floor. The building was constructed in a simplified Colonial Revival style with a limestone and stucco foundation, brick masonry walls, and side gable and hipped roofs and a gabled center section flanked by wings with hip-roofs. Three chimneys project above the steeply pitched roofline and double-hung wood sash windows contain two-over-two lights and screens. Both wings contain exterior concrete steps with pipe railings and exterior fire stairs, which were added later for egress from the second floor. The building includes an original projecting one-story center porch. The lower floor of the building was rehabilitated in the 1950s and again in 2008. The second floor was rehabilitated in the 1990s. The building is currently used for administrative office use.

Historic Significance. This building, originally constructed as the base hospital and then converted into administrative space in 1911, is a historic property and contributes to the historic and architectural significance of the fort as one of six buildings constructed during the Interim Period of 1900-1912 of the Fort Bliss Historic District, which is listed on the National Register of Historic Places. The primary exterior character-defining features are the shape and mass of the building including the brick walls, front projecting porch, historic windows and doors, central stair, masonry chimneys, and roof form and roof vents. Historic character-defining interior finishes that have survived past renovations include wood trim and plaster walls and a narrow floor plan.

Original Design Intelligence. The historic design of the building includes a variety of original design intelligence features that promote efficient energy usage in the building. These features include:

- Solid historic brick walls that provide a higher thermal value than contemporary brick;
- Plaster walls with horsehair or pig hair for increased insulation;
- Building orientation perpendicular to summer winds and operable main floor windows provide for natural cross ventilation;
- Building orientation and windows located high on the roof to enhance amount and quality of natural light year-round;
- Roof and attic openings provide for added ventilation;
- Masonry chimneys and open staircase provide a stack effect which allows hot summer air to escape;
- Deep front porch provides natural shading;
- Basement provides cool airflow through convection currents;
- Narrow floor plan/externally loaded;

- Tall, wide windows that provide solar lighting;
- Sloped interior ceiling facilitates interior solar lighting; and
- Open floor plan on second level permits air circulation.

Not all these features have continued functioning as designed due to prior renovations. For example, the staircase from the basement is no longer open to provide convection currents to higher floors, the ventilators on the roof are no longer functioning. These features, properly maintained and integrated into any future rehabilitation or modernization projects in the building, can help meet occupant comfort expectations while contributing to energy efficiency.

Project Alternatives

For each Fort Bliss Building 1 Project Alternative (FTBL 001-01 through FTBL 001-04), the Study Team estimated construction cost and construction-related (scope 3) GHG emissions as well as Scope 2 emissions for ongoing building operations. These estimated outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative cost and environmental performance of each alternative over a 30-year period with a standard two percent discount rate. Table III-1 summarizes the key assumptions and construction costs for each Project Alternative at Fort Bliss Building 1.

Table III-1
Summary of Fort Bliss Project Alternatives – Building 1

Project Alternative	Building GSF		Building Features		Construction Cost	
	Total	Footprint	LEED	AT/FP	Total	Per SF
FTBL 001-01: Sustainment-Status Quo	22,842	15,256	n/a	No	$ 1,413,053	$ 62
FTBL 001-02: Demolition and New Construction	22,842	15,256	52	Yes	$ 8,707,799	$ 381
FTBL 001-03: Modernization with HPS	22,842	15,256	58	Yes	$ 7,030,562	$ 308
FTBL 001-04: Modernization with AT/FP	22,842	15,256	58	Yes+	$ 7,639,083	$ 334

Note:
+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

FTBL 001-01: Sustainment – Status Quo

The Sustainment-Status Quo alternative is not a true construction alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building in the absence of a full modernization over the period of analysis. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this Project Alternative.

In order to establish an energy performance baseline for Fort Bliss Building 1 that is consistent with other buildings evaluated in this Study, the Project Team assumed a hypothetical 1980s-era

HVAC system with no substantial overhauls and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 8,493,404 kBtu of energy consumption, all of it accounted for by electricity consumption (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project Alternatives FTBL 001-02, FTBL 001-03, and FTBL 001-04 for the purposes of calculating LEED points for energy efficiency gains.

FTBL 001-02: DEMOLITION AND NEW CONSTRUCTION

This Project Alternative includes the full demolition of the existing structure, and the removal of the foundation and extant utility, drainage, and other system hookups and replacement with a modern one-story office building with a basement matching the extant footprint of approximately 15,300 square feet. The demolition cost estimate for this Project Alternative is $733,500 and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site work estimate category.

Construction Costs. The new building will also be constructed on a raised foundation to accommodate the site flood line. The building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shell, and building sitework to increase standoff distance from the building exterior. The estimated total construction cost for this Project Alternative is $8,708,000, or $381 per square foot. As shown in Table III-2, the largest single cost category for this alternative is the services installation cost of $2,110,000, accounting for roughly 24 percent of total cost. This cost includes installation of new HVAC, plumbing, electrical, fire suppression, communications, and security systems as well as the installation of two passenger elevators. The shell cost of $1,971,000 accounts for roughly 23 percent of total cost and includes the construction of concrete masonry unit walls with reinforced steel and a brick veneer cladding as well as the costs of installing AT/FP compliant windows and steel exterior doors.

LEED Points Calculation. The new building will be designed to attain a LEED score of 52 points, achieving a LEED Silver level of performance. As shown in Table III-3, the bulk of these points are earned in the Energy and Atmosphere category due to the 32 percent reduction in energy consumption from the status quo baseline and the use of a geothermal ground source heat pump HVAC system (see Table III-4 below). The next most significant category is the Indoor Environmental Quality category, where points were earned for providing enhanced air and light in the building's interior space to reduce energy consumption.

FTBL 001-03: FULL MODERNIZATION WITH HPS

This Project Alternative includes the full modernization of the existing structure for office space within a strict interpretation of the Secretary of the Interior's Standards for the Rehabilitation of Historic Properties or Historic Preservation Standards (HPS). These standards call for the preservation of the building's interior and exterior character-defining historic features, which include but are not limited to the original brick masonry walls, and chimneys, window arrangement and orientation to maximize natural light and moderate solar gain, and remaining historic wood trim and plaster. The two-story historic brick masonry shell and core structural features, including chimneys, stairways, and intermediate floors will be retained, while all non-historic interior finishes dating from past partial renovations will be gutted. Historic windows will be retained and rehabilitated as much as possible and any non-salvageable historic windows will be replaced with windows matching the historic dimensions and composition. Blast performance for the windows will be enhanced by using a film. Customary DoD AT/FP and progressive collapse treatments will not be included in this modernization Project Alternative, as certain customary AT/FP treatments, including blast-proof windows and doors and steel-reinforced concrete walls, are not compatible with the historic preservation standards for preserving exterior and interior character-defining features. Instead, alternative load path and enhanced local resistance improvements are specified as permitted under the UFC.

Construction Costs The total construction cost of this preservation-focused modernization is estimated at $7,031,000, or $308 per square foot. As shown in Table III-2 suppression, communications, and security systems are virtually identical to those installed in the new construction Project Alternative. Roughly 17 percent of total cost is made up of work on the building's shell including rehabilitation and selective replacement of historic window and door units, selective repairs to the historic brick walls both the interior and exterior and replacement of selected fenestration elements. Gutting and selective demolition costs in this Project Alternative total just over $467,600 and include asbestos and lead-based paint abatement costs.

LEED Points Calculation The modernized historic building would meet a LEED Silver standard with an estimated score of 58 points, as shown in summary Table III-3. These points include most of those earned by the new construction Project Alternative as well as additional points for reuse of existing structural and non-structural building elements and for the historic building's somewhat higher energy performance, due primarily to the higher thermal insulation value of the historic brick shell.

FTBL 001-04: FULL MODERNIZATION WITH AT/FP

In contrast, Project Alternative FTBL001-04 specifies a full modernization of Building 1, but without strict adherence to HPS standards and application of customary DoD treatments for AT/FP and progressive collapse. While the historic shell and core structural elements will all be maintained, as in Project Alternative FTBL 001-03, this Project Alternative will not prioritize the preservation of interior and exterior character-defining historic features over other priorities, including AT/FP and contemporary standards for occupant comfort. For instance, all historic windows and exterior doors will be replaced with AT/FP blast resistant windows and steel doors in the same locations as in the existing building. Walls will also be reinforced with steel beams for further strengthening, as historic brick does not protect against a direct blast. The remaining interior finishes will be more liberally gutted than in FTBL 001-03 and replaced with modern finishes, though some key character-defining elements will be preserved.

Construction Costs These AT/FP and other additional modernization features are estimated to total to a construction cost of $7,639,000, or $334 per square foot. As in the other Project Alternatives, Table III-2 shows services installation costs make up the largest share of total cost, owing to the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in the historic building. Shell costs make up approximately 19 percent of the total due to the high cost of installing all new AT/FP compliant windows and doors and other upgrades to the existing shell. Gutting and selective demolition costs total an estimated $623,000 and include all asbestos and lead-based paint abatement costs.

LEED Points Calculation This modernization Project Alternative FTBL 001-04 will achieve the same green building performance as the modernization with HPS in FTBL 001-03, attaining a LEED Silver standard with 58 points. As shown in Table III-3 the bulk of these points are derived primarily from the modernized building's superior energy performance relative to status quo baseline that is a result of the specification of a geothermal ground source heat pump HVAC system as well as to the reuse of extant structural and non-structural elements.

FTBL 001: ALTERNATIVES COMPARISON

Project Alternative FTBL 001-02 has the highest estimated construction cost of any construction alternative for Fort Bliss Building 1, while alternatives FTBL 001-03 and FTBL 001-04 are estimated to cost roughly 19 and 12 percent less (Table III-2). The most substantial drivers for the cost difference between the new construction and both modernization alternatives are the demolition, substructure, shell and site work costs, as Project Alternative FTBL 001-02 called for demolition of the entire building and replacement of the building, building pad, and related site elements. Services installation and interiors costs are comparable across three alternatives, as substantial interior gutting and full replacement of core building services systems were included in both of the modernization scenarios. The principal drivers for the difference in estimated construction cost between the two modernization Project Alternatives come in the demolition, shell, and interiors costs. These costs were higher for Project Alternative FTBL 001-04 due to the less stringent preservation of interior character-defining features and the more costly installation of AT/FP compliant windows, doors, and steel reinforced walls. Both modernization Project Alternatives do show slightly higher costs in both interiors and services work than the new construction alternative, owing to the added cost of installation in an existing brick building.

However, the overall cost increase in the new construction alternative in the building's demolition, shell, and substructure costs are more than sufficient to make either modernization Project Alternative more economical in the construction phase.

Energy Consumption

As shown in Table III-4, the two modernization Project Alternatives, FTBL 001-03 and FTBL 001-04, slightly outperform the new construction Project Alternative FTBL 001-02, in terms of ongoing energy consumption. While all three Project Alternatives were treated with identical ground-source heat pump geothermal HVAC systems, Table III-4 shows that both modernization Project Alternatives will consume slightly less energy each year (measured in kBtu) than the new construction Project Alternative. Compared to the baseline energy consumption scenario represented by the FTBL 001-01 Sustainment/Status Quo Project Alternative, all three new construction and modernization Project Alternatives are estimated to achieve a 32 to 33 percent reduction in energy consumption.

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Table III-2
Summary of Construction Costs
FTBL 001: All Project Alternatives

Category	Cost Estimate 01. Sustainment - Status Quo	02. Demolition and New Construction	03. Modernization with HPS	04. Modernization with AT/FP
Demolition	$ -	$ 733,457	$ 467,586	$ 623,448
Substructure	$ 25,200	$ 611,156	$ 96,075	$ 96,075
Shell	$ 468,688	$ 1,970,836	$ 1,198,916	$ 1,434,634
Interiors	$ 289,724	$ 555,379	$ 558,420	$ 592,859
Services	$ 219,443	$ 2,109,824	$ 2,241,489	$ 2,238,235
Sitework	$ -	$ 643,075	$ 328,375	$ 320,428
Special Construction	$ -	$ 18,666	$ 18,666	$ 29,391
Hard Cost Subtotal	$ 1,003,055	$ 6,087,014	$ 4,909,527	$ 5,335,070
General conditions (25%)	$ 250,764	$ 1,545,306	$ 1,246,996	$ 1,355,570
Security escalation (2%)	$ -	$ 94,210	$ 82,197	$ 87,656
USACE design (7%)	$ 87,767	$ 540,857	$ 436,449	$ 474,450
USACE SOIH (5.7%)	$ 71,468	$ 440,412	$ 355,394	$ 386,337
Soft Cost Subtotal	$ 409,999	$ 2,620,785	$ 2,121,035	$ 2,304,013
Construction Cost Total	$1,413,053	$ 8,707,799	$ 7,030,562	$ 7,639,083
Construction Cost PSF	$62	$ 381	$ 308	$ 334
% Difference from FTBL 0 2	-84%	N/A	-19%	-12%

Sources: Preservation Associates; BAE Urban Economics Inc. 2012.

Table III-3
Summary of LEED Points Calculation
FTBL 001: All Project Alternatives

Category	02 Demo and New Construction	03 Modernization with HPS	04 Modernization with ATFP	Maximum Points
Sustainable Sites	11	11	11	26
Water Efficiency	2	2	2	10
Energy and Atmosphere	19	21	21	35
Materials and Resources	4	9	9	14
Indoor Environmental Quality	14	13	13	15
Innovation and Design Process	1	1	1	6
Regional Priority Credits	1	1	1	4
Total	52	58	58	110
Certification Level	Silver	Silver	Silver	NA

Sources: Center for Resource Solutions; Comfort Design; BAE Urban Economics, 2012.

Table III-4
Summary of Energy Consumption, Building Operations
FTBL 001: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Primary heating	429	4,823	850	2,924
Primary cooling	1,401,085	920,778	876,520	918,676
Auxiliary	1,008,974	956,937	944,635	958,687
Lighting	4,866,333	2,676,483	2,676,483	2,676,483
Receptacle	1,216,583	1,216,583	1,216,583	1,216,583
Cogeneration	0	0	0	0
Total kBtu/yr [1]	8,493,404	5,775,604	5,715,071	5,773,353
Energy Savings from Baseline [2]	N/A	32.00%	32.71%	32.03%

Notes:
[1]All energy consumption reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.
[2]Scenario FTBL: 001-01 serves as the baseline building performance rating for energy consumption

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions Estimates

Table III-5 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for Fort Bliss Building 1. Overall, Project Alternative FTBL 001-02 would generate almost 48 percent more GHG emissions than the modernization Project Alternative FTBL 001-03 and almost 40 percent more than under Project Alternative FTBL 001-04. The total GHG emissions saved with the two modernization Project Alternatives over the new construction alternative was between approximately 626,000 and 754,000 CO_2e Kilograms. On a per square-foot basis, new construction would generate approximately 69 Kg CO_2e per square foot compared to 36 Kg CO_2e per square foot for FTBL 001-03 and 42 Kg CO_2e per square foot for FTBL 001-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative FTBL 001-02 due to the requirement to install an entirely new substructure. In the two modernization Project Alternatives, FTBL 001-03 and FTBL 001-4, only light treatments were required to reuse the existing substructure. Similarly, GHG emissions for construction of a new building shell are higher for Project Alternative FTBL 001-02 since it introduces the most new building materials. Interior GHG emissions are higher in Project Alternatives FTBL 001-03 and FTBL 001-04 than for FTBL 001-02 due to the way that paint is treated in the GHG calculators as opposed to materials for new construction that include paint. Services GHG emissions are higher in FTBL 001-02 than for the two modernization Project Alternatives due to a requirement of having a HVAC system that has a slightly larger tonnage than in the other two modernization Project Alternatives. The total GHG emissions saved with the two modernization Project Alternatives was between approximately 626,000 and 754,000 CO_2e kilograms.

Table III-5
Summary of Scope 3 GHG Emissions
FTBL 001: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demo and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Substructure	3.2	210.1	5.8	3.2
Shell	81.6	719.4	307.2	432.6
Interiors	33.9	107.1	135.2	140.9
Services	83.4	410.0	346.9	346.9
Equipment & Furnishings	-	-	-	-
Special Construction	-	1.9	1.9	1.9
Building Sitework	0.1	136.2	33.8	33.3
Collateral Equipment	-	-	-	-
Total MT CO2e	202.2	1,584.7	830.9	958.9
Total Kg CO2e [1]	202,160	1,584,749	830,938	958,853
Kg CO2e per SF	8.86	69.43	36.41	42.01
% change from 02	-87.2%	N/A	-47.6%	-39.5%

Notes:
[1] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-6 presents GHG emission estimates for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 was not calculated since the use of natural gas for heating water is considered a “wash” across the alternatives and would also be immaterial compared to Scope 2 and Scope 3 emissions. Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction and transportation of debris. Scope 2 emissions are similar across the new construction and modernization Project Alternatives since in all three of these Project Alternatives new efficient HVAC systems are installed. Looking over the entire 30-year period of analysis, the total GHG emissions generated by the modernization Project Alternatives range from 6.3 to 8.5 percent less than total emissions generated by the new construction Project Alternative.

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Table III-6
Summary of GHG Emissions Scope 1, 2, & 3
FTBL 001: All Project Alternatives

Emissions Scope [1]	01: Sustainment-Status Quo	02: Demo and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Scope 1	-	-	-	-
Scope 2	12,301.2	8,364.9	8,277.3	8,361.7
Scope 3	202.2	1,584.7	830.9	958.9
Total MT CO2e	12,503.3	9,949.7	9,108.2	9,320.5
Total Kg CO2e [2]	12,503,343	9,949,676	9,108,230	9,320,547
Kg CO2e per SF	547	436	399	408
% change from 02	25.7%	N/A	-8.5%	-6.3%

Notes:

[1] Represents cumulative scope emissions over 30 year life cycle.
[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full LCCA for FTBL 001 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full LCCA is presented in Appendix F. Tables III-7 and III-8 provide a summary of these LCCA across the Project Alternatives.

As shown in Table III-7, FTBL 001-03 shows the lowest net present value (NPV) among the three scenarios. New construction and full modernization with AT/FP each have a total NPV of approximately $8.0 million without consideration of the value of GHG emissions and $8.3 million with GHG emissions of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction was 13.7 percent higher at $9.3 million without GHG factored into the NPV and $9.6 million with monetized GHG emissions included. Project Alternative FTBL 001-04 registered a NPV of approximately $8.5 million without monetized GHG and $8.8 million with GHG, approximately 5.7 percent higher than FTBL 001-03. The average CO_2 value per metric ton in 2012 dollars was $37.36. The key driver of these results is the lower initial capital investment associated with the Project Alternative; the operating cost profile for building under the new construction and both modernization Project Alternatives varies only slightly due to differences in energy consumption.

In Table III-8, breaks out the contribution of monetizing GHG emissions to the NPVs reported in Table III-7. Overall the NPV of monetized GHG raises the total project NPVs by approximately three percent across Project Alternatives FTBL 001-02 through FTBL 001-04. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization Project Alternatives, the NPV of the GHG component is approximately 12.2 percent less for Project Alternative FTBL 001-03, and 8.2 percent less for Project Alternative FTBL 001-04.

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Table III-7: Life Cycle Cost Analysis Summary: FTBL 001

Project Alternative	Non Discounted Costs by Component: Initial Investment	Recurring	Residual Value	Total Costs: Non Discounted	Discounted - No GHG Factor	Discounted - w/GHG
FTBL 001-01: Sustainment-Status Quo	$ 1,413,053	$ 4,412,233	$ -	$ 5,825,286	$ 4,633,189	$ 4,957,645
FTBL 001-02: Demolition and New Construction	$ 8,707,799	$ 3,934,495	$ (3,769,689)	$ 8,872,605	$ 9,314,907	$ 9,592,548
FTBL 001-03: Modernization with HPS	$ 7,030,562	$ 3,923,858	$ (3,102,498)	$ 7,851,923	$ 8,038,442	$ 8,282,166
FTBL 001-04: Modernization with AT/FP	$ 7,639,083	$ 3,934,102	$ (3,316,482)	$ 8,256,703	$ 8,522,780	$ 8,777,667

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.36
Base Date:	10/01/12

Sources: Preservation Associates; BAE Urban Economics, 2012.

Table III-8: Greenhouse Gas Valuation Summary: FTBL 001

Project Alternative	GHG Emissions by Scope (MT CO2e): Scope 1	Scope 2	Scope 3	Total	GHG Value: Non Discounted	Discounted
FTBL 001-01: Sustainment-Status Quo	-	12,301.18	202.16	12,503.34	$ 467,078	$ 324,456
FTBL 001-02: Demolition and New Construction	-	8,364.93	1,584.75	9,949.68	$ 371,050	$ 277,641
FTBL 001-03: Modernization with HPS	-	8,277.29	830.94	9,108.23	$ 339,946	$ 243,725
FTBL 001-04: Modernization with AT/FP	-	8,361.69	958.85	9,320.55	$ 347,822	$ 254,887

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.36
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Fort Bliss Building 115 Analysis

Existing Conditions

Building Description. Building 115 is a two-story (with partial basement) rectangular structure with a footprint of approximately 5,700 square feet and 9,351 gross square feet that was constructed as enlisted men's barracks in 1915. Floor-to-ceiling heights are 9 feet in the basement and 11 feet on the ground floor and second floor. The building was constructed with a poured-concrete foundation, brick walls, and a brick belt course above the second floor windows and is covered with a medium double-pitched hipped roof. An open, two-story full-width porch is located on the west side of the building and included under the building's hipped roof. Double-hung wood sash windows with six-over-six lights and screens are used throughout the building. The lower floor of the building was rehabilitated in the 1950s and the second floor in the 1990s, and it is currently used for administrative office space.

Historic Significance. This building was constructed as cavalry barracks during the Army expansion of Fort Bliss in response to the border raids by Pancho Villa from Mexico beginning in 1911. It contributes to the significance of the Fort Bliss Historic District as an example of enlisted men's barracks based on a standardized Army quartermaster plan and is one of fifty buildings built during the First Expansion Period of 1913-1917. The primary exterior character-defining historic features are the shape and mass of the building, historic fired red brick exterior walls, and roof form. Historic character-defining interior features that have survived past renovations include wood trim, ceiling heights, historic doors, transoms, windows and plaster walls, non-mechanical vents, and a narrow floor plan.

