ERDC/CERL TR-11-27

US Army Corps of Engineers®
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Center for the Advancement of Sustainability Innovations (CASI)

Integration of Sustainable Practices Into Standard Army MILCON Designs

Annette L. Stumpf, Julie L. Webster, Richard L. Schneider, Elisabeth M. Jenicek, Justine A. Kane, and Kelly L. Fishman

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Construction Engineering Research Laboratory

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Construction Engineering Research Laboratory
U.S. Army Engineer Research and Development Center
2902 Newmark Drive
Champaign, IL 61822

https://casi.erdc.usace.army.mil/

Final report

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Washington, DC 20314-1000

Under MIPRW74RDV00120696, "Integration of Energy/Sustainable Practices into Standard Army MILCON Designs"

Abstract: The US Army Corps of Engineers (USACE) works to integrate sustainability and energy efficiency into military construction (MILCON) projects. This project originated with an effort to determine funding levels needed for MILCON project budgets to support planning, programming, design, and construction that meets all current and near-term energy and sustainability mandates. The project team assessed current practices and costs, emerging technologies, and performed analyses of five standard designs to develop a set of ideas to help meet net-zero energy, water, and sustainability targets. The objectives of this research were to investigate building features, construction methods, and materials to optimize standard designs for FY13 and beyond MILCON projects for purposes of energy reduction and sustainability, and to ensure that those standard designs meet all the applicable energy reduction and sustainable design policies.

Building features, construction methods, and materials determined viable based on feasibility and life-cycle cost analysis are recommended for inclusion in the appropriate standard design for the FY13 program and beyond. Standard design updates could begin with recommendations from this project, and follow-on effort to add feasible, cost-effective ideas into the standards are recommended. As sustainability strategies are perfected, they should be applied to other Army building types.

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Preface

This study was conducted for Headquarters, U.S. Army Corps of Engineers under Project "COS / ERDC-CERL Adapt-Build Model Sustainability Charrettes, Military Interdepartmental Purchase Request MIPRW74RDV00120696, "Integration of Energy/Sustainable Practices into Standard Army MILCON Designs," dated 15 January 2010. The technical monitors were George Lea and Scott Wick.

The work was performed by the Engineering Processes Branch (CF-N) of the Facilities Division (CF), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Donald K. Hicks was Chief, CEERD-CF-N; L. Michael Golish was Chief, CEERD-CF; and Martin J. Savoie was the Technical Director for Installations. William D. Goran was Director of the Center for the Advancement of Sustainability Innovations (CASI), and Richard Schneider and Annette Stumpf were the leaders of the CASI Sustainable Facilities and Infrastructure Technology Focus Area. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

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- David W. Koper, US Army Engineer District, Philadelphia
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COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
foot-pounds force	1.355818	joules
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
pounds (force) per inch	175.1268	newtons per meter
square feet	0.09290304	square meters
square miles	2.589998 E+06	square meters

1 Introduction

1.1 Background

The United States Army Corps of Engineers (USACE) is working to integrate sustainability and energy efficiency into military construction (MILCON) projects. Due to the nature of Design-Build construction contracting, current standard designs, and the military budgeting process, there have been mixed results in terms of sustainability and energy performance. Federal, Army, and USACE energy and sustainability requirements can be difficult to meet with constrained budgets and construction schedules. Even so, project delivery teams are achieving more successes at meeting United States Green Building Council (USGBC) Leadership in Environmental and Energy Design (LEED) standards.

There is typically a delay between the date federal or Department of Defense (DoD) requirements are mandated and when USACE interprets the requirements and determines how to include them in USACE policy, criteria, project budgets and scope. MILCON project budgets are established a year or more before the project is designed or constructed, and the cost estimate/scope addresses only mandates in place during programming, not any requirements that have been subsequently added.

This project originated with an effort to determine funding levels needed for MILCON project budgets to support planning, programming, design, and construction that meets all current and near-term energy and sustainability mandates.

The large team who collaborated on this project, entitled “MILCON Energy Enhancement and Sustainability Study of Five Army Buildings,” performed a complex assessment of current practices and costs, state-of-the-art technologies, and LEED/energy analysis for five standard designs with the intent to develop a set of ideas to help USACE work toward the net-zero energy, water and sustainability targets. Planning ahead to meet those energy, water, and sustainability mandates will enable USACE to budget sufficient resources to meet the requirements in future construction projects.

The ERDC-CERL LEED team members who were a part of this larger project focused on documenting lessons learned during the LEED validation site visits, best-practice and missed-opportunity LEED credits, and achieving recently specified LEED credits.

1.2 Objectives

The objectives of this research were to investigate design features, construction methods, and materials to optimize five selected standard designs for MILCON projects funded in FY13 and beyond in terms of energy reduction and sustainability; and to ensure that, at minimum, those standard designs meet all applicable energy reduction and sustainable design policies. For the five selected standard designs, researchers were tasked to provide specific recommendations for:

- designing buildings that support net-zero-ready installations
- designing buildings that achieve 65% energy reduction compared to CBECS 2003 (based on EISA 2007 requirement for 2015)
- reducing domestic water consumption by 30%
- reducing waste water production by 50%
- reducing operating costs by 25%.

1.3 Approach

The following tasks were completed to meet the objectives of this project:

- The Army Sustainable Design and Development (SDD) validation team visited a representative sample of MILCON FY09 and FY10 projects to assess how well project delivery teams were able to achieve LEED and energy efficiency targets. ERDC-CERL facilitated and participated in all the validation team site visits and collected a library of case studies and lessons learned which could be successfully applied to the five building types being studied and other MILCON projects. The ERDC-CERL LEED team did an extensive analysis of similar facilities that were visited during the SDD validation site visits and applied those lessons learned to this research project.
- ERDC-CERL and Pacific Northwest National Laboratory (PNNL) LEED team members are participating in an ESTCP demonstration project funded by DoD intended to validate whether "whole building" design achieves a higher building performance. ESTCP project SI-0724 "Design Monitoring, and Validation of a High Performance Building"

was applied to PN 65830 Fort Bragg Combined Emergency Services Station (CESS). (http://www.serdp.org/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-200724) The CESS is expected to earn a LEED-NC 2.2 Platinum rating, and one of the ESTCP research project tasks is to share the lessons learned with USACE Centers of Standardization. ESTCP team members from PNNL participated with CERL LEED team members in meetings with the Centers of Standardization during this project, and developed Technical Notes which are available on the HQUSACE COS website at url: https://eportal.usace.army.mil/sites/COS/HQ/default.aspx

- Investigated "green" product availability, capabilities, and shortcomings for TechNote series.
- Visited Centers of Standardization (COSs) to solicit input: Savannah, GA (01-05 March 2010, 26-29 July 2010), Fort Worth, TX (05-07 April 2010), and Norfolk (23-25 August 2010).
- Collected and evaluated data from Army Sustainable Design and Development/LEED validation teams reviews (and other projects) to assess current LEED achievements and identify opportunities for improvement.
- Prioritized LEED strategies for implementation to achieve mandate objectives.
- Identified missed-opportunity credits (i.e., those missing from most projects) and investigated which were recommended in terms of satisfying mandates and LEED point accumulation.
- Conducted Army-wide topical webinars to educate staff and solicit input from practitioners.
- Assessed "green" design, acquisition, and construction practices compatible with Army processes.
- Reviewed some Unified Facility Guide Specifications (UFGSs) and Unified Facilities Criteria (UFCs) for sustainability objectives.

The results of these tasks were used in studying the feasibility of implementing sustainable-design strategies. For those strategies thought to be viable, pricing data were collected to determine the cost delta between the five current building standards and their new sustainable versions.

Cost estimating for the project was done by the USACE Fort Worth District. Figures generated by their staff were transferred to PAX system administrators for input into the DD Form 1391 PAX processing system. The 1391 template information (e.g., scope and cost) was incorporated into the

PAX system based on facility type, location of construction, energy or sustainability feature, its cost, and the life-cycle costing data for Fiscal Year 2013 and beyond.

Early in the project, a process was developed to refine and propose a method of testing for the new building standards. It is shown in Figure 1.

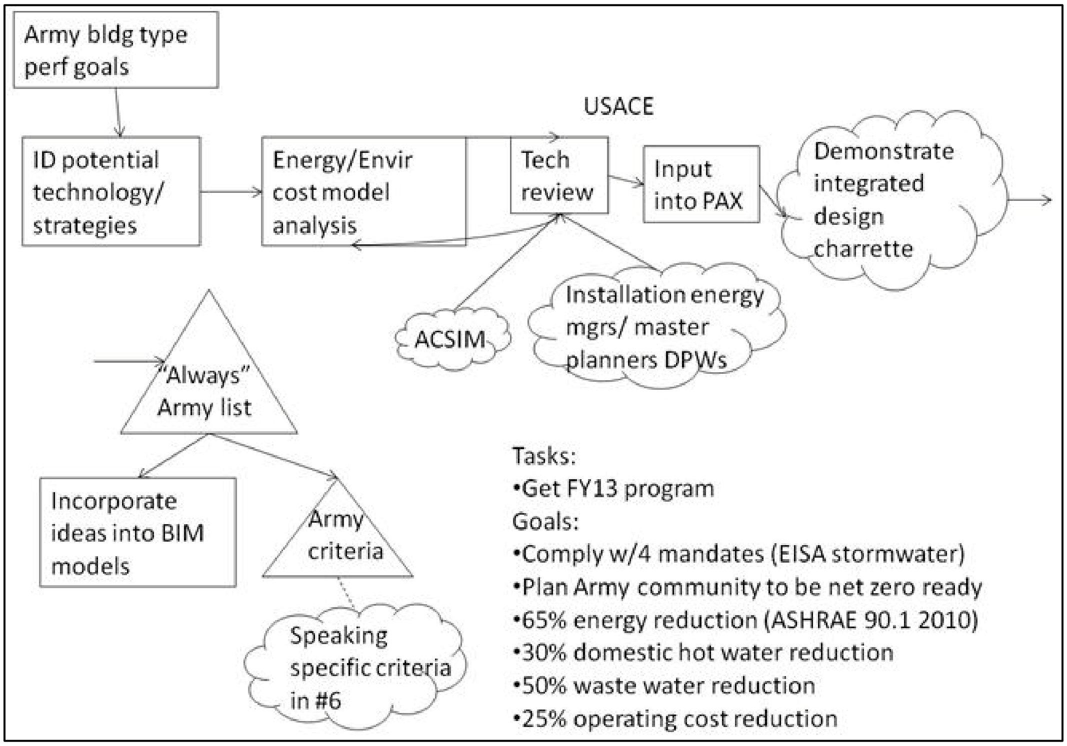

Figure 1. Research process to achieve compliance.

1.4 Scope

This study focuses on the following Army standard facility types:

- Battalion/Brigade Headquarters (BN/BDE HQ)
- Company Operations Facilities (COF)
- Dining Facilities (DFAC)
- Tactical Equipment Maintenance Facilities (TEMF)
- Unaccompanied Enlisted Personnel Housing (UEPH).

Selections were based on those facility types programmed in the greatest numbers over the next 5 years. With the exception of UEPH, selections included all standard facility types with fully developed Adapt-Build models. Not only were the Adapt-Build models conducive to the computer modeling and simulations in this study, but their prescriptive nature allowed for the direct and expedient incorporation of study findings into the design process. This integration would have been cumbersome in the performance based Design-Build delivery mode. The specific building projects used for this research included:

- Brigade Headquarters (BDEHQ): 4th Brigade Combat Complex Heavy Brigade HQ, Fort Stewart, FY10 LI 62033
- Company Operations Facility (COF): 4th Brigade Combat Complex (Heavy) COF, Fort Stewart, FY10 LI 62033
- Dining Facility (DFAC): 108th ADA Complex DFAC, Fort Bragg, FY11 LI 74987
- Tactical Equipment Maintenance Facility (TEMF): Vehicle Maintenance Shop 7th Transportation Battalion, Fort Bragg, FY 10 LI 20807
- Unaccompanied Enlisted Personnel Housing (UEPH): PH68835 Fort Leavenworth MP Barracks.

1.5 Mode of technology transfer

Complete results from the collaborative research project addressing the five standard designs are described in the 2011 report "*MILCON Energy Enhancements and Sustainability Study of Five Army Buildings – Summary Report*[1]." This report will be made available by HQUSACE when it is completed. That report covers energy efficiency, cost implications, and other details not addressed by this technical report.

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[1] "*MILCON Energy Enhancements and Sustainability Study of Five Army Buildings- Summary Report*" Collaboration by USACE, ERDC-CERL, NREL and PNNL will be published and made available by HQUSACE in 2011.

Table 1. LEED credits addressed in this technical report.

Sustainable Sites (26 pts)			
SSPR1	**req**		**Construction Activity Pollution Prevention**
SS1	**1**		**Site Selection**
SS2	**5**		**Development Density & Community Connectivity**
SS3	**1**		**Brownfield Redevelopment**
SS4.1	**6**		**Alternative Transportation**, Public Transportation Access
SS4.2	**1**		**Alternative Transportation**, Bicycle Storage & Changing Rooms
SS4.3	**3**		**Alternative Transportation**, Low Emitting & Fuel Efficient Vehicles
SS4.4	**2**		**Alternative Transportation**, Parking Capacity
SS5.1	**1**		**Site Development,** Protect or Restore Habitat
SS5.2	**1**		**Site Development,** Maximize Open Space
SS6.1	**1**		**Stormwater Design**, Quantity Control
SS6.2	**1**		**Stormwater Design**, Quality Control
SS7.1	**1**		**Heat Island Effect**, Non-Roof
SS7.2	**1**		**Heat Island Effect**, Roof
SS8	**1**		**Light Pollution Reduction**
Water Efficiency (10 pts)			
WEPR1	**req**		**Water Use Reduction**, 20% Reduction
WE1	**2 to 4**		**Water Efficient Landscaping**
WE2	**2**		**Innovative Wastewater Technologies**
WE3	**2 to 4**		**Water Use Reduction**
Indoor Environmental Quality (15 pts)			
IEQPR1	**req**		**Minimum IAQ Performance**
IEQPR2	**req**		**Environmental Tobacco Smoke (ETS) Control**
IEQ1	**1**		**Outdoor Air Delivery Monitoring**
IEQ2	**1**		**Increased Ventilation**
IEQ3.1	**1**		**Construction IAQ Management Plan**, During Construction
IEQ3.2	**1**		**Construction IAQ Management Plan**, Before Occupancy
IEQ4.1	**1**		**Low-Emitting Materials**, Adhesives & Sealants
IEQ4.2	**1**		**Low-Emitting Materials**, Paints & Coatings
IEQ4.3	**1**		**Low-Emitting Materials**, Carpet Systems
IEQ4.4	**1**		**Low-Emitting Materials**, Composite Wood & Agrifiber Products
IEQ5	**1**		**Indoor Chemical & Pollutant Control**
IEQ6.1	**1**		**Controllability of Systems**, Lighting
IEQ6.2	**1**		**Controllability of Systems**, Thermal Comfort
IEQ7.1	**1**		**Thermal Comfort**, Compliance
IEQ7.2	**1**		**Thermal Comfort**, Validation
IEQ8.1	**1**		**Daylight & Views**, Daylight 75% of Spaces
IEQ8.2	**1**		**Daylight & Views**, Views for 90% of Spaces

2 Primary Mandates, Policies, Standards and Metrics

2.1 Federal policy

2.1.1 Executive Order 13514 (2009)

Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (5 October 2009) sets sustainability goals for federal agencies and focuses on making improvements in their environmental, energy and economic performance. The executive order requires federal agencies to set a 2020 greenhouse gas emissions reduction target within 90 days; increase energy efficiency; reduce fleet petroleum consumption; conserve water; reduce waste; support sustainable communities; and leverage federal purchasing power to promote environmentally-responsible products and technologies.

2.1.2 Executive Order 13423 (2007) and the HPSB Guiding Principles (2008)

EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (24 January 2007) sets goals in the areas of energy efficiency, acquisition, renewable energy, toxics reductions, recycling, renewable energy, sustainable buildings, electronics stewardship, fleets, and water conservation. In addition the order requires more widespread use of environmental management systems as the framework in which to manage and continually improve these sustainable practices.

Furthermore, EO 13423 requires federal agencies to comply with high performance sustainable building (HPSB) principles in new construction and major renovation of agency buildings per the *High Performance and Sustainable Buildings Guidance* (December 2008) issued by the Office of Management and Budget (OMB).[2] In the companion Memorandum of Understanding (MOU), signatory agencies committed to follow a set of principles in the siting, design, construction, and commissioning of federal buildings. The HPSB principles (or "Guiding Principles") are as follows:

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[2] U.S. Department of Energy Guide (DOE G) 413.3-6, High Performance Sustainable Building, Washington, DC: DOE, 20 June 2008.

- employ integrated design
- optimize energy performance
- protect and conserve water
- enhance indoor environmental quality
- reduce environmental impact of materials.

2.1.3 Energy Independence and Security Act of 2007

The *Energy Independence and Security Act* (EISA) of 2007 was enacted to move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the federal government, and for other purposes. EISA 2007 sets federal energy management requirements in several areas. Those pertaining to high-performance buildings are shown in Table 2.

Table 2. EISA sections relevant to sustainable federal buildings.[3]

EISA Section	EISA Requirement
323	Requires an estimation of future building energy performance and a description of energy efficient and renewable energy systems.
401	Defines 'High Performance Green Buildings.'
431	Requires that total energy use in federal buildings, relative to the 2005 level, be reduced 30% by 2015. Defines "Commissioning".
432	Directs that federal energy managers conduct a comprehensive energy and water evaluation for each facility at least once every four years.
433	Requires that fossil-fuel energy use—relative to the 2003 level—be reduced 55% by 2010 and be eliminated (100% reduction) by 2030 (new federal buildings and major renovations only). Requires the identification of a High Performance Green Building certification system and the certification of 5% of the total number of buildings annually certified by a federal agency.
434	Requires that each federal agency ensure that major replacements of installed equipment (e.g., heating and cooling systems), or renovation or expansion of existing space, employ the most energy efficient designs, systems, equipment and controls that are life-cycle cost effective.
435	Prohibits federal agencies from leasing buildings that have not earned an EPA Energy Star label.
436	Requires GSA to establish an Office of Federal High-Performance Green Buildings to coordinate green building information and activities within GSA and with other federal agencies. The Office must also develop standards for federal facilities, establish green practices, review budget and life-cycle costing issues, and promote demonstration of innovative technologies.
437	Directs GAO to audit the implementation of activities required under this subtitle. The audit must cover budget, life-cycle costing, contracting, best practices, and agency coordination.

[3] EISA 2007.