Original Design Intelligence. The historic design of the building includes a variety of original design intelligence features that promote thermal comfort in the building. These features include:

- Solid historic brick walls that provide higher thermal value than contemporary brick
- Plaster walls with horsehair or pig hair for increased insulation
- Building orientation perpendicular to summer winds and operable windows provide for natural cross ventilation and quality of natural light year-round
- Deep two-story porch on west side and wide over-hanging eaves throughout provide natural shading
- Non-mechanical vents in foundation and roof ventilators provide cool airflow through convection currents
- Transoms which bounce light from the exterior to the interior of the building

These features can be found still intact in the building and should be maintained and integrated into any future rehabilitation or modernization project in the building since they can help meet occupant comfort expectations while contributing to energy efficiency.

Project Alternatives

The Study Team estimated construction cost and construction-related Scope 3 GHG emissions as well as Scope 2 emissions for ongoing building operations for the four Project Alternatives. These estimated outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative costs and environmental performance of each Project Alternative over a 30-year period at a two percent real discount rate. Table III-9 summarizes the key assumptions and construction costs for each Project Alternative at Fort Bliss Building 115.

Table III-9
Summary of Fort Bliss Project Alternatives – Building 115

	Building GSF		Building Features		Construction Cost	
Project Alternative	Total	Footprint	LEED	AT/FP	Total	Per SF
FTBL 115-01: Sustainment-Status Quo	9,351	5,700	n/a	No	$ 613,479	$ 66
FTBL 115-02: Demolition and New Construction	9,351	5,700	52	Yes	$5,166,222	$ 552
FTBL 115-03: Modernization with HPS	9,351	5,700	54	Yes	$3,625,554	$ 388
FTBL 115-04: Modernization with AT/FP	9,351	5,700	54	Yes+	$3,905,689	$ 418

Note:
+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

FTBL 115-01: SUSTAINMENT – STATUS QUO

The Sustainment-Status Quo Project Alternative is not a true construction alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this Project Alternative.

In order to establish an energy performance baseline for Fort Bliss Building 115 that is consistent with other buildings evaluated in this Study, the Project Team assumed a hypothetical 1980s-era HVAC system with no substantial overhauls and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 2,845,283 kBtu of energy consumption, all of it accounted for by electricity consumption (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project Alternatives FTBL 115-02, FTBL 115-03, and FTBL 115-04 for the purposes of calculating LEED points.

FTBL 0115-02: DEMOLITION AND NEW CONSTRUCTION

This construction Project Alternative includes full demolition of the existing structure, and demolition of the foundation and extant utility, drainage, and other system hookups and replacement with a modern two-story office building with a basement matching the extant building envelope of approximately 9,400 square feet. The demolition cost estimate for this Project Alternative is $300,000 and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site work estimate category.

Construction Costs. The new building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shells, and building site work to increase standoff distance from the building exterior. The estimated total construction cost for this Project Alternative is $5,166,000, or $552 per square foot. As shown in Table III-10, the largest single cost category for this Project Alternative is the shell cost of $1,346,000, which accounts for approximately 26 percent of total cost and includes the construction of concrete masonry unit walls with reinforced steel and a brick veneer cladding as well as the cost of installing AT/FP compliant windows and steel exterior doors. The services installation cost of $1,172,000 accounts for slightly less than 23 percent of total cost and includes installation of new HVAC, plumbing, electrical, fire suppression, communications, and security systems as well as the installation of one passenger elevator.

LEED Points Calculation. The new building will be designed to attain a LEED score of 52 points, achieving a LEED Silver level. As shown in Table III-12, the bulk of these points are earned in the Energy and Atmosphere category due to the 43 percent reduction in energy consumption from the status quo baseline and the use of a geothermal ground source heat pump HVAC system for over seven percent of the building's total energy consumption. The next most significant category is the Indoor Environmental Quality category, where points were earned for providing enhanced air and light in the building's interior space to reduce energy consumption. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FTBL 115-03: FULL MODERNIZATION WITH HPS

This Project Alternative includes the full modernization of the existing structure for office space within a strict interpretation of the Secretary of the Interior's Standards for the Rehabilitation for Historic Properties or historic preservation standards (HPS). These standards call for the preservation of the building's interior and exterior character-defining historic features, which include the original brick masonry walls, windows, window arrangement and orientation to maximize natural light and moderate solar gain and remaining historic wood trim and plaster. The two-story historic brick masonry shell and core structural features, stairways and intermediate floors will all be retained, while all non-historic interior finishes dating from past partial renovations will be removed. Historic windows will be retained and rehabilitated as much as possible and any non-salvageable historic windows will be replaced with windows matching the historic dimensions and composition. Blast performance of the windows will be enhanced by using a film. As with FTBL: 001, customary DoD AT/FP and progressive collapse treatments will not be included in this modernization Project Alternative, as certain customary AT/FP treatments, including blast-proof windows and doors and steel-reinforced concrete walls, are not compatible with HPS for preserving exterior and interior character-defining features. Instead, alternative load path and enhanced local resistance improvements are specified as permitted under the UFC.

Construction Costs The total construction cost of this preservation-focused modernization is estimated at $3,625,500, or $388 PSF. As shown in Table III-10, nearly one-third of this cost stems from the installation of modern HVAC, plumbing, electrical, fire suppression, communications, and security systems identical to those installed in the new construction alternative. Approximately one-fifth of total cost is made up of work on the building's shell including rehabilitation and selective replacement of historic window and doors, selective repairs to the historic brick walls on both the interior and exterior and replacement of selected fenestration elements. Gutting and selective demolition costs in this Project Alternative total $144,000 and include asbestos and lead-based paint abatement costs.

LEED Points Calculation This modernized historic building would qualify for LEED Silver certification with an estimated score of 54 points (see Table III-11). These points include most of those earned by the new construction Project Alternative as well as additional points for reuse of existing structural and non-structural building elements and for the historic building's slightly better energy performance, due primarily to the higher thermal insulation value of the historic brick shell. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FTBL 115-04: FULL MODERNIZATION WITH AT/FP

In contrast, Project Alternative FTBL 115-04 specifies a full modernization of Building 115, but without strict adherence to HPS standards and compliance with AT/FP standards applying DoD's customary, prescriptive treatments. While the historic shell and core structural elements will all be maintained, as in Project Alternative FTBL 115-03, this Project Alternative will not prioritize the preservation of interior and exterior character-defining historic features in order to apply customary AT/FP and progressive collapse treatments. For this Project Alternative, all historic windows and exterior doors will be replaced with AT/FP blast-resistant windows and steel doors in the same locations as in the existing building. Walls will also be reinforced with steel beams for further strengthening, as historic brick does not protect against a direct blast. The remaining interior finishes will be more liberally gutted than in FTBL 115-03 and replaced with modern finishes, though some key character-defining elements will be preserved.

Construction Costs. These AT/FP and other additional modernization features are estimated to total to a construction cost of $3,906,000, or $418 per square foot. As in the other Project Alternatives, Table III-10 shows services installation costs make up the largest share of total cost owing to the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in the historic building. Shell costs make up approximately 22 percent of the total due to the high cost of installing new AT/FP compliant windows and doors and other upgrades to the existing shell. Gutting and selective demolition costs total an estimated $192,000 and include all asbestos and lead-based paint abatement costs.

LEED Points Calculation. This modernization alternative will achieve the same green building performance as the modernization with HPS in FTBL 115-03, attaining a LEED Silver level with 54 points. As shown in Table III-11, these points include most of those earned by the new construction alternative as well as additional points for reuse of existing structural and non-structural building elements and for the historic building's superior energy performance, due primarily to the higher thermal insulation value of the historic brick shell. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FTBL 115: ALTERNATIVES COMPARISON

Project Alternative FTBL 115-02 New Construction and Demolition has the highest estimated construction cost of any construction alternative for Building 115. Modernization Project Alternatives FTBL 115-03 and FTBL 115-04 are estimated to cost roughly 30 and 24 percent less, respectively (see Table III-9). The most substantive drivers for the cost difference between the new construction and both modernization Project Alternatives are the demolition, substructure, and shell costs, as Project Alternative FTBL 115-02 calls for demolition of the entire building and replacement of the building, building pad, and related site elements. Services installation and interiors costs are comparable across all three Project Alternatives, as substantial interior gutting and full replacement of core building services systems were included in both of the modernization Project Alternatives.

The principal drivers for the difference in estimated construction costs between the two modernization Project Alternatives come in the demolition, shell, and interiors costs. These costs were higher for Project Alternative FTBL 115-04 due to the less stringent preservation and greater replacement of interior character-defining features and the more costly installation of customary AT/FP treatments for windows, doors, and steel reinforced walls. Both modernization Project Alternatives do show slightly higher costs in services work than the new construction Project Alternative owing to the added cost of installing new systems in an existing brick building. However, the overall cost increase in the new construction Project Alternative in the building's demolition, shell, and substructure costs are more than sufficient to make either modernization Project Alternative more economical than the new construction Project Alternative.

Table III-10
Summary of Construction Costs
FTBL 115: All Project Alternatives

	Cost Estimate			
Category	01. Sustainment - Status Quo	02. Demolition and New Construction	03. Modernization with HPS	04. Modernization with AT/FP
Demolition	$ -	$ 300,261	$ 144,142	$ 192,178
Substructure	$ 39,040	$ 301,890	$ 13,040	$ 13,040
Shell	$ 188,982	$ 1,345,742	$ 707,346	$ 855,655
Interiors	$ 76,815	$ 172,760	$ 131,440	$ 140,104
Services	$ 130,640	$ 1,172,127	$ 1,188,715	$ 1,174,583
Sitework	$ -	$ 305,088	$ 338,584	$ 343,702
Special Construction	$ -	$ 9,333	$ 9,333	$ 9,333
Hard cost subtotal	$ 435,477	$ 3,607,201	$ 2,532,599	$ 2,728,596
General conditions (25%)	$ 108,869	$ 916,810	$ 643,399	$ 693,113
Security escalation (2%)	$ -	$ 60,037	$ 40,997	$ 43,854
USACE design (7%)	$ 38,104	$ 320,883	$ 225,190	$ 242,589
USACE SOIH (5.7%)	$ 31,028	$ 261,291	$ 183,369	$ 197,537
Soft cost subtotal	$ 178,001	$ 1,559,021	$ 1,092,955	$ 1,177,093
Construction cost total	$ 613,479	$ 5,166,222	$ 3,625,554	$ 3,905,689
Construction cost PSF	$ 66	$ 552	$ 388	$ 418
% Difference from 02	-88%	N/A	-30%	-24%

Sources: Preservation Associates; BAE Urban Economics Inc. 2012.

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Table III-11
Summary of LEED Points Calculation
FTBL 115: All Project Alternatives

Category	02 Demo and New Construction	03 Modernization with HPS	04 Modernization with ATFP	Maximum Points
Sustainable Sites	11	11	11	26
Water Efficiency	2	2	2	10
Energy and Atmosphere	19	17	17	35
Materials and Resources	4	9	9	14
Indoor Environmental Quality	14	13	13	15
Innovation and Design Process	1	1	1	6
Regional Priority Credits	1	1	1	4
Total	52	54	54	110
Certification Level	Silver	Silver	Silver	NA

Sources: Center for Resource Solutions; Comfort Design; BAE Urban Economics, 2012.

Energy Consumption

As shown in Table III-12, the two modernization Project Alternatives, FTBL 115-03 and FTBL 115-04, also slightly outperform the new construction Project Alternative, FTBL 115-02, in terms of ongoing energy consumption. While all three Project Alternatives were treated with identical ground-source heat pump geothermal HVAC systems, Table III-12 shows that both modernization Project Alternatives will consume slightly less energy each year (measured in kBtu) than the new construction Project Alternative. Compared to the baseline energy consumption Project Alternative FTBL 115-01 Sustainment – Status Quo, all three construction and modernization Project Alternatives are estimated to achieve a 43 percent reduction in energy consumption. The slight reduction in total energy consumption in the two modernization Project Alternatives are primarily due to difference in the thermal properties of specified building materials.

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Table III-12
Summary of Energy Consumption Building Operation
FTBL 115: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Primary heating	0	0	0	0
Primary cooling	804,572	256,988	246,093	252,076
Auxiliary	306,209	255,374	253,114	252,332
Lighting	1,387,602	763,181	763,181	763,181
Receptacle	346,900	346,900	346,900	346,900
Cogeneration		0	0	0
Total kBtu/yr [2]	2,845,283	1,622,443	1,609,288	1,614,489
Energy Savings from baseline [3]	N/A	43%	43%	43%

Notes:
[1] Primary heating electricity consumption is included in the primary cooling category due to electric heat pump configuration.
[2]All energy consumption is reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.
[3] Scenario 01 serves as the baseline building performance rating for energy consumption.

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions Estimates

Table III-13 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for Fort Bliss Building 115. Overall, Project Alternative FTBL 115-02 would generate almost 56 percent more GHG emissions than the modernization Project Alternative FTBL 115-03 and almost 48 percent more under Project Alternative FTBL 115-04. The total GHG emissions saved with the two modernization Project Alternatives was between approximately 443,100 CO_2e kilograms and 530,300 CO_2e kilograms. On a per square-foot basis, new construction would generate approximately 107 Kg CO_2e per square foot compared to 47 Kg CO_2e per square foot for FTBL 115-03 and almost 57 Kg CO_2e per square foot for FTBL 115-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative FTBL 115-02 due to the requirement to install an entirely new substructure. In the two modernization Project Alternatives, FTBL 115-03 and FTBL 115-4, only very light treatments were required to reuse the existing substructure. Similarly, GHG emissions for building shell are higher for Project Alternative FTBL 001-02 since it introduces the most new building materials. Interior GHG emissions are similar across the new construction and two modernization Project Alternatives due to similar levels of new building materials introduced. Services GHG emissions are higher in FTBL 115-02 than for the two modernization Project Alternatives due to a requirement of having a HVAC system that has a slightly larger tonnage than in the other two modernization Project Alternatives.

Table III-13
Summary of Scope 3 GHG Emissions
FTBL 115: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Substructure	4.2	50.1	1.6	1.6
Shell	12.7	593.6	157.7	243.5
Interiors	7.1	29.0	23.9	25.4
Services	48.4	226.0	181.1	181.1
Equipment & Furnishings	-	-	-	-
Special Construction	-	1.0	1.0	1.0
Building Sitework	-	109.8	77.8	77.8
Collateral Equipment	-	-	-	-
Total MT CO2e	72.4	1,009.5	443.1	530.3
Total KG CO2e [1]	72,440	1,009,510	443,088	530,259
Kg CO2e per SF	7.75	107.96	47.38	56.71
% change from 02	-92.8%	N/A	-56.1%	-47.5%

Notes:
[1]1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-14 presents GHG emission estimates for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 was not calculated since the use of natural gas for heating water is considered a “wash” across the alternatives and would also be immaterial compared to Scope 2 and Scope 3 emissions. Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction and transportation of debris. Scope 2 emissions are similar across the new construction and modernization Project Alternatives since in all three of these Project Alternatives new efficient HVAC systems are installed. Looking over the entire 30-year period of analysis, the total GHG emissions generated by the modernization Project Alternatives range from 14.6 to 17.4 percent less than total emissions generated by new construction.

Table III-14
Summary of GHG Emissions Scope 1, 2, & 3
FTBL 115: All Project Alternatives

Emissions Scope [1]	01: Sustainment-Status Quo	02: Demo and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Scope 1	-	-	-	-
Scope 2	4,120.9	2,349.8	2,330.8	2,338.3
Scope 3	72.4	1,009.5	443.1	530.3
Total MT CO2e	4,193	3,359	2,774	2,869
Total Kg CO2e [2]	4,193,341	3,359,325	2,773,860	2,868,566
Kg CO2e per SF	448	359	297	307
% change from 02	24.8%	N/A	-17.4%	-14.6%

Notes:
[1] Represents cumulative scope emissions over 30 year life cycle.
[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full LCCA for FTBL 115 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full LCCA is presented in Appendix F. Tables III-15 and III-16 provide a summary of these LCCA across the Project Alternatives.

As shown in Table III-15, FTBL 115-03 shows the lowest net present value (NPV) among the three scenarios. Full modernization with HPS shows a total NPV of approximately $3.7 million without consideration of the value of GHG emissions and $3.8 million with GHG emissions of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction was 23.5 percent higher at $4.9 million without GHG factored into the NPV and $5.0 million with monetized GHG emissions included. Project Alternative FTBL 115-04 registered a NPV of approximately $3.9 million without monetized GHG and $4.0 million with GHG, approximately 5.4 percent higher than FTBL 115-03. The average CO_2 value per metric ton in 2012 dollars was $37.36. The key driver of these results is the level of initial capital investment associated with the Project Alternative; the operating cost profile for building under the new construction and two modernization Project Alternatives varies only slightly due to differences in energy consumption.

Table III-16 breaks out the contribution of monetizing GHG emissions to the NPVs reported in Table III-15. Overall the NPV of monetized GHGs raises the total project NPVs by approximately two percent across Project Alternatives FTBL 115-02 through FTBL 115-04. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization

Project Alternatives, the NPV of the GHG component is approximately 22.7 percent less for Project Alternative FTBL 115-03, and 18.0 percent less for Project Alternative FTBL 115-04.

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Table III-15: Life Cycle Cost Analysis Summary: FTBL 115

Project Alternative	Non Discounted Costs by Component: Initial Investment	Recurring	Residual Value	Total Costs: Non Discounted	Discounted - No GHG Factor	Discounted - w/GHG Factor
FTBL 115-01: Sustainment-Status Quo	$ 613,479	$ 1,695,225	$ -	$ 2,308,704	$ 1,848,623	$ 1,957,488
FTBL 115-02: Demolition and New Construction	$ 5,166,222	$ 1,480,271	$ (2,300,273)	$ 4,346,220	$ 4,857,655	$ 4,956,278
FTBL 115-03: Modernization with HPS	$ 3,625,554	$ 1,477,960	$ (1,645,759)	$ 3,457,755	$ 3,715,117	$ 3,791,391
FTBL 115-04: Modernization with AT/FP	$ 3,905,689	$ 1,478,874	$ (1,755,478)	$ 3,629,085	$ 3,928,686	$ 4,009,546

NOTES:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.36
Base Date:	10/01/12

Sources: Preservation Associates; BAE Urban Economics, 2012.

Table III-16: Greenhouse Gas Valuation Summary: FTBL 115

Project Alternative	GHG Emissions by Scope (MT CO2e): Scope 1	Scope 2	Scope 3	Total	GHG Value: Non Discounted	Discounted
FTBL 115-01: Sustainment-Status Quo	-	4,120.90	72.44	4,193.34	$ 156,646	$ 108,865
FTBL 115-02: Demolition and New Construction	-	2,349.82	1,009.51	3,359.33	$ 125,068	$ 98,622
FTBL 115-03: Modernization with HPS	-	2,330.77	443.09	2,773.86	$ 103,444	$ 76,274
FTBL 115-04: Modernization with AT/FP	-	2,338.31	530.26	2,868.57	$ 106,944	$ 80,860

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.36
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

St. Juliens Creek Annex | Norfolk, VA

Installation Description

St. Juliens Creek Annex (SJCA) is a 490-acre facility situated at the confluence of St. Juliens Creek and the south branch of the Elizabeth River in the City of Chesapeake, located in southeastern Virginia. The Norfolk Naval Shipyard is located approximately 5 miles to the north. The current primary mission of SJCA is to provide a radar testing range and administrative and warehousing facilities for nearby Norfolk Naval Shipyard and other local Naval activities. SJCA also provides administrative office space, light industrial shops and storage facilities for several tenant commands; including Space and Naval Warfare Systems Command, Defense Revitalization and Marketing Office, Mid-Atlantic Regional Maintenance Center; and a cryogenics school. The installation is part of Naval Station Norfolk.[1]

Environment and Energy Sources

St. Juliens Creek Annex is located in a maritime climate on the Atlantic Ocean on the east coast of the United States with high humidity in the summer and a moderate freeze-thaw cycle in the winter. Monthly temperatures range from an average low of 41 degrees Fahrenheit (5 C) in January to an average high of 79 degrees (26 C) in July. Average annual precipitation at the site is approximately 45 inches and annual evening relative humidity averages at 58 percent. The Annex purchases its electricity from Dominion Power, an investor-owned utility with an over 27,000 MW portfolio serving wholesale and retail energy customers in 15 states. Dominion owns and operates over 35 power generation facilities across the Atlantic region, Midwest, and New England, with over half of all facilities located in Virginia. These generation stations provide electricity from a variety of fuel sources, with 47 percent from burning coal and 35 percent from nuclear generation, including the North Anna Nuclear Power Station located roughly 100 miles northwest of St. Juliens. Fourteen percent of Dominion electricity is sourced from burning natural gas, with an increasing amount of that gas being sourced via hydraulic fracturing technology from domestic shale gas deposits. Hydroelectric, wind, methane recapture, biomass, and solar energy sources make up less than four percent of the total generation mix. Natural gas for water heating at St. Juliens is also purchased from Dominion, though these costs are not considered in this Study, as explained in the Methodology section.

[1] Information taken from Naval Facilities Command (NAVFAC) fact sheet.

Figure III-4
Location of St. Juliens Creek Annex
Chesapeake, Virginia

Historic Significance

The St. Juliens Creek Annex Historic District represents an integrated military-industrial complex associated with the production and storage of naval munitions during World War I. The St. Juliens Creek Annex was established as St. Juliens Magazine in 1897 and served as a naval ordinance assembly facility and ammunition depot until 1975. It is located one mile to the south of the Norfolk Naval Shipyard and is now a division of the Naval Station Norfolk. Its period of historic significance spans 1897 to 1919, encompassing a time during which St. Juliens helped produce the majority of the Mark VI mines used in the North Sea Mine Barrage. All of the surviving World War I-era buildings were determined to be associated with this historic event. According to a December 2008 Historical Overview of the St. Juliens Creek Annex Historic District Report completed for the Commander, Navy Region Mi-Atlantic Norfolk, VA:

> "The St. Juliens Creek Historic District is a remarkably consistent complex of mainly industrial buildings whose efficient design has allowed for continuous use for nearly a century. The district is characterized by lengthy rows of large, low-rise warehouses and magazine aligned along a regular street grid and railroad tracks. The warehouse buildings are generally long, linear structures with low-pitched roofs and loading docks. The interiors of the warehouses are spare and utilitarian, with exposed structural components such as concrete and masonry walls, steel or wooden roofs and ceiling beams and trusses, and wood or concrete floors. The unusually wide spacing between the warehouses and magazines, another typical feature of the district, was dictated by safety considerations."

The complex contains both historic and non-historic buildings which are more than 50 years old, and represents one of the few surviving US examples of a military-industrial development directly associated with World War I. Currently the primary mission-critical use of the facility is to provide a radar-testing range, as well as administrative and warehousing facilities for Norfolk Naval Shipyard and other local Navy activities.

In consultation with installation managers, the Study Team selected Building 61 and Building 168. Currently both buildings are underutilized and rated Q4 and Q2, respectively, and would require different levels of treatment for modernization. These two buildings were chosen from a site with over thirty warehouses in various states of condition from Q2 to Q4. The Installation Master Plan has identified a need for new office space for the environmental management staff at the installation; this mission-critical use will be the subject of the Project Alternatives analyzed at this base.

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Figure III-5
Photos of Buildings 61 and 168
St. Juliens Creek Annex, Chesapeake VA

Building 61

Building 168

Figure III-6
Photos of Building 61
St. Juliens Creek Annex, Chesapeake VA

Building: 61: Exterior

Building 61: Interior

Building 61: Clay Tile Wall

Building 61: Window

St. Juliens Creek Annex Building 61 Analysis

Existing Conditions

Building Description. Building 61 is part of a group of ten buildings within the St. Juliens Creek Annex Historic District which were constructed in 1917. The building is a rectangular one-story structure with terra cotta masonry unit (hollow clay tile) exterior walls reinforced with steel columns and trusses. Pilasters of terra cotta masonry units encase the columns and project 4 inches from the interior and exterior surfaces of the side walls. At the top of the exterior side walls is a projecting stuccoed masonry spandrel that is flush with the outer face of the pilasters.

The pilasters and spandrel visually frame the wall panels of each structural bay. The terra cotta masonry units in the walls, including the pilasters and spandrel are stuccoed on the exterior and their fluted interior faces are left exposed. The gable parapets are capped with glazed terra cotta wall copings, some of which are missing. The building measures 199 feet long by 52 feet wide at a ceiling height of 14 feet with a gable roof reaching a total of 26 feet with six round metal ventilators mounted along the ridge.

A loading platform is located along the southeast side with a cantilevered canopy spanning the platform and a non-original structural concrete ramp at one end. Twenty-seven of twenty-eight original industrial steel windows remain and there are currently four steel door frames in the locations of the original doors. There are additional hollow metal doors near the ends of the building and a 14-by-14 foot upward coiling steel service door in the northwest end. The interior of the building is relatively unchanged since construction and remains open warehouse space with unfinished walls and no interior portioning, electrical, or plumbing systems.

The roof was replaced in 1955 with corrugated asbestos ceiling panels and the floor is an unfinished concrete slab foundation rising to four feet above grade. The condition of the stucco, clay masonry units, and concrete slab is severely deteriorated. The building, containing 10,251 gross square feet is currently in use as a warehouse and has been identified for conversion to administrative office use in order to accomplish mission requirements.

Historic Significance. This building is a historic property that contributes to the significance of the history and architecture of the St. Juliens Creek Annex Historic District, which is listed on the National Register of Historic Places. The history of the Annex is recognized because of its function as a general warehouse or magazine during the period of significance (1897-1919). It is described as a magazine on an October 29, 1917 map of the Warehouse district.

Character Defining Features. The primary character-defining features are the shape and mass of the building including the steel columns and framing which enable large open interior space, stuccoed exterior walls, the original windows remaining behind masonry fill panels, the five remaining pairs of shutters, the roof form including the canopy, the loading platform and the large circular ventilators.

Original Design Intelligence. The historic design of the building includes a variety of original design intelligence features that promote thermal comfort in the building. These features include:

- Aerated mass construction with hollow clay tiles for increased insulation;
- Window orientation pattern and operable windows provide for natural cross ventilation;
- Skylight windows located high on the roof to provide interior lighting;
- Roof openings at ventilators provide added ventilation;
- Internal airflow is enhanced through open floor plan; and
- Long elevation of the building sited perpendicular to summer winds.

Properly maintained and integrated into any future rehabilitation or modernization projects, these features can help meet occupant comfort expectations while contributing to energy efficiency.

Project Alternatives

For each SJCA Project Alternative SJCA 061-01 through SJCA 061-04, the Study Team estimated construction costs and construction-related Scope 3 GHG emissions as well as Scope 2 GHG emissions from ongoing building operations. These estimation outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative costs and environmental performance of each alternative over a 30-year period with a two percent real discount rate. Table III-17 summarizes the key assumptions and construction cost for each Project Alternative for SJCA Building 61.

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Table III-17
Summary of SJCA Project Alternatives – Building 61

Project Alternative	Building GSF		Building Features		Construction Cost	
	Total	Footprint	LEED	AT/FP	Total	Per SF
SJCA 061-01: Sustainment - Status Quo	10,251	10,251	n/a	No	$ 2,242,713	$ 219
SJCA 061-02: Demolition & New Construction	10,251	10,251	53	Yes	$ 4,570,115	$ 446
SJCA 061-03: Modernization with HPS	10,251	10,251	59	Yes	$ 3,812,517	$ 372
SJCA 061-04: Modernization with AT/FP	10,251	10,251	59	Yes+	$ 4,260,220	$ 416

+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

SJCA 061-01: SUSTAINMENT – STATUS QUO

The Sustainment-Status Quo Project Alternative is not a true construction alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building in the absence of a full modernization over the period of analysis. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this Project Alternative.

In order to establish an energy performance baseline for SJCA Building 61 that is consistent with other buildings evaluated in this Study, the Project Team assumed a hypothetical 1980s-era HVAC system with no substantial overhauls and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 2,978,177 kBtu of energy consumption, all of it accounted for by electricity consumption (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project Alternatives SJCA 061-02, SJCA 061-03, and SJCA 061-04 for the purposes of calculating LEED points.

SJCA 061--02: DEMOLITION AND NEW CONSTRUCTION

This construction Project Alternative includes the full demolition of the existing building, demolition of the foundation and extant utility, drainage, and other system hookups, and replacement with a modern one-story office building with a basement matching the extant footprint of approximately 10,251 square feet. The demolition cost estimate for this alternative is $329,000 and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site work estimate category.

Construction Costs. The new building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shells, and building site work to increase standoff distance from the building exterior. The estimated total construction cost for this Project Alternative is $4,570,000, or $446 per square foot. As shown in Table III-18, the largest single cost category for this Project Alternative is the services installation cost of $1,008,000, which accounts for just over than 22 percent of total cost and includes the installation of new HVAC, plumbing, electrical, fire suppression, communications, and security systems. The next highest cost is the shell construction cost of $935,000, which includes the construction of concrete masonry unit walls with reinforced steel and a brick veneer cladding as well as the costs of installing AT/FP compliant windows and steel exterior doors. The brick veneer cladding was chosen for this material's greater durability in the humid climate.

LEED Points Calculation. The new building will be designed to attain a LEED score of 53 points, qualifying for LEED Silver certification. As shown in Table III-19 the bulk of these points are earned in the Energy and Atmosphere category due to the 43 percent reduction in energy consumption from the status quo baseline and the use of a geothermal ground source heat pump HVAC system. The next most significant category is the Indoor Environmental Quality category, where points were earned for the use of low-emitting floor, wall, and ceiling finishes and the installation of controllable lighting systems, among other features. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 061--03: FULL MODERNIZATION WITH HPS

This Project Alternative includes the full modernization of the existing structure for office space within a strict interpretation of the Secretary of the Interior's Standards for the Rehabilitation of Historic Properties, or Historic Preservation Standards (HPS). These standards call for the preservation of the building's interior and exterior character-defining historic features. As Building 61 has remained in its historic use as a warehouse space with minimal interior finishes, the bulk of preserved features were exterior or in the building shell, including the preservation of existing window orientation and pattern, and placement of roof ventilators. The existing exterior loading platform will also be retained and repaired extensively with epoxy and sealant treatments. Historic windows will be retained and rehabilitated as much as possible and any non-salvageable historic windows will be replaced with windows matching the historic dimensions and composition. Blast performance for the windows will be enhanced by using a film to meet AT/FP standards. Prescriptive and customary insertion of blast-proof windows and doors will not be included in this modernization alternative, as they would not be compatible with the Secretary's standards for preserving exterior and interior character-defining features. However, because the exterior walls will be clad with a replacement of the historic stucco and concrete sealant treatments, the existing hollow clay masonry units will be replaced with concrete masonry units for enhanced blast resistance without compromising the exterior character of the building.

Construction Costs The total construction cost of this preservation-focused modernization Project Alternative is estimated at $3,812,500, or $372 per square foot. As shown in Table III-18, nearly 30 percent of this cost stems from the installation of modern HVAC, plumbing, electrical, fire suppression, communications, and security systems that are generally similar to those installed in the new construction Project Alternative. Roughly one-fifth of total cost is made up of work on the building's shell including rehabilitation and selective replacement of historic window and door units, replacement of hollow clay tiles with concrete masonry units, and replacement of the exterior stucco finish. Gutting and selective demolition costs in this alternative are low, at just under $20,000 owing to the minimal amount of interior features to be removed as part of modernization.

LEED Points Calculation The modernized historic building would qualify for LEED Silver certification with an estimated score of 59 points (see Table III-19). These points include most of those earned by the new construction Project Alternative as well as additional points for reuse of existing structural and non-structural building elements. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 061-04: FULL MODERNIZATION WITH AT/FP

In contrast, Project Alternative SJCA 061-04 specifies a full modernization of Building 61, but without strict adherence to HPS and application of customary DoD treatments for AT/FP and progressive collapse. This difference is not as pronounced owing to the open and unfinished character of the historic warehouse structure. In this alternative, the interior improvements will be entirely removed and replaced with modern interior finishes. This Project Alternative will not prioritize the preservation of interior or exterior character-defining historic features over other priorities, such as AT/FP. While the historic foundation, roof, and steel beam shell will be retained, the existing terra cotta masonry units in the exterior walls will be replaced with concrete masonry units for blast prevention and progressive collapse in line with DoD's customary treatments to meet AT/FP standards. All historic windows and exterior doors will be replaced with AT/FP blast resistant windows and steel doors in the same locations as in the existing building.

Construction Costs. These AT/FP and other additional modernization features are estimated to total to a construction cost of $4,260,220, or $416 PSF. As in the other alternatives, Table III-18 shows services installation costs make up the largest share of total cost, owing to the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in the historic building. Shell costs make up approximately 24 percent of the total in this Project Alternative due to the wholesale replacement of existing clay brick units with concrete masonry units and the addition of a brick veneer exterior treatment. This treatment was chosen, as in the new construction Project Alternative, both to reference historic brick buildings in the vicinity and for this material's improved durability in the humid climate. As in Project Alternative SJCA 061-03, gutting and selective demolition costs are estimated to be $22,000 owing to the minimal interior finishes. This cost includes all asbestos and lead-based paint abatement costs.

LEED Points Calculation. This modernization alternative will achieve the same green building performance as the modernization with HPS in SJCA 061-03, qualifying for LEED Silver certification with 59 points. As shown in Table III-19 the bulk of these points are derived from the inclusion of a geothermal ground source heat pump HVAC system as well as to the reuse of extant structural and non-structural building elements. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 061: ALTERNATIVES COMPARISON

Project Alternative SJCA 061-02 New Construction and Demolition has the highest estimated construction cost of any construction alternative for Building 61, while Project Alternatives SJCA 061-03 and 061-04 are estimated to cost approximately 17 and 7 percent less (see Table III-18). This cost differential is relatively low, given the substantial amount of shell, substructure, and interiors renovation work allowed in a historic building with very minimal interior character-defining features and because the building's current deteriorated condition required a substantial amount of repair work, even in Project Alternative SJCA 061-03. The most substantial drivers for the cost difference between the new construction and both modernization Project Alternatives are the demolition, substructure, and shell costs, as Project Alternative SJCA 061-02 called for demolition of the entire building and replacement of the building, building pad, and related site elements. Services installation and interiors costs are comparable across all three Project Alternatives, as substantial interior gutting and full replacement of core building services systems were included in both of the modernization Project Alternatives. The principal drivers for the difference in estimated construction cost between the two modernization Project Alternatives come in the substructure and shell costs. These costs were higher for Project Alternative SJCA 061-04 due to the less stringent preservation standards that allow for the installation of costlier AT/FP compliant windows and doors, and the addition of exterior brick veneer. Both modernization Project Alternatives do show slightly higher costs in services work than the new construction alternative, owing to the added cost of installing new systems in an existing historic building. However, the overall cost increase in the new construction Project Alternative in the building's demolition, shell, and substructure costs are more than sufficient to make either modernization Project Alternative more economical in the construction phase.

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Table III-18
Summary of Construction Costs
SJCA 061: Project Alternatives

Category	Cost Estimate 01. Sustainment - Status Quo	02. Demolition and New Construction	03. Modernization with HPS	04. Modernization with AT/FP
Demolition	$ -	$ 329,160	$ 19,555	$ 21,738
Substructure	$ 1,239,602	$ 344,080	$ 122,560	$ 186,560
Shell	$ 56,842	$ 935,110	$ 745,847	$ 1,011,890
Interiors	$ 64,309	$ 267,828	$ 325,465	$ 324,813
Services	$ 385,160	$ 1,008,470	$ 1,112,653	$ 1,093,885
Sitework	$ -	$ 326,362	$ 347,314	$ 348,942
Special Construction	$ -	$ 10,800	$ 10,800	$ 10,800
Hard cost subtotal	$ 1,745,913	$ 3,221,809	$ 2,684,194	$ 2,998,628
General conditions (25%)	$ 261,887	$ 818,284	$ 682,635	$ 762,797
Security escalation (2%)	$ -	$ 51,326	$ 46,346	$ 52,559
USACE design (6%)	$ 120,468	$ 245,485	$ 204,791	$ 228,839
USACE SOIH (5.7%)	$ 114,445	$ 233,211	$ 194,551	$ 217,397
Soft cost subtotal	$ 496,800	$ 1,348,305	$ 1,128,323	$ 1,261,592
Construction cost total	$2,242,713	$ 4,570,115	$ 3,812,517	$ 4,260,220
Construction cost PSF	$219	$ 446	$ 372	$ 416
% Difference from 02	-51%	N/A	-17%	-7%

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-19
Summary of LEED Points Calculation
SJCA 061: Project Alternatives

Category	02 Demo and New Construction	03 Modernization with HPS	04 Modernization with ATFP	Maximum Points
Sustainable Sites	11	11	11	26
Water Efficiency	2	2	2	10
Energy and Atmosphere	20	22	22	35
Materials and Resources	4	9	9	14
Indoor Environmental Quality	14	13	13	15
Innovation and Design Proces	1	1	1	6
Regional Priority Credits	1	1	1	4
Total	53	59	59	110
Certification Level	Silver	Silver	Silver	NA

Sources: Center for Resource Solutions; Comfort Design; BAE Urban Economics, 2012.

Energy Consumption

As shown in Table III-20, the energy consumption pattern for Building 61 differs slightly from that seen at other installations. Here, the new construction Project Alternatives SJCA 061-02 Demolition and New Construction and SJCA 061-04 Modernization with AT/FP are estimated to consume and equal amount of total annual energy, while Project Alternative SJCA 061-03 Modernization with HPS, very slightly outperforms both. This pattern is primarily a result of the exterior wall and window treatments applied. Substantially thicker windows are installed in both the SJCA 061-02 and SJCA 061-04 alternatives and a thick single pane of glass permits greater heat transfer than a dual pane glass window.

Table III-20
Summary of Energy Consumption, Building Operations
SJCA 061: Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Primary heating[1]	0	0	0	0
Primary cooling	621,041	200,046	194,497	200,046
Auxiliary	125,785	67,515	65,099	67,515
Lighting	1,785,081	981,794	981,794	981,794
Receptacle	446,270	446,270	446,270	446,270
Cogeneration	0	0	0	0
Total kBtu/yr [2]	2,978,177	1,695,625	1,687,660	1,695,625
Energy Savings f r baseline [3]	N/A	43%	43%	43%

Notes:

[1] Primary heating electricity consumption is included in the primary cooling category, due to electric heat pump configuration.

[2] All energy consumption is reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.

[3] Scenario 01 serves as the baseline building performance rating for energy consumption.

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions Estimates

Table III-21 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for SJCA Building 61. Overall, Project Alternative SJCA 061-02 would generate almost 44 percent more GHG emissions than the modernization Project Alternative SJCA 061-03 and almost 30 percent more than under Project Alternative SJCA 061-04. The total GHG emissions saved with the two modernization Project Alternatives over the new construction alternative was between approximately 280,600 and 441,000 CO_2e kilograms. On a per square-foot basis, new construction would generate approximately 92 Kg CO_2e per square foot compared to 52 Kg CO_2e per square foot for SJCA 061-03 and 64 Kg CO_2e per square foot for SJCA 061-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative SJCA 061-02 due to the requirement to install an entirely new foundation compared to the two modernization Project Alternatives, SCJA 061-03 and SCJA 061-4, for which less-energy consuming materials were required to reuse existing substructure. Similarly, GHG emissions for construction of a new building shell are higher for Project Alternative SJCA 061-02 since it introduces the most new building materials. Project Alternative SJCA 061-04 shows higher GHG emissions for shell work due to the installation of blast-proof-doors and windows. The two modernization Project Alternatives have slightly higher interior GHG emissions due to the way that paint is treated in the GHG calculators as opposed to materials for new construction that include paint.

Table III-21
Summary of Scope 3 GHG Emissions
SJCA 061: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Substructure	19.5	200.6	33.8	75.2
Shell	8.1	384.4	162.6	251.7
Interiors	13.3	80.0	82.9	82.7
Services	26.5	176.3	160.3	160.3
Equipment & Furnishings	-	-	-	-
Special Construction	-	1.1	1.1	1.1
Building Sitework	-	98.2	89.0	89.0
Collateral Equipment	-	-	-	-
Total MT CO2e	67.4	940.7	529.7	660.1
Total Kg CO2e [1]	67,416	940,681	529,687	660,050
Kg CO2e per SF	6.58	91.76	51.67	64.39
% change from 02	-92.8%	N/A	-43.7%	-29.8%

Notes:
[1] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-22 presents GHG emission estimated for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 was not calculated since the use of natural gas for heating water is considered a wash across the Project Alternatives and would also be an immaterial quantity compared to Scopes 2 and 3. As would be expected, Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction and transportation of debris. Scope 2 emissions are similar across the new construction and modernization Project Alternatives since all three new highly efficient HVAC systems are installed. Looking over the entire 30-year period of analysis, total GHG emissions generated by the modernization Project Alternatives ranges from 9.1 to 13.7 percent less than the new construction Project Alternative.

Table III-22
Summary of GHG Emissions Scope 1, 2, & 3
SJCA 061: All Project Alternatives

Emissions Scope [1]	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Scope 1	-	-	-	-
Scope 2	3,755.2	2,138.0	2,128.0	2,138.0
Scope 3	67.4	940.7	529.7	660.1
Total MT CO2e	3,823	3,079	2,658	2,798
Total Kg CO2e [2]	3,822,595	3,078,684	2,657,645	2,798,054
Kg CO2e per SF	373	300	259	273
% change from 02	24.2%	N/A	-13.7%	-9.1%

Notes:

[1] Represents cumulative scope emissions over 30 year life cycle.
[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full TOC analysis for SJCA 061 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full TOC analysis is presented in Appendix F. Tables III-23 and III-24 provide a summary of these TOC analyses across the Project Alternatives.

As shown in Table III-23, SJCA 061-03 shows the lowest net present value (NPV) among the three scenarios. This Project Alternative, Modernization with HPS, shows a NPV of $3.9 million without consideration of the value of GHG emissions and $4.0 million with GHG emission of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction Project Alternative SJCA 061-02 was 13.8 percent higher at approximately $4.6 million without GHG emissions considered and approximately $4.7 with monetized GHG emissions included. Modernization with AT/FP Project Alternative SJCA 061-04 registered a NPV of approximately $4.3 million both with and without consideration of GHG emissions.[2] The average CO_2e value per metric ton in 2012 dollars was $25.57. The key driver of these results is the lower initial capital investment associated with the Project Alternative SJCA 061-03; the operating cost profile for building under the new construction and both modernization Project Alternatives varies only slightly due to minimal differences in energy consumption.

Table III-24 breaks out the contribution of monetizing GHG emissions to the total NPVs that are reported in Table III-23. Overall, the NPV of monetized GHG raises the total project NPVs by approximately two percent across Project Alternatives SJCA 061-02 through SJCA 061-04. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization Project Alternatives, the NPV of the GHG component is approximately 18.0 percent less for Project Alternative SJCA 061-03, and 11.3 percent less for Project Alternative SJCA 061-04.

[2] Due to rounding, the approximated values report as $4.3 million; there is an $80,300 difference between the two figures as shown on Table III-23.

Table III-23: Life Cycle Cost Analysis Summary: SJCA 061

	Non Discounted Costs by Component			Total Costs		
Alternative	Initial Investment	Recurring	Residual Value	Non Discounted	No GHG Factor	w/GHG Factor
SJCA 061-01: Status Quo - Sustainment	$ 2,242,713	$ 1,953,301	$ -	$ 4,196,014	$ 3,620,942	$ 3,720,197
SJCA 061-02: Demolition and New Construction	$ 4,570,115	$ 1,645,186	$ (2,004,815)	$ 4,210,485	$ 4,562,966	$ 4,653,509
SJCA 061-03: Modernization with HPS	$ 3,812,517	$ 1,645,186	$ (1,793,037)	$ 3,664,666	$ 3,937,295	$ 4,011,507
SJCA 061-04: Modernization with AT/FP	$ 4,260,220	$ 1,645,186	$ (2,003,646)	$ 3,901,760	$ 4,256,812	$ 4,337,150

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.25
Base Date:	10/01/12

Source: BAE Urban Economics, 2012.