EISA Section	EISA Requirement
438	Requires federal facility development projects with a footprint exceeding 5,000 sf to use site planning, design, construction, and maintenance strategies to control storm water runoff.
439	Directs GSA to review the current use of, and design a strategy for increased use of cost-effective lighting, ground source heat pumps, and other technologies in GSA facilities.
440	Authorizes $4 million per year over five years to support work under sections 434-439 and 482.
441	For the purpose of conducting life-cycle cost calculations, increases the time period from 25 years, in prior law, to 40 years.
523	Requires 30% of the hot water demand in new federal buildings (and major renovations) to be met with solar hot water equipment, provided it is life-cycle cost-effective.
542	Establishes grants for development, implementation, and installation of onsite renewable energy technologies that generate electricity from renewable resources (solar, wind, fuel cells, and biomass) on or in any government building

2.1.4 Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPAct 2005) established a number of energy management goals for federal facilities and fleets. It also amended portions of the National Energy Conservation Policy Act (NECPA). EPAct 2005 sets federal energy management requirements in several areas, including: metering and reporting, energy-efficient product procurement, energy savings performance contracts, building performance standards, renewables energy requirement, and alternative fuel use. Of particular interest is Section 109 of the Act that sets forth the requirements for federal building performance:

- Directs new federal buildings—commercial or residential—to be designed 30% below ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) standards or the International Energy Code.
- Includes the application of sustainable design principles for new buildings.
- Requires federal agencies to identify new buildings in their budget requests and those that meet or exceed the standards, which the US Department of Energy (DOE) must include in its annual report.[4,5]

[4] U.S. Department of Energy. 4 May 2010. Energy Efficiency & Renewable Energy, Federal Energy Management Program, Laws and Regulations. *Energy Policy Act of 2005*. http://www1.eere.energy.gov/femp/regulations/epact2005.html#bps (Accessed 28 January 2011).

[5] It should be mentioned that EISA 2007 and E.O. 13423 were issued subsequent to the passage of EPAct 2005 and these authorities update many of the energy management requirements of EPAct 2005.

2.2 Army policy

2.2.1 ECB 2011-1

Engineering and Construction Bulletin (ECB) No. 2011-1, *High Performance Energy and Sustainability Policy* (CECW-CE, 19 January 2011), implements new policies and procedures into the Military Construction, Army (MCA) program. This ECB recommends technologies and strategies that resulted from the MILCON Energy Enhancement and Sustainability Study of Five Army Buildings project.
http://www.wbdg.org/ccb/ARMYCOE/COEECB/ecb_2011_1.pdf

The ECB includes a list of project features that are thought to aggressively enhance the energy and sustainability performance of Army buildings (Table 3). These features are considered technical requirements for all projects from FY13 on. However, any energy-related design decisions involving major systems and features that exceed 1 percent of the programmed amount (PA) in cost require a life cycle cost analysis (LCCA). Out-year provisions provide for central plant and centralized renewable energy production for multiple buildings. Furthermore, all MCA projects meeting the minimum program requirements (MPR) for LEED certification are to be planned, designed, and built to be GBCI-certified at the Silver level or higher. Certain requirements must be met in terms of LEED credit choices; these are outlined in Table 4.[6]

Attachment A of ECB 2011-1 lists viable energy and sustainability enhancements that projects must consider.

[6] Engineering and Construction Bulletin No. 2011-1, High Performance Energy and Sustainability Policy (CECW-CE, 19 January 2011).

Table 3. Energy and sustainability enhancements.

1	Optimize building orientation (East-West Axis with Passive Solar Shading Geometry)
2	Tight construction w/ Infiltration less than .15 cfm per square foot of exterior envelope area at 75 PA
3	Added insulation to high performance “Passivehaus” levels
4	Design detailing to avoid thermal bridges that allow heat to bypass insulation
5	Windows: Triple-pane, Energy Star, with low-E coatings appropriate to climatic zone.
6	Lighting: lower lighting consumption to average 0.75W/ft2 or less.
	a) Low maintenance, low wattage-per-lumen technologies, e.g. SSL/LED fixtures
	b) Occupancy, Vacancy, and Daylighting sensors for active ambient light control
	c) Increase vertical glazing by 50% over standard designs
	d) Increase Skylight to Floor Area (SFA) fraction to 3% over corridors, admin areas & office
	e) Use digital multi-zone lighting controls with individually addressable fixtures
7	“Cool Roof’ Finishes where cooling load exceeds heating (e.g. Climate Zones 1-5)
8	Top Tier Energy Star or FEMP rated appliances and equipment.
9	Demand/user controlled High Efficiency HVAC equipment per ASHRAE 189.1
10	Optimize HVAC zones with respect to user schedules and occupancy.
11	Include Energy Recovery Ventilation (ERV) systems with >75% efficiency
12	Dedicated Outside Air System (DOAS) for ventilation with heat recovery for assembly and heat/fume generating activities
13	Indirect Evaporative Pre-Cooling (IEPC or IDEC) for Dry Climates (Climate Zones *x* B)
14	HVAC equipment efficiency ratings (e.g. COP) that exceed ASHRAE 189.1 (C) requirements
15	High Efficiency condensing boilers with >90% efficiency and/or incorporate Ground Source Heat Pump technology
16	NEMA MG1 Premium Efficiency / Electronically Commutated Motors (ECM) motors
17	Variable Air Volume (VAV) or hydronic distribution; consider
	a) Radiant heating systems, especially in maintenance bays
	b) “Radiant” cooling systems in ceilings
18	Measurement and Verification (M&V) systems
19	On-site Renewable Energy elements:
	a) Transpired Solar Collectors in Climate Zones 2A to 8.
	b) SSL/LED parking and street lighting; site-specific light distribution patterns
	c) Prepackaged pole-mounted solar site lighting solutions
	d) Include 30% demand solar water heating in areas where the average sun exposure is equal or greater than 4.0 kWh/m2 per day according to the National Renewable Energy Lab (http://www.nrel.gov/gis/solar.html) in accordance with the SDD policy.
20	Maximum flow rates for plumbing fixtures per ASHRAE 189.1
	a) Dual-flush toilets
	b) Waterless Urinals: urinals that use either no water or no potable water (e.g. may use harvested rainwater or reclaimed graywater)
21	Stormwater management: Meet local codes and Low Impact Development (LID) best practices (e.g. pervious pavement, rainwater harvesting, swales, bioretention ponds)

Table 4. Favored LEED credit categories.[7]

Credits required to meet first 40% of Silver Certification point total (any combination)	Credits required in all MCA projects (where applicable)
(a) SS 7.1 Heat Island Effect, Non-Roof	(a) SS 6.1 Stormwater Design, Quantity Control
(b) SS 7.2 Heat Island Effect, Roof	(b) SS 6.2 Stormwater Design, Quality Control
(c) SS 8 Light Pollution Reduction	(c) WE 1 Water Efficient Landscaping: No potable water used for irrigation
(d) WE 1.1 Water Efficient Landscaping - Reduce Potable Water Use by 50%	(d) WE 3 Water Use Reduction: earn at least two points under this credit
(e) WE 1.2 Water Efficient Landscaping - No Potable Use or No Irrigation	(e) EA 1 Optimize Energy: earn at least 15 points under this credit
(f) WE 2 Innovative Wastewater Technologies	(f) EA 3 Enhanced Commissioning
(g) WE 3 Water Use Reduction	(g) EA 5 Measurement and Verification
(h) EA 1 Optimize Energy Performance	(h) MR 2 Construction Waste Management
(i) EA 2 On-Site Renewable Energy	(i) MR 4 Recycled Content
(j) EA 3 Enhanced Commissioning	(j) IEQ 3.1 Construction IAQ Management Plans
(k) EA 5 Measurement & Verification	(k) IEQ 3.2 Construction IAQ Management Plans
(l) EA 6 Green Power	(l) IEQ 7.1 Thermal Comfort Design
(m) IEQ 1 Outside Air Delivery Monitoring	
(n) IEQ 8.1 Daylight & Views - Daylight 75% of Spaces	
(o) ID 1.1-1.5 Innovative Design, if achieved for energy and/or water savings	
(p) RP 1.1-1.4 Regional Priorities, if achieved for energy and/or water savings	

2.2.2 ECB 2010-14

ECB No. 2010-14, *Improving Building Performance through Enhanced Requirements for Energy Performance and Select LEED Credits* (CECW-CE, 28 June 2010) derives from an Army Memorandum dated 12 May 2010 addressing *Constructive Use of FY 2010 and Future Bid Savings*. The purpose of the ECB was to establish new requirements for enhanced energy performance and select LEED credits for all MCA projects, effective as noted in Table 5. This ECB expires after the FY13 program.

Table 5. Summary of ECB 2010-14 requirements.

Contract Type (target baseline)	New Requirement or Target
USACE Contract, Design-Build (30% below the consumption of a baseline building compared to ASHRAE 90.1-2004)	at least 40% below the consumption of a baseline building compared to ASHRAE Standard 90.1-2007
	option for an additional 10% energy savings for a total of 50% energy consumption savings compared to ASHRAE Standard 90.1-2007
USACE Contract, Design-Bid-Build	at least 40% below the energy consumption of a baseline building

[7] The 40 percent minimum is stipulated in the Department of Defense Sustainable Buildings Policy (DUSD (I&E), 25 Oct 10).

Contract Type (target baseline)	New Requirement or Target
(30% ASHRAE 90.1-2004 baseline)	meeting the requirements of ASHRAE 90.1-2007
	may design a building to achieve greater than 40% energy reduction if this can be accomplished within the authorized program amount
USACE Contract, LEED credits to be included in solicitation requirements (n/a)	A. WE 1 Water Efficient Landscaping – No potable water used for irrigation. Applicable to all projects. B. WE 3 Water Use Reduction – At least 30% reduction. Applicable to all projects. C. EA 1 Optimize Energy points that correspond to energy use reduction indicated in paragraph 2 of the ECB. D. EA 3 Enhanced Commissioning – Improved O & M (training, manuals and follow-up). Applicable to all buildings with LEED Silver requirement. E. IEQ 7.1 Thermal Comfort Design – Improved indoor environment. Applicable to all buildings with LEED Silver requirement.

2.3 Other

2.3.1 ASHRAE 189.1

ASHRAE 189.1 was adopted as part of the Army Sustainability Policy per a policy memorandum issued by Ms. Katherine Hammack on October 27, 2010. Standard 189.1 covers a wide range of topics – site sustainability, water and energy use efficiency, indoor environmental quality, and the impact of a building on the atmosphere, materials and resources. The Army policy sets ASHRAE 189.1 as the baseline for efficient military construction projects and major renovations. Project teams will need to understand the details of ASHRAE 189.1 in order to comply with the requirements, and the ASHRAE publication "Standard 189.1-2009 User's Manual" should be very informative. ASHRAE publications are available to USACE project team members via the MADCAD library within the Whole Building Design Guide (WBDG) Construction Criteria Base (CCB) at url: http://www.wbdg.org/references/ngstandards.php?a=army

2.3.2 LEED 2009

The LEED Green Building Rating System™ is a voluntary standard that defines high performance sustainable buildings—which are healthier, more environmentally responsible, and more cost effective to operate.[8] The primary reason for using LEED 2009 as a metric for the sustainable design of Army standard facilities is the requirement in EISA to have at

8 DOE G 413.3-6, p B-1.

least 5% of new federal construction LEED certified annually.[9] LEED certification validates that a building is a high performing, sustainable structure. Certification also benchmarks a building's performance to support ongoing analysis over time to quantify the return on investment of green design, construction, systems, and materials.[10]

Table 6. Mapping mandates, policies, standards to LEED. (Double click table to access full-size table).

Mapping Mandates/Policies/Standards (MPS) to LEED®

● Required
◑ Less Stringent Requirements/Building or Site Specific
○ Related/Best Practices Guidance

Click on Credit Name for LEED® NC 2009 Rating System
Enter Page Number by Page Up/Down Arrows to See Credit Language

		Pts	EPAct 2005	EISA 2007	EO 13423	EO 13514	HPSB GP 12/1/08	SDD Policy 10/27/10	Army, Fed Regs & Policies	ECBs	ASHRAE 189.1	All to Left	All to Left but 189.1	* Credits, Getting Now
	Sustainable Sites	**Pts**												
Prereq 1	Construction Activity Pollution Prevention, p. 1			○	◑	◑	◑	●	●	●	●	●	●	●
Credit 1	Site Selection, p. 2	1		○				●	○		●	●	●	◑
Credit 2	Development Density and Community Connectivity, p. 3	5		○				◑	○		◑	◑	◑	
Credit 3	Brownfield Redevelopment, p. 5	1		○				◑	○		◑	◑	◑	
Credit 4.1	Alternative Transportation—Public Transportation Access, p. 6	6		○		○		◑			◑	◑	◑	
Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms, p. 7	1		○		○		○			○	○	○	◑
Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles, p. 8	3		○		○						○	○	◑
Credit 4.4	Alternative Transportation—Parking Capacity, p. 10	2		○		○						○	○	◑
Credit 5.1	Site Development—Protect or Restore Habitat, p. 12	1						○	○		○	○	○	
Credit 5.2	Site Development—Maximize Open Space, p. 13	1												◑
Credit 6.1	Stormwater Design—Quantity Control, p. 14	1		●	●	●	●	●	●	●	●	●	●	○
Credit 6.2	Stormwater Design—Quality Control, p. 15	1		◑	◑	◑	◑	◑	●	●	◑	●	●	
Credit 7.1	Heat Island Effect—Non-roof, p. 16	1						●			●	●	●	○
Credit 7.2	Heat Island Effect—Roof, p. 17	1				○		●	◑		●	●	●	○
Credit 8	Light Pollution Reduction, p. 19	1						◑	◑		◑	◑	◑	◑
	Possible Points: 26 Subtotals: Required Only	●		1	1	1	1	4	2	2	4	5	5	0
	Water Efficiency													
Prereq 1	Water Use Reduction—20% Reduction, p. 21		○	○	●	●	●	●	●	●	●	●	●	●
Credit 1	Water Efficient Landscaping, p. 23	2 to 4												
	Reduce by 50%	2			●	●	●	●			●	●	●	●
	No Potable Water Use or Irrigation	4						◑		●	◑	●	●	
Credit 2	Innovative Wastewater Technologies, p. 25	2			○	○	○	○			○	○	○	
Credit 3	Water Use Reduction, p. 26	2 to 4												
	Reduce by 30%	2	○	○	○	○	○	●	○	●	◑	●	●	●
	Reduce by 35%	3						◑			◑	◑	◑	
	Reduce by 40%	4						◑			◑	◑	◑	
	Possible Points: 10 Subtotals: Required Only	●			2	2	2	4		6	2	6	6	4
	Energy and Atmosphere													
Prereq 1	Fundamental Commissioning of Building Energy Systems, p. 29			●	●	●	●	●	●	●	●	●	●	●
Prereq 2	Minimum Energy Performance, p. 31		◑	●	●	●	●	●	●	●	●	●	●	●
Prereq 3	Fundamental Refrigerant Management, p. 34			○	●	●	●	●	●	●	●	●	●	●
Credit 1	Optimize Energy Performance, p. 35	1 to 19												
	Improve by 30% for New Buildings or 26% for Existing Building Renovations	10	◑	●	●	●	●	●	●	●	●	●	●	●
	Improve by 40% for New Buildings or 36% for Existing Building Renovations	15		◑						●		●	●	changed
	Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19		◑						◑		◑	◑	
Credit 2	On-Site Renewable Energy, p. 38	1 to 7												
	3% Renewable Energy	2	○	○	○	○	○	◑	○	○	○	◑	◑	
	5% or more Renewable Energy	3	○	○	○	○	○	◑	○	○	○	◑	◑	
Credit 3	Enhanced Commissioning, p. 39	2		◑	●	●	●	●	◑	●	●	●	●	
Credit 4	Enhanced Refrigerant Management, p. 41	2			○	○	○	○	○			○	○	○
Credit 5	Measurement and Verification, p. 43	3			◑	◑	◑	◑	○	●	◑	◑	◑	
Credit 6	Green Power, p. 45	2				○						○	○	
	Possible Points: 35 Subtotals: Required Only	●		10	12	12	12	12	10	20	12	17	17	10
	Materials and Resources													
Prereq 1	Storage and Collection of Recyclables, p. 47			○	●	●	●	●	●	●	●	●	●	●
Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof, p. 48	1 to 3												
Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements, p. 49	1												
Credit 2	Construction Waste Management, p. 50	1 to 2												
	50% Recycled or Salvaged	1			●	●	●	●	●	●	●	●	●	●
	75% Recycled or Salvaged	2												
Credit 3	Materials Reuse, p. 51	1 to 2						○			○	○	○	
Credit 4	Recycled Content, p. 52	1 to 2												
	10% of Content	1		○	○	○	○	●	○	●	●	●	●	●
	20% of Content	2												
Credit 5	Regional Materials, p. 53	1 to 2												
	10% of Materials	1						●			●	●	●	◑
	20% of Materials	2												
Credit 6	Rapidly Renewable Materials, p. 54	1		○	○	○	○	○			○	○	○	
Credit 7	Certified Wood, p. 55	1			○	○	○	●			●	●	●	○
	Possible Points: 14 Subtotals: Required Only	●			1	1	1	4	1	2	4	4	4	2
	Indoor Environmental Quality													
Prereq 1	Minimum Indoor Air Quality Performance, p. 57			○	●	●	●	●	●	●	●	●	●	●
Prereq 2	Environmental Tobacco Smoke (ETS) Control, p. 58			○	●	●	●	●	●	●	●	●	●	●
Credit 1	Outdoor Air Delivery Monitoring, p. 60	1						●			●	●	●	●
Credit 2	Increased Ventilation, p. 61	1			○	○	○	○				○	○	○
Credit 3.1	Construction IAQ Management Plan—During Construction, p. 63	1		○	●	●	●	●		●	●	●	●	◑
Credit 3.2	Construction IAQ Management Plan—Before Occupancy, p. 64	1		○	●	●	●	●		●	◑	●	●	●
Credit 4.1	Low-Emitting Materials—Adhesives and Sealants, p. 66	1		○	◑	◑	◑	●			●	●	●	●
Credit 4.2	Low-Emitting Materials—Paints and Coatings, p. 68	1		○	◑	◑	◑	●			●	●	●	●
Credit 4.3	Low-Emitting Materials—Flooring Systems, p. 69	1		○	◑	◑	◑	●			●	●	●	◑
Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products, p. 71	1		○	◑	◑	◑	●			●	●	●	◑
Credit 5	Indoor Chemical and Pollutant Source Control, p. 72	1		○				◑			◑	◑	◑	○
Credit 6.1	Controllability of Systems—Lighting, p.73	1		○	◑	◑	◑	◑	○		○	◑	◑	◑
Credit 6.2	Controllability of Systems—Thermal Comfort, p. 74	1		○					○			○	○	○
Credit 7.1	Thermal Comfort—Design, p. 75	1		○	●	●	●	●	○	●	●	●	●	●
Credit 7.2	Thermal Comfort—Verification, p. 76	1						○			○	○	○	
Credit 8.1	Daylight and Views—Daylight, p. 77	1		○	◑	◑	◑	◑	◑		◑	◑	◑	
Credit 8.2	Daylight and Views—Views, p. 81	1												
	Possible Points: 15 Subtotals: Required Only	●			3	3	3	8		3	6	8	8	5
	Innovation and Design Process													
Credit 1.1	Requires EnergyStar Equipment, p. 83	1						◑	◑		◑	◑	◑	◑
Credit 1.2	Green Cleaning Plan, p. 83	1						◑			◑	◑	◑	○
Credit 1.3	Transportation Management Plan, p. 83	1						◑			◑	◑	◑	
Credit 1.4	Integrated Design, p. 83	1			◑	◑	◑	◑				◑	◑	
Credit 1.5	Air Tightness, p. 83	1								◑		◑	◑	
Credit 2	LEED Accredited Professional, p. 84	1								●		●	●	●
	Possible Points: 6 Subtotals: Required Only	●								1		1	1	1
	Regional Priority Credits													
Credit 1.1	Regional Priority: Specific Credit, p. 85	1												
Credit 1.2	Regional Priority: Specific Credit, p. 85	1												
Credit 1.3	Regional Priority: Specific Credit, p. 85	1												
Credit 1.4	Regional Priority: Specific Credit, p. 85	1												
	Possible Points: 4 Subtotals: Required Only	●												
	Totals													
	Total Points: Required	●	**0**	**11**	**19**	**19**	**19**	**32**	**13**	**34**	**28**	**41**	**41**	**22**
	Total Points: Less stringent requirements/Building Specific	◑	**10**	**12**	**11**	**11**	**11**	**31**	**6**	**5**	**28**	**33**	**33**	**15**
	Total Points: Related/Best Practice Guidance	○	**5**	**37**	**13**	**28**	**13**	**10**	**22**	**3**	**11**	**18**	**18**	**10**
	Possible Points: 114 Grand Total Points		**15**	**60**	**43**	**58**	**43**	**73**	**41**	**42**	**67**	**92**	**92**	**47**

Points have not been double counted

* This last column only is based on a study by ERDC/CERL to determine which LEED credits were being achieved in past projects by the 5 building types.
1-2 building types achieved = ○
3-4 building types achieved = ◑
5 building types achieved = ●

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 114

[9] EISA Section 433(a)(v).

[10] DOE G 413.3-6, p B-1.

3 Water as a Scarce Resource

Water resources are in crisis. The distribution of the Earth's water is such that only 0.785% of the total global water is readily available to human use (Figure 2).[11] While the amount of fresh water globally is finite, human demand for this life-sustaining resource continues to grow. The human pressures affecting water resources are most often related to factors such as demographics, economic trends, legal decisions, and climatic fluctuations.

[11] U.S. Department of the Interior. U.S. Geological Survey. 14 December 2010. "Where is Earth's water Located?" <http://ga.water.usgs.gov/edu/earthwherewater.html>. Accessed 15 December 2010.

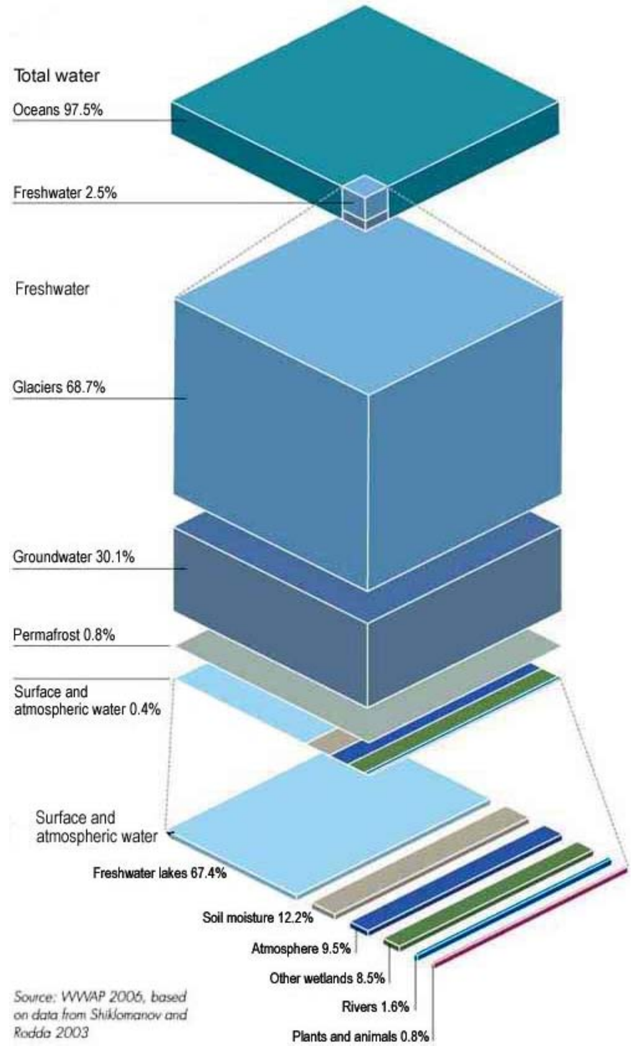

Figure 2. Distribution of Earth's water.[12]

3.1 Water Use

Estimated water use in the United States for 2005 was 410 billion gallons per day (Bgal/d). This is slightly less than the estimate for 2000. Total water withdrawals decreased by 1 percent between 2000 and 2005, while the population increased by 5 percent and continued the 50-year trend of population shift from rural to urban areas. The greatest increases in water use since 1950, when the U. S. Geological Survey began its series of water-use compilations, were experienced in Southern and Western states with commensurate increases in water demand following. Water use in the

[12] U.S. Department of the Interior. U.S. Geological Survey. 14 December 2010. "Where is Earth's water Located?" <http://ga.water.usgs.gov/edu/earthwherewater.html>. Accessed 15 December 2010. Direct reference to: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

United States peaked in 1980 due primarily to progressively greater amounts of water withdrawn for irrigation and thermoelectric power generation.[13]

Freshwater withdrawals accounted for 85 percent of the total water withdrawals. Thermoelectric-power generation consumed nearly 42 percent of freshwater withdrawals, irrigation accounted for 37 percent, and public supply accounted for 13 percent. Moreover, nearly 30 percent of all fresh surface-water withdrawals occurred in five States (California, Idaho, Colorado, Texas and Illinois) and more than half of fresh groundwater withdrawals occurred in six (California, Texas, Nebraska, Arkansas, Idaho, and Florida).[14]

Department of the Army installations used over 58 billion gallons of potable water at a cost of $57.6 M in FY 2009.[15] Water resource availability varies regionally and seasonally, placing some Army installations in positions of water scarcity. Water issues of concern include groundwater depletion, climate change, water law, energy and water, water quality, and the condition of water infrastructure systems.

By the year 2015, it is estimated that 36 states will face serious water shortages. A recent Army study found that nearly 100 of the 411 installations included (23 percent) lie within watersheds that are highly vulnerable to water crisis situations.[16] Figure 3 shows watershed health in a 5-tiered rating system with Army installations depicted as dots.

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13 Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009; Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, p.XX.

14 Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009; Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, p.52.

15 Department of the Army FY 09 Annual Energy Management Report.

16 Jenicek, Elisabeth M., Natalie R.D. Myers, Donald F. Fournier, Kevin Miller, MeLena Hessel, Rebecca Carroll, and Ryan Holmes. September 2009. Army Installations Water Sustainability Assessment: an evaluation of vulnerability to water supply. Champaign, IL: ERDC/CERL. Technical Report. ERDC/CERL TR-09-38.

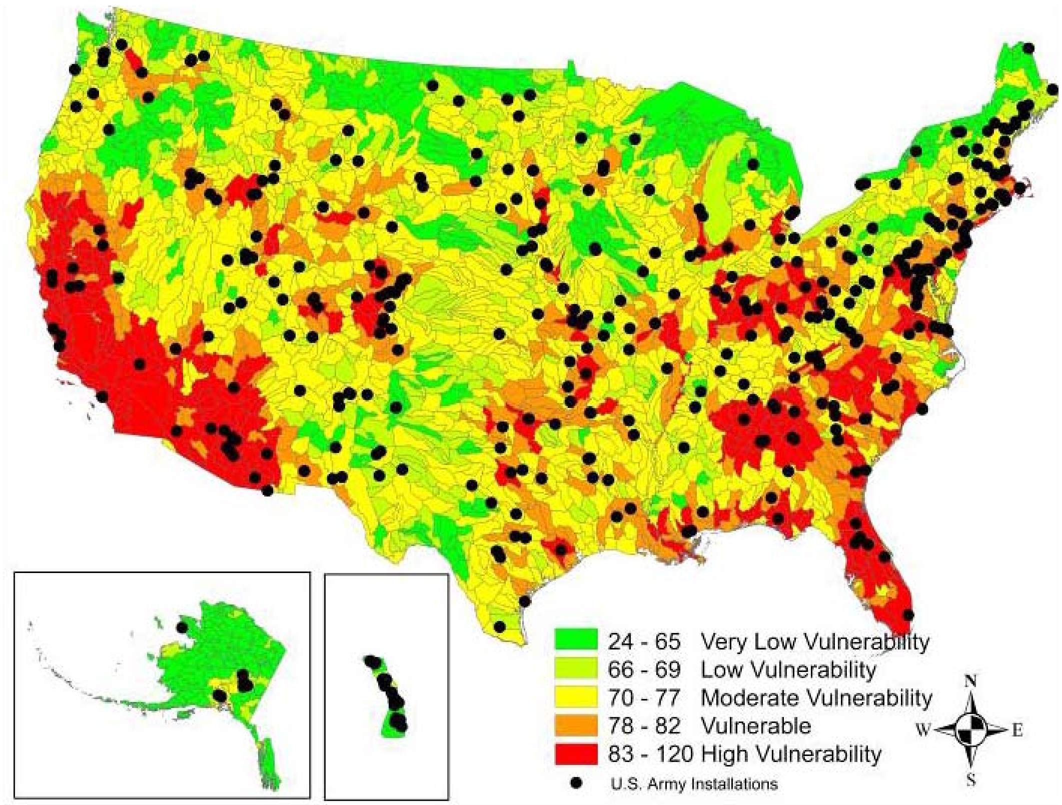

Figure 3. Water vulnerability.[17]

Although water scarcity remains a critical issue for drier regions, localized droughts are becoming more prevalent and extending for longer time periods. Climate change will impact water supplies. Water supplies in 70 percent of counties may be at risk to climate change. The Water Supply Sustainability Index with Climate Change Impacts map in Figure 4 indicates where water shortages are most likely to occur. The map serves as a starting point for more detailed analysis, either at more local scales or on specific economic sectors.[18]

[17] Elisabeth M Jenicek, Sustainable Installations Regional Resource Assessment (SIRRA™) web-based database analysis tool output, ERDC-CERL, 2010.

[18] Roy, Sujoy, B. L. Chen, E. Girvetz, E. P. Maurer, W. B. Mills, and T. M. Grieb. 2010. Evaluating sustainability of projected water demands under future climate change scenarios. New York: Natural Resources Defense Council.

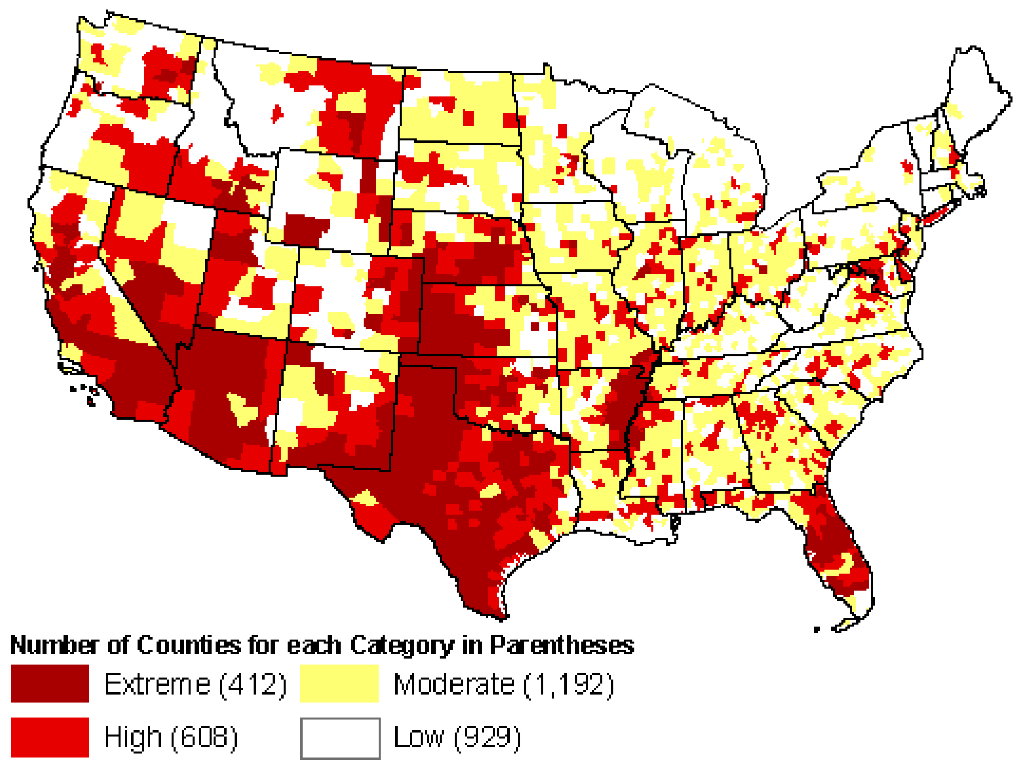

Figure 4. Water Supply Sustainability Index (2050) with climate change impacts.[19]

While using water efficiently should remain a top priority, alternative sources of water – including those available at the building level – should be considered a part of the water supply mix.[20]

Recognize that some states prohibit rainwater collection systems, particularly in the West, because of aquifer recharge and water rights issues (see Section 3.3). Figure 5 indicates areas identified by the US Global Change Program as having the potential for future water conflict. The El Paso region – the region containing Fort Bliss – is considered to have a substantial potential for future conflict.[21]

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[19] Jenicek, Elisabeth M., Natalie R.D. Myers, Donald F. Fournier, Kevin Miller, MeLena Hessel, Rebecca Carroll, and Ryan Holmes. September 2009. Army Installations Water Sustainability Assessment: an evaluation of vulnerability to water supply. Champaign, IL: ERDC/CERL. Technical Report. ERDC/CERL TR-09-38.

[20] Jenicek, Elisabeth M., Natalie R.D. Myers, Donald F. Fournier, Kevin Miller, Rebecca Carroll, MeLena Hessel, and Ryan Holmes. 2009. Army Installations Water Sustainability Assessment: an evaluation of vulnerability to water supply. ERDC/CERL TR-09-38. Champaign: ERDC/CERL. September 2009.

[21] Jenicek, Elisabeth M., Natalie R.D. Myers, Donald F. Fournier, Kevin Miller, Rebecca Carroll, MeLena Hessel, and Ryan Holmes. 2009. Army Installations Water Sustainability Assessment: an evaluation of vulnerability to water supply. ERDC/CERL TR-09-38. Champaign: ERDC/CERL. September 2009.

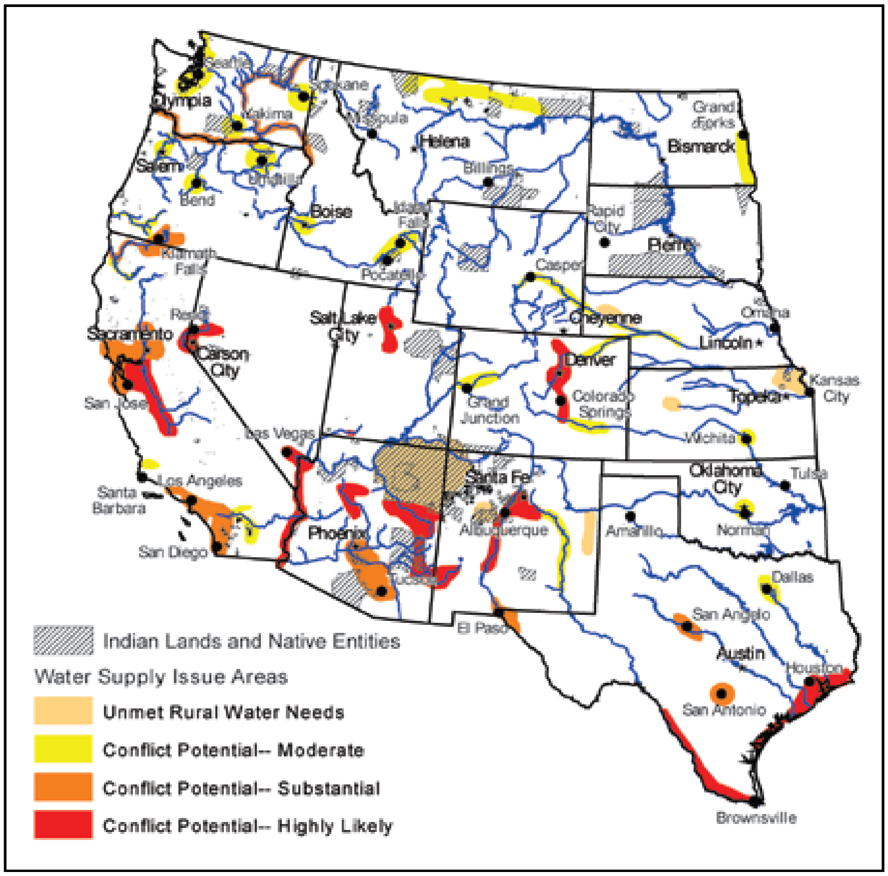

Figure 5. Future water conflict potential.[22]

3.2 Governing Legislation

Allocation of water in the United States is determined on the state level and is often based on decisions made during times of more plentiful supply and lower demand. An example of how these historical decisions play out in the 21st century is the Law of the River, a set of collective agreements that divide the rights to the waters of the Colorado River among seven states. The main provisions were established in 1922 and currently allocate more rights than there is water available from the river. The Colorado serves 30 million people and travels more than 1400 miles from its origin in the Rocky Mountains to the river's mouth at the Upper Gulf of California (Sea of Cortez).[23]

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[22] U.S. Global Change Research Program. 2009. Global Climate Change Impacts in the United States. New York: Cambridge University Press, 2009. http://globalchange.gov/publications/reports/scientific-assessments

[23] Institute of Electrical and Electronic Engineers (IEEE). 2009. Congress and DOE Focusing Intensified Attention on Energy-Water Nexus. IEEE-USA Today's Engineer online. September 2009. http://www.todaysengineer.org/2009/Sep/energywater.Asp

Disputed water is becoming all too common in the United States. Over 95 percent of available freshwater resources in the United States cross state boundaries and are affected by compacts. Although there are 39 inter-state freshwater compacts in the United States, some areas, such as a part of the Mississippi River Basin, do not have compacts in place.[24] Many existing compacts base water allocation on an overly optimistic forecast of water availability, particularly given regional warming trends.

The U.S. Energy Independence and Security Act of 2007 (EISA) requires covered facilities to complete comprehensive water assessments every four years. This must include the re-commissioning of each facility, and the implementation of cost-effective water efficiency measures. Additional policies governing installation water use include EO 13423 (26 January 2007) and 13514 (8 October 2009). Both require an annual reduction of water per square foot of building space (as compared to a 2007 baseline) by 2 percent, or a total of 16 percent, from 2008 to 2015. EO 13514 extends this requirement through 2020. Additionally, EO 13514 directs agencies to identify, promote, and implement water reuse strategies that reduce potable water consumption. It also includes requirements for industrial, landscaping, and agricultural water use. To achieve these requirements, federal facilities must employ a variety of water conservation and efficiency measures.