Table III-24: Greenhouse Gas Valuation Summary: SJCA 061

	GHG Emissions by Scope (MT CO2e)				GHG Value	
Alternative	Scope 1	Scope 2	Scope 3	Total	Non Discounted	Discounted
SJCA 061-01: Status Quo - Sustainment	-	3,755.18	67.42	3,822.60	$ 142,795	$ 99,255
SJCA 061-02: Demolition and New Construction	-	2,138.00	940.68	3,078.68	$ 114,612	$ 90,543
SJCA 061-03: Modernization with HPS	-	2,127.96	529.69	2,657.65	$ 99,064	$ 74,212
SJCA 061-04: Modernization with AT/FP	-	2,138.00	660.05	2,798.05	$ 104,252	$ 80,338

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.25
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

St. Juliens Creek Annex Building 168 Analysis

Existing Conditions

Building Description. Building 168 is identical to Building 61 in most respects except condition where it is in better overall condition, rated Q2 in contrast to Q4 for Building 61. A rectangular one-story elongated warehouse of concrete masonry unit exterior walls with a concrete sealant finish, the building measures 199 feet by 52 feet and occupies a footprint of roughly 10,251 gross square feet. The building has a gabled roof reaching a maximum height of 26 feet with 14 foot ceilings at the exterior walls. A concrete loading platform runs the length of the northwest side of the building with a cantilevered canopy spanning the platform, similar to Building 61. Large freight doors line the loading platform. The interior finishes are minimal, and, like Building 61, it is currently used as a warehouse. The building has been designated for conversion to administrative office space in order to accomplish mission requirements.

Historic Significance. Building 168 was built during World War II as a general warehouse. Though it was built more than 50 years ago, Building 168 is located just outside the boundaries of the St Juliens Creek Annex Historic District and is not a historic property.

Original Design Intelligence. Though it is not deemed a contributing structure to the Historic District, Building 168 does include some original design intelligence features that promote efficient energy usage in the building. These features include:

- Aerated mass construction with a steel frame;
- Narrow floor plan that is externally loaded;
- A crawl space with piers to provide ventilation;
- Roof openings at ventilators provide added ventilation;
- Long elevation of the building sited perpendicular to summer winds; and
- Sloped roof allows for increased natural light from rooftop vents.

Properly maintained and integrated into any future rehabilitation or modernization projects in the building, these features, still intact, can help meet occupant thermal comfort expectations while contributing to energy efficiency.

Project Alternatives

For each SJCA Building 168 Project Alternative (SJCA 168-01 through SJCA 168-04), the Study Team estimated construction cost and construction-related Scope 3 GHG emissions as well as Scope 2 emissions for ongoing building operations for the four Project Alternatives. These estimated outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative costs and environmental performance of each Project Alternative over a 30-year period with a standard two percent discount rate. Table III-25 summarizes the key assumptions and construction costs for each SJCA 168 Project Alternative and the cost and GHG emissions of each Project Alternative.

Table III-25
Summary of St Juliens Creek Annex Project Alternatives – Building 168

	Building GSF		Building Features		Construction Cost	
Project Alternative	Total	Footprint	LEED	AT/FP	Total	Per SF
SJCA 168-01: Sustainment - Status Quo	10,251	10,251	n/a	No	$ 359,745	$ 35
SJCA 168-02: Demolition & New Construction	10,251	10,251	53	Yes	$ 4,807,667	$ 469
SJCA 168-03: Modernization with HPS	10,251	10,251	59	Yes	$ 3,537,950	$ 345
SJCA 168-04: Modernization with AT/FP	10,251	10,251	59	Yes+	$ 3,525,624	$ 344

Note:
+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

SJCA 168-01: SUSTAINMENT – STATUS QUO

The Sustainment-Status Quo Project Alternative is not a true alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this Project Alternative.

In order to establish an energy performance baseline for SJCA Building 168 that is consistent with other buildings evaluated in this Study, the Study Team assumed a hypothetical 1980s-era HVAC system with no substantial overhauls and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 3,075,000 kBtu of energy consumption, all of it accounted for by electricity consumption (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project

Alternatives SJCA 168-02, SJCA 168-03, and SJCA 168-04 for the purposes of calculating LEED points.

SJCA 168-02: DEMOLITION AND NEW CONSTRUCTION

This construction alternative includes the full demolition of the existing structure, removal of the foundation and extant utility, drainage, and other system hookups, and replacement with a modern one-story office building with a basement matching the extant footprint of approximately 10,251 square feet. As shown in Table III-26, the demolition cost estimate for this Project Alternative is $329,000 and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site-work estimate category.

Construction Costs. The new building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shells, and building site-work to increase standoff distance from the building exterior. The estimated total construction cost for this alternative is $4,808,000, or $469 per square foot. As shown in Table III-26, the largest single cost category for this alternative is the services installation cost estimate at $979,000, which includes the installation of new HVAC, plumbing, electrical, fire suppression, communications, and security systems. The next highest cost is the shell cost of $960,000, which accounts for the brick veneer cladding specified for the building's concrete masonry unit exterior walls as well as the costs of installing AT/FP compliant windows and steel exterior doors. The brick veneer cladding was chosen for this material's greater durability in the humid climate.

LEED Points Calculation. The new building will be designed to attain a LEED score of 53 points, achieving a LEED Silver certification. As shown in Table III-27 the bulk of these points are earned in the Energy and Atmosphere category due to the 43 percent reduction in energy consumption from the status quo baseline and the use of a GSHP HVAC system. The next most significant category is the Indoor Environmental Quality category, where points were earned for the use of low-emitting floor, wall, and ceiling finishes and the installation of controllable lighting systems, among other features. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 168-03: FULL MODERNIZATION WITH HPS

This Project Alternative includes the full modernization of the existing structure for office space subject to application of the Secretary of the Interior's Standards for the Rehabilitation for Historic Properties, or historic preservation standards (HPS). Though Building 168 is not a historic property eligible for listing on the National Register of Historic Places, it is a World War II-era building over 50 years old and, for the purposes of this Study, preservation standards were generally applied for the purposes of comparison to SJCA 0168-04 and conserving materials for reuse, though the building does not include substantial interior or exterior character-defining historic features.

As Building 168 has remained in its historic use as a warehouse space with minimal interior finishes, the bulk of preserved features were exterior in the building shell, including the preservation of existing freight doors, and replacement with replicas where needed and the placement of roof ventilators. The existing exterior loading platform will also be retained and repaired as needed. Existing windows will be retained and rehabilitated as much as possible and any non-salvageable existing windows will be replaced with windows matching the existing dimensions and composition. Blast performance of the windows will be enhanced by using a film to meet AT/FP standards. Prescriptive and contemporary insertion of blast-proof windows and doors will not be included in this modernization alternative, as they would not be compatible with the application of HPS. Existing concrete masonry walls will be retained and will be clad with a stucco and concrete sealant treatment similar to the extant cladding treatment.

Construction Costs The total construction cost of this conservation-focused modernization is estimated at $3,538,000, or $345 per square foot. As shown in Table III-26, nearly one-third of this cost stems from the installation of modern HVAC, plumbing, electrical, fire suppression, communications, and security systems identical to those installed in the new construction alternative. Approximately 17.8 percent of total cost is made up of work on the building's shell including rehabilitation and selective replacement of existing window and door units, selective repairs to the existing concrete masonry unit walls and replacement of the exterior stucco and sealant finish. Gutting and selective demolition costs in this alternative are low, at $31,000 owing to the minimal amount of interior features to be removed in the modernization.

LEED Points Calculation This modernized older building would qualify for LEED Silver certification with an estimated score of 59 points (see Table III-27). These points include most of those earned by the new construction Project Alternative as well as additional points for reuse of existing structural and non-structural building elements. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 061-04: FULL MODERNIZATION WITH AT/FP

In contrast, Project Alternative SJCA 168-04 specifies a full modernization of Building 168, but without application of HPS. Again, in the case of Building 61, this difference is not as pronounced owing to the open and unfinished character of this non-historic warehouse structure. In this Project Alternative, the interior will be entirely gutted and replaced with modern interior finishes. This Project Alternative will not prioritize the preservation of interior or exterior character-defining historic features over other priorities, including AT/FP. While the existing foundation, roof, and steel beam shell with concrete masonry units will be retained, AT/FP blast resistant windows and steel doors will be installed in a pattern similar to Building 61.

Construction Costs. These prescriptive and customary AT/FP treatments and other additional modernization features are estimated to total a construction cost of $3,525,624, or $344 per square foot. As in the other alternatives, Table III-26 shows services installation costs make up the largest share of total cost, owing to the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in this older, existing building. Shell costs make up nearly 25 percent of the total in this Project Alternative due to the addition of a brick veneer exterior treatment and the installation of blast-proof windows and doors. This treatment was chosen, as in the new construction Project Alternative, both to reference historic brick buildings elsewhere at the installation and for this material's improved durability in the humid climate. As in Project Alternative SJCA 061-03, gutting and selective demolition costs are estimated at a low $35,000 owing to the minimal interior finishes. This cost includes all asbestos and lead-based paint abatement costs.

LEED Points Calculation. As shown in Table III-27, this modernization Project Alternative will achieve the same green building performance as SJCA 168-03, qualifying for LEED Silver certification with 59 points. Appendix E provides more detailed information and demonstrates the LEED point calculations.

SJCA 061: ALTERNATIVES COMPARISON

Project Alternative SJCA 168-02 New Construction and Demolition has the highest estimated construction cost of any construction alternative for Building 168, while Project Alternatives SJCA 168-03 and SJCA 168-04 are estimated to cost roughly 26 and 27 percent less. respectively (see Table III-26). This cost differential is primarily driven by the substantially lower amount of demolition and replacement costs involved in the modernization Alternatives than in new construction. The key driver for the minimal cost difference between these two modernization Project Alternatives is the slightly higher cost of services installation in Project Alternative SJCA 168-03. =No strict preservation standards used for these Project Alternatives. Both modernization Project Alternatives do show slightly higher costs in services work than the new construction Project Alternative, owing to the added cost of installing new systems in an existing building. However, the overall cost increase in the new construction Project Alternative in the building's demolition, shell, and substructure costs are more than sufficient to make either modernization Project Alternative more economical in the construction phase.

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Table III-26
Summary of Construction Costs
SJCA 168: Project Alternatives

Category	Cost Estimate: 01. Sustainment-Status Quo	02. Demolition and New Construction	03. Modernization with HPS	04. Modernization with AT/FP
Demolition	$ -	$ 329,160	$ 31,275	$ 34,775
Substructure	$ 66,000	$ 395,787	$ 63,960	$ 127,960
Shell	$ 28,830	$ 961,102	$ 626,067	$ 613,731
Interiors	$ 77,248	$ 267,828	$ 339,650	$ 339,650
Services	$ 85,573	$ 978,953	$ 1,104,111	$ 1,048,060
Sitework	$ -	$ 322,787	$ 273,487	$ 265,633
Special Construction	$ -	$ 10,800	$ 51,636	$ 51,636
Hard cost subtotal	$ 257,651	$ 3,266,417	$ 2,490,186	$ 2,481,445
General conditions (25%)	$ 64,413	$ 934,234	$ 633,474	$ 631,267
Security escalation (2%0	$ -	$ 60,490	$ 43,708	$ 43,621
USACE design (6%)	$ 19,324	$ 280,270	$ 190,042	$ 189,380
USACE SOIH (5.7%)	$ 18,358	$ 266,257	$ 180,540	$ 179,911
Soft cost subtotal	$ 102,094	$ 1,541,250	$ 1,047,764	$ 1,044,178
Construction cost total	$ 359,745	$ 4,807,667	$ 3,537,950	$ 3,525,624
Construction cost PSF	$ 35	$ 469	$ 345	$ 344
% Difference from 02	-93%	N/A	-26%	-27%

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

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Table III-27
Summary of LEED Points Calculation
SJCA 168: Project Alternatives

Category	02 Demo and New Construction	03 Modernization with HPS	04 Modernization with AT/FP	Maximum Points
Sustainable Sites	11	11	11	26
Water Efficiency	2	2	2	10
Energy and Atmosphere	20	22	22	35
Materials and Resources	4	9	9	14
Indoor Environmental Quality	14	13	13	15
Innovation and Design Process	1	1	1	6
Regional Priority Credits	1	1	1	4
Total	53	59	59	110
Certification Level	Silver	Silver	Silver	NA

Sources: Center for Resource Solutions; Comfort Design; BAE Urban Economics, 2012.

Energy Consumption

As shown in Table III-28, the energy consumption pattern for Building 168 differs slightly from that seen at other installations and is similar to Building 61 at SJCA. Here, the new construction Project Alternatives SJCA 169-02 Demolition and New Construction and SJCA 168-04 Modernization with AT/FP are estimated to consume and equal amount of total annual energy, while Project Alternative SJCA 168-03 Modernization with HPS, very slightly outperforms both. This pattern is primarily a result of the exterior wall and window treatments applied. Substantially thicker windows are installed in both the SJCA 061-02 and SJCA 061-04 alternatives and a thick single pane of glass permits greater heat transfer than a dual pane glass window.

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Table III-28
Summary of Energy Consumption, Building Operations
SJCA 168: All Project Alternatives

Category	01: Sustainment - Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Primary heating[1]	0	0	0	0
Primary cooling	641,502	206,471	200,335	206,471
Auxiliary	134,520	72,413	69,449	72,413
Lighting	1,839,081	1,011,496	1,011,496	1,011,498
Receptacle	459,770	459,770	459,770	459,770
Cogeneration	0	0	0	0
Total kBtu/yr [2]	3,074,873	1,750,150	1,741,050	1,750,152
Energy Savings f r baseline [3]	N/A	43%	43%	43%

Notes:

[1] Primary heating electricity consumption is included in the primary cooling category, due to electric heat pump configuration.

[2] All energy consumption is reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.

[3] Scenario 01 serves as the baseline building performance rating for energy consumption.

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions

Table III-29 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for SJCA Building 168. Overall, modernization Project Alternative SJCA 168-03 would generate almost 48.7 percent less GHG emissions than the Project Alternative SJCA 168-02, and modernization Project Alternative SJCA 168-04 almost 47.9 percent less than under new construction Project Alternative SJCA 168-02. The total GHG emissions saved with the two modernization Project Alternatives over the new construction alternative was between approximately 437,000 and 430,000 CO_2e kilograms. On a per square-foot basis, new construction would generate approximately 88 Kg CO_2e per square foot compared to 45 Kg CO_2e per square foot for SJCA 168-03 and 46 Kg CO_2e per square foot for SJCA 168-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative SJCA 168-02 due to the requirement to install an entirely new foundation compared to the two modernization Project Alternatives, SJCA 168-03 and SCJA 168-4, for which less-energy consuming materials were required to reuse the existing substructure. Similarly, GHG emissions for construction of a new building shell are higher for Project Alternative SJCA 168-02 since it introduces the most new building materials. The two modernization Project Alternatives have slightly higher interior GHG emissions due to the way that paint is treated in the GHG calculators as opposed to materials for new construction that include paint. Services GHG emissions are higher in SJCA 168-02 than for the two modernization Project Alternatives due to a requirement of having a HVAC system that has a slightly larger tonnage than in the other two modernization Project Alternatives.

Table III-30 presents GHG emission estimates for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 is not reported for the reasons discussed in the Methodology, GHG Emissions Estimation section. Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction and transportation of debris. Scope 2 emissions are similar across the new construction and modernization Project Alternatives since in all three of these Project Alternatives new efficient GSHP HVAC systems are installed. Looking over the entire 30-year period of analysis, the total GHG emissions generated by the modernization Project Alternatives range from 13.9 to 13.3 percent less than total emissions generated by new construction.

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Table III-29
Summary of Scope 3 GHG Emissions
SJCA 168: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Substructure	4.0	197.1	6.2	10.9
Shell	4.2	357.3	114.0	115.9
Interiors	11.3	75.9	88.1	88.1
Services	24.5	167.5	156.0	156.2
Equipment & Furnishings	-	-	-	-
Special Construction	-	1.1	7.5	7.5
Building Sitework	-	98.7	89.0	89.0
Collateral Equipment	-	-	-	-
Total MT CO2e	43.9	897.6	460.8	467.7
Total Kg CO2e [1]	43,934	897,601	460,778	467,660
Kg CO2e per SF	4.29	87.56	44.95	45.62
% change from 02	-95.1%	N/A	-48.7%	-47.9%

Notes:

[1] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-30
Summary of GHG Emissions Scope 1, 2, & 3
SJCA 168: All Project Alternatives

Emissions Scope [1]	01: Sustainment - Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Scope 1	-	-	-	-
Scope 2	3,877.1	2,206.5	2,195.4	2,206.8
Scope 3	43.9	897.6	476.5	483.4
Total MT CO2e	3,921	3,104	2,672	2,690
Total Kg CO2e [2]	3,921,025	3,104,090	2,671,896	2,690,114
Kg CO2e per SF	383	303	261	262
% change from 02	26.3%	N/A	-13.9%	-13.3%

Notes:

[1] Represents cumulative scope emissions over 30 year life cycle.

[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full TOC analysis for SJCA 168 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full TOC analysis is presented in Appendix F. Tables III-31 and III-32 provide a summary of these TOC analyses across the Project Alternatives.

As shown in Table III-31, SJCA 168-03 shows the lowest net present value (NPV) among the three scenarios. This Project Alternative, Modernization with HPS, shows a NPV of $3,753,000 without consideration of the value of GHG emissions and $3,827,000 with GHG emission of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction Project Alternative SJCA 168-02 was 34 percent higher at approximately $5,034,000 without GHG emissions considered and approximately $5,129,000 with monetized GHG emissions included. Modernization with AT/FP Project Alternative SJCA 168-04 registered a NPV of approximately $3,751,000 without GHG emissions valued and $3,827,000 with GHG emissions. The average CO_2e value per metric ton in 2012 dollars was $37.26. The key driver of these results is the higher initial capital investment associated with the Project Alternative SJCA 168-02; the operating cost profile for building under the new construction and both modernization Project Alternatives varies only slightly due to minimal differences in energy consumption.

Table III-32 breaks out the contribution of monetizing GHG emissions to the total NPVs that are reported in Table III-31. Overall, the NPV of monetized GHG raises the total project NPVs by approximately two percent across Project Alternatives SJCA 168-02 through SJCA 168-04. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization Project Alternatives, the NPV of the GHG component is approximately 22.4 percent less for Project Alternative SJCA 168-03, and 20.6 percent less for Project Alternative SJCA 168-04.

Table III-31: Life Cycle Cost Analysis Summary: SJCA 168

	Non Discounted Costs by Component			Total Costs		
Alternative	Initial Investment	Recurring	Residual Value	Non Discounted	No GHG Factor	w/GHG Factor
SJCA 168-01: Status Quo - Sustainment	$ 359,745	$ 1,976,528	$ -	$ 2,336,274	$ 1,810,253	$ 1,911,792
SJCA 168-02: Demolition and New Construction	$ 4,807,667	$ 1,658,285	$ (2,117,113)	$ 4,348,840	$ 4,741,864	$ 4,832,630
SJCA 168-03: Modernization with HPS	$ 3,537,950	$ 1,656,126	$ (1,657,701)	$ 3,536,374	$ 3,753,056	$ 3,827,062
SJCA 168-04: Modernization with AT/FP	$ 3,525,624	$ 1,662,772	$ (1,650,219)	$ 3,538,177	$ 3,751,201	$ 3,826,888

Notes

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.27
Base Date:	10/01/12

Source: BAE Urban Economics, 2012.

Table III-32: Greenhouse Gas Valuation Summary: SJCA 168

	GHG Emissions by Scope (MT CO2e)				GHG Value	
Alternative	Scope 1	Scope 2	Scope 3	Total	Non Discounted	Discounted
SJCA 168-01: Status Quo - Sustainment	-	3,877.09	43.93	3,921.02	$ 146,484	$ 101,539
SJCA 168-02: Demolition and New Construction	-	2,206.49	897.60	3,104.09	$ 115,580	$ 90,766
SJCA 168-03: Modernization with HPS	-	2,195.42	476.47	2,671.90	$ 99,620	$ 74,005
SJCA 168-04: Modernization with AT/FP	-	2,206.76	483.36	2,690.11	$ 100,297	$ 75,687

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.27
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Installation Description

F.E. Warren Air Force Base (FEW) is the oldest continuously active installation of the United States Air Force. The installation measures roughly five square miles and is located three miles west of Cheyenne, WY. (See Figure III-7). Established in 1867, it is home to the 90th Missile Wing and Headquarters of the 20th Air Force Space Command.

Environment and Energy Sources

F.E. Warren is located in the arid western plains, subject to a snowy mountain climate with severe freeze-thaw exposure and hot dry summers. Monthly temperatures range from an average low of 18 degrees Fahrenheit (-8 C) in January to an average high of 83 degrees F (28 C) in July. The location experiences an average of 175 days below freezing each year. Average annual precipitation at the site is approximately 14.5 inches and annual evening relative humidity averages at 38 percent.

The installation supplies its energy needs through a mix of on- and off- site sources. For building heating, the installation operates a district heating system that distributes steam generated by a natural gas boiler. Natural gas is purchased from the Cheyenne Light, Fuel and Power Co. Electricity for the installation is purchased from the Western Area Power Administration, an agency of the US Department of Energy that sells electricity generated by federal hydroelectric projects in 11 western states. While this means that no carbon emissions for electricity generation can be directly attributed to operations at F.E. Warren, affecting carbon accounting for Scope 2 Greenhouse Gas emissions, it should be remembered that all electricity in the western grid is ultimately sourced from all generation facilities feeding into that grid and so any efficiency gains in electricity consumption at F.E. Warren will still result in indirect Greenhouse Gas savings. Emissions from the installation's on-site natural gas heating system are directly attributable to the installation's Scope 1 emissions profile.