The Army Sustainable Design and Development Policy was recently updated (1 October 2010) to change the way the Army will approach efficient design of facilities. The revision includes incorporation of sustainable design and development principles, following guidance as detailed in ASHRAE Standard 189.1. The Army's Installation Management Campaign Plan (5 March 2010) contains a number of goals, objectives, and metrics related to water conservation. The Army Energy Security Implementation Strategy (13 January 2009), intended to supersede the Campaign Plan, and is currently under revision to include provisions for water conservation. The DoD Strategic Sustainability Performance Plan (1 August 2010) echoes the water conservation criteria found in the other documents. Table 7 summarizes federal, DoD, and Army policies that affect water use.

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[24] Hall, N. and B. B. Stuntz. 2009. U.S. water stewardship: A critical assessment of interstate watershed agreements. Watermark Initiative.

Table 7. Policies that affect water use on Army installations.

Title	Proponent	Date	Requirements/Standards
EPAct 1992		1992	Required 1.6 gpf toilets
EPAct 2005, Public Law 109-58		8/8/2005	--
OSD Memo - Installation Energy Policy Goals		11/18/2005	--
EISA 2007		12/19/2007	Comprehensive audits of 25% covered facilities/year; Implement water efficiency measures; Measure and verify water savings (requires metering); Restore pre-construction site conditions
E.O. 13423		1/29/2007	2% annual reduction from 2008 to 2016; Requires Installation Water Management Plan; Requires annual water audits of 10% of facility SF; Encouraged to purchase water efficient products, including WaterSense labeled; Encouraged to use existing tools: Best Practices from E.O. 13123
DOE Supplemental Guidance to E.O. 13423	DOE	3/29/2007	Baseline development, efficiency opportunity identification, and reporting
E.O. 13514		10/8/2009	Extends water efficiency goal to 2020; Establishes goal for industrial, landscaping, agricultural; ID, promote & implement water reuse strategies consistent with state law
DoDI 4170.11		9/9/2009	Adopts requirements of E.O. 13423 and EISA 2007
Army Energy Security Implementation Strategy	IMCOM	1/13/2009	Will be revised to include impacts of energy on water availability/demand
Installation Mgmt Campaign Plan	IMCOM	3/5/2010	Establishes Energy Efficiency and Security objective; EN-1: Reduce energy and water consumption; EN1-1: Institutionalize savings & conservation procedures; Metric: % of key positions w/energy & water mgmt accountability; Metric: % reduction in water consumption per SF; Metric: % of installations with CEMWPs; Metric: % of installations with CEMWPs; EN 1-2: Provide full-time, trained & certified mgrs to lead pgm on installation & regions; Metric: % of trained/certified energy managers; EN 1-3: Create tools to measure data & trends for energy/water; Metric: % of eligible buildings with advanced meters; Metric: % of buildings connected to a UMCS; Metric: % of installations inputting AEWRS accurately, on time, & 100%; EN 1-4: Instill an energy-conscious culture in our communities; Metric: % of installations w/awareness activities during EAM; Metric: % of installations w/strategic media programs targeted to commy; Metric: % of installations w/active local energy awards program; EN-2: Increase energy & water efficiency and modernize infrastructure; EN2-1: % validated energy perf. For new constr, restoration, modernization (UFC 3-400-01 & IMCOM Energy Standards; EN2-2: Incorporate LEED reqmts into the design and construction processes; EN2-3: Execute modernization of Army facilities to reduce energy use

Title	Proponent	Date	Requirements/Standards
DoD Strategic Sustainability Performance Plan		8/1/2010	Incorporates water efficiency requirements from EO 13514
Army Sustainable Design and Dev Policy Update		10/1/2010	30% reduction as compared to baseline as per ASHRAE 189.1 (new construction); 50% reduction in outdoor potable water use as compared to baseline
Army Energy and Water Campaign Plan - OBE	ACSIM	12/1/2007	Established Initiative #4 to conserve water resources; Assess water use, cost and availability at installations, Improve water storage and distribution systems; Increase efficiency of plumbing fixtures; Limit use of potable water for irrigation and use native plants; Increase efficiency and reduce losses in process water use; Prioritize projects and develop implementation strategies; Develop technical standards and training for project develop; ID water resources for future demands to meet mission critical needs
AR 420-1, Army Facilities Management		2/12/2008	Requires staffing for energy/water based on installation SF; Requires recycled water where life cycle cost effective; Requires Water Resource Management Plan; Requires water meters in new construction
AR 420-41, Acquisition & Sale of Utilities Services		9/15/1990	Identifies reimbursable customers for utility services on installations; Utility rates include O&M costs plus transmission losses; Requires utility purchaser to install meter (this is being changed)
Other Miscellaneous			
Green Plumbing & Mechanical Code Supplement	IAPMO		--
WaterSense Program	DOE		Criteria for faucets, shower heads, toilets, urinals, landscape irr. Controllers; Certification program for housing
WBDG Federal Green Const Guide for Specifiers			Section 22 40 00 (Section 15400) Plumbing Fixtures
WBDG: "Protect and Conserve Water"			--
PNNL-15320, Market Assess for Federal Sector	FEMP	8/1/2005	Assesses water conservation potential in the federal sector

3.3 Water Law

Water regulation in the US is determined on a state by state basis, as shown in Figure 6. This report surveys water rights in Georgia and Kansas, two project locations that include standard building types of interest.

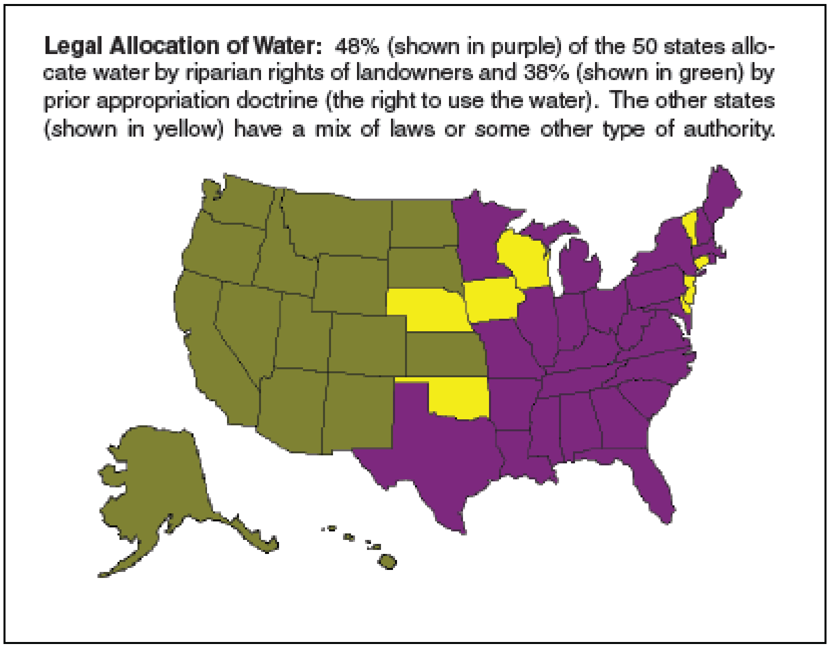

Figure 6. Water rights vary by state.[25]

3.3.1 Georgia, as it relates to Fort Benning water

Water availability from most surface water sources in Georgia is legally limited by the state's 2001 Interim Instream Flow Protection Strategy, which for an instream withdrawal, such as the one proposed for Fort Benning, allows the applicant to withdraw either:

1. The lesser of the monthly 7Q10 or the inflow to that point,[26]
2. A minimum determined by a site-specific study, or
3. 30 percent of the mean annual average flow.

However, this policy does not apply to heavily regulated streams such as the Chattahoochee, for which the state is committed to finding a consensus approach for flow protection.[27]

Although it is unclear from the interim policy precisely what policy should be applied to the Chattahoochee and other heavily regulated streams, it is presumed that the state's older instream flow policy still applies to those

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[25] Association of State Drinking Water Administrator, National Analysis of State Drinking Water Programs in the Areas of Water Availability, Variability, and Sustainability (WAVS), February 2009.

[26] The "7Q10" flow is a 7-day consecutive low flow which recurs at a frequency of once every 10 years.

[27] Board of Natural Resources, State of Georgia, May 2001. Interim instream flow protection strategy. Water issues white paper.

streams. This policy states that in the absence of other flow limits as established by the Georgia Department of Natural Resources (DNR), surface water users must allow the annual 7Q10 flow to pass downstream so long as such a flow would not unreasonably adversely affect the stream or other users.[28] The 7Q10 flow is the lowest 7-day average flow with a recurrence interval of 10 years. In theory, the 7Q10 flow of the Chattahoochee River at the intake point for Fort Benning's water supply represents the legal limit for the installation's water withdrawal.

Of course, this older policy was updated precisely because of doubts about its ability to adequately protect minimum river flows. As the interim flow policy states: "[the] DNR's 7Q10 rule…is NOT based on the science of how much water should remain in a stream to maintain a healthy aquatic community," [emphasis original].[29]

3.3.2 Kansas, as it relates to Fort Riley water

The Republican River Compact allocates all of the waters of the Republican River basin between Colorado, Nebraska, and Kansas. Colorado is permitted to use an annual total of 54,100 acre-feet, Kansas 190,300 acre-feet annually, and Nebraska 234,500 acre-feet annually.[30] In 1998, Kansas filed a complaint with the U.S. Supreme Court claiming that Nebraska had violated the Compact by allowing the unimpeded construction of thousands of wells that were hydraulically connected to the Republican River and its tributaries. Kansas also accused Nebraska of using more water than it was allowed under the Compact, thus depriving Kansas of its full claims. The state of Colorado was also added in the lawsuit since the headwaters of the Republican River are located there, making the case Kansas v. Nebraska and Colorado.[31]

The case was settled in 2003, and during that year the three states reached agreement on the Republican River Compact Association (RRCA) ground-

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[28] Board of Natural Resources 2001.

[29] Board of Natural Resources 2001, p 26.

[30] Republican River Compact. 1942. About the compact.

http://www.republicanriver.com/CompactInfo/RepublicanRiverCompact/tabid/159/Default.aspx

[31] Colorado Division of Water Resources. The Republican River Compact.

http://water.state.co.us/wateradmin/RepublicanRiver.asp water model.[32] However, continued disputes over Nebraska's alleged overuse of water, and the disagreement over Colorado's plan to build a pipeline to the North Fork Republican River from a wellfield several miles to the north of the river, highlight the complexity of water rights issues in the Republican River basin. As a military installation, Fort Riley is not subject to state water regulations. However, due to the interconnectedness of the surface and groundwater systems in the area, the amount of water that other users are allowed to withdraw from the rivers and its alluvial aquifers affect the supply available to Fort Riley.

3.4 Water costs

Water costs are rising as demand threatens to outstrip supply; however, price is a lagging indicator and may not rise precipitously until emergency conservation measures are needed. Notably, water costs are not directly tied to its scarcity.

Army installations are subject to the prevailing rates for water supply. Army water rates are sporadically and sometimes inaccurately reported through Army Energy and Water Reporting System (AEWRS).[33] There is a wide variation in water rates; the average of these rates is $3.05/Kgal and increases approximately 4.8 percent annually. Costs remain higher for installations in California, Massachusetts, and the Washington D.C. region.[34]

3.5 Other considerations

Throughout the United States, aging infrastructure poses additional threats to the water supply. The condition of distribution systems is of grave concern as leaks waste precious water. Every year, approximately 240,000 water main breaks occur. This leads to an annual 1.7 trillion gal of water lost, at a cost of $2.6 billion. Unfortunately, the privatized utilities

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[32] Kansas Department of Agriculture. 2010. Republican River Compact and Enforcement Update. http://www.ksda.gov/interstate_water_issues/content/142

[33] U.S. Army Audit Agency. 2010. Water Conservation Resources. Audit Report: A-2010-0158-FFE. 18 August 2010.

[34] American Water Works Association (AWWA) and Raftelis Financial Consultants, Inc. 2009. 2008 Water and wastewater rate survey. Denver: AWWA.

program places the burden for infrastructure maintenance and repair on contractors.[35]

The American Water Works Association targets 15 percent as a typical figure for unaccounted for water.[36] The American Society of Civil Engineer's (ASCE) Infrastructure Report Card gives drinking water a "D-." ASCE further identifies an annual shortfall of at least $11 billion needed to replace facilities at the end of their useful life and to comply with existing and future water regulations.[37]

The USEPA's Gap Analysis estimated that if water system investment remains static, the funding shortfall could exceed $500 billion by 2020, $271 billion for clean water capital costs and $263 billion for drinking water capital costs.[38]

Infrastructure condition is important for two reasons. The age and condition of water distribution systems on-post are similar to those off-post. The reality of water loss through distribution system leakage was addressed in one form through utility privatization. For installations that purchase water from municipal utilities, condition of local infrastructure can affect availability of water to the Army.

In addition, water and energy are interconnected commodities. Water systems use large amounts of energy to heat, cool, and treat water; simultaneously, water is used for hydro-power, and cooling water is critical in power plants that would otherwise overheat as they generate large amounts of electricity. Both are under pressure to decrease consumption; both will be affected by the future changes in climate and availability.

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[35] U.S. Environmental Protection Agency. 2007. Addressing the Challenge Through Innovation. Aging Water Infrastructure Research Program, Office of Research and Development, National Risk Management Research Laboratory. EPA/600/F-07. Cincinnati, OH: EPA-ORD-NRMRL. September 2007.

[36] American Water Works Association (AWWA). 2009. Water audits and loss control programs. AWWA Manual M36. Denver: American Water Works Association.

[37] American Society of Civil Engineers (ASCE). 2009. Report card for America's infrastructure. Accessed 10 August 2010. <http://www.infrastructurereportcard.org/fact-sheet/wastewater>

[38] U.S. Environmental Protection Agency (USEPA). 2002. The Clean Water and Drinking Water Infrastructure Gap Analysis. EPA-816-R-02-020. Washington DC: USEPA. September 2002.

4 Sustainable Sites (SS)

The LEED Sustainable Sites (SS) credits concentrate on the building's landscape, hardscape, and other exterior functions of the building. The Centers of Standardization (COS) maintain authority for the building program and a "5-foot rule," or a "buffer zone" that surrounds the building.[39] The contracted A/E is responsible for site-specific design of anything beyond this boundary. To further complicate matters, in some instances the COS District contracts one design/build firm to construct the building, and the geographic District (responsible for supporting a specific installation) contracts another firm to develop the site amenities.

LEED SS credits relevant to this study include SS credit 6.1 on Stormwater Design - Quantity Control, SS credit 6.2 on Stormwater Design - Quality Control, SS credit 7.2 on the Heat Island Effect – Roofs, and SS credit 8 on Light Pollution Reduction.[40]

The LEED SS credits provide integrated project delivery teams the opportunity to help Army projects work towards the net zero water targets if they consider rainwater capture and reuse as part of their stormwater management strategies.

4.1 SSc6.1, Stormwater Design—Quantity control

Stormwater quantity control aims to limit disturbance of natural movement, distribution, and quality of water in order to maintain the natural hydrology of the land. This can be achieved through various techniques that reduce impervious cover, increase filtration, and reduce pollution in water runoff, otherwise referred to as abstractions.[41]

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39 The primary difficulty in implementing SS credits involves the Centers of Standardization (COS) "five-foot rule." Standardized facility designs are intentionally generic to allow for their use at various locations. Consequently, there is no standardized site development. Standard designs extend no further than five feet from the building perimeter. This prevents most SS credits from being addressed in a standardized design.

40 LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. p. 1-3.

41 LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. p. 91.

Conventional approaches to stormwater control typically collect runoff in large facilities at the base of drainage areas. The new principles of low impact development (LID) focus on controlling abstractions at the source with micro-scale controls scattered throughout the site. LID aims to reduce the impacts of development and preserve the land's natural features.[42]

4.1.1 Criteria for federal buildings

UFC 3-210-10, LID, provides technical criteria, requirements, and references for the planning and design of applicable projects to comply with stormwater requirements under Section 438 of the EISA, enacted in December 2007 (hereafter referred to as EISA Section 438).[43]

EISA Section 438 requires federal projects with a footprint over 5,000 square feet to "maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow." The project 'footprint' includes all hard, horizontal surfaces and areas of land disturbed by the project development. This includes the building area, roads, parking, and sidewalks.[44]

The Deputy Under Secretary of Defense (Installations and Environment) memorandum, effective January 2010 (Appendix C) directs DoD components to implement EISA Section 438 using LID techniques in accordance with the methodology described below.[45]

4.1.2 Techniques

In order to choose an appropriate LID design, the designer must determine the site-specific predevelopment hydrology using local meteorology and published data, simulation modeling techniques, etc.
The designer needs to calculate the initial abstraction based on the runoff curve number (CN) of the site, the total depth of increase in runoff, the de-

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[42] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005. P. 1-4.

[43] United States Department of Defense. 15 November 2010. Unified Facilities Criteria (UFC) 3-210-20: Low Impact Development. p. 1. http://www.wbdg.org/ccb/DOD/UFC/ufc_3_210_10.pdf. Accessed 2 December 2010.

[44] Ibid. p.2.

[45] Ibid.

sign storage.[46] All formulas are taken from the Natural Resources Conservation Service (NRCS).

[Formula 1]:[47] *Initial Abstraction* (inches): $Ia = 0.2*S$

Where, S = potential maximum retention after runoff begins (inches): (1000/CN)-10

$$D = \frac{(P - 0.2 * S')^2}{(P + 0.8 * S')} - \frac{(P - 0.2 * S)^2}{(P + 0.8 * S)}$$

[Formula 2]:[48] *Total Depth of increase in runoff* (inches):

For P > 0.2*S. Otherwise, the following is used: $\frac{(P - 0.2 * S)^2}{(P + 0.8 * S)} = 0$

Where, P = design storm rainfall depth (inches)

S & S' = potential maximum retention after runoff begins (inches) during the pre- and post-development conditions, respectively

[Formula 3]:[49] *Design Storage:* $VLID = D * A$

Where, D = total depth of increase in stormwater runoff (inches) calculated above

A = drainage area or the area of the parcel being developed (square units)

LID practices fall into three main categories: infiltration, storage and reuse, and evapotranspiration (ET). Infiltration both reduces the volume of stormwater runoff on the site and filters pollutants from the water. Storage and reuse, simply stores the stormwater abstractions for use on the site, either for landscaping or within the building. ET is the process of evaporation, sublimation, and transpiration of water from the earth's surface to the atmosphere. Each of these categories has several execution techniques, summarized in Table 8.

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[46] Department of Defense. 15 NOVEMBER 2010. *Unified Facilities Criteria (UFC).* "Low Impact Development." UFC 3-210-10. Pp. 11-12. PDF.

[47] Ibid.

[48] Ibid. P 12.

[49] Ibid.

Table 8. Low impact development techniques.

Infiltration	Storage & Reuse	Evapotranspiration
Bioretention	Rain Barrels	Bioretention
Vegetated Swales	Cisterns	Vegetated Swales
Permeable Pavement	Disconnected Downspouts	Vegetated Roofs
Sub-surface Retention		
Vegetated Roofs		

4.1.2.1 Bioretention

Bioretention works by directing water from an impervious surface to a collection area. Bioretention systems designs must take into account the existing site conditions, especially the soil types. A bioretention area is composed of a mix of vegetation that removes pollutants and attenuates the abstractions.[50] Depending on site conditions, storm water may directly runoff from an impervious surface into the bioretention area, or a grass buffer zone may be used to reduce velocities and assist in the filtration process.[51]

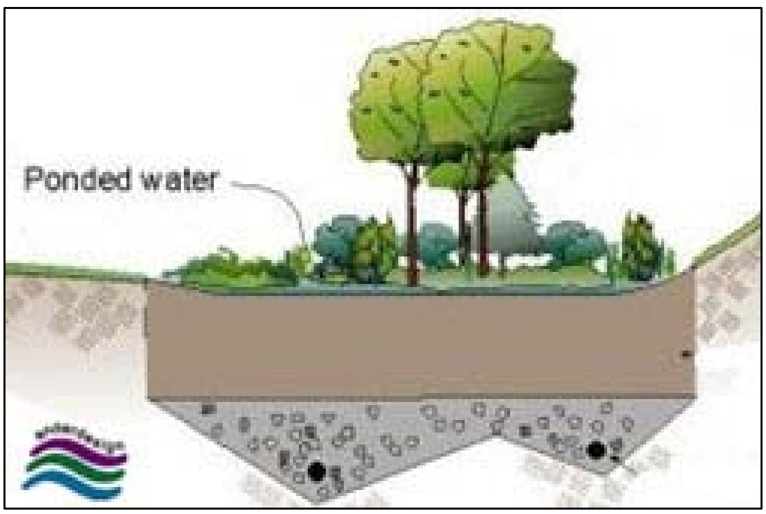

Figure 7. Bioretention system.[52]

[50] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005. P. 2.

[51] Bitter, Susan D. and J.K. Bowers. “Bioretention as a Water Quality Best Management Practice.” 2003. Technical Note #29 from Watershed Protection Techniques. 1(3): 114-116. http://www.stormwatercenter.net/ Practice/110-Bioretention.pdf. Accessed 2 December 2010.

[52] Guillette, Anne. 2010. “Low Impact Development Technologies.” Whole Building Design Guide. http://www. wbdg.org/resources/lidtech.php. Accessed 7. December 2010.

There are six typical components found in bioretention areas:

1. Grass buffer strips helps to reduce velocities and assist in the filtration process
2. Sand bed is used to aerate and drain and to assist in filtering out pollutants
3. Ponding areas store the excess abstractions until it percolates and/or evaporates
4. Organic layers provide a medium for biological growth that aids in the decomposition petroleum-based materials.
5. Planting soils provide an area for vegetation growth. Planting soils also contain clays which absorb hydrocarbons and heavy metals.
6. Vegetation consumes the water.

Bioretention facilities are less costly than traditional structural stormwater conveyance systems. Construction of a bioretention area ranges from $5,000 and $10,000 per acre. Additional savings can include reduced costs for storm drainpipe. At one medical office in Prince George's County, Maryland, bioretention practices reduced the amount of storm drain pipe length from 800 to 230 feet. This resulted in a savings of $24,000, 50 percent of the overall drainage cost for the site.[53,54]

4.1.2.2 Vegetated swales

Vegetated swales can be applied in a variety of site conditions and are relatively inexpensive to construct. They are typically used along streets and highways, where pH levels drop below 7.[55]

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[53] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005. P. 5, 15-17.

[54] Department of Environmental Resources, Division of Environmental Management, Watershed Protection Branch. Prince George's County, Department of Environmental Resources. 1993. Design Manual For Use of Bioretention in Stormwater Management, Prince George's County, Maryland.

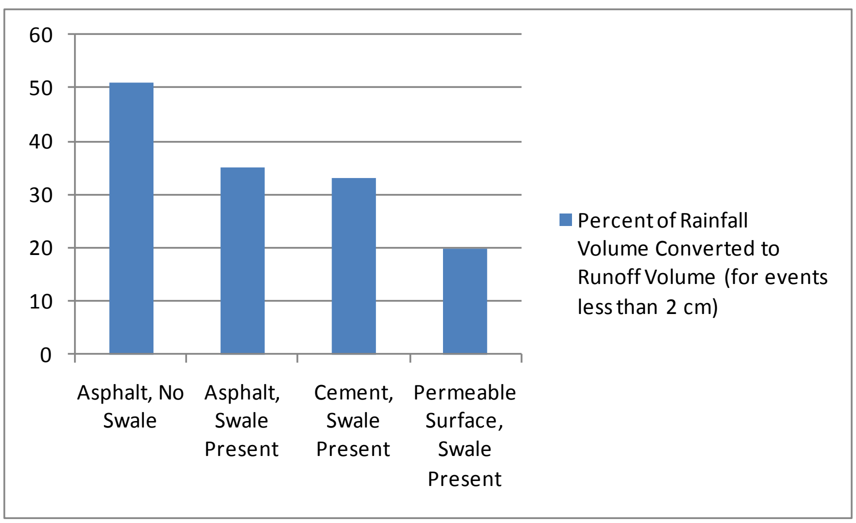
[55] United States Department of Transportation and the Federal Highway Administration. Office of Infrastructure R&D Turner-Fairbank Highway Research Center and Office of Environment and Planning. "Is Highway Runoff a Serious Problem?" FHWA Environmental Technology Brief. Publication Number: FHWA-RD-98-079.
<http://www.fhwa.dot.gov/publications/research/infrastructure/structures/98079/runoff.cfm>. Accessed 2 December 2010.

Figure 8. Roadside vegetated swale.[56]

Engineered swales are less costly than a traditional structural conveyance system. A curb and gutter/storm drain inlet system or a storm drain pipe system ranges from $40–50 per running foot. A vegetated swale would reduce costs by one-half to two-thirds of the cost of a conventional system.[57]

Table 9 below shows the effect of a swale on stormwater runoff volumes (data from US Environmental Protection Agency 2005).

Table 9. Rainfall volume converted to runoff volume.[58]



[56] Guillette, Anne. 2010. “Low Impact Development Technologies.” Whole Building Design Guide. <http://www. wbdg.org/resources/lidtech.php>. Accessed 7 December 2010.

[57] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005, P. 7.

[58] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005.

4.1.2.3 Permeable pavement

The use of permeable pavements allows stormwater to percolate into the soils and greatly reduce runoff, and promotes recharge. Porous pavements are applicable for low traffic areas. Pavers range in cost from $2-4.[59]

Figure 9. Porous pavers.[60]

4.1.2.4 Vegetated roofs

A vegetated roof, commonly referred to as a “green roof,” has layers of vegetation, drainage, and filtration that help reduce reducing abstractions. A vegetated roof can increase the design life of a roof membrane by many years by protecting it from ultraviolet radiation.

Vegetated roofs are covered in Section 4.3 of this report, in the Heat Island Effect.

4.1.2.5 Sub-surface retention facilities

Sub-surface retention facilities can be constructed below parking lots, sidewalks, and roads. Water filters through porous pavement and/or aggregate at the edges of an impervious pavement.[61]

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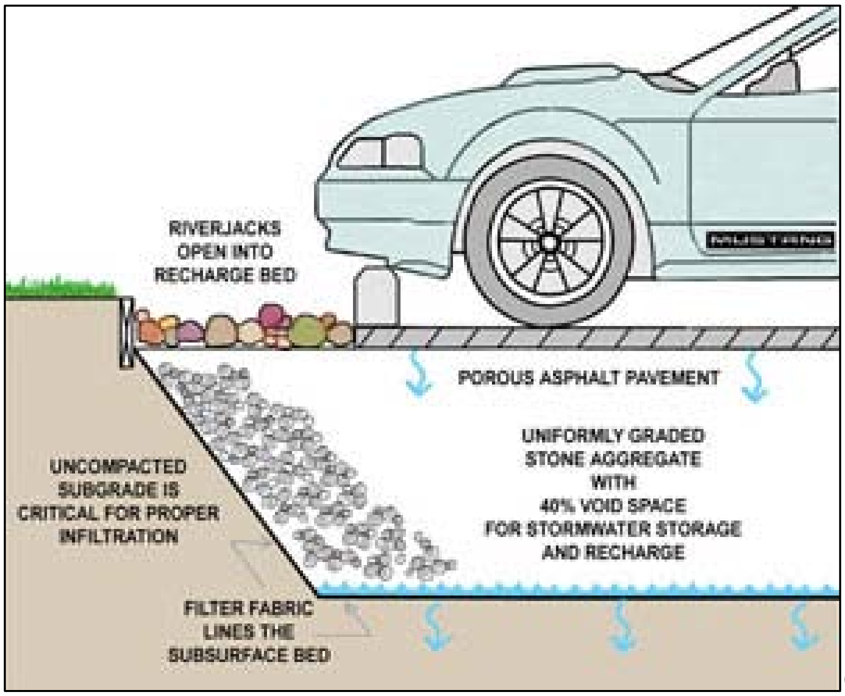
[59] Ibid. P. 8.

[60] Guillette, Anne. 2010. “Low Impact Development Technologies.” Whole Building Design Guide. http://www. wbdg.org/resources/lidtech.php. Accessed 7 December 2010.

[61] Ibid.

The cost of a sub-surface retention facility is higher than a conventional parking lot, but saves the expenses of running stormwater piping and sewer inlets. A sub-surface retention facility is illustrated in Figure 10 below.



[62]

Figure 10. Sub-surface retention facility.

4.1.2.6 Cisterns and rain barrels

Cisterns and rain barrels collect and store excessive stormwater, to be used at a later time. They may be constructed on-site, or pre-fabricated and placed above or below ground. They may be made from nearly any impervious, water-retaining material. Cisterns are distinguishable from rain barrels by their larger sizes and available shapes (Table 10).[63]

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[62] Guillette, Anne. 2010. "Low Impact Development Technologies." Whole Building Design Guide. http://www. wbdg.org/resources/lidtech.php. Accessed 7 December 2010.

[63] Low Impact Development Center, Inc. December 2010. Urban Design Tools: Low Impact Development. "Rain Barrels and Cistern Specifications." http://www.lid-stormwater.net/raincist_specs.htm. Accessed 7 December 2010.

Table 10. Cistern and rain barrel types.[64]

Composition	Cost	Size	Comments
Fiberglass	$0.50-2.00/gal	500-20,000 gal	Can last for decades w/out deterioration; easily repaired; can be painted
Concrete	$0.3-1.25/gal	10,000 gal +	Risks of cracks and leaks, but these are easily repaired; immobile; smell and taste of water some-times affected, but the tank can be retrofitted with a plastic liner
Metal	$0.50-1.50/gal	150-2,500 gal	Lightweight and easily transported; rusting and leaching of zinc can pose a problem, but this can be mitigated with a potable-approved liner
Polypropylene	$0.35-1.00/gal	300-10,000 gal	Durable and lightweight; black tanks result in warmer water if tank is exposed to sunlight; clear/translucent tanks foster algae growth
Wood	$2.00/gal	700-50,000	Aesthetically pleasing, sometimes preferable in public areas and residential neighborhoods
Polyethylene	$0.75-1.67/gal	300-5,000 gal	--
Welded Steel	$0.80-4.00/gal	30,000-1 million gal	--
Rain Barrel	$100	55-100 gal	Avoid barrels that contain toxic materials; add screens for mosquitoes

Cisterns and rain barrels generally include the following components:[65]

1. Solid cover that is secure and child-proof
2. Screen at the entrance to filter out leaves and bugs
3. Course inlet filter
4. Clean-out valve
5. Overflow pipe
6. Manhole for access
7. Sump and drain
8. Extraction system (tap or pump)
9. Soak-away to prevent ponding near the tank
10. Sediment trap (optional)
11. Lock (optional)

[64] Department of the Army. U.S. Army Corps of Engineers. 22 March 2010. Facilities Engineering Environmental. "Rainwater Harvesting for Army Installations." Public Works Technical Bulletin PWTB 200-1-75. Pp A-39. http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_75.pdf. Accessed 7 December 2010. Direct reference to: Texas Water Development Board (TWDB). 2005. The Texas Manual on Rainwater Harvesting. 3d ed. Austin, TX: Texas Water Development Board. P. 46.

[65] Low Impact Development Center, Inc. December 2010. Urban Design Tools: Low Impact Development. "Rain Barrels and Cistern Specifications." http://www.lid-stormwater.net/raincist_specs.htm. Accessed 7 December 2010.

12. Second sub-surface tank (optional)
13. Volume calculator (optional)

Cistern capacity needed to harvest roof runoff from a large storm event can be calculated with the following formula:

[Formula 4][66] *Catchment Runoff* (gallons): catchment area (sqft) * rainfall expected in a local high volume storm (ft) * 7.48 gal/sqft * runoff coefficient

Note: This is the *minimum* cistern capacity needed to capture the roof runoff.

4.1.2.7 Disconnected downspouts

Conventional downspouts direct stormwater runoff from gutters into storm sewers. Disconnected downspouts direct stormwater into bioretention cells, vegetated swales, and other LID systems. This practice reduces runoff into surface waters and the possibility of a combined sewer overflow (CSO) events. Stormwater could also be redirected to rain barrels or cisterns for later irrigation use.[67]

4.2 SSc 6.1, Stormwater Design—Quality control

Stormwater quality control aims to limit pollution in natural water sources by managing runoff. Runoff treatment must remove 80 percent of post-development total suspended solids (TSS).[68] Table 11 below shows various management practices for removing TSS from stormwater runoff.

[66] Lancaster, Brad. 2006. *Rainwater Harvesting for Drylands*. Volume 1. Appendix 3: Water-Harvesting Calculations. P. 131. PDF. Online. <http://www.oasisdesign.net/water/rainharvesting/drylandsbook/Appendix3Calculations.pdf>. Accessed 21 December 2010.

[67] United States Environmental Protection Agency. Office of Water. Low Impact Development (LID): A literature review. EPA-841-B-00-005. October 2005. P. 8.

[68] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. p. 101.

Table 11. Management practices for removing TSS from stormwater runoff.

Technique	Average TSS Removal	Probable Range of TSS Removal	Factors to Consider
Infiltration Basin	75%	50-100%	soil percolation rates, trench surface area, storage volumes
Infiltration Trench	75%	50-100%	soil percolation rates, trench surface area, storage volumes
Vegetated Filter Strip	65%	40-90%	runoff volume, slope, soil infiltration rate
Grass Swale	60%	20-40%	runoff volume, slope, soil infiltration rate, vegetated cover, buffer length
Porous Pavement	90%	60-90%	percolation rates, storage volume
Open Grid Pavement	90%	60-90%	percolation rates
Sand Filter Infiltration Basin	80%	60-90%	treatment volume, filtration media
Water Quality Inlet	35%	10-35%	maintenance, sedimentation storage volume
Water Quality Inlet with Sand Filter	80%	70-90%	sedimentation storage volume, depth of filter media
Oil/Grit Separator	15%	10-25%	sedimentation storage volume, outlet configuration
Extended Detention Dry Pond	45%	50-90%	storage volume, detention time, pond shape
Wet Pond	60%	50-90%	pool volume, pond shape
Extended Detention Wet Pond	80%	50-90%	pool volume, pond shape, detention time
Constructed Stormwater Wetlands	65%	50-90%	storage volume, detention time, pond shape, wetland's biota, seasonal variation

4.3 SSc7.1, Heat Island Effect—Non-roof

When large areas of dark, non-reflective surfaces absorb solar radiation and then radiate that heat, the ambient air temperature increases. This phenomenon is called the *heat island effect*. Light-colored surfaces, reflective surfaces, and surfaces covered with vegetation can reduce the radiation from buildings and their immediate areas.[69]

SS Credit 7.1 aims to reduce the heat island effect by using various strategies in 50 percent of a site’s hardscape. Strategies include shading vegetation and/or structures, use of hardscape materials that have a solar reflectance index (SRI) value of 29 or greater, use of open-grid or pervious

[69] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. Pp. 2, 109, 119.

pavement (see Section 4.1.2.3).[70] Table 12 below indicates SRI values for standard paving materials.

Table 12. Solar Reflectance Index (SRI) for standard paving materials.[71]

Material	Emissivity	Reflectance	SRI
Typical new gray concrete	0.9	0.35	35
Typical weathered gray concrete	0.9	0.20	19
Typical new white concrete	0.9	0.70	86
Typical weathered white concrete	0.9	0.40	45
New asphalt	0.9	0.05	0
Weathered asphalt	0.9	0.10	6

4.4 SSc7.2, Heat Island Effect—Roof

SS Credit 7.2 aims to reduce the heat island effect through the building's roofing system by using materials with higher SRI values and/or vegetated roofing systems.

Vegetated roofs may be installed atop conventional flat or sloped roofs, with added insulation. They reduce energy consumption and air pollution, add aesthetic appeal to a building, and offer protection to conventional waterproofing.[72] Moreover, a vegetated roof can increase the design life of a roof membrane by many years by protecting it from ultraviolet radiation. Figure 11 summarizes the effects that a vegetated roofing system has on water runoff.

[70] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. Pp 109.

[71] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. Pp 112.

[72] United States Environmental Protection Agency. "Green Roofs." http://www.epa.gov/heatisld/mitigation/ greenroofs.htm. Accessed 7 December 2010.

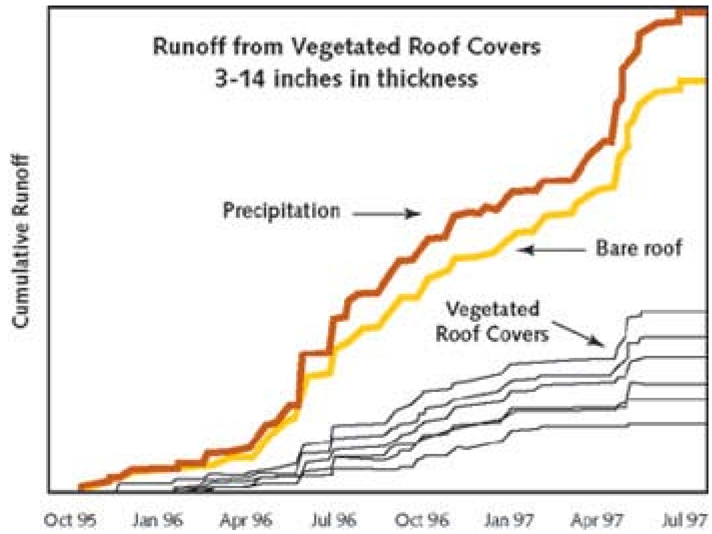

Figure 11. Vegetated roof cover runoff.[73]

Vegetated roofs are categorized as either extensive or intensive. Extensive vegetated roofs are up to six inches deep and are used to satisfy specific performance requirements. This category requires little maintenance (e.g., annual weeding or application of slow-releasing fertilizer). Intensive green roofs are much deeper and resemble a plaza with lawns, landscaping, trees, and walkways.[74] For Army purposes, since they are virtually self-sustaining, extensive vegetated roofs are preferred over intensive vegetated roofs.