Historic Significance

Originally named for Civil War General David A. Russell, F.E. Warren was established in 1867 to provide defense for the construction of the transcontinental railroad from indigenous Native American tribes. Fort Russell initially stationed the 30th Cavalry, which participated in the Great Sioux Indian War, most notably remembered for the defeat of troops commanded by Lt. Col. George Custer. In 1885, the post was reassigned to house eight infantry divisions and the Army built 27 red brick buildings and planted thousands of trees. From 1885 to 1930, more than 220 brick buildings were constructed and all remain in service today. The installation was renamed in honor of Wyoming Governor and Civil War veteran Francis E. Warren in 1930. The base was transferred to Air Force jurisdiction after World War II in 1947 and ultimately came to house the 90th Missile Wing and Headquarters of the 20th Air Force Space Command. Because of the lasting integrity of the base's historic brick structures and historic architectural and landscape setting, the base was listed on the National Register of Historic Places in 1975. The base was designated a National Historic Landmark.

In consultation with installation managers, the Study Team selected Building 222 and Building 323. Building 222 is currently in use as barracks while Building 323 serves as a wood shop. The Installation Master Plan has identified a need for new office space for the environmental management staff at the installation; this mission-critical use will be the subject of the Project Alternatives analyzed at this base.

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Figure III-7
Location of Francis E. Warren Air Force Base
Cheyenne, Wyoming

Figure III-8
Photos of Building 222
F.E. Warren, Cheyenne WY

Building 222 - Front

Building 222 – Wing at Rear

Building 222 – Porch Detail

Figure III-9
Photos of Building 323
F.E. Warren, Cheyenne WY

Building 323 - Front

Building 323 - Rear

Building 323 – Side Detail

F.E. Warren Building 222 Analysis

Existing Conditions

Building Description. Building 222 is one of six three-story (including basement) red brick masonry structures that frame one side of the historic parade ground. They were constructed as enlisted men's barracks between 1906 and 1910. This U-shaped, gable-roofed edifice consists of a main transverse section measuring 150 by 29 feet and two brick rear ells. A two-tiered veranda extends fully across the front facades and is supported by white-painted wooden Doric columns linked by black-painted iron pipe rails. Windows are two over two sash with stone sills and segmental brick arches. The structure occupies an extant footprint of 10,842 square and contains a total of 32,526 gross square feet. The historic interior of the building was substantially gutted within the last twenty years and replaced with a contemporary drywall and asbestos tile interior supported by steel framing, though the historic brick exterior, porches, windows, and doors are intact. The building is currently in use as barracks and has been identified for conversion to administrative office space.

Historic Significance. Building 222 was built as a part of the original set of red brick buildings constructed beginning in 1885. The building is a common type of barracks structure designed by the Army Quartermaster in the late 19th century. There are hundreds of examples of this building type still in existence at other Army installations nationwide. Despite the changes to the interior of Building 222, this structure is a historic property that contributes to the significance of the history and architecture of the F. E. Warren National Historic Landmark District. Exterior character-defining features include the shape and mass of buildings, red brick exterior walls, two-story open porch, pitched roof form, and original windows.

Original Design Intelligence. Despite the changes to the interior of Building 222, the historic design of the building still includes a variety of original design intelligence features that could promote thermal comfort and improve energy efficiency in the building. These features include:

- Solid mass brick wall with high thermal inertia;
- Natural ventilation from operable windows;
- Cross ventilation window orientation pattern;
- Roof openings/attic ventilation;
- Masonry chimney that provides stack effect;
- Long elevation of the building sited perpendicular to summer winds;

- Tall wide windows/foundational windows to provide solar lighting;
- Sloped ceiling to provide interior solar lighting;
- Deep two-story porch to use as shading device;
- Building orientation to enhance amount and quality of light; and
- Basement to provide cool airflow through convection currents.

These features, properly maintained and integrated into any future rehabilitation or modernization project in the building, could provide energy savings while meeting occupant comfort expectations.

Project Alternatives

Construction cost and construction-related (Scope 3) GHG emissions were estimated for both baseline Project Alternatives FEW 222-01 Sustainment-Status Quo and FEW 222-02 Demolition and New Construction and both modernization Project Alternatives FEW 222-03 Modernization with SOIS and FEW 222-04 Modernization with AT/FP. These estimated outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative cost and environmental performance of each alternative over a 30-year period with a two percent real discount rate. Table III-33 summarizes the key assumptions and cost estimates for each Project Alternative for Building 222 at F.E. Warren.

Table III-33
Summary of FEW Project Alternatives – Building 222

	Building GSF		Building Features		Construction Cost	
Project Alternative	Total	Footprint	LEED	AT/FP	Total	Per SF
FEW 222-01: Sustainment-Status Quo	32,526	10,842	n/a	No	$ 2,799,729	$ 86
FEW 222-02: Demolition and New Construction	30,200	10,920	51	Yes	$ 9,426,338	$ 312
FEW 222-03: Modernization with HPS	32,526	10,842	53	Yes	$ 7,623,391	$ 234
FEW 222-04: Modernization with AT/FP	32,526	10,842	53	Yes+	$ 8,558,230	$ 263

Note:
+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

FEW 222-01: SUSTAINMENT – STATUS QUO

The Sustainment-Status Quo Project Alternative is not a true construction alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this Project Alternative.

In order to establish an energy performance baseline for F.E. Warren Building 222 that is consistent with other buildings evaluated in this Study, the Project Team assumed a hypothetical 1980s-era HVAC system with no substantial overhauls and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 8,892,000 kBtu of energy consumption, accounted for by both electricity consumption and natural gas consumption for building area (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project Alternatives FEW 222-02, FEW 222-03, and FEW 222-04 for the purposes of calculating LEED points for energy efficiency gains.

FEW 222-02: DEMOLITION AND NEW CONSTRUCTION

This Project Alternative includes the full demolition of the existing structure, and razing of the foundation and extant utility, drainage, and other system hookups and replacement with a modern two-story office building with a basement with a footprint of 10,920 square feet and containing a total 30,200 gross square feet, within 10 percent of the extant footprint of 10,842 square feet and extant size of 32,500 gross square feet. As shown in Table III-34, the demolition cost estimate for this Project Alternative is approximately $1,135,000, and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site-work estimate category.

Construction Costs. The new building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shell, and building site-work to increase standoff distance from the building exterior. The estimated total construction cost for this Project Alternative is $9,426,000, or $312 per square foot. As shown in Table III-34, the services installation cost of approximately $2,308,000 accounts for just under 25 percent of total construction cost and includes the installation of new geothermal HVAC, plumbing, electrical, fire suppression, communications, and security systems. Remaining non-demolition hard costs total $3,501,000 and are accounted for primarily for building shell work using concrete masonry units reinforced with steel columns and clad with brick veneer as well as the installation of AT/FP compliant blast resistant windows and doors (note: due to the structure of the architectural specifications applied to FEW, construction costs are summarized in broader categories than in other installations where the standard RS Means construction categorization was applied consistently). The brick veneer cladding was chosen to reference the historic red brick that dominates the historic district.

LEED Points Calculation. The new building will be designed to attain a LEED score of 51 points, qualifying for a LEED Silver certification. As shown in Table III-35, the bulk of these points are earned in the Energy and Atmosphere category due to the 31 percent reduction in energy consumption from Project Alternative FEW 222 01: Sustainment - Status Quo baseline and the use of a geothermal ground source heat pump HVAC system. The next most significant category is the Indoor Environmental Quality category, where points were earned for the use of low-emitting floor, wall, and ceiling finishes and the installation of controllable lighting systems, among other features. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW 222-03: MODERNIZATION WITH HPS

This Project Alternative includes the full modernization of the existing structure for office space within a strict interpretation of the Secretary of the Interior's Standards for the Rehabilitation of Historic Properties, or historic preservation standards (HPS). These standards call for the preservation of the building's interior and exterior character-defining historic features, which include the original brick masonry walls, and chimneys, window arrangement and orientation to maximize natural light and moderate solar gain and remaining historic wood trim and plaster. The two-story historic brick masonry shell and core structural features, including chimneys, stairways, and intermediate floors will all be retained, while all non-historic interior finishes dating from past partial renovations will be gutted. Historic windows will be retained and rehabilitated as much as possible and any non-salvageable historic windows will be replaced with windows matching the historic dimensions and composition. Blast performance of the windows will be enhanced by using a film. Customary interpretations of UFC for AT/FP and progressive collapse will not be included in this modernization Project Alternative, as the customary treatments, including blast-proof windows and doors and steel reinforced concrete walls, are not compatible with HPS for preserving exterior and interior character-defining features. Instead, alternative load path and enhanced local resistance improvements are specified as permitted under the UFC.

Construction Costs. The total construction cost of this preservation-focused modernization is estimated at $7,623,000, or $234 per square foot. As shown in Table III-34 approximately 34 percent of this cost stems from the installation of modern HVAC, plumbing, electrical, fire suppression, communications, and security systems identical to those installed in the new construction Project Alternative. Remaining non-demolition hard costs total to $2,480,000 accounted for primarily by work on the building's shell including rehabilitation and selective replacement of historic window and door units, selective repairs to the historic brick masonry unit walls and historic porch as well as AT/FP treatments. Gutting and selective demolition costs are estimated at just over $800,000.

LEED Points Calculation The modernized historic building will attain a LEED Silver certification with an estimated score of 53 points (see Table III-35). These points include most of those earned by the new construction alternative as well as additional points for reuse of existing structural and non-structural buildings elements and for the historic building's slightly better energy performance. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW222-04: MODERNIZATION WITH AT/FP

In contrast, Project Alternative FEW 222-04 specifies a full modernization of Building 222, but without strict adherence to HPS standards and application of customary DoD treatments for AT/FP and progressive collapse. While the historic shell and core structural elements will all be maintained, as in Project Alternative FEW 222-03, this Project Alternative will not prioritize the preservation of interior and exterior character-defining historic features over other priorities, including AT/FP and contemporary standards for occupant comfort. For instance, all historic windows and exterior doors will be replaced with AT/FP blast resistant windows and steel doors in the same locations as in the existing building. Walls will also be reinforced with steel beams for further strengthening, as historic brick does not protect against a direct blast. The remaining interior finishes will be more liberally gutted than in FEW 222-03 and replaced with modern finishes, though some key character-defining elements will be preserved.

Construction Costs These AT/FP and other additional modernization features are estimated to total to a construction cost of $8,558,000, or $263 per square foot. As in the other Project Alternatives, Table III-34 shows services installation costs make up the largest share of total cost, owing to the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in the historic building. Remaining non-demolition hard costs total to $3,049,000 accounted for primarily by work on the building's shell including rehabilitation and selective replacement of historic window and door units, selective repairs to the historic brick masonry unit walls and historic porch. Gutting and selective demolition costs are estimated at $888,000.

LEED Points Calculation This modernization Project Alternative will achieve the same green building performance as the strict historic modernization on FEW 222-03, attaining 53 LEED points, sufficient to qualify for Silver certification. As shown in Table III-35 the bulk of these points are derived from the inclusion of a geothermal ground source heat pump HVAC system, the reuse of extant structural and non-structural elements, as well as the modernized building's slightly better energy performance compared to new construction. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW 222: ALTERNATIVES COMPARISON

Alternative FEW 222-02 New Construction and Demolition has the highest estimated construction cost of any construction alternative for Building 222, while Project Alternatives FEW 222-03 and

FEW 222-04 are estimated to cost roughly 19 and nine percent less, respectively (see Table III-34). This cost differential is relatively low, given the substantial amount of shell, substructure, and interiors renovation work allowed in a historic building with very minimal intact interior character-defining features.

The most substantial drivers for the cost difference between the new construction and both modernization alternatives are the demolition and shell costs, as Project Alternative FEW 222-02 called for demolition of the entire building and replacement of the building, building pad, and related site elements. Services installation and interiors costs are comparable across all three alternatives, as substantial interior gutting and full replacement of core building services systems were included in both of the modernization Project Alternatives.

The principal drivers for the difference in estimated construction cost between the two modernization Project Alternatives come in the demolition, shell, and interiors costs, where Project Alternative FEW 222-04 allowed for greater gutting and replacement of interior finishes and also specified more costly customary AT/FP treatments for windows and doors. Both modernization alternatives do show slightly higher costs in services work than the new construction alternative, owing to the added cost of installing new systems in an existing historic building. However, the overall cost increase in the new construction alternative in the building's demolition, shell, and substructure costs are more than sufficient to make either modernization scenario more economical in the construction phase.

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Table III-34
Summary of Construction Costs
FEW 222: All Project Alternatives

Category	01. Sustainment - Status Quo	02. Demolition and New Construction	03. Modernization with HPS	04. Modernization with AT/FP
Demolition	$ 584,365	$ 1,334,808	$ 800,898	$ 887,748
Services	$ 227,144	$ 2,308,390	$ 2,572,655	$ 2,536,472
Other Costs	$ 1,318,498	$ 3,500,607	$ 2,480,203	$ 3,048,837
Hard cost subtotal	$ 2,130,006	$ 7,143,805	$ 5,853,755	$ 6,473,057
General conditions (25%)	$ 409,617	$ 1,451,993	$ 1,125,722	$ 1,326,446
Security escalation (2%)	$ 40,962	$ 116,159	$ 90,058	$ 106,116
USACE design (6.6%)	$ 102,404	$ 383,326	$ 297,191	$ 350,182
USACE SOIH (5.7%)	$ 116,741	$ 331,054	$ 256,665	$ 302,430
Soft cost subtotal	$ 669,723	$ 2,282,533	$ 1,769,635	$ 2,085,173
Construction cost total	$ 2,799,729	$ 9,426,338	$ 7,623,391	$ 8,558,230
Construction Cost per SF	$ 86	$ 312	$ 234	$ 263
% Difference from 02	-70%	N/A	-19%	-9%

Sources: Preservation Associates; BAE Urban Economics Inc. 2012.

Table III-35
Summary of LEED Points Calculation
FEW 222: Project Alternatives

Energy Consumption

As shown in Table III-36, the two modernization Project Alternatives, FEW 222-03 and FEW 222-04, also slightly outperform the new construction Project Alternative, FEW 222-02, in terms of ongoing energy consumption. While all three Project Alternatives were treated with identical ground-source heat pump geothermal HVAC systems, Table III-36 shows that both modernization Project Alternatives will consume slightly less energy each year (measured in kBtu) than the new construction Project Alternative. Compared to the baseline energy consumption Project Alternative FEW 222-01 Sustainment – Status Quo, the three construction and modernization Project Alternatives are estimated to achieve between a 31 to 32 percent reduction in energy consumption. The slight reduction in total energy consumption in the two modernization Project Alternatives are primarily due to differences in the thermal properties of specified building materials.

Table III-36
Summary of Energy Consumption, Building Operations
FEW 222: All Project Alternatives

Category	01: Sustainment- Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Primary heating	12,431	266,132	254,308	258,663
Primary cooling	809,167	401,722	395,186	399,112
Auxiliary	1,182,666	653,150	612,511	615,203
Lighting	5,740,822	3,676,333	3,676,333	3,676,333
Receptacle	1,146,937	1,146,937	1,146,937	1,146,937
Cogeneration	0	0	0	0
Total kBtu/yr [1]	8,892,023	6,144,274	6,085,275	6,096,248
Energy Savings from Baseline [2]	N/A	31%	32%	31%

Notes:
[1]All energy consumption reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.
[2]Scenario 01 serves as the baseline building performance rating for energy consumption

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions Estimates

Table III-37 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for FEW Building 222. Overall, modernization Project Alternative FEW 222-03 would generate almost 53 percent less GHG emissions than Project Alternative FEW 222-02 and Project Alternative FEW 222-04 would generate approximately 38 percent less than under Project Alternative FEW 222-02. The total GHG emissions saved with the two modernization Project Alternatives was between approximately 834,000 CO_2e kilograms and 1,141,000 CO_2e kilograms. On a per square-foot basis, new construction would generate approximately 72 Kg CO_2e per square foot compared to 32 Kg CO_2e per square foot for FEW 222-03 and approximately 41 Kg CO_2e per square foot for FEW 222-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative FEW 222-02 due to the requirement to install an entirely new foundation. In the two modernization Project Alternatives, FEW 222-03 and FEW 222-4, only very light treatments were required to reuse the existing substructure. Similarly, GHG emissions for building shell are higher for Project Alternative FEW 222-02 since it introduces the most new building materials. Interior GHG emissions are similar across the new construction and two modernization Project Alternatives due to similar levels of new building materials introduced.

Table III-37
Summary of Scope 3 GHG Emissions
FEW 222: All Project Alternatives

Category	01: Sustainment-Status Quo	02: Demolition and New Construction	03: Modernization with HPS	04: Modernization with AT/FP
Substructure	6.5	121.1	83.0	31.9
Shell	74.4	1,405.9	454.5	788.5
Interiors	20.8	119.4	46.6	65.8
Services	59.8	458.9	444.3	449.0
Equipment & Furnishings	-	-	-	-
Special Construction	-	-	-	-
Building Sitework	2.6	67.6	3.8	4.0
Collateral Equipment	-	-	-	-
Total MT CO2e	164.1	2,172.8	1,032.3	1,339.2
Total Kg CO2e [1]	164,098	2,172,830	1,032,279	1,339,186
Kg CO2e per SF	5.05	71.95	31.74	41.17
% Change from 02	-92.4%	N/A	-52.5%	-38.4%

Notes:
[1] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-38 presents GHG emission estimates for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 emissions were calculated by the Study Team for FEW but were essentially immaterial. Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction, building materials and transportation of debris. Scope 2 emissions are similar across the new construction and modernization Project Alternatives since in all three of these Project Alternatives new efficient

HVAC systems are installed. Looking over the entire 30-year period of analysis, the total GHG emissions generated by the two modernization Project Alternatives ranges from 10.6 to 14.5 percent less than total emissions generated by new construction.

Table III-38
Summary of GHG Emissions Scope 1, 2, & 3
FEW 222: All Project Alternatives

Emissions Scope [1]	01: Sustainment-Status Quo	02: Demolition and New Construction	222-03: Modernization with HPS	222-04: Modernization with AT/FP
Scope 1	10.1	5.0	3.2	5.6
Scope 2	8,951.0	6,120.6	6,062.9	6,072.4
Scope 3	164.1	2,172.8	1,032.3	1,339.2
Total MT CO2e	9,125.2	8,298.5	7,098.4	7,417.2
Total Kg CO2e [2]	9,125,216	8,298,506	7,098,389	7,417,223
Kg CO2e per SF	281	255	218	228
% change from 02	10.0%	N/A	-14.5%	-10.6%

Notes:
[1] Represents cumulative scope emissions over 30 year life cycle.
[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full LCCA for FEW 222 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full LCCA is presented in Appendix F. Tables III-39 and III-40 provide a summary of these LCCA across the Project Alternatives.

As shown in Table III-39, FEW 222-03 shows the lowest net present value (NPV) among the three scenarios. The full modernization with HPS shows a total NPV of approximately $9,767,000 without consideration of the value of GHG emissions and $9,951,000 with GHG emissions of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction was 11.1 percent higher at $10,959,000 without GHG factored into the NPV and $11,196,000 with monetized GHG emissions included. Project Alternative FEW 222-04 registered a NPV of approximately $10,448,000 without monetized GHG and $10,657,000 with GHG, approximately 6.6 percent higher than FEW 222-03. The average CO_2e value per metric ton in 2012 dollars was $36.61. The key driver of these results is the lower initial capital investment associated with the Project Alternative; the operating cost profile for building under the new construction and two modernization Project Alternatives varies only slightly due to differences in energy consumption.

Table III-40 breaks out the contribution of monetizing GHG emissions to the NPVs reported in Table III-39. Overall the NPV of monetized GHG raises the total project NPVs by approximately 2 to 2.2 percent across Project Alternatives FEW 222-02 through FEW 222-04. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization Project Alternatives, the NPV of the GHG component is approximately 18.2 percent less for Project Alternative FEW 222-03, and 12.0 percent less for Project Alternative FEW 222-04.

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Table III-39: Life Cycle Cost Analysis Summary: FEW 222

Project Alternative	Non Discounted Costs by Component: Initial Investment	Recurring	Residual Value	Total Costs: Non Discounted	Discounted - No GHG Factor	Discounted - w/GHG Factor
FEW 222-01: Sustainment-Status Quo	$ 2,799,729	$ 6,052,421	$ -	$ 8,852,150	$ 7,203,043	$ 7,444,412
FEW 222-02: Demolition and New Construction	$ 9,426,338	$ 5,239,738	$ (3,825,087)	$ 10,840,989	$ 10,958,636	$ 11,195,962
FEW 222-03: Modernization with HPS	$ 7,623,391	$ 5,551,534	$ (3,225,178)	$ 9,949,746	$ 9,756,497	$ 9,950,588
FEW 222-04: Modernization with AT/FP	$ 8,558,230	$ 5,553,184	$ (3,626,046)	$ 10,485,368	$ 10,447,755	$ 10,656,506

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 36.61
Base Date:	10/01/12

Sources: Preservation Associates; BAE Urban Economics, 2012.

Table III-40: Greenhouse Gas Valuation Summary: FEW 222

Project Alternative	GHG Emissions by Scope (MT CO2e): Scope 1	Scope 2	Scope 3	Total	GHG Value: Non Discounted	Discounted
FEW 222-01: Sustainment-Status Quo	10.13	8,950.99	349.07	9,310.19	$ 340,880	$ 241,369
FEW 222-02: Demolition and New Construction	5.03	6,120.65	2,319.78	8,445.46	$ 309,102	$ 237,326
FEW 222-03: Modernization with HPS	3.17	6,062.94	1,069.66	7,135.77	$ 264,763	$ 194,091
FEW 222-04: Modernization with AT/FP	5.59	6,072.45	1,445.60	7,523.64	$ 276,540	$ 208,752

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 36.61
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

F.E. Warren Building 323 Analysis

Existing Conditions

Building Description. Building 323 is one of a dozen one-story rectangular-shaped red brick masonry structures at FEW that were constructed between 1906 and 1909. The building features a gabled roof with an elevated monitor to provide light and ventilation to the interior of the building. There are two large segmentally arched double doors at each end and one near the center of each side, originally used to move horses into and out of the structure. Six-over-six sash window with stone sills and segmental brick arches are located on the east and west facade of the building and the first two bays of the building on the north and south ends. The remainder of the bays on the north and south sides are occupied by smaller arched windows to provide natural light and ventilation to the horse stalls. The building occupies a footprint of 10,385 square feet and contains 13,485 gross square feet. Though the building interior has been altered considerably with the removal of the horse stalls to serve as a woodshop, the exterior remains little changed, and the building has now been identified for conversion to administrative office use in order to accomplish mission requirements.