The components of an extensive vegetated roof system include the following:

1. The roof structure must support the vegetated roof. Vegetated roofs are regulated by the International Code Council (ICC) and are treated as ballasted roofs. ICC does not specify testing methods, but does require that the saturated weight of the system be treated as an additional dead load. Live load requirements are added for maintenance foot traffic and regulated pedestrian access.[75] In addition, traditional insulation must be applied either above or below the structure[76] (see Figure 12).

[73] Miller, Charlie. 2010. "Extensive Green Roofs." Whole Building Design Guide. http://www.wbdg.org/resources/greenroofs.php. Accessed 7 December 2010.

[74] Ibid.

[75] Ibid.

[76] Peck, S. and M. Kuhn. 2003. Design Guidelines for Green Roofs. Canada Mortgage and Housing Corporation and the Ontario Association of Architects. Pp 4.

2. Waterproofing or a roofing membrane is required to keep the water from entering the building. An integral root repellent is advised.
3. A drainage layer with water reservoirs controls the settlement of water.
4. A filter cloth allows for water penetration to the roots, but contains the growing medium.
5. The growing medium, which may or may not include soils, creates a bed in which the plants grow.
6. The plants are often selected based on the region so that minimal maintenance is required[77].

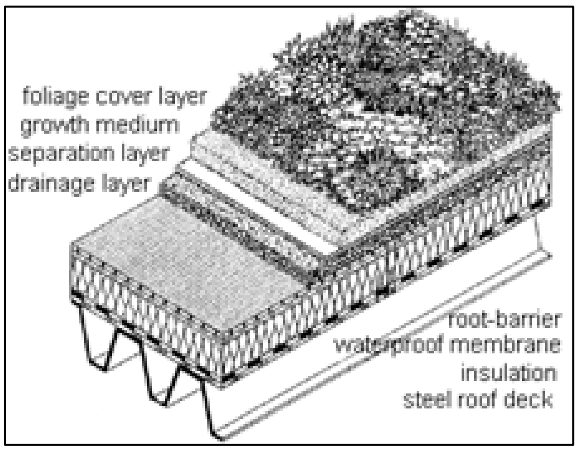

Figure 12. Extensive vegetated roofing components.[78]

The National Roofing Contractors Association (NRCA) is developing guidelines for waterproofing under vegetated roofing systems. Additionally, ASTM International is developing guideline and testing procedures for products related to vegetated roof systems.

CERL investigated use of a vegetated roof for a Fort Worth District project and learned two useful guidelines for successful installation of a vegetated roof.

(1) Each vegetated roof is best designed by an expert who considers the specific climate, roof loading, building structure, appropriate plant species, etc.
(2) Purchase the vegetated roof as a system instead of a collection of components to insure an enforceable warranty.

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[77] Ibid.

[78] Miller, Charlie. 2010. "Extensive Green Roofs." Whole Building Design Guide. http://www.wbdg.org/ resources/greenroofs.php. Accessed 7 December 2010.

The costs of installing a vegetated roofing system are summarized in Table 13 below.

Table 13. Vegetated roofing system costs.[79]

Component	Cost
Design & Specifications	5-10% of total roofing cost
Project Administration and Site Review	2.5-5% of total roofing cost
Re-roofing with root repelling membrane	$100-160 per sm. ($10-15 per sf)
Green Roof System (curbing, drainage layer, filter cloth, growing medium)	$55-110 per sm ($5-10 per sf)
Plants	$11-32 per sm ($1-3 per sf)
Installation/Labor	$32-86 per sm ($3-8 per sf)
Maintenance	$13-21 per sm ($1.25-2 per sf) for the first 2 years only
Irrigation System	$21-43 per sm ($2-4 per sf)

It is advised that designers hire a consultant when designing a green roofing system, and that said system maintain a manufacturer's warranty.

4.5 SSc8: Light Pollution Reduction

Light pollution reduction aims to minimize light trespass from the building and immediate site, reduce sky glow, improve visibility at night, and reduce glare. This could be achieved through improved daylighting techniques that reduce the requirements for electrical lighting (see Chapter 6, Daylighting) and shielding any non-emergency luminaries.

In addition, the lighting densities for exterior lighting, required for safety and comfort, should be adjusted to meet ANSI/ASHRAE/IESNA Standard 90.1-2007. Standard lighting power densities for building exteriors are provided in Table 14.

[79] Peck, S. and M. Kuhn. 2003. Design Guidelines for Green Roofs. Canada Mortgage and Housing Corporation and the Ontario Association of Architects. Pp 15.

Table 14. Lighting power densities for building exteriors.[80]

	Applications	Lighting Power Densities
Tradable Surfaces	Uncovered Parking Areas	
	Parking lots and drives	0.15 W/sqft
	Building Grounds	
	Walkways less than 10 feet wide	1.0 W/linear foot
	Walkways 10 feet wide or greater; Plaza areas; Special Feature Areas	0.2 W/sqft
	Stairways	1.0 W/sqft
	Building Entrances and Exits	
	Main entries	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width
	Canopies and Overhangs	
	Canopies (free-standing, attached, and overhangs)	1.25 W/sqft
	Outdoor Sales	
	Open areas (including vehicle sales lots)	0.5 W/sqft
	Street frontage for vehicle sales lots in addition to "open area" allowance	20 W/linear foot of door width
Non-Tradable Surfaces	Building Facades	0.2 W/sqft for each illuminated wall of surface of 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	250 W per location plus 90 W per attitional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25 W/sqft of uncovered areas (covered areas are included in "Canopies and Overhangs")
	Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	0.5 W/sqft of uncovered areas (covered areas are included in "Canopies and Overhangs")
	Drive-up windows	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry

Table 15 identifies four project zone classifications for exterior lighting, as defined by IESNA RP-33.

[80] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. p. 133.

Table 15. Exterior lighting zones.[81]

Zone	Horiz FC	Vert FC	Site Fixtures Emitting at a 90° Angle (%)	Notes
LZ1, Dark	0.01	0.01	0	national parks, state parks forest land, rural areas
LZ2, Low	0.10	0.10	2	no greater than 0.01 fc (horizontal and vertical) 10 feet beyond site; primary residential zones, heighborhood buisness districts, light industrial with limited nighttime use, residential mised-use areas
LZ3, Medium	0.20	0.20	5	no greater than 0.01 fc (horizontal and vertical) 15 feet beyond site; all areas not included in LZ1, LZ2, or LZ4; commercial/industrial, high-density residential
LZ4, High	0.60	0.60	10	no greater than 0.01 fc (horizontal and vertical) 15 feet beyond site; area must be designated as such by local jurisdiction (local zoning authority); high-activity commercial districts in major metropolitan

After determining the zone classification of the site, manufacturer's fixture data and photometric data can be used to determine the initial lumens. Lighting design software can predict the power and light densities of the lamps selected. Adjustments can be made at this time to reduce the overall output on the site. Further, lamps can be adjusted so as to avoid emitting at or above 90 degrees, thus reducing the exterior sky glow and light trespass.[82]

[81] *LEED Reference Guide for Green Building Design and Construction.* 2009. U.S. Green Building Council. Washington, D.C. p. 129-30, 137.

[82] Ibid. P 136-7.

5 Water Efficiency (WE)

Water efficiency aims to increase local aquifer recharge, to reduce wastewater generation and potable water demand through the use of water-conserving fixtures, to implement water-efficient landscaping, and to recycle potable water.[83] Water conservation is so important to the Army that Ms. Katherine Hammack, Assistant Secretary of the Army for Installations, Energy and Environment [ASA (IE&E)], has established a vision of having five installations reach the Net Zero water target by 2020.

5.1 Criteria for federal buildings

Whenever available, WaterSense specifications will be recommended as part of these efficiency measures. WaterSense is an USEPA program that helps consumers choose quality, water efficient products and services.[84] The USEPA works with manufacturers to develop water efficient specifications for various products and provides WaterSense labels to products that have been independently certified to meet specifications. The USEPA is still in the process or developing its full body of specifications. Thus, it is recommended that the WaterSense website (http://www.epa.gov/ watersense/) be checked regularly to keep installations and designers abreast of new specifications or updates to existing specifications.[85]

The implementation instructions for E.O. 13423 direct federal agencies to purchase WaterSense products whenever possible.[86] WaterSense products are thus both the water-efficient and E.O. 13423-compliant choice. EISA also limits federal agency purchases of certain products to those that are designated by the FEMP or Energy Star qualified.[87]

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[83] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. p. 193.

[84] WaterSense. http://www.epa.gov/watersense/.

[85] Environmental Protection Agency. 2010. WaterSense Website. http://www.epa.gov/watersense/

[86] U.S. Department of Energy Guide (DOE G) 413.3-6, High Performance Sustainable Building, Washington, DC: DOE, 20 June 2008.

[87] Sissine, F. 2007. Energy Independence and Security Act of 2007: A Summary of Major Provisions. Congressional Research Service. Accessed 22 July 2009. http://energy.senate.gov/public/_files/RL342941.pdf

The USACE/IMCOM Energy and Water Conservation Design Guide (For Sustainment, Restoration and Modernization (SRM) and MILCON Projects) is currently being updated to include water efficiency requirements. The revised version will be available at url: http://www.wbdg.org/references/pa_dod_energy.php

5.2 WEp1/WEc3—Water use reduction

Water-use reduction can be achieved through the use of water-conserving fixtures. These include high-efficiency toilets (HETs), dual-flush toilets, composting toilets, high-efficiency urinals (HEUs), waterless urinals, low-flow lavatories, low-flow showers, and low-flow kitchen sinks. These products are further explained in the next section and in the tech notes referenced at the end of this report. The calculations for the five building types evaluated in this study follow in the Building water usage section on page 61.

5.2.1 Water-conserving fixtures

Various water-conserving fixtures include HETs, dual-flush toilets, non-water urinals, high-efficiency urinals HEUs, low-flow lavatories, low-flow showers, shower timers, low-flow kitchen sinks, and composting toilets. In addition, efficient kitchen equipment may be used to reduce water consumption in the DFAC. This is further explained in the Building water usage section of this report (page 61).

In addition to the performance of fixtures themselves, other areas of investigation, such as the effects of lower flows on drainline transport, are being examined. Drainline transport is an emerging concern as flush volumes are reduced to as low as 1.0 gallon, the primary concern being that clogging and backups could occur as water volumes are reduced. The issue is of international concern and a Dry Drain Forum was featured at the world's largest plumbing exposition, the ISH Frankfurt trade fair. In order to mitigate the effects of reduced flow in drains, Australia now requires two water fixtures upstream from low flow fixtures per AS/NZS 3500.2. Others, such as the International Associate of Plumbing and Mechanical Officials (IAPMO), are likely to follow suit.[88]

[88] DeMarco, Pete. *A Status Report: Reduced Flows in Building Drains.* IAPMO. PowerPoint Presentation, WaterSmart Innovations Conference, October 2010.

5.2.1.1 High-efficiency toilets (HETs)

HETs assist in reducing water usage, while physically resembling conventional water closet fixtures.[89] Recent advances in flushing technology allow HETs to remove waste with less water by increasing water velocity. Like dual-flush toilets, HETs can be combined with automatic sensors. HETs use 20 percent less water than mandated by the U.S. Energy Policy Act of 1992. HETs range from 1 to 1.28 gallons of water per flush. Those certified under the EPA's WaterSense program must use no more than an average flush volume of 1.1 gallons.[90]

5.2.1.2 Dual-flush toilets

Dual-flush toilets provide two flush options for users to dispose of liquid or solid wastes. They may be combined with automatic sensors, although this practice is not recommended due to wasted flushes. In this study, dual-flush toilets used 1.6 and 1.1 gpf for the solid and liquid flushes, respectively. Many venders sell products that meet this standard; however, the Sydney Smart 305 by Caroma, boasts a 1.28/ 0.8 gpf dual-flush toilet.[91]

5.2.1.3 Dual-flush conversion kits

Dual-flush conversion kits that allow single-flush toilets to have a dual-flush mode are now commercially available in the US Conversion kits reduce the flush volume of low flushes by 30 percent, whereas full flushes remain at 1.6 gpf. Dual-flush conversion kits pose potential problems. There are three primary concerns with the kits: the changing of the full flush profile, unsatisfactory performance because of incomplete exchanges of water in the toilet bowl, and adjustability of the retro valves that allows the user to increase the flush volume well above the originally rated volume of the fixture. Each of these three issues could lead to an increase in gpf, negating all environmental and economic savings. Additionally, instal-

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[89] Note that flush quality in some efficient toilets is undermined by non-flushable recyclable toilet paper that builds up in the bowl and eventually plugs the toilet. Those who occupy and service buildings with such paper should observe toilet and paper performance and report shortcomings to building managers for correction.

[90] USACE HQ, Centers of Standardization, Shared Documents, TechNote on High Efficiency Toilets (HETs). https://eportal.usace.army.mil/sites/COS/HQ/Shared%20Documents/Forms/AllItems.aspx. Accessed 19 November 2010.

[91] Ibid.

ling an after-market conversion kit will likely void the manufacturer's warranty.[92]

5.2.1.4 Non-water urinals

Non-water urinals contribute to decreased water usage and costs. Replacing wall-mounted fixtures with non-water urinals and specifying their use in all new buildings can result in lower water costs, reduced sewage treatment, and less required pumping power. In recent years, non-water urinals have become more prevalent in commercial, federal, and DoD facilities.[93]

It is recommended that project teams follow the Australian code requirement and install two water fixtures upstream from non-water urinals to ensure adequate flow in drain lines.

5.2.1.5 High-efficiency urinals (HEUs)

The Energy Policy Act of 1992 mandated that "low-flush" urinals use no more than 1 gallon of water per flush (gpf). Recently, HEUs, which use no more than 0.5 gpf, became available. HEUs may be suitable for retrofits when conditions are less suitable for the use of non-water urinals (for instance if there are existing copper drain lines or inadequate pipe slope).

Mandatory provisions:

- *Army:* currently requires nonwater urinals.
- *ASHRAE 189.1-2009:* Maximum flush volume of 0.5 gal (1.9 L), determined IAW ASME A112.19.2/CSA B45.1. Nonwater urinals shall comply with ASME A112.19.19 (vitreous china) or IAPMO Z124.9 (plastic) as appropriate.
- *WaterSense*: urinals must have effective flush volumes of 0.5 gal (1.9 L) or less.

[92] Koeller and Company, *A Caution on Dual-Flush Conversion Devises for Tank-Type, Gravity-Fed Toilets*, July 2009.

[93] Stumpf, Annette. 2010. "Non-Water Urinals." *TechNotes.*

5.2.1.6 Low-flow lavatories

Low-flow lavatories produce 0.5 to 1.5 gallons of water per minute, reducing water usage from 40 percent to 70 percent. These fixtures are designed to be as effective as conventional faucets.

5.2.1.7 Public lavatory faucets

Mandatory provisions: *ASHRAE 189.1-2009:* Maximum flow rate of 0.5 gpm (1.9 L/min) when tested IAW ASME A112.18.1/CSA B125.1.

5.2.1.8 Public metering self-closing faucet

Mandatory provisions: *ASHRAE 189.1-2009:* Maximum water use of 0.25 gal (1.0 L) per metering cycle when tested IAW ASME A112.18.1/CSA B125.1.

5.2.1.9 Residential bathroom lavatory sink faucets

Mandatory provisions:

- *ASHRAE 189.1-2009:* maximum flow rate of 1.5 gpm (5.7 L/min) when tested IAW ASME A112.18.1/CSA B125.1, and shall comply with the performance criteria of the USEPA *WaterSense* High-Efficiency Lavatory Faucet Specifications.
- *WaterSense*: residential lavatory faucets must have flow rates of 1.5 gpm or less at 60 psi.

5.2.1.10 Residential kitchen faucets

Mandatory provisions:

- *ASHRAE 189.1-2009:* maximum flow rate of 2.2 gpm (8.3 L/min) when tested IAW ASME A112.18.1/CSA B125.1.

5.2.1.11 Low-flow showerheads

Rather than reducing water pressure, low-flow showerheads constrict water through smaller apertures, thus increasing the velocity of the water, and focus the water flow. Consequently, they remain as effective as conventional showerheads. The U.S. Energy Policy Act of 1992 requires that all flow fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm. The low-flow showerheads used in this study are designed to operate within 1.5 gallons of water per minute.[94]

Mandatory provisions:

- *ASHRAE 189.1-2009:* Maximum flow rate of 2.0 gpm (7.6 L/min) when tested IAW ASME A112.18.1/CSA B125.1.
- *WaterSense*: Showerheads must have maximum flow rates of no more than 2.0 gpm (7.6 L/min) at 80 psi.

5.2.1.12 Shower timers

Showers account for nearly 17 percent of residential indoor water use. All *WaterSense* labeled showerheads meet both water efficiency and performance criteria, which is based on spray coverage and spray force criteria.

Automated shower timers cuts shower time and limits water usage. Full-flow of water is allowed for a pre-determined duration, 5, 8, or 11 minutes, for example. A warning beep alerts the user 60 seconds before this time that full-slow will be shut off. After the allotted time, water flow becomes restricted, typically by 2/3 of the full-flow setting. The restricted flow allows the user to finish rinsing off, but discourages a continued shower.

In a recent study conducted at a UCSB Santa Cruz dormitory, showerheads were retrofitted with ShowerMinder shower timers. In the men's bathrooms, this resulted in an 18 percent shower time savings and a total of 996.53 gallons of water saved. The average shower time in the women's bathroom saw a 24 percent reduction, yielding 3383.27 saved gallons of water.[95]

5.2.1.13 Composting toilets

Composting toilets have been used since the 1970s. However, the relatively high cost, level of behavioral adaptation required, and unique maintenance requirements have led to slow adoption of this technology. Despite these factors, composting toilets provide an innovative and efficient solu-

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[94] USACE HQ, Centers of Standardization, Shared Documents, TechNote on Fixtures: Low-Flow Showerheads. https://eportal.usace.army.mil/sites/COS/HQ/Shared%20Documents/Forms/AllItems.aspx

[95] ShowerMinder. Environmental Affairs Board, UCSB Associated Students http://sustainability.ucsb.edu/tgif/08-09/final/ShowerMinders_FinalReport.pdf

tion for Army installations that need to provide toilet facilities in locations where traditional water and sewage infrastructure is not feasible or cost effective. Composting toilets are currently being used at Fort Bliss, 29 Palms, and China Lake to service rifle ranges and remote training facilities. In both instances, local contractors are used for maintenance in order to ensure proper functioning of the stand-alone units, although Clivus Multrum, Inc., the manufacturer, does offer maintenance service with each system it sells.

The five stand alone and two two-stall Clivus Multrum, Inc. models employed at Fort Bliss and 29 Palms are the M54 Trailhead Series, which is fully ADA compliant and ideal for remote locations. Each unit accommodates 22,000 uses per fixture per year, and relies on solar powered ventilation to inhibit odors.[96] Using natural biological decomposition to convert human waste into reusable end-products, the storage capacity is an astonishing 300 liquid gallons (6,000 uses) and its nutrient-rich product can be used to fertilize landscaping. Regular maintenance includes the addition of bulking material to the compost chamber and moistening of the compost matter, whereas periodic maintenance, including the removal of liquid end-product and solid compost, is dependent upon usage.[97]

It is important to note that there is a significant behavioral component to using composting toilets, particularly as most rely upon the separation of liquid and solids and therefore contain separate chambers within the toilet bowl. Users must be aware of this and exercise proper caution to ensure system performance. Manufacturers include materials that address these concerns and help communicate them to users. Composting toilets are not recommended for high-use facilities where traditional sewage connections are readily available; however they do represent a waterless solution that is well-suited to the conditions found on remote areas of many Army installations. As reports of the performance of units at Fort Bliss, 29 Palms, and China Lake become available in the future, installation facility managers should look for ideal situations in which to implement this technology.

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[96] Clivus Multrum Inc., Restroom Structures—M54 Trailhead Series. http://www.clivusmultrum.com/restroom-structures.php

[97] Clivus Multrum, Inc., M54 Series Planning Manual, August 2009.

Composting toilets often have municipal code issues with regard to permitting, use of National Sanitation Foundation (NSF) approved units, and annual Health Department inspections.[98]

5.2.1.14 DFAC kitchen equipment

Although excluded from the LEED-NC 2009 water use reduction calculations, water efficiency measures in commercial kitchens hold high potential for water conservation. These measures usually involve the straightforward retrofit, replacement, or, occasionally, elimination of an appliance or fixture. Most, though not all, of these potential savings exist in the dishwashing arena. Water efficiency measures not related to dishwashing involve the retrofit or replacement of outdated icemakers and steamers (see Table 16).[99]

Dishwashing is one of the most water-intensive activities in commercial kitchens. One way to save water on dishwashing is to reduce the number of dishes to be washed. In cafeteria settings, some colleges have reported success with reducing water usage by eliminating cafeteria trays (with concurrent food waste reductions). In addition, training workers to scrape soiled dishes instead of pre-rinsing them before putting them in the dishwasher will help commercial kitchens conserve water.

When dishes must be pre-rinsed, water savings can be realized through the replacement of older pre-rinse spray valves (PRSVs) with newer low-flow ones that use no more than 1.15 gpm at 60 psi. New PRSVs cost around $50, making replacement cost-effective over the short-term.

Likewise, replacing older dishwashers with new, Energy Star models – a water conservation method for commercial kitchens – is often cost-effective. This is due to the combination of water and energy savings that can be achieved from such a replacement. Using dishwashers only with full loads can save additional water. Furthermore, conventional dishwasher conveyer belts consume 8 gallons of water per minute (gpm); whereas, a high-efficiency dishwasher conveyer belt requires as little as 2.5 gpm.

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[98] Sustainable Sources, Compost Toilets-Implementation Issues-Regulatory. http://composttoilet.sustainablesources.com/

[99] USGBC, *LEED 2009 for Healthcare*, Water Efficiency, Prerequisite 1, Water Use Reduction, 25.

Similar reductions can be made through other cleaning devices, including plate troughs, garbage disposals, water brooms, and pre-rinse spray valves. A conventional plate trough uses up to 15 gpm of water; whereas, a re-circulating plate trough only uses 2-3 gpm. Alternatively, eliminating scraping troughs, which use water to move waste to food waste disposers, will result in even greater water savings.

In addition, conventional garbage disposals use 5-8 gpm. These units may be replaced with garbage strainers, which use 2 gpm. Otherwise, food waste disposers could be eliminated entirely. There are pros and cons to eliminating food waste disposers; however, when possible, composting is always considered an environmentally preferable option.

Commercial icemakers generally come in two types – water-cooled and air-cooled. Water-cooled icemakers run water through the machine, generally without recirculation, to remove the rejected heat. Replacement of once-through water-cooled icemakers with air-cooled Energy Star icemakers will generate water savings. While air-cooled units generally use marginally more energy than water-cooled units, the difference is not enough to offset the higher initial cost and water-use of once-through units.[100] Additionally, recent research suggests that air-cooled icemakers actually are more energy efficient when embedded energy is taken into consideration (in addition to direct energy).[101] When replacement is not an option or is expensive, it is sometimes possible to retrofit a water-cooled icemaker into an air-cooled or recirculating water-cooled machine. Further, savings can be made by switching the type of ice formed. Conventional ice cube machines consume 130-180 gallons of water per 100 pounds of ice. Alternatively, high-efficiency ice flake machines require 12-20 gallons of water per 100 pounds of ice.

Traditional boiler-based steamers cook food by running a constant stream of steam and regularly draining the resultant water out, a process that takes relatively large amounts of both water and energy. Replacing traditional boiler-based steamers with boilerless steamers or connectionless

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[100] U.S. Environmental Protection Agency. 2008. Summary of Rationale for ENERGY STAR Ice Machine Specification. USEPA. Accessed 22 July 2009. http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/ice_machines/Ice_Machine_Decision_Memo.pdf

[101] Koeller and Company. 2008. A Report on Potential Best Management Practices. California Urban Water Conservation Council.

steamers, which use 1-2 gallons per hour (gph) compared to 30-40 gph for a conventional boiler/steamer,[102] will result in water savings (Table 16).

Table 16. Commercial equipment performance requirements.[103]

Equipment	Capacity	Baseline
Commercial Clothes Washer	< 80 lbs	9 gallons/CF/cycle
Commercial Dishwashers		
Undercounter/High Temp		1.98 gallons/rack
Undercounter/Low Temp		1.95 gallons/rack
Door Type/High Temp		1.44 gallons/rack
Door Type/Low Temp		1.85 gallons/rack
Single Tank Rack Conveyor/High Temp		1.13 gallons/rack
Single Tank Rack Conveyor/Low Temp		1.23 gallons/rack
Multi-Tank Rack Conveyor/High Temp		1.1 gallons/rack
Multi-Tank Rack Conveyor/Low Temp		0.99 gallons/rack
Flight Type		180 gallons/hour
Commercial Water-Cooled Ice Machines	<450 lb/day	< 25 gal/100 lb ice; Must be on closed cooling loop; Once-through cooling not allowed
Commercial Air-Cooled Ice Machine	> 450 lb/day	< 25 gal/100 lb ice
With remote condensing unit (w/o remote compressor)	< 1,000 lb/day	< 25 gal/100 lb ice
With remote condensing unit (w/o remote compressor)	> 1,000 lb/day	< 25 gal/100 lb ice
With remote condensing unit (w/ remote compressor)	< 934 lb/day	< 25 gal/100 lb ice
With remote condensing unit (w/ remote compressor)	> 934 lb/day	< 25 gal/100 lb ice
Self-Contained Unit (SCU)		< 25 gal/100 lb ice
Food Steamers		
Boiler type steam cooker - batch cooking		8 gallons/hour/pan
Boilerless type steam cooker - high production/cook to order		8 gallons/hour/pan
Combination Oven		
Countertop or stand mounted		40 gph
Roll-in		60 gph
Other Equipment		Performance baseline based on industry standards

5.2.1.15 DFAC kitchen procedures

Also note that various procedures in the kitchen could change to conserve water. Spray hoses are often used to wash down the kitchen floors; alternatively, more efficient water brooms could be used to quickly clean floors without consuming as much water.

In addition, frozen meat is often quickly thawed by placing said meat into a sink and turning the faucet on. Rather than using hot water to thaw

[102] Arizona Department of Water Resources, Technologies - Kitchen Equipment. <http://www.azwater.gov/AzDWR/StatewidePlanning/Conservation2/Technologies/TechKitchen_Equipment.htm>

[103] USGBC, LEED 2009 for Healthcare Rating System, November 2010.

meat, researchers recommend removing the meat from the freezer prior to use and allowing the meat to thaw naturally as it sits out.

The Food Service Technology Center website has useful information on procedures and technologies which save water and energy in commercial kitchens. See url: http://www.fishnick.com/

5.2.1.16 Boot-wash and equipment/vehicle wash

Although not accounted for in the water calculations, it is important to note that boot-wash and equipment/vehicle wash systems could employ harvested rainwater or sanitized recycled water for operation and use.

Although vehicle washing takes place at a facility (Central Vehicle Wash Station or CVWS) outside the scope of this report, this activity holds high potential for large water savings. Fort Carson's $7 million CVWS utilizes a closed-loop system. It washes approximately 10,000 vehicles annually and can operate without added water for extended periods of time. Since its inception in 1987, the wash station has seen a savings of 3 billion gallons of water.[104]

5.2.2 Water calculations

This section explains the calculation methodology used to determine wastewater reductions. The reduction rates are comparisons between the baseline model and three design proposals. The baseline model uses conventional water fixtures, whereas the design proposals use various water-conserving fixtures. All calculations evaluate annual wastewater volumes from fixtures.

Each building type has four sheets within its data set: "Changeable Figures," "Flush Fixtures," "Flow Fixtures," and "Combined." A user changes the values in the "Changeable Figures" sheet only. All figures update automatically in the subsequent data sheets.

Within "Changeable Figures," a user determines the number of each occupant type and each type's male : female ratio. This automatically generates

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[104] Chvala, William D., Jr. 9 August 2006. Pacific Northwest National Laboratory. "Federal Examples of Water Reuse." PDF Online. <http://www1.eere.energy.gov/femp/pdfs/energy06_chvala_8b.pdf>. Accessed 7 January 2011.

head counts, which are used for the calculations directly. In addition, the user determines the number of days that the facility is in use, and whether s/he would like to test a conservative or liberal set of values. These will adjust the number of daily uses for the soldier occupant type. For example, a conservative number will increase the number of showers that a soldier takes in the UEPH from 1 to 2. It will also assume that a soldier uses the water closet 5 times in a day in order to account for weekends and holidays when the soldiers spend more time in this facility. A liberal figure will assume that the soldier spends most of his/her day out in the field and will use the other facilities for this function.

Figure 13 below shows an example of a “Changeable Figures” sheet that was used to generate the quantities and supplementary graphs in the sections that follow.

UEPH Changeable Figures	
Days of Operation	365
Percent of Male Restrooms With Urinals	0

	FTE		Soldiers		Students and Visitors	
	M	FM	M	FM	M	FM
Head Count	2	2	57	57	0	0
Percentage	50	50	50	50	50	50
Total		4		114		0

	A	B	C
Conservative figure (accounts for maximum soldier usage) = 5,0 [A]; 2,3 [B]; 5,2 [C]	5	2	5
Non-Conservative figure (accounts for minimum soldier usage) = 3,0 [A]; 1,2 [B]; 3,1 [C]	0	3	2

***The highlighted cells with red font are "changeable figures."**
Only change figures on this sheet.
All other figures will be atuomatically updated based on these changes.

Figure 13. Example of a “Changeable Figures” sheet.

The “Flush Fixtures” and “Flow Fixtures” sheets show a break-down of water usage for each fixture type, both conventional and water-conserving. No input is needed from the user on these sheets. Example of these sheets are provided in Figure 14 and Figure 15.

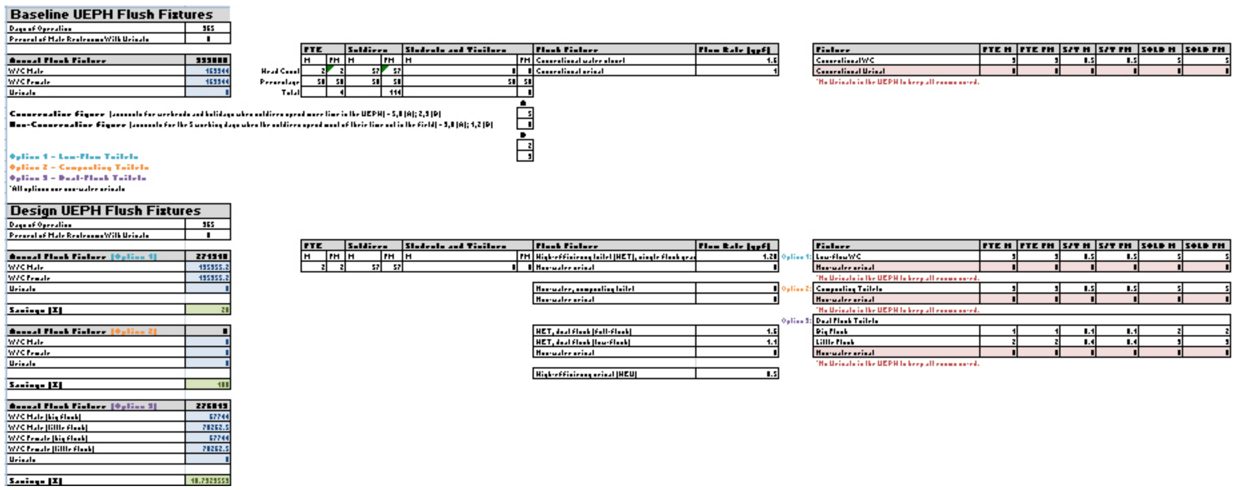


Figure 14. Example of a “Flush Fixtures” sheet.

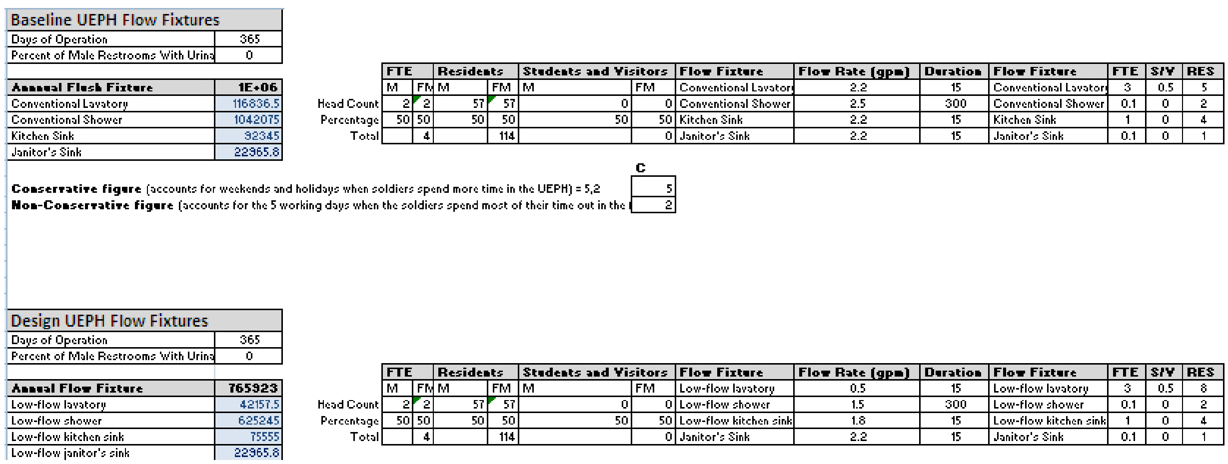


Figure 15. Example of a “Flow Fixture” sheet.

The “Combined” sheet shows a summary of the water usage of both the flush and flow fixtures. This sheet generates an overall annual waste water consumption figure and compares the design values to the baseline values to determine the possible waste water savings. An example of this sheet is provided in Figure 16.

Total UEPH Water Consumption	
Days of Operation	365
Percent of Male Restrooms With Urinals	0

Total Annual Water Consumption	Gallons	Savings (%)
Baseline Annual Consumption	1614110.30	0.00
Option 1	1037833.70	35.70
Option 2	765923.30	52.55
Option 3	1041936.30	35.45

Baseline Annual Flush Fixture	339888.00
W/C Male	169944.00
W/C Female	169944.00
Urinals	0.00

Design Annual Flush Fixture (Opti	271910.40
W/C Male	135955.20
W/C Female	135955.20
Urinals	0.00
Savings (%)	20.00

Design Annual Flush Fixture (Opti	0.00
W/C Male	0.00
W/C Female	0.00
Urinals	0.00
Savings (%)	100.00

Design Annual Flush Fixture (Opti	276013.00
W/C Male (big flush)	67744.00
W/C Male (little flush)	70262.50
W/C Female (big flush)	67744.00
W/C Female (little flush)	70262.50
Urinals	0.00
Savings (%)	18.79

Baseline Annual Flow Fixture	1274222.30
Conventional Lavatory	116836.50
Conventional Shower	1042075.00
Kitchen Sink	92345.00
Janitor's Sink	22965.80

Design Annual Flow Fixture	765923.30
Low-flow lavatory	42157.50
Low-flow shower	625245.00
Low-flow kitchen sink	75555.00
Janitor's Sink	22965.80
Savings (%)	39.89

Figure 16. Example of "Combined" sheet.

5.2.3 Assumptions

Various assumptions were made with regard to occupancy, flow rates, and daily usage in order to compute the overall annual volume of water consumption.

Approximate occupancy quantities of each facility were provided by the LEED submittals. These occupancy quantities were broken down into three occupant types: Full-time employees (FTE), soldiers, and students/visitors (S/V). Each occupant type is sub-divided into genders in order to generate proper figures for the water closet and urinal usage calculations. Occupancy break-downs are summarized in Table 17.

Table 17. Occupancy break-downs for five building types.

COS		FTE		Soldiers		S & V	
	Gender	M	F	M	F	M	F
UEPH	*Head Count*	2	2	57	57	0	0
	Percentage	50	50	50	50	50	50
	Total		4		114		0
DFAC	*Head Count*	27	27	2340	1560	0	0
	Percentage	50	50	60	40	50	50
	Total		54		3900		0
COF	*Head Count*	249	83	0	0	2	2
	Percentage	75	25	50	50	50	50
	Total		332		0		4
TEMF	*Head Count*	66	10	0	0	2	2
	Percentage	87	13	50	50	50	50
	Total		76		0		4
BDEHQ	*Head Count*	56	14	0	0	140	35
	Percentage	80	20	50	50	80	20
	Total		70		0		175

The baseline calculations use conventional fixtures. Conventional fixture flow-rates were based on the values from the 2009 *LEED Reference Guide for Green Building Design and Construction*. The design calculations use various types of low-flow fixtures. Low-flow rates came from Niagara Conservation, Vortens, and Zurn EcoVantage manufacturer fixture data sheets.

Three design options were tested in order to distinguish savings from different flush fixtures. The first design option utilized HETs; the second, composting toilets; the third, dual-flush toilets. All of the design options utilized waterless urinals where appropriate.

Table 18 summarizes the gallons per minute flow-rates of both flush and flow fixtures:

Table 18. Flow rates for flush and flow fixtures.

Flush Fixture	Flow Rate (gpm)
Conventional water closet	1.60
Conventional urinal	1.00
High-efficiency toilet (HET), single fluch gravity	1.28
HET, dual flush (full-flush)	1.60
HET, dual flush (low-flush)	1.10
Non-water, composting toilet	0.00
High-efficiency urinal (HEU)	0.50
Non-water urinal	0.00
Flow Fixture	
Conventional private lavatory	2.20
Conventional shower	2.50
Conventional kitchen sink	2.20
Conventional janitor's sink	2.20
Conventional wash fountain	3.80
Low-flow lavatory	0.50
Low-flow shower	1.50
Low-flow kitchen sink	1.80

Note that in this study, dual-flush toilets used 1.6 and 1.1 gpf for the solid and liquid flushes, respectively. Many venders sell products that meet this standard; however, the Sydney Smart 305 by Caroma, boasts a 1.28/0.8 gpf dual-flush toilet. In addition, this study uses low-flow lavatories with a flow-rate of 0.5 gpm, per the stipulation of the *LEED Reference Guide for Building Design and Construction*. Although such low-flow lavatories exist, a minimum of 1.5 gpm was recommended by various venders due to sanitation and health concerns.