Historic Significance Building 323 was constructed originally to serve as a stable and it played a key role in FEW's role as an early cavalry post in the American West. This building is a historic property that contributes to the significance of the history and architecture of the F. E. Warren National Historic Landmark District as an example of a standardized Army plan for a stable which was built during the period of significance of the district. Character defining features include the shape and mass of the building including the interior wood framing which enable large open interior spaces, red brick exterior walls, the original windows and doors, chimney and the roof shape.

Original Design Intelligence. Despite the changes to the interior of Building 323, the historic design of the building still includes a variety of original design intelligence features that promote efficient energy usage in the building. These features include:

- Solid mass brick wall with high thermal inertia;
- Natural ventilation from operable windows;
- Cross ventilation from window orientation pattern;
- Windows located high on the wall and in the roof monitor to provide interior lighting;
- Roof openings/attic ventilation;

- Masonry chimney that provides stack effect;
- Narrow floor plan/externally loaded;
- Sloped ceiling to provide interior solar lighting;
- Building orientation to enhance amount and quality of light; and
- Non-mechanical vents.

These features, properly maintained and integrated into any future rehabilitation or modernization projects, can help meet occupant comfort expectations while contributing to energy efficiency.

Project Alternatives

The Study Team estimated construction costs and construction-related Scope 3 GHG emissions as well as Scope 2 emissions for ongoing building operations for the four Project Alternatives. These estimated outputs were then used to calculate the life cycle cost in dollars, carbon dioxide equivalent (CO_2e) emissions, and monetized CO_2e emissions to evaluate the relative costs and environmental performance of each Project Alternative over a 30-year period at a two percent real discount rate.

For Building 323, the Study Team specified a photovoltaic system for the structure as part of the 04-Modernization with AT/FP Project Alternative to be eligible for a Gold LEED certification and to explore the impact on adding a renewal energy source to the analysis. This approach had been proposed in the original Demonstration Plan but was eliminated for the other buildings due to the complexity of adding in another variable into the demonstration of calculating life-cycle GHG emissions as well as the desire by DoD study stakeholders to investigate the impact of AT/FP treatments on costs and GHG emissions. Ideally, a renewal energy source would be subject to its own cost-benefit analysis as part of the specification process. For this particular specification, no independent cost-benefit analysis was completed due to scope limitations.

Table III-41 summarizes the key assumptions and construction costs for each Project Alternative at FEW Building 323.

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Table III-41
Summary of FEW Project Alternatives – Building 323

Project Alternative	Building GSF		Building Features		Construction Cost	
	Total	Footprint	LEED	AT/FP	Total	Per SF
FEW 323-01: Sustainment - Status Quo	13,485	10,385	n/a	No	$ 1,184,186	$ 88
FEW 323-02: Demolition, New Construction	13,485	10,385	54	Yes	$ 4,134,303	$ 307
FEW 323-03: Modernization with HPS	13,485	10,385	57	Yes	$ 2,999,326	$ 222
FEW 323-04: Modernization w/ AT/FP + PV System	13,485	10,385	63	Yes+	$ 4,326,110	$ 321

Note:
+ Current prescriptive practices and treatments.

Sources: Preservation Associates; Center for Resource Solutions; BAE Urban Economics, 2012.

FEW 323-01: SUSTAINMENT – STATUS QUO

The Sustainment-Status Quo alternative is not a construction alternative, but rather a rough approximation of standard repairs and upgrades that would likely occur in the building. Full system overhauls of HVAC, plumbing, and electrical systems, for example, are not included in this alternative.

In order to establish an energy performance baseline for F.E. Warren Building 323 that is consistent with other buildings evaluated in this Study, the Project Team assumed a hypothetical 1980s-era HVAC system with no substantial overhaul and modeled the energy performance of the building based on that system operating in the building's current state. No historic energy consumption data were available since the installation has been unmetered. Using the methodology set forth for energy consumption, the Study Team estimated an energy consumption baseline of 2,564,000 kBtu of energy consumption, accounted for by both electricity consumption and natural gas consumption for building heating (note: water heating technology was not considered in this study as it is unaffected by building design and construction). This baseline is used to determine the degree of energy savings achieved by Project Alternatives FEW 323-02, FEW 323-03, and FEW 323-04.

FEW 323-02: DEMOLITION AND NEW CONSTRUCTION

This construction alternative includes the full demolition of the existing structure, and razing of the foundation and extant utility, drainage, and other system hookups and replacement with a modern one-story office building with a basement with a footprint of 10,385 square feet and containing a total 13,485 gross square feet. As indicated in Table III-42, the demolition cost estimate for this alternative is $536,000 and this cost includes asbestos and lead-based paint abatement and demolition material hauling and tipping fees. Site preparation costs for the replacement building are included in the building site-work estimate category.

Construction Costs. The new building will be constructed to meet LEED Silver standards for new construction and incorporate AT/FP security enhancement features, including blast resistant windows and doors, reinforced structural steel shell, and building site-work to increase standoff distance from the building exterior. The estimated total construction cost for this alternative is $4,134,000, or $307 per square foot. As shown in Table III-42, the services installation cost of $1,015,000 accounts for about 25 percent of total construction cost and includes the installation of new HVAC, plumbing, electrical, fire suppression, communications, and security systems. Remaining non-demolition costs total to $1,588,000 and are accounted for primarily for building shell work using concrete masonry units reinforced with steel columns and clad with a brick veneer as well as the installation of AT/FP compliant blast resistant windows and doors. The brick veneer cladding was chosen to reference the historic red brick that dominates the historic district.

LEED Points Calculation. The new building will be designed to attain a LEED score of 54 points, achieving a LEED Silver certification. As shown in Table III-43 the bulk of these points are earned in the Energy and Atmosphere category due to the 38 percent reduction in energy consumption from the status quo baseline and the use of a geothermal ground source heat pump HVAC system. The next most significant category is the Indoor Environmental Quality category, where points were earned for the use of low-emitting floor, wall, and ceiling finishes and the installation of controllable lighting systems, among other features. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW 323-03: MODERNIZATION WITH HPS

This alternative includes the full modernization of the existing structure for office space within a strict interpretation of the Secretary of the Interior's Standards for the Rehabilitation of Historic Properties, or historic preservation standards (HPS). These standards call for the preservation of the building's interior and exterior character-defining historic features, which include the original brick masonry walls, and chimneys, window arrangement and orientation to maximize natural light and moderate solar gain and remaining historic wood trim. The one-story historic red brick masonry shell and core structural features, including chimneys, stairways, and intermediate floors will all be retained, while all non-historic interior finishes dating from past partial renovations will be gutted. Historic windows will be retained and rehabilitated as much as possible and any non-salvageable historic windows will be replaced with windows matching the historic dimensions and composition. Blast performance of the windows will be enhanced by using a film. Customary interpretations of UFC for AT/FP and progressive collapse will not be included this modernization Project Alternative, as the customary treatments, including blast-proof windows and doors and steel reinforced concrete walls, are not compatible with HPS for preserving exterior and interior character-defining features. Instead, alternative load path and enhanced local resistance improvements are specified as permitted under the UFC.

Construction Costs The total construction cost of this preservation-focused modernization is estimated at $2,999,000, or $222 PSF. As shown in Table III-42 over one-third of this cost stems from the installation of geothermal HVAC, plumbing, electrical, fire suppression, communications, and security systems identical to those installed in the new construction alternative. Remaining non-demolition hard costs total to $1,048,000 accounted for primarily by work on the building's shell including rehabilitation and selective replacement of historic window and door units and selective repairs to the historic brick masonry unit walls. Gutting and selective demolition costs are estimated at $131,000.

LEED Points Calculation The modernized historic building will attain a LEED Silver certification with an estimated score of 57 points (see Table III-43). These points include most of those earned by the new construction alternative as well as additional points for reuse of existing structural and non-structural buildings elements. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW 323-04: MODERNIZATION WITH AT/FP AND PV SYSTEM

In contrast, alternative 323-04 specifies a full modernization of Building 323, but without strict adherence to SOIS standards. While the historic shell and core structural elements will all be maintained, as in alternative 323-03, this alternative will not prioritize the preservation of interior and exterior character-defining historic features over other priorities, including applying prescriptive and customary AT/FP and progressive collapse treatments. For instance, all historic windows and exterior doors will be replaced with AT/FP blast resistant windows and steel doors in the same locations as in the existing building. Walls will also be reinforced with steel beams for further strengthening, as historic brick does not protect against a direct blast. The remaining interior finishes will be more liberally gutted than in 323-03 and replaced with modern finishes, though some key character-defining elements will be preserved.

As explained earlier in the summary of Project Alternatives for Building 323, Project Alternative FEW 323-04 specifies achieving a LEED Gold standard by incorporating a rooftop solar photovoltaic (PV) system. The assumptions for this system are as follows with sources noted:

System Size and Configuration:

- Assumed 9,838 square feet of usable roof space for a solar PV system;
- The National Renewable Energy Laboratory (NREL) developed PVWatts, an online tool to estimate energy production from grid-connected solar PV systems (source: http://www.nrel.gov/rredc/pvwatts/);
- An average 4 kW system covers 377 square feet of roof space (source: http://www.nrel.gov/rredc/pvwatts/changing_parameters.html);

- The building is oriented north-south, angled toward the northeast at about a 15 degree angle and the roof is sloped and faces east and west –this translates to a 104.45 kW system;
- Calculations were made using PVWatts for both sides of the roof at 52.2 kW each (source: http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/US/code/pvwattsv1.cgi); and
- PVWatts assumptions: (i) data were for Cheyenne, WY; (ii) 4/12 pitched roof (18.4 degrees); (iii) azimuth angle of 105 degrees for the east facing roof and 285 degrees for the west facing roof; and (iv) 246,651 kWh per year electrical energy consumption (per the Study Team's Scope 2 calculations).

Solar PV Output:

- 65,272 kWh per year for the east-facing roof;
- 55,937 kWh per year for the west-facing roof;
- 121,209 kWh total per year produced for the building; and
- 49.1% of annual electricity consumption can be covered by the solar PV system.

Solar PV Costs:

- Solar PV prices have been dramatically dropping in the past few years;
- $4.27 per watt was the average installed cost in the U.S. for Quarter 4, 2012 Source: Solar Energy Industries Association (SEIA): http://www.seia.org/research-resources/us-solar-market-insight-2012-year-review;
- Assuming the system is 104.45 kW, the estimated installed cost is $446,022; and
- This translates to $45.34 per square foot.

Construction Costs These AT/FP and other additional modernization features, including a substantial investment in a solar PV system as specified above, are estimated to total to a construction cost of $4,326,000, or $321 per square foot. As in the other alternatives, Table III-42 shows services installation costs make up the largest share of total cost, accounting for nearly 35 percent of total project cost in this Project Alternative. This cost includes the installation of entirely new HVAC, plumbing, electrical, fire safety, and communications systems in the historic building in addition to the solar photovoltaic system. Remaining non-demolition hard costs total to $1,862,000 accounted for primarily by work on the building's shell including rehabilitation and selective replacement of historic window and doors and selective repairs to the historic brick masonry unit walls. Gutting and selective demolition costs are estimated at $74,000.

LEED Points Calculation. This modernization Project Alternative will achieve a substantially higher green building performance than either the strict historic modernization in Project Alternative FEW 323-03 or new construction Project Alternative FEW 323-02, attaining a LEED Gold certification with 63 points. This level of LEED exceeds DoD’s Silver standards. As shown in Table III-43, the bulk of these points are derived from the modernized building’s superior energy performance relative to new construction and to the inclusion of a geothermal ground source heat pump HVAC system along with the use of solar photovoltaic electricity system. The reuse of extant structural and non-structural elements and inclusion of water-saving technologies also boost the building’s green building performance in Project Alternative FEW 323-04. Appendix E provides more detailed information and demonstrates the LEED point calculations.

FEW 323: ALTERNATIVES COMPARISON

Project Alternative FEW 323-04 Modernization with AT/FP and Solar PV System has the highest estimated construction cost of any Project Alternative for FEW Building 323, owing to the expense of the solar PV system. Note that the other Project Alternatives do not have a solar PV system so the comparison for Building 323 is less meaningful. This Project Alternative cost approximately five percent more than the new construction Project Alternative FEW 323-02 and 44 percent more than Modernization with HPS Project Alternatives FEW 323-03. (See Table III-42).

Comparing Demolition and New Construction Project Alternative FEW 323-02 with Modernization with HPS Project Alternative FEW 323-03, the modernization with HPS project would cost approximately 27 percent less. The most substantial drivers for the cost difference between the new construction and FEW 323-03 modernization Project Alternatives are demolition, substructure, and shell costs.

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Table III-42
Summary of Construction Costs
FEW 323: All Project Alternatives

Category	Cost estimate: 01 Sustainment - Status Quo	02 Demolition and New Construction	03 Modernization with HPS	04 Modernization with AT/FP plus Solar PV(a)
Demolition	$ 29,293	$ 535,911	$ 131,080	$ 73,596
Services	$ 348,681	$ 1,014,985	$ 1,144,756	$ 1,496,761
Other Costs	$ 566,739	$ 1,587,779	$ 1,047,568	$ 1,862,071
Hard cost subtotal	$ 944,713	$ 3,138,675	$ 2,323,404	$ 3,432,428
General conditions (25%)	$ 146,467	$ 643,171	$ 405,229	$ 746,601
Security escalation (2%)	$ 14,647	$ 51,454	$ 81,046	$ 59,728
USACE design (6%)	$ 36,617	$ 154,361	$ 97,255	$ 44,796
USACE SOIH (5.7%)	$ 41,743	$ 146,643	$ 92,392	$ 42,556
Soft cost subtotal	$ 239,474	$ 995,629	$ 675,922	$ 893,682
Construction cost total	$1,184,186	$ 4,134,303	$ 2,999,326	$ 4,326,110
Construction Cost per SF	$ 88	$ 307	$ 222	$ 321
% Difference from 02	-71%	N/A	-27%	5%

Notes:

[a] FEW 323-04 costs reflects inclusion of rooftop solar PV system..

Sources: Preservation Associates; BAE Urban Economics Inc. 2012.

Table III-43
Summary of LEED Points Calculation
FEW 323: All Project Alternatives

Category	02 Demo and New Construction	03 Modernization with HPS	04 Modernization with ATFP plus Solar PV	Maximum Points
Sustainable Sites	11	11	11	26
Water Efficiency	2	2	2	10
Energy and Atmosphere	21	20	25	35
Materials and Resources	4	9	9	14
Indoor Environmental Quality	14	13	13	15
Innovation and Design Process	1	1	2	6
Regional Priority Credits	1	1	1	4
Total	54	57	63	110
Certification Level	Silver	Silver	Gold	NA

Note: 2009 LEED fro New Construction and Major Renovations Project Checklist

Sources: Center for Resource Solutions; Comfort Design; BAE Urban Economics, 2012.

Energy Consumption

As shown in Table III-44, the two modernization Project Alternatives, FEW 323-03 and FEW 323-04, also slightly outperform the new construction Project Alternative, FEW 323-02, in terms of ongoing energy consumption. While all three Project Alternatives were treated with identical ground-source heat pump geothermal HVAC systems, Table III-44 shows that both modernization Project Alternatives will consume slightly less energy each year (measured in kBtu) than the new construction Project Alternative. Compared to the baseline energy consumption Project Alternative FEW 323-01 Sustainment – Status Quo, the construction and two modernization Project Alternatives are estimated to achieve between a 38 to 40 percent reduction in energy consumption. The slight reduction in total energy consumption in the two modernization Project Alternatives are primarily due to differences in the thermal properties of specified building materials.

Table III-44
Summary of Energy Consumption, Building Operations
FEW 323: All Project Alternatives

Category	01 Sustainment - Status Quo	02 Demolition and New Construction	03 Modernization with HPS	04 Modernization with AT/FP plus Solar PV
Primary heating	14,420	30,537	28,245	20,080
Primary cooling	519,724	181,544	143,398	183,944
Auxiliary	576,229	416,524	381,176	387,000
Lighting	2,419,280	1,330,605	1,330,605	1,330,605
Receptacle	604,820	604,820	604,820	604,820
Cogeneration	0	0	0	0
Total kBtu/yr [1]	4,134,473	2,564,030	2,488,244	2,526,449
Energy Savings from Baseline [2]	N/A	38%	40%	39%

Notes:
[1]All energy consumption reported in annual kBtu of Source Energy. Source energy accounts for all recurring energy costs associated with building operations.
[2]Scenario 01 serves as the baseline building performance rating for energy consumption

Sources: Comfort Design; BAE Urban Economics, 2012.

GHG Emissions Estimates

Table III-45 reports the estimated GHG emissions resulting from the construction-related Scope 3 emissions of each Project Alternative for FEW Building 323. When compared to the new construction Project Alternative, the Modernization with HPS Project Alternative FEW 323-03 is approximately 56.5 percent lower in terms of CO_2 emissions; the Modernization with AT/FP FEW

323-04 is 44.0 percent lower than the new construction Project Alternative. The total GHG emissions saved with the two modernization Project Alternatives was between approximately 456,000 and 585,000 CO_2e kilograms. On a per square foot basis, new construction would generate approximately 77 Kg CO_2e per square foot compared to 33 Kg CO_2e per square foot for FEW 323-03 and approximately 43 Kg CO_2e per square foot for FEW 323-04.

The GHG emissions calculated for the substructure are significantly higher in the Project Alternative FEW 323-02 due to the requirement to install an entirely new foundation. In the two modernization Project Alternatives, FEW 323-03 and FEW 323-4, only very light treatments were required to reuse the existing substructure. Similarly, GHG emissions for building shell are higher for Project Alternative FEW 323-02 since it introduces the most new building materials.

Table III-45
Summary of Scope 3 GHG Emissions
FEW 323: All Project Alternatives

Category	01 Sustainment - Status Quo	02 Demolition and New Construction	03 Modernization with HPS	04 Modernization with AT/FP plus Solar PV
Substructure	6.1	65.1	11.2	19.7
Shell	56.6	580.8	150.3	230.3
Interiors	7.7	36.2	18.9	30.3
Services	48.6	338.4	268.7	298.6
Equipment & Furnishings	-	-	-	-
Special Construction	-	-	-	-
Building Sitework	0.0	15.3	1.4	0.9
Collateral Equipment	-	-	-	-
Total MT CO2e	119.0	1,035.8	450.4	579.7
Total Kg CO2e [1]	119,047	1,035,793	450,420	579,732
Kg CO2e per SF	8.83	76.81	33.40	42.99
% change from 02	-88.5%	N/A	-56.5%	-44.0%

Notes:
[1] 1 MT CO2e = 1,000 Kg CO2e
Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Table III-46 presents GHG emission estimates for Scopes 2 and 3 over the 30-year period of analysis. Scope 1 emissions were calculated by the Study Team for FEW but were essentially found to be immaterial at the parametric project planning stage. Scope 2 emissions are much larger than Scope 3 emissions since Scope 2 emissions are the result of ongoing consumption of energy during the period of building use and occupancy while Scope 3 emissions are a one-time expenditure of energy for construction, building materials and transportation of debris. Scope 2 emissions are similar across the FEW 323-02 and FEW 323-03 Project Alternatives with FEW 323-03 performing slightly better due to the higher insulation value of existing materials. FEW

323-04 Modernization with AT/FT plus Solar PV obtains a large reduction in Scope 2 emissions due to the effect of the solar PV system which cuts emissions nearly in half. Looking over the entire 30-year period of analysis, the total GHG emissions generated by the two modernization Project Alternatives ranges from 18.4 to 48.2 percent less than total emissions generated by new construction, although the impact of FEW 323-04 is comparable due to its specification of a solar PV system. One question that is not addressed in this analysis is whether new construction would have resulted in the ability to install a larger solar PV system than specified in FEW 323-04. Clearly, had a solar PV system been specified for FEW 323-02, the Scope 2 difference would have been greatly reduced, if not eliminated, and the total difference across all Scopes would have been less. The experiment with FEW 323-04 does indicate that a historic structure can achieve very significant GHG emissions reductions, especially when renewable energy is maximized at the building or site.

Table III-46
Summary of GHG Emissions Scope 1, 2, & 3
FEW 323: All Project Alternatives

Emissions Scope [1]	01 Sustainment-Status Quo	02 Demolition and New Construction	03 Modernization with HPS	04 Modernization with AT/FP plus Solar PV
Scope 1	16.4	1.2	2.5	1.2
Scope 2	4,203.6	2,555.4	2,478.0	1,281.3
Scope 3	119.0	1,035.8	450.4	579.7
Total MT CO2e	4,339.1	3,592.4	2,930.9	1,862.2
Total Kg CO2e [2]	4,339,058	3,592,425	2,930,884	1,862,241
Kg CO2e per SF	322	266	217	138
% change from 02	20.8%	N/A	-18.4%	-48.2%

Notes:
[1] Represents cumulative scope emissions over 30 year life cycle.
[2] 1 MT CO2e = 1,000 Kg CO2e

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

Life-cycle Cost Analysis Results

The Study Team prepared a full LCCA for FEW 323 incorporating initial construction and demolition costs and operating costs associated with each Project Alternative over the 30-year period of analysis. The full LCCA is presented in Appendix F. Tables III-47 and III-48 provide a summary of these LCCA across the Project Alternatives.