Daily uses were based on the 2009 *LEED Reference Guide for Building Design and Construction* for each occupant type. Values for soldiers were based on the resident occupant type for most instances; however, these values may be altered to account for more or less usage in each building type by choosing a conservative or liberal value within the "Changeable Values" sheet, as described previously.

5.2.4 Formulas

The calculations determine an approximate annual volume of water consumption. Volumes are determined based on the different occupants and their respective usage in that building.

Flush fixtures include water closets and urinals. Three different design options were proposed. The first utilized low-flow water closets and non-water urinals; the second called for composting toilets and non-water urinals; the third called for dual-flush toilets and non-water urinals.

For each type of water closet, water usage volume is calculated by multiplying the days of facility operation by the sum of the male and female usage. Male and female usages are products of the FTE and S/V populations, the gallons per flush, and the daily flushes per person, based on the occupant type.

In addition to the water closet, the calculations for the male population take urinals into account; whereas, for the female population, only the water closet is used. Urinals do not exist in the UEPH in order to keep all of the rooms genderless.

Flow fixtures include lavatories, kitchen and janitorial sinks, showers, and wash fountains. The consumption volume for flow fixtures is a product of the total population of FTE, Soldiers, and S/V, the gallons per minute divided by 60 seconds per minute, and the daily uses per person, based on the occupant type.

5.2.5 Building water usage

Each of the five building types experiences different levels of water consumption.

5.2.5.1 UEPH

As indicated in the charts below, the largest consumer of water in the UEPH is showers. In the baseline and design options 1 and 3, toilets consume the second largest quantity of water. Note that in design option 2, composting toilets, the consumption of water by toilets is eliminated. The water consumption break-down by fixture is shown in Figure 17.

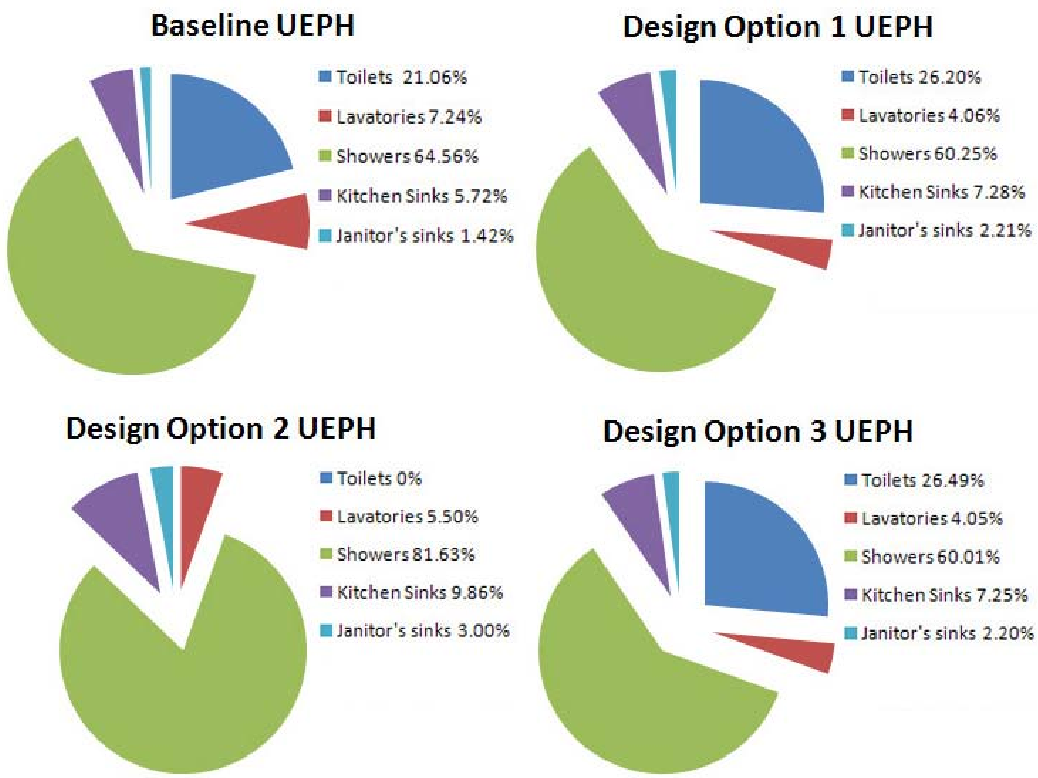
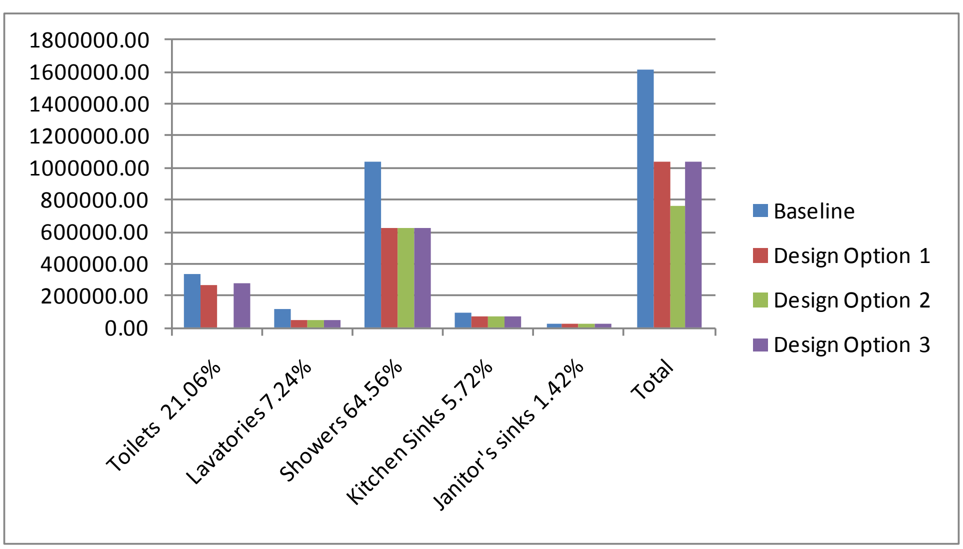


Figure 17. UEPH water consumption by design option.

Table 19 summarizes a comparison between the baseline and three design options and each respective model's water consumption by water fixture. The largest consumer, showers, also sees the largest reduction with the subsequent design proposal changes.

Table 19. UEPH water consumption.



5.2.5.2 DFAC

Kitchen equipment consumes the most water in the DFAC. However, these calculations are beyond the scope of this study. Only flush and flow fixtures were assessed. Several steps could be taken to potentially achieve an 80-90 percent savings of water for kitchen equipment. These were described above in the DFAC kitchen equipment section on page 52. The water consumption break-down by fixture is shown in Figure 18.

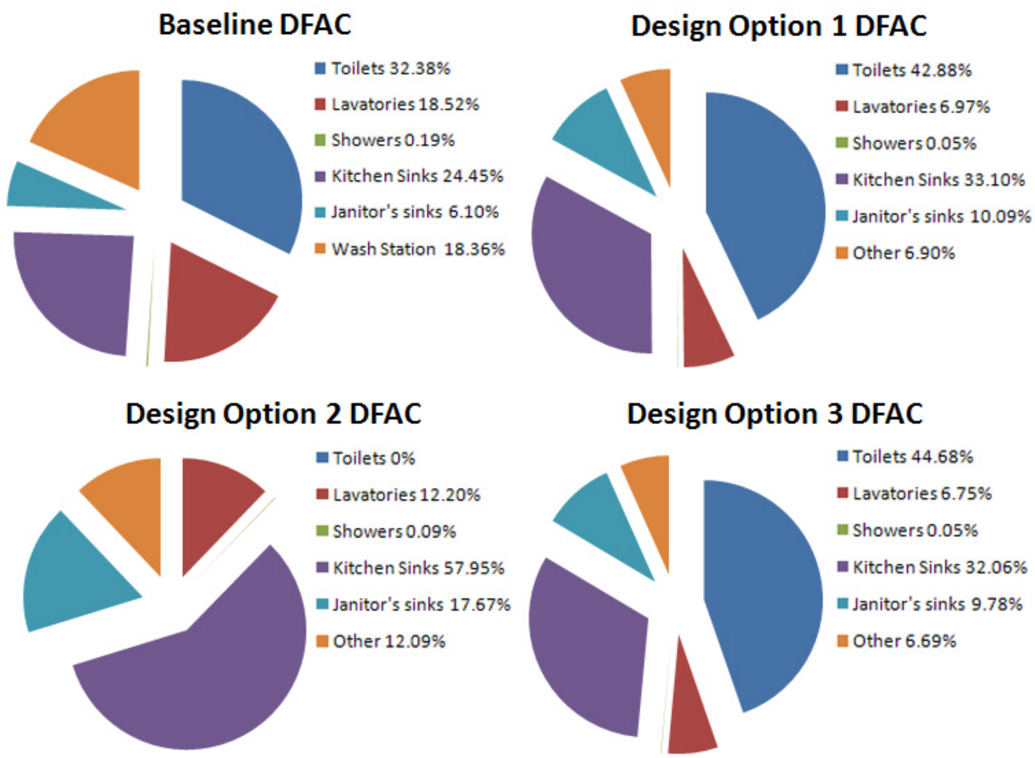
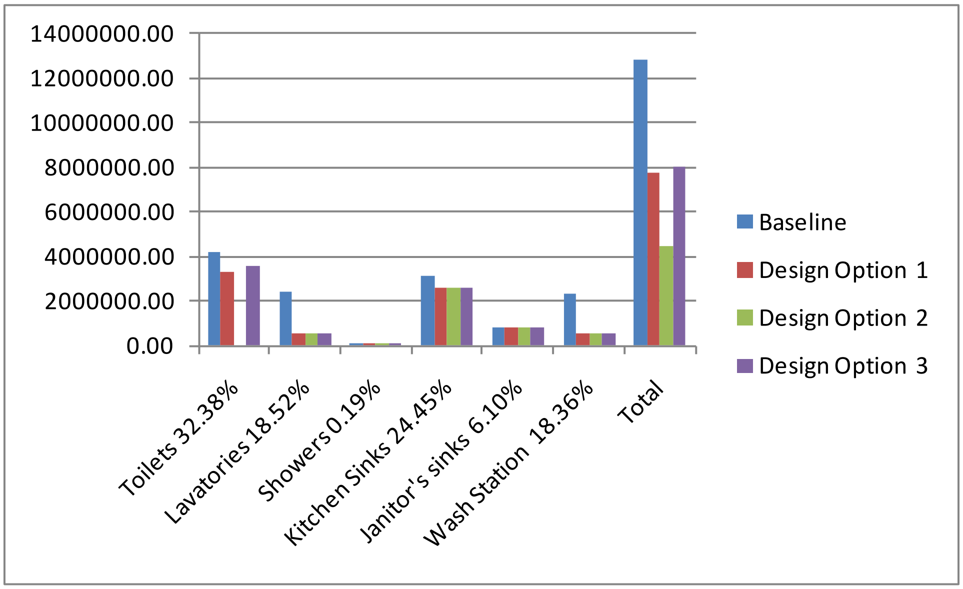


Figure 18. DFAC water consumption by design option.

Table 20 below summarizes a comparison between the baseline and three design options and each respective model's water consumption by water fixture.

Table 20. DFAC water consumption.



5.2.5.3 COF

As indicated in the charts below, the largest consumer of water in the COF is toilets. By using water conserving fixtures, the water usage of toilets dramatically reduces, as seen in design option 2. The water consumption break-down by fixture is shown in Figure 19.

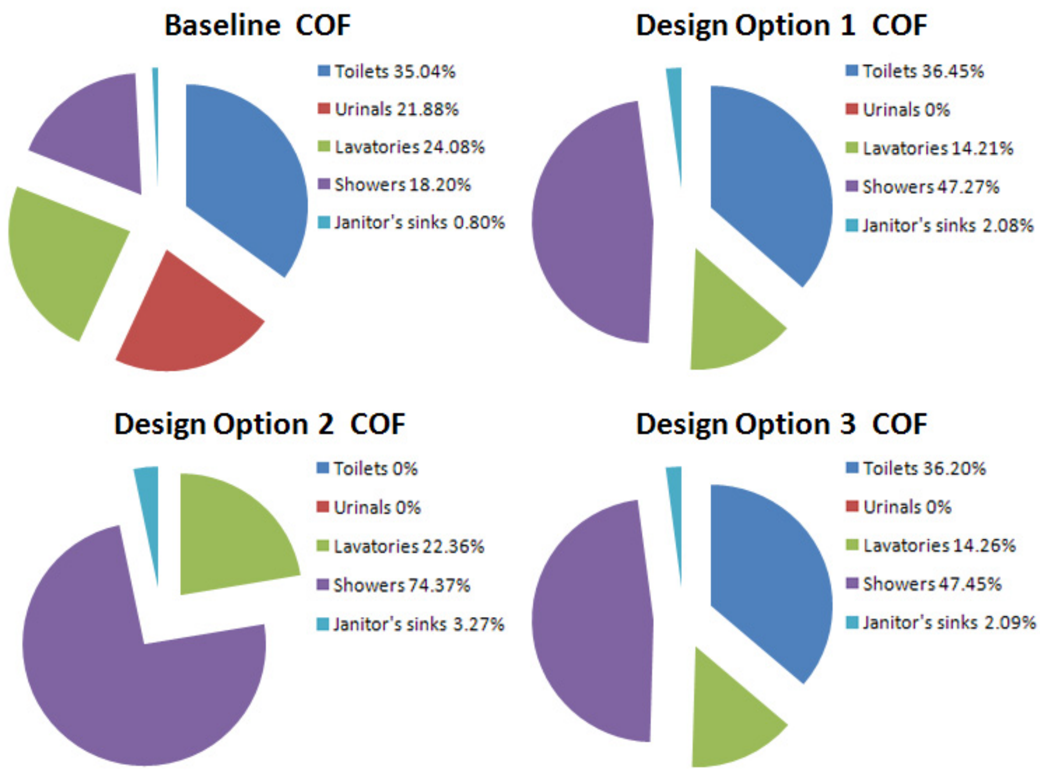
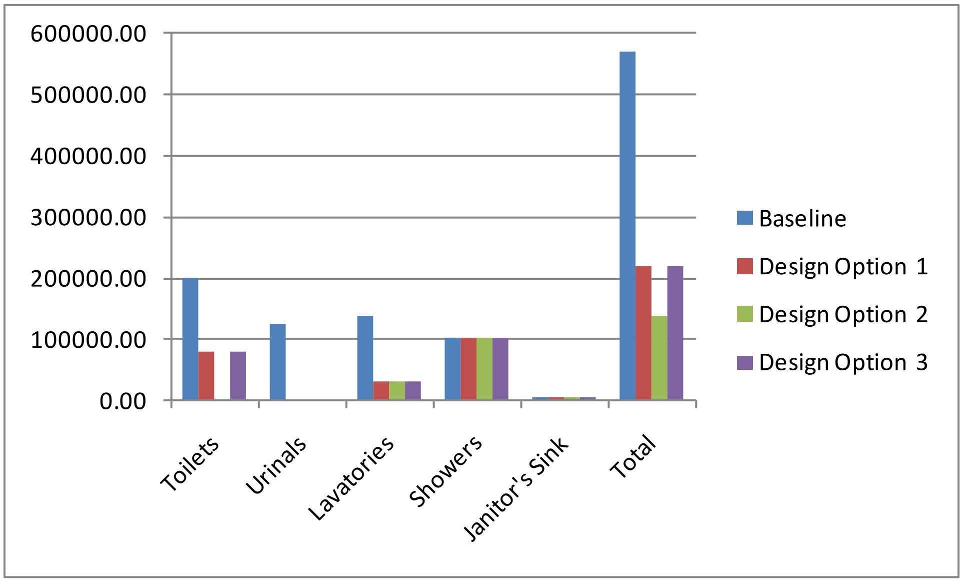


Figure 19. COF water consumption by design option.

Table 21 below summarizes a comparison between the baseline and three design options and each respective model's water consumption by water fixture.

Table 21. COF water consumption.



5.2.5.4 TEMF

Note that the water calculations for this report focus on flush and flow fixtures only. Like the DFAC, specialty equipment exists in the TEMF and is not accounted for in this report. The water consumption break-down by fixture is shown in Figure 20.

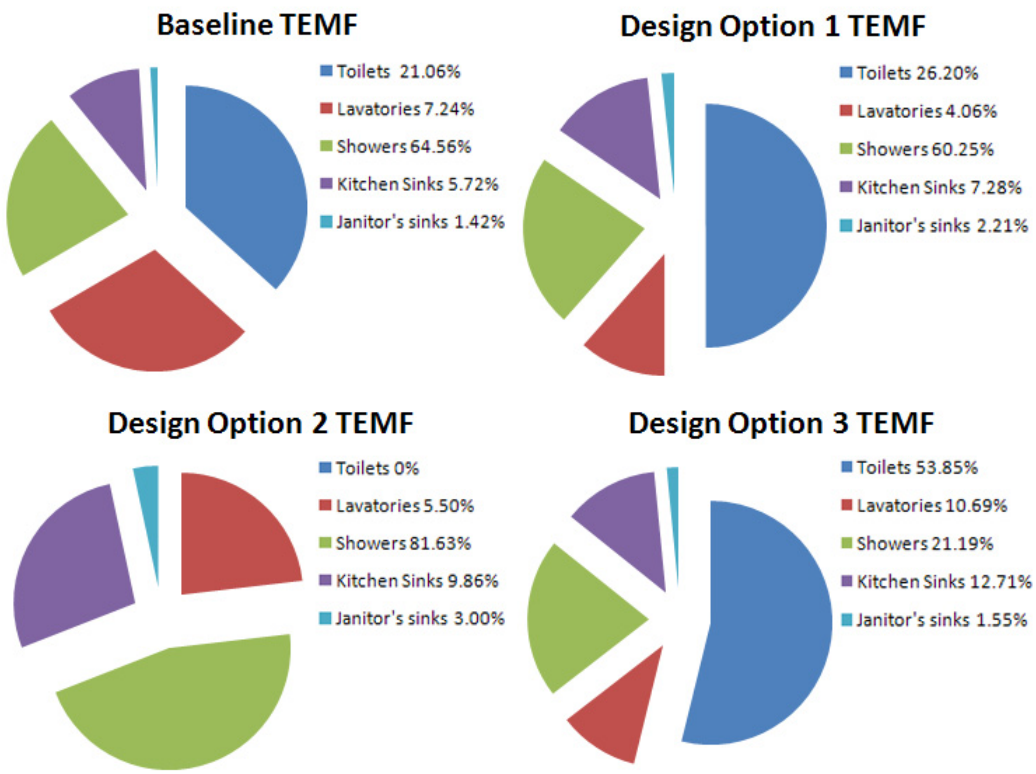