As shown in Table III-47, FEW 323-03 shows the lowest net present value (NPV) among the three scenarios. The full modernization with HPS shows a total NPV of approximately $3,870,000 without consideration of the value of GHG emissions and $3,950,000 with GHG emissions of the project life-cycle monetized and incorporated into the LCCA analysis. The NPV for new construction was 19.5 percent higher at $4,801,000 without GHG factored into the NPV and $4,906,000 with monetized GHG emissions included. Project Alternative FEW 323-04 registered a NPV of approximately $4,645,000 without monetized GHG and $4,700,000 with GHG, approximately four percent lower than FEW 323-02 even with the cost burden of the solar PV system specified for this Project Alternative. The average CO_2e value per metric ton in 2012 dollars was $37.35. The key driver of these results is the lower initial capital investment associated with the Modernization with HPS Project Alternative FEW 323-03 and the recurring cost savings obtained by AT/FP plus Solar PV Project Alternative FEW 323-04 (although it should be noted that no separate cost-benefit analysis was performed for the solar PV system).

Table III-48 breaks out the contribution of monetizing GHG emissions to the NPVs reported in Table III-47. Overall the NPV of monetized GHG raises the total project NPVs by approximately 1.2 to 2.0 percent across Project Alternatives FEW 323-02 through FEW 323-04. The increase is less with FEW 323-04 (e.g., 1.2 percent compared to 2.0 percent for the other two) since FEW 323-04 generates half as much GHG emissions. Note that comparing the GHG component NPV of the new construction Project Alternative with the two modernization Project Alternatives, the NPV of the GHG component is approximately 23.4 percent less for Project Alternative FEW 323-03, and approximately 47.7 percent less for Project Alternative FEW 323-04.

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Table III-47: Life Cycle Cost Analysis Summary: FEW 323

Project Alternative	Non Discounted Costs by Component: Initial Investment	Recurring	Residual Value	Total Costs: Non Discounted	Discounted - No GHG	Discounted - w/GHG
FEW 323-01: Sustainment - Status Quo	$ 1,184,186	$ 2,594,721	$ -	$ 3,778,907	$ 3,068,097	$ 3,181,223
FEW 323-02: Demolition, New Construction	$ 4,134,303	$ 2,308,859	$ (1,701,058)	$ 4,742,104	$ 4,800,549	$ 4,905,532
FEW 323-03: Modernization with HPS	$ 2,999,326	$ 2,295,437	$ (1,355,898)	$ 3,938,864	$ 3,869,683	$ 3,950,019
FEW 323-04: Modernization with AT/FP plus Solar PV	$ 4,326,110	$ 2,087,882	$ (2,010,279)	$ 4,403,712	$ 4,645,392	$ 4,700,302

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.35
Base Date:	10/01/12

Sources: Preservation Associates; BAE Urban Economics, 2012.

Table III-48: Greenhouse Gas Valuation Summary: FEW 323

Project Alternative	GHG Emissions by Scope (MT CO2e): Scope 1	Scope 2	Scope 3	Total	GHG Value: Non Discounted	Discounted
FEW 323-01: Sustainment - Status Quo	16.38	4,203.63	119.05	4,339	$ 162,074	$ 113,126
FEW 323-02: Demolition and New Construction	1.24	2,555.39	1,035.79	3,592	$ 133,719	$ 104,983
FEW 323-03: Modernization with HPS	2.47	2,478.00	450.42	2,931	$ 109,216	$ 80,336
FEW 323-04: Modernization with AT/FP plus Solar PV	1.24	1,281.26	579.73	1,862	$ 69,323	$ 54,911

Notes:

Study Period (years):	30
Real Discount Rate:	2.00%
Average CO2e Value/MT (undiscounted)	$ 37.35
Base Date:	10/01/12

Sources: Center for Resource Solutions; BAE Urban Economics, 2012.

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Introduction

In this final section, the Study Team presents its findings and recommendations related to our having undertaken this demonstration of a revised LCCA analysis which quantifies life cycle costs with the price of GHG emissions included. Our findings are divided into two broad categories: (i) findings that specifically address the Performance Objectives set forth at the beginning of the Study; and (ii) other relevant findings that the Study Team made while performing this Study. Finally, the Study Team offers a number of recommendations regarding potential changes to how DoD prepares economic analysis and funding requests for MILCON and modernization projects.

Findings: Performance Objectives

Performance Objective #1

As presented earlier in Table I-1 and repeated here in Table IV-1, the Study Team set forth Performance Objective #1 as follows:

Table IV-1
Performance Objective #1

No.	Performance Objective	Success Criteria
1	Demonstrate that a planning level building project can reuse existing buildings (both historic and non-historic) using sustainable design and energy-efficiencies on a cost-effective basis compared to new construction serving the same mission-critical use.	Reuse of existing historic and non-historic buildings achieve a 15 percent or more NPV cost reduction compared to new construction.

The results for all the buildings by Project Alternative are presented in Tables IV-2 and IV-3. Table IV-2 shows the NPV of project life cycle costs in a traditional fashion without the incorporation of monetized GHG values. Table IV-2 incorporates GHG values in the NPV of life cycle costs.

Overall Result

Overall, based upon the specifications and cost estimates prepared for each Project Alternative, a 15 percent Net Present Value life cycle cost savings by modernizing existing buildings compared to new construction was achieved in five of twelve modernization Project Alternatives. The two modernization

Project Alternatives for Building 115 at FTBL and Building 168 at SJCA reach the 15 percent targeted NPV cost reduction. At FEW, Project Alternative 323-003 (Modernization with HPS) also reaches the 15 percent target. The NPV reduction in life-cycle costs for modernization Project Alternatives for Building 1 at FTBL, Building 61 at SJCA, and Building 222 at FEW did not make the 15 percent target, although Project Alternative FTBL 001-3 and SJCA 061-03 were within ten percent of the goal with a 13.7 percent cost reduction relative to new construction. Building 222, which had the most interior demolition and replacement requirements under the modernization Project Alternatives only reach a 11 percent NPV cost savings under Project Alternative FEW 222-03 and 7.4 percent under Project Alternative FEW 222-04. These results (i.e., the number and identity of Project Alternatives meeting the 15 percent threshold) are the same with and without incorporating GHG emission values into the LCCA Analysis as shown in Tables IV-2 and IV-3.

Sensitivity and Key Observations

Existing Pre-War Building can be cost-effective when compared to new construction but cost-savings are sensitive to the level of interior improvements put in place with the modernization project and how one approaches compliance with AT/FP and progressive collapse requirements. Since greater costs frequently are incurred meeting security and progressive collapse standards, typically interpreted by DoD project planners and designers, in the Modernization with AT/FP Project Alternatives, the overall life cycle NPV savings are diminished in comparison with the Modernization with HPS and AT/FP treatments specifically tailored to the structure. Second, as would be expected, buildings with a high level of existing prior interior improvements (subsequent to the original construction) may cost more to modernize than existing buildings with intact original interiors or open interiors.

By specifying building treatments that result in LEED Silver for the new construction and modernization Project Alternatives, the operating cost profile of the Project Alternatives converge and result in similar energy consumption and operating expense patterns. Since energy costs are a significant portion of a building's life-cycle costs, any percent difference in project NPV cost attributable to construction cost differences is diminished as one adds similar levels of operating costs to the LCCA NPV totals.

Table IV-4 shows that the actual construction cost savings associated with modernization Project Alternatives when compared to new constructions costs could meet a 15 percent cost reduction target in eight of the twelve modernization Project Alternatives. For the modernization Project Alternatives that do not make this targeted reduction, the primary reason is the increased costs of AT/FP treatments[1]

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[1] Note that for FEW 323-04, the Project Alternative also includes a solar PV system that contributes to a higher overall life-cycle NPV cost compared to other Project Alternatives.

Table IV-2
Summary of Results for Performance Objective #1
NPV of Life Cycle Costs without Factoring GHGs

Installation/Building/Project Alternative	Life Cycle Cost: Net Present Value (a)	Life Cycle Cost: % Difference from New Construction	
Fort Bliss			
Building 1			
FTBL 001-02: Demolition and New Construction	$ 9,314,907	NA	
FTBL 001-03: Modernization w ith HPS	$ 8,038,442	-13.7%	
FTBL 001-04: Modernization w ith AT/FP	$ 8,522,780	-8.5%	
Building 115			
FTBL 115-02: Demolition and New Construction	$ 4,857,655	NA	
FTBL 115-03: Modernization w ith HPS	$ 3,715,117	-23.5%	(b)
FTBL 115-04: Modernization w ith AT/FP	$ 3,928,686	-19.1%	(b)
St. Juilens Creek Annex			
Building 61			
SJCA 061-02: Demolition and New Construction	$ 4,562,966	NA	
SJCA 061-03: Modernization w ith HPS	$ 3,937,295	-13.7%	
SJCA 061-04: Modernization w ith AT/FP	$ 4,256,812	-6.7%	
Building 168			
SJCA 168-02: Demolition and New Construction	$ 4,741,864	NA	
SJCA 168-03: Modernization w ith HPS	$ 3,753,056	-20.9%	(b)
SJCA 168-04: Modernization w ith AT/FP	$ 3,753,056	-20.9%	(b)
F.E. Warren			
Building 222			
FEW 222-02: Demolition and New Construction	$ 10,958,636	NA	
FEW 222-03: Modernization w ith HPS	$ 9,756,497	-11.0%	
FEW 222-04: Modernization w ith AT/FP	$ 10,447,755	-4.7%	
Building 323			
FEW 323-02: Demolition, New Construction	$ 4,800,549	NA	
FEW 323-03: Modernization w ith HPS	$ 3,869,683	-19.4%	(b)
FEW 323-04: Modernization w ith AT/FP plus Solar PV	$ 4,645,392	-3.2%	

Notes:
(a) Excludes CO2e monetary value.
(b) Achieved 15% NPV Cost Reduction Target = [shaded box]

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Table IV-3
Summary of Results for Performance Objective #1
NPV of Life Cycle Costs with Monetized GHGs

Installation/Building/Project Alternative	Life Cycle Cost: Net Present Value with GHG (a)	Life Cycle Cost: % Difference from New Construction	
Fort Bliss			
Building 1			
FTBL 001-02: Demolition and New Construction	$ 9,592,548	NA	
FTBL 001-03: Modernization with HPS	$ 8,282,166	-13.7%	
FTBL 001-04: Modernization with AT/FP	$ 8,777,667	-8.5%	
Building 115			
FTBL 115-02: Demolition and New Construction	$ 4,956,278	NA	
FTBL 115-03: Modernization with HPS	$ 3,791,391	-23.5%	(b)
FTBL 115-04: Modernization with AT/FP	$ 4,009,546	-19.1%	(b)
St. Juilens Creek Annex			
Building 61			
SJCA 061-02: Demolition and New Construction	$ 4,653,509	NA	
SJCA 061-03: Modernization with HPS	$ 4,011,507	-13.8%	
SJCA 061-04: Modernization with AT/FP	$ 4,337,150	-6.8%	
Building 168			
SJCA 168-02: Demolition and New Construction	$ 4,832,630	NA	
SJCA 168-03: Modernization with HPS	$ 3,827,062	-20.8%	(b)
SJCA 168-04: Modernization with AT/FP	$ 3,826,888	-20.8%	(b)
F.E. Warren			
Building 222			
FEW 222-02: Demolition and New Construction	$ 11,195,962	NA	
FEW 222-03: Modernization with HPS	$ 9,950,588	-11.1%	
FEW 222-04: Modernization with AT/FP	$ 10,656,506	-4.8%	
Building 323			
FEW 323-02: Demolition, New Construction	$ 4,905,532	NA	
FEW 323-03: Modernization with HPS	$ 3,950,019	-19.5%	(b)
FEW 323-04: Modernization with AT/FP plus Solar PV	$ 4,700,302	-4.2%	

Notes:
(a) Incorporates CO_2e monetary value on a per MT basis.
(b) Achieved 15% NPV Cost Reduction Target = [shaded box]

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Table IV-4
Construction Cost Comparisons

Installation/Building/Project Alternative	Total Construction and Demolition	% Difference from New Construction	
Fort Bliss			
Building 1			
FTBL 001-02: Demolition and New Construction	$ 8,707,799	NA	
FTBL 001-03: Modernization with SOIS	$ 7,030,562	-19.3%	(b)
FTBL 001-04: Modernization with AT/FP	$ 7,639,083	-12.3%	
Building 115			
FTBL 115-02: Demolition and New Construction	$ 5,166,222	NA	
FTBL 115-03: Modernization with HPS	$ 3,625,554	-29.8%	(b)
FTBL 115-04: Modernization with AT/FP	$ 3,905,689	-24.4%	(b)
St. Juilens Creek Annex			
Building 61			
SJCA 061-02: Demolition and New Construction	$ 4,570,115	NA	
SJCA 061-03: Modernization with HPS	$ 3,812,517	-16.6%	(b)
SJCA 061-04: Modernization with AT/FP	$ 4,260,220	-6.8%	
Building 168			
SJCA 168-02: Demolition and New Construction	$ 4,807,667	NA	
SJCA 168-03: Modernization with HPS	$ 3,537,950	-26.4%	(b)
SJCA 168-04: Modernization with AT/FP	$ 3,525,624	-26.7%	(b)
F.E. Warren			
Building 222			
FEW 222-02: Demolition and New Construction	$ 9,426,338	NA	
FEW 222-03: Modernization with HPS	$ 7,623,391	-19.1%	(b)
FEW 222-04: Modernization with AT/FP	$ 8,558,230	-9.2%	
Building 323			
FEW 323-02: Demolition, New Construction	$ 4,134,303	NA	
FEW 323-03: Modernization with HPS	$ 2,999,326	-27.5%	(b)
FEW 323-04: Modernization with AT/FP plus Solar PV	$ 4,326,110	4.6%	

Notes:
(a) Excludes CO2e monetary value.
(b) Achieved 15% NPV Cost Reduction Target = [shaded box]

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Performance Objective #2

As presented earlier in Table I-1 and repeated here in Table IV-5, the Study Team set forth Performance Objective #2 as follows:

Table IV-5
Performance Objective #2

No.	Performance Objective	Success Criteria
2	Demonstrate that a planning level building project involving existing buildings (both historic and non-historic) can achieve GHG reductions exceeding GHG reductions in new construction.	Reuse of existing buildings demonstrates a 15% or greater reduction in GHGs (broken down by Scope 1, 2, and 3 emissions) compared to new buildings in a planning level analysis.

The results for all the buildings by Project Alternative are presented in Table IV-6, displaying total life cycle CO_2e in metric tons broken down by Scopes 1, 2 and 3.

Overall Result

Overall, every modernization Project Alternative achieves the 15 percent target reduction for Scope 3 emissions, reflecting the differences among Project Alternatives from introduced new building materials and transportation of demolition debris. The target is not met for Scope 2 emissions and this is an expected result since each Project Alternative was designed to meet LEED Silver standards primarily from energy efficiency gains. Results for Scope 1 are available for F.E. Warren buildings and the 15 percent standard is met for Project Alternative FEW 222-03. With all CO_2e emission considered, the 15 percent target is achieved in two of twelve modernization scenarios and within ten percent of the objective in three other Project Alternatives. This suggests that reuse of existing Pre-War Buildings can offer significant Scope 3 CO_2e emission savings (e.g., avoided new emissions) and similar Scope 2 emissions as new construction.

Sensitivity

The LCCA GHG analysis is highly sensitive to how the Project Alternatives are specified with respect to building materials and systems. The Study Team took the approach of specifying a full modernization with new HVAC and other building systems that meet the energy performance standards for obtaining LEED Silver level. Similar systems were specified for new construction Project Alternatives and the result was a highly similar pattern of Scope 2 GHG emissions. Project planners can increase (or decrease) the relative energy efficiency of the Project Alternatives and obtain different Scope 2 results. The point of the Study Team's specification approach is that Pre-War Buildings can realize a robust energy efficiency standard and contribute to DoD meeting its GHG reduction goals.

Key Observations

Scope 1 emissions, as shown in the case of the two original built FEW, tend to be non-material factors in total CO_2e missions[2]; Scope 2 and Scope 3 CO_2e emissions account for 99 percent of total CO_2e metric tons for all new construction and modernization Project Alternatives. The Study Team found that Pre-War Buildings can achieve similar energy consumption results as new construction by leveraging the building's original design intelligence and incorporating energy-efficient HVAC and other systems as part of the modernization scope of work. FEW 323-04, which included a solar PC system, demonstrates that existing historic structures can be modernized to achieve additional Scope 2 reductions with onsite energy generation as would also be the case with new construction,

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[2] The Study Team acknowledges monitoring and reducing Scope 1 emissions are important for ongoing building operation; this statement is made in the context what level of effort is appropriate when preparing parametric economic and GHG analysis of project alternatives for funding under MILCON or other facility improvement programs.

Table IV-6
Performance Objective #2
GHG Reduction In Metric Tons by Scope

	MT CO_2e Emissions (a)							
Installation/Building/Project Alternative (b)	Scope 1 (c)	% Difference from New Construction	Scope 2 (d)	% Difference from New Construction	Scope 3 (e)	% Difference from New Construction	TOTAL	% Difference from New Construction
Fort Bliss								
Building 1								
FTBL 001-02: Demolition and New Construction	-	NA	8,365	NA	1,585	NA	9,950	NA
FTBL 001-03: Modernization with HPS	-	-	8,277	-1.0%	831	-47.6% (f)	9,108	-8.5%
FTBL 001-04: Modernization with AT/FP	-	-	8,362	0.0%	959	-39.5% (f)	9,321	-6.3%
Building 115								
FTBL 115-02: Demolition and New Construction	-	NA	2,350	NA	1,010	NA	3,359	NA
FTBL 115-03: Modernization with HPS	-	-	2,331	-0.8%	443	-56.1% (f)	2,774	-17.4% (f)
FTBL 115-04: Modernization with AT/FP	-	-	2,338	-0.5%	530	-47.5% (f)	2,869	-14.6%
St. Juilens Creek Annex								
Building 61								
SJCA 061-02: Demolition and New Construction	-	NA	2,138	NA	941	NA	3,079	NA
SJCA 061-03: Modernization with HPS	-	-	2,128	-0.5%	530	-43.7% (f)	2,658	-13.7%
SJCA 061-04: Modernization with AT/FP	-	-	2,138	0.0%	660	-29.8% (f)	2,798	-9.1%
Building 168								
SJCA 168-02: Demolition and New Construction	-	NA	2,206	NA	898	NA	3,104	NA
SJCA 168-03: Modernization with HPS	-	-	2,195	-0.5%	476	-46.9% (f)	2,672	-13.9%
SJCA 168-04: Modernization with AT/FP	-	-	2,207	0.0%	483	-46.2% (f)	2,690	-13.3%
F.E. Warren								
Building 222								
FEW 222-02: Demolition and New Construction	5.0	NA	6,121	NA	2,320	NA	8,445	NA
FEW 222-03: Modernization with HPS	3.2	-36.9% (f)	6,063	-0.9%	1,070	-53.9% (f)	7,136	-15.5% (f)
FEW 222-04: Modernization with AT/FP	5.6	11.2%	6,072	-0.8%	1,446	-37.7% (f)	7,524	-10.9%
Building 323								
FEW 323-02: Demolition, New Construction	1.2	NA	2,555	NA	1,036	NA	3,592	NA
FEW 323-03: Modernization with HPS	2.5	98.1%	2,478	-3.0%	450	-56.5% (f)	2,931	-7.8%
FEW 323-04: Modernization with AT/FP plus Solar PV	1.2	0.0%	2,517	-1.5%	720	-30.5% (f)	3,238	-4.2%

Notes:
(a) MT CO_2e is metric tons of carbon dioxide equivalent GHG emissions.
(b) Excludes Project Alternative 01 Sustainment-Status Quo.
(c) Broken into Scope 1 for FEW Project Alternatives only. Represents energy usage controlled at building.
(d) Represents emissions associated with purchased electricity for building operation.
(e) Represents emissions associated with the manufacture and transportation of building materials; transportation of debris in demolition.
(f) Achieved 15% GHG reduction target = [shaded box] set forth in Performance Objective #2.

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Performance Objective #3

As presented earlier in Table I-1 and repeated here in Table IV-7, the Study Team set forth Performance Objective #3 as follows:

Table IV-7
Performance Objective #3

No.	Performance Objective	Success Criteria
3	Develop a more complete LCCA that includes the monetary value of carbon offsets incorporated into the LCCA.	Demonstrate a 5 percent reduction in project NPV due to carbon offset values.

Overall Results

As presented in Table IV-8, none of the Project Alternatives achieved Performance Objective 3 since the dollar values of GHG emissions, while material, are not high enough to impact relative total NPV life cycle costs among Project Alternatives. The dollar value of the life-cycle CO_2e is shown as a separate item and the GHG difference of Project Alternatives 03 and 04 are calculated against the Project Alternative 02 base. The GHG differences are then shown as a percent of the total NPV costs for Project Alternative 04. The contribution of monetized GHG to NPV life cycle cost reduction ranges from just over one fifth to one-half a percent.[3] As shown on Table IV-9, the differences in life-cycle GHG emissions between Project Alternatives 03 and 04 against Project Alternative 04 are large (all are over 5 percent) but impact of these differences is greatly reduced when set against total life-cycle NPV. In other words, big differences among small numbers had little impact on relative total NPV life cycle costs.

The overall cost significance of monetized CO_2e values and incorporating them into the TOC Analysis is shown in Table IV-9. Monetizing CO_2e MTs increased total project NPV costs between approximately 1.9 and 2.9 percent.[4] Although the specific percent reduction target of Performance Objective 3 is not met, the true economic cost, including environmental costs, of each Project Alternatives is better reflected by incorporating these values into the LCCA Analysis.

Sensitivity

The Study Team investigated the overall sensitivity of the LCCA to CO_2e pricing. The LCCA analyses utilized the medium forecasted average price of $36.92 per CO_2e ton for Scope 3 emissions and point forecast prices for Scope 1 and 2 emissions (e.g., by-year forecasted prices were used for the Scopes 1 and 2 emissions generated in that forecast year). Increasing the CO_2e price schedule to the high

[3] This range excludes FEW 323-04.
[4] FEW 323-04 shows lower cost impact due to the savings arising from the onsite electrical generation. This result is not included since the Project Alternative FEW 323-02 and 03 did not have a similar system.

scenario that would apply a \$88.70 per CO_2e ton for Scope 3 emissions and high point estimates for Scopes 1 and 2 would not change the LCCA results with respect to this Performance Objective #3. The overall monetized CO_2e cost as a percent of total life-cycle NPV costs, however, would be increased significantly to approximately four to six percent.

Key Observations

For the MILCON process, incorporation of monetized CO_2e values will likely not have a material impact on the results of economic analysis completed as part of a project's LCCA. However, it would be valuable to document the life-cycle CO_2e impacts on a metric ton or kilogram basis and report it so that it can be considered as part of the project alternative selection criteria for the purpose of minimizing new GHG Scope 3 emissions associated with military construction programs.

In other words, Military planners could calculate a CO_2e per square foot, for example, to rank project alternatives. So the project selection decision would then seek to minimize both economic costs (total NPV life cycle costs) with lowest environmental impact (per square foot CO_2e emission, for example). Table IV-10 shows what the Project Alternatives in this Study would look like on a CO_2e kilogram per square foot basis. The Study Team will discuss this concept in further detail in the recommendations section of this Study.

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Table IV-8
GHG Contribution to Total NPV Cost Reduction

Installation/Building/Project Alternative	NPV Life Cycle Costs with Monetized GHG (a)	Contribution of GHG to NPV Life Cycle Cost Reduction: NPV of Life Cycle CO2e	$ Difference from New Construction	GHG Difference as % of Total New
Fort Bliss				
Building 1				
FTBL 001-02: Demolition and New Construction	$ 9,592,548	$ 277,641	NA	NA
FTBL 001-03: Modernization with HPS	$ 8,282,166	$ 243,725	$ (33,916)	-0.354%
FTBL 001-04: Modernization with AT/FP	$ 8,777,667	$ 254,887	$ (22,754)	-0.237%
Building 115				
FTBL 115-02: Demolition and New Construction	$ 4,956,278	$ 98,622	NA	NA
FTBL 115-03: Modernization with HPS	$ 3,791,391	$ 76,274	$ (22,349)	-0.451%
FTBL 115-04: Modernization with AT/FP	$ 4,009,546	$ 80,860	$ (17,763)	-0.358%
St. Juilens Creek Annex				
Building 61				
SJCA 061-02: Demolition and New Construction	$ 4,653,509	$ 90,543	NA	NA
SJCA 061-03: Modernization with HPS	$ 4,011,507	$ 74,212	$ (16,331)	-0.351%
SJCA 061-04: Modernization with AT/FP	$ 4,337,150	$ 80,338	$ (10,205)	-0.219%
Building 168				
SJCA 168-02: Demolition and New Construction	$ 4,832,630	$ 95,368	NA	NA
SJCA 168-03: Modernization with HPS	$ 3,827,062	$ 74,005	$ (21,363)	-0.442%
SJCA 168-04: Modernization with AT/FP	$ 3,826,888	$ 75,687	$ (19,681)	-0.407%
F.E. Warren				
Building 222				
FEW 222-02: Demolition and New Construction	$ 11,195,962	$ 237,326	NA	NA
FEW 222-03: Modernization with HPS	$ 9,950,588	$ 194,091	$ (43,234)	-0.386%
FEW 222-04: Modernization with AT/FP	$ 10,656,506	$ 208,752	$ (28,574)	-0.255%
Building 323				
FEW 323-02: Demolition, New Construction	$ 4,905,532	$ 104,983	NA	NA
FEW 323-03: Modernization with HPS	$ 3,950,019	$ 80,336	$ (24,646)	-0.502%
FEW 323-04: Modernization with AT/FP plus Solar PV	$ 4,700,302	$ 54,911	$ (50,072)	-1.021%

Notes:
(a) Incorporates CO2e monetary value on a per MT basis.

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Table IV-9
GHG Contribution to Total NPV Project Alternative Costs

	Life Cycle Cost			
	Total Project Life Cycle Costs		Monetized GHG Cost Impact	
Installation/Building/Project Alternative	NPV with Monetized GHG	Monetized CO2e as % of Project NPV	NPV of Life Cycle CO2e	% Difference from New Construction
Fort Bliss				
Building 1				
FTBL 001-02: Demolition and New Construction	$ 9,592,548	2.894%	$ 277,641	NA
FTBL 001-03: Modernization with HPS	$ 8,282,166	2.943%	$ 243,725	-12.2%
FTBL 001-04: Modernization with AT/FP	$ 8,777,667	2.904%	$ 254,887	-8.2%
Building 115				
FTBL 115-02: Demolition and New Construction	$ 4,956,278	1.990%	$ 98,622	NA
FTBL 115-03: Modernization with HPS	$ 3,791,391	2.012%	$ 76,274	-22.7%
FTBL 115-04: Modernization with AT/FP	$ 4,009,546	2.017%	$ 80,860	-18.0%
St. Juilens Creek Annex				
Building 61				
SJCA 061-02: Demolition and New Construction	$ 4,653,509	1.946%	$ 90,543	NA
SJCA 061-03: Modernization with HPS	$ 4,011,507	1.850%	$ 74,212	-18.0%
SJCA 061-04: Modernization with AT/FP	$ 4,337,150	1.852%	$ 80,338	-11.3%
Building 168				
SJCA 168-02: Demolition and New Construction	$ 4,832,630	1.973%	$ 95,368	NA
SJCA 168-03: Modernization with HPS	$ 3,827,062	1.934%	$ 74,005	-22.4%
SJCA 168-04: Modernization with AT/FP	$ 3,826,888	1.978%	$ 75,687	-20.6%
F.E. Warren				
Building 222				
FEW 222-02: Demolition and New Construction	$ 11,195,962	2.120%	$ 237,326	NA
FEW 222-03: Modernization with HPS	$ 9,950,588	1.951%	$ 194,091	-18.2%
FEW 222-04: Modernization with AT/FP	$ 10,656,506	1.959%	$ 208,752	-12.0%
Building 323				
FEW 323-02: Demolition, New Construction	$ 4,905,532	2.140%	$ 104,983	NA
FEW 323-03: Modernization with HPS	$ 3,950,019	2.034%	$ 80,336	-23.5%
FEW 323-04: Modernization with AT/FP plus Solar PV	$ 5,384,413	1.718%	$ 92,531	-11.9%

Notes:
(a) Incorporates CO2e monetary value on a per MT basis.

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Table IV-10
CO_2e Kilograms per Square Foot by Project Alternative

Installation/Building/Project Alternative	Total Life Cycle CO2e KG	CO2e KG per Sq. Ft.	% Difference from New Construction
Fort Bliss			
Building 1			
FTBL 001-02: Demolition and New Construction	9,949,676	436	NA
FTBL 001-03: Modernization w ith HPS	9,108,230	399	-8.5%
FTBL 001-04: Modernization w ith AT/FP	9,320,547	408	-6.3%
Building 115			
FTBL 115-02: Demolition and New Construction	3,359,325	359	NA
FTBL 115-03: Modernization w ith HPS	2,773,860	297	-17.4%
FTBL 115-04: Modernization w ith AT/FP	2,868,566	307	-14.6%
St. Juilens Creek Annex			
Building 61			
SJCA 061-02: Demolition and New Construction	3,078,684	300	NA
SJCA 061-03: Modernization w ith HPS	2,657,645	259	-13.7%
SJCA 061-04: Modernization w ith AT/FP	2,798,054	273	-9.1%
Building 168			
SJCA 168-02: Demolition and New Construction	3,104,090	303	NA
SJCA 168-03: Modernization w ith HPS	2,671,896	261	-13.9%
SJCA 168-04: Modernization w ith AT/FP	2,690,114	262	-13.3%
F.E. Warren			
Building 222			
FEW 222-02: Demolition and New Construction	8,298,506	275	NA
FEW 222-03: Modernization w ith HPS	7,098,389	218	-14.5%
FEW 222-04: Modernization w ith AT/FP	7,417,223	228	-10.6%
Building 323			
FEW 323-02: Demolition, New Construction	3,592,425	266	NA
FEW 323-03: Modernization w ith HPS	2,930,884	217	-18.4%
FEW 323-04: Modernization w ith AT/FP plus Solar PV	1,862,241	138	-48.2%

Notes:
(a) Excludes CO2e monetary value.

Sources: Seraph LCC; BAE Urban Economics, Inc., 2012.

Performance Objective #4

As presented earlier in Table I-1 and repeated here in Table IV-11, the Study Team set forth Performance Objective #4 as follows:

Table IV-11
Performance Objective #4

No.	Performance Objective	Success Criteria
4	Demonstrate that a growing installation's mission-critical needs can be met with an older (historic or non-historic) existing building.	Full documentation in a checklist format of reuse building compatibility with mission-critical use requirements.

Source: ESTCP Project SI 0931Demonsttration Plan.

Overall Results

The Study meets this Performance Objective overall but has relaxed strict application of AT/FP and HPS standards for the purposes of comparison in Project Alternative 03 and Project Alternative 04, respectively[5]. This objective requires full correspondence of the characteristics of the building and its use with the following Department of Defense United Facilities Criteria and other applied standards as appropriate for the chosen alternative:

- UFC 1-200-01 General Building Requirements;
- UFC 4-610-01 Administrative Facilities;
- UFC 1-900-01 Selection of Methods for the Reduction, Reuse and Recycling of Demolition Waste;
- UFC 3-310-04 Seismic Design for Buildings;
- UFC 4-010-01 Unified Facilities Criteria DoD Minimum Antiterrorism Standards for Buildings;
- UFC 3-400-01 Energy Conservation;
- Anti-terrorism Force Protection Standards;
- The Secretary of the Interior's Standards for the Rehabilitation of Historic Buildings ;
- Minimum Silver certifiable LEEDS level performance per 2009 LEED Silver for New ;Construction and Major Renovations; and
- Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings.

The Study Team prepared a master checklist for the Project Alternatives. For calculating LEED points,

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[5] The only exception is for Project Alternative FEW 3-04 under which a solar PV system was added to the specifications in addition to customary AT/FP treatments; this variation was made to study the effect on Scope 2 emissions of obtaining a LEED Gold level through onsite energy generation.

the Study Team prepared a detailed LEED checklist using the 2009 LEED Silver for New Construction and Major Renovations; these checklists are provided in the Appendix. The Study Team conferred with installation managers as part of the LEED checklist preparation to determine eligibility of the proposed Project Alternatives for points.

Key Observations

The mission use for this Study was general administrative office space and the Study has found that a variety of existing Pre-War Buildings can be adaptively reused for this use. However, the findings for this Performance Objective #4 suggest that Military planners should carefully and fully consider the reuse and modernization of existing buildings for other types of uses as well.

The Study Team identified original design intelligence features in all of the existing buildings. The Study Team found that these features can promote efficient energy usage in the building and, if still functional or recoverable through the modernization, may contribute significantly to lowering the Scope 2 emissions when combined with current technology available for modernization of existing buildings. Original design intelligence features should be viewed as a system of building design features that work with the Pre-War building to lower GHG emissions. Original design intelligence features vary between buildings but can include solid brick walls with a higher thermal value than contemporary brick, externally loaded narrow floor plans, over-hanging eves, and building orientation perpendicular to prevailing winds. Military planners should approach their formulation of project alternatives with the idea of leveraging these design features in mind.

One issue that arose during the Study is the cost-effectiveness of typical AT/FP and progressive collapse treatments observed by the Study Team for Pre-War Buildings. Military Services are currently investing a significant portion of their installation facility budgets on complying with AT/FP and progressive collapse standards. As part of their project planning and design, military planners, engineers and architects strictly interpret these standards in a prescriptive and rigid manner. The result can be a piece-meal, expensive investment for a single building when a higher security payback might be to invest these same funds for security improvements for a cluster of buildings or installation-wide. Since there is currently no nationally recognized code for new or existing buildings that specifically address security issues, one could argue that AT/FP standards should be formulated to permit flexibility and a range of improvement options to meet security objectives.

Added flexibility with AT/FP could lead to cost-effective solutions to meet security standards. Often, considerable sums are expended to meet the letter of the standards without consideration to cost-effectiveness or identifying and pursuing appropriate design exceptions or meeting the AT/FP requirements through site planning. Examples include compliance with stand-off requirements or requirements triggered when going from two stories to three stories. Moreover, building treatments intended to meet the AT/FP standards at times do not result in providing additional force protection, and, in some cases, actually may weaken an existing structure. Too little attention is given to the inherent force protection capability of the existing structure and for historic properties AT/FP treatments are often irreversible. The overall impact of meeting AT/FP standards related to modernizing existing historic or non-historic facilities could be significant as the cost and GHG data for Project Alternative 04 indicate.

Traditional project planning approaches and tools, reinforced by DoD's MILCON and Sustainment, Restoration and Maintenance funding, focus on incremental investments typically on a building-by-building basis without focusing on clusters of like existing structures and/or an installation-wide approach as part of the installation master plan to meet AT/FP goals. It was apparent to the Study Team that there is a need to determine how to apply risk management-based decisions to historic and existing facilities, design, operations, and security. Such an analysis would include TOC life cycle and cost benefit analysis evaluating high probability hazard /threat events and low probability hazard/threat events with the costs and benefits of providing public access and force protection. At the installation level, master planning guidelines and instructions do not mandate an economic cost-benefit analysis as part of the evaluations of plan alternative and formulation of a preferred alternative. The foregoing notwithstanding, DoD at the same time seeks to make wise and financially prudent allocations of its Congressional appropriation in order to meets its mission in a cost-effective manner. Ultimately, smart security is extremely process dependent and site specific and what are needed are master planning and project planning tools that deliver cost-effective AT/FP improvements rather than rigid prescriptive building requirements.

Performance Objective #5

As presented earlier in Table I-1 and repeated here in Table IV-12, the Study Team set forth Performance Objective #5 as follows:

Table IV-12
Performance Objective #5

No.	Performance Objective	Success Criteria
5	Demonstrate comprehensive LCCA framework that more thoroughly measures both cost and life cycle assessment of carbon footprint reduction in a manner that can be incorporated into DoD existing MILCON approval process (DD 1391).	User survey results that measure the tool's average user satisfaction at a minimum of 60 percent, and no fatal flaws identified in the tool's application to the MILCON process.
		User survey results that measure opinions about the compatibility of the tool with LEED certification process at a minimum average of 60 percent acceptability.

Source: ESTCP Project SI 0931Demonsttration Plan.

Overall Results

This objective was not met due to complexity of estimating GHG emissions. To complete the GHG emission analysis, the Study Team had to use different calculators with different underlying algorithms to estimate Scope 1, 2, and 3 emissions.[6] In addition, to calculate Scope 3 emissions for new building materials, the Study Team used both the Athena EcoCalculator and the ECI-LCA using different calculators for both different Scope levels and different aggregation of building materials. If a whole building assembly was specified, the EcoCalculator was used. If specific building components on a subassembly basis were not available in the EcoCalculator, the Study Team used the EIO-LCA calculator. In order for this demonstration technology to be used by Military planners in the MILCON project formulation and analysis process, a simpler, more integrated carbon calculator is needed. In addition, the Study Team encountered challenges when translating building construction specifications from RSMeans to the carbon calculators. Building components and materials did not line up clearly between the cost estimates and existing carbon calculator input fields. Due to the many challenges encountered to implement this demonstration, it was not practical to ask field Military planners to attempt to use or evaluate this process. Existing, off-the-shelf tools are simply not ready for widespread use.

Key Observations

There is a need for a one-stop carbon calculator package to estimate Scope 1, 2 and 3 emissions. Carbon calculators should be organized with the same building component categories and naming conventions utilized by the more commonly used cost estimation software such as RSMeans. Further, there is a need for a carbon calculator which delineates the emissions for work and materials commonly used and repaired in the modernization of existing buildings rather than just for new construction.

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[6]The Study Team previously had identified that this would be the case in its Demonstration Plan.

Recommendations

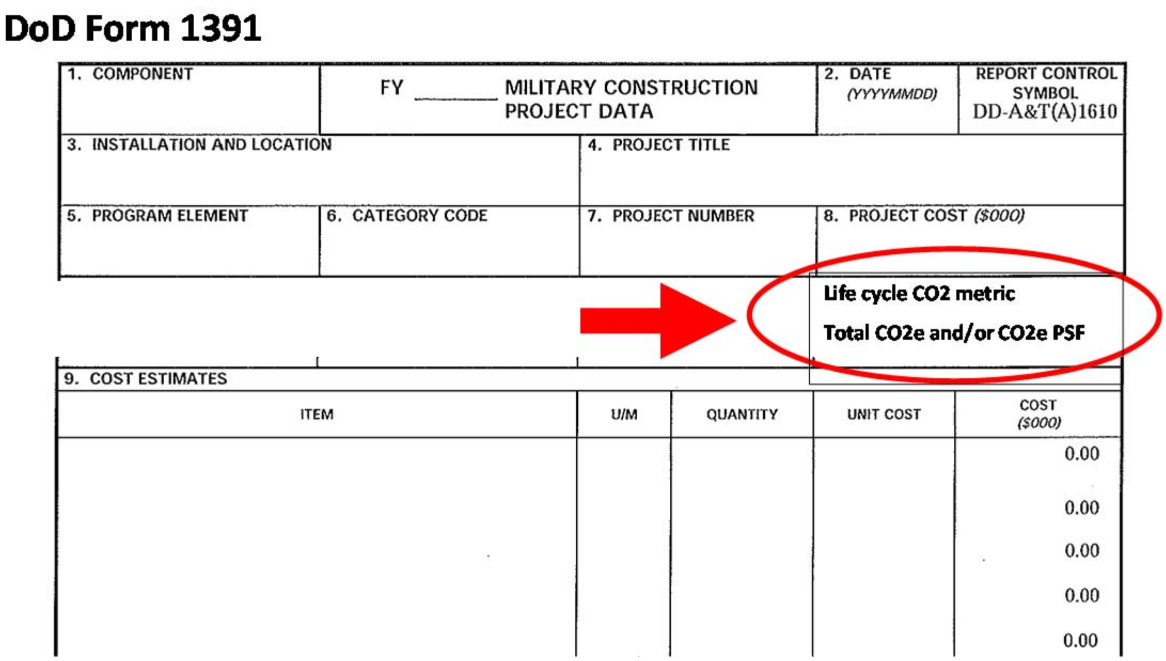
Based upon the findings from this Study, the Study Team offers the following recommendations for consideration by DoD:

DoD MILCON Planning Process

Integration of CO_2e Metrics into Project Planning Process

Integrate new CO_2e metric into MILCON construction project economic evaluation of life-cycle costs, such as a CO_2e kilograms per square foot measure and report CO_2e emissions in parallel with economic analysis in project funding requests on forms such as the D1301. Figure IV-1 illustrates this concept. Incentivize project planners to select low CO_2e project alternatives by requiring CO_2e emissions reporting on project summary forms, such as the D1391s, that are used to prioritize projects in the MILCON budgeting process.

Figure IV-1
Add GHG Emissions As Decision Factor for Project Funding



DoD Form 1391

1. COMPONENT	FY ______ MILITARY CONSTRUCTION PROJECT DATA	2. DATE (YYYYMMDD)	REPORT CONTROL SYMBOL DD-A&T(A)1610
3. INSTALLATION AND LOCATION	4. PROJECT TITLE		
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

Life cycle CO2 metric
Total CO2e and/or CO2e PSF

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
				0.00
				0.00
				0.00
				0.00
				0.00

More Emphasis on Existing Buildings as Viable Project Alternative

DoD's Pre-War Buildings offer opportunities to accommodate new mission requirements and meet energy efficiency goals of DoD. DoD's Pre-War masonry buildings are an underutilized resource for meeting DoD GHG carbon reduction goals. Economic analyses prepared for proposed MILCON projects should carefully examine the potential of existing buildings for modernization and adaptive reuse since they can often offer opportunities to save energy both in terms of GHG emissions associated with initial construction and ongoing energy consumption while preserving important historic resources at the same time. DoD should consider prioritizing the modernization of historic buildings with intact interiors (original design intelligence) to meet mission needs, reduce construction costs and reduce GHG at all DoD installations.

Evaluate GHG Tradeoffs Early in the Project Formulation Process

When formulating building specifications and treatments, Military planners should evaluate the GHG emission tradeoffs of proposed new buildings materials and treatment options early in the conceptual design process to minimize overall Scope 3 impacts. Significant differences in Scope 3 results are found among different building materials and treatments and the project planning process should emphasize low CO_2e impact choices prior to the LCCA phase of project analysis.

Design Guidelines

DoD-wide and Military Services design guidelines should include specifications for minimum Scope 3 footprint and reinforce the importance of selection of low CO_2e building specifications. Design guidelines could also provide information to project planners regarding a structure's original design intelligence and how to leverage it to meet DoD's energy conservation goals.

MILCON Contracting and Procurement

Military Service procurement for architectural, planning, and engineering services should include requirements for qualified historic architects, engineers and the development of accurate planning level specifications (or firms as subcontractors) to ensure that contractors have the internal capacity to fully and accurately evaluate Pre-War Buildings as well as other older, existing buildings. This would help overcome the institutional bias for new construction that can be found at many firms providing architectural and engineering services to the government. Cost estimates and construction bid requests should ask for material quantities in addition to costs so that GHG impacts can be evaluated or validated. Small business set-asides for architectural firms with a strong historic preservation practice could be provided as contract opportunities.

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AT/FP Standards

Meeting Anti-terrorism and Force Protection Standards

Military Services are currently investing a significant portion of their installation facility budgets on complying with Anti-terrorism Force Protection (ATFP) standards. It is recommended that Military planners identify and document current practices of Military Services related to installation master planning and modernizing existing historic under ATFP standards by reviewing a sample of completed master plans and projects. Further, it would be very beneficial to formulate an installation master planning tool that provides a risk-adjusted cost/benefit analysis of alternative ATFP compliance treatments (addressing the site-wide versus building specific ATFP standard compliance issues), with accompanying suggestions to revising current installation master planning guidance documents and instructions. Finally, it is suggested that Military planners formulate a project-specific parametric modeling tool that permits planners, engineers, and architects to evaluate cost-benefit of alternative building treatments and inherent force protection capability to optimize ATFP performance while maintaining historic building integrity. Identifying and reusing the original design intelligence of the Pre-War buildings provides long term energy efficiencies and lowers GHG emissions.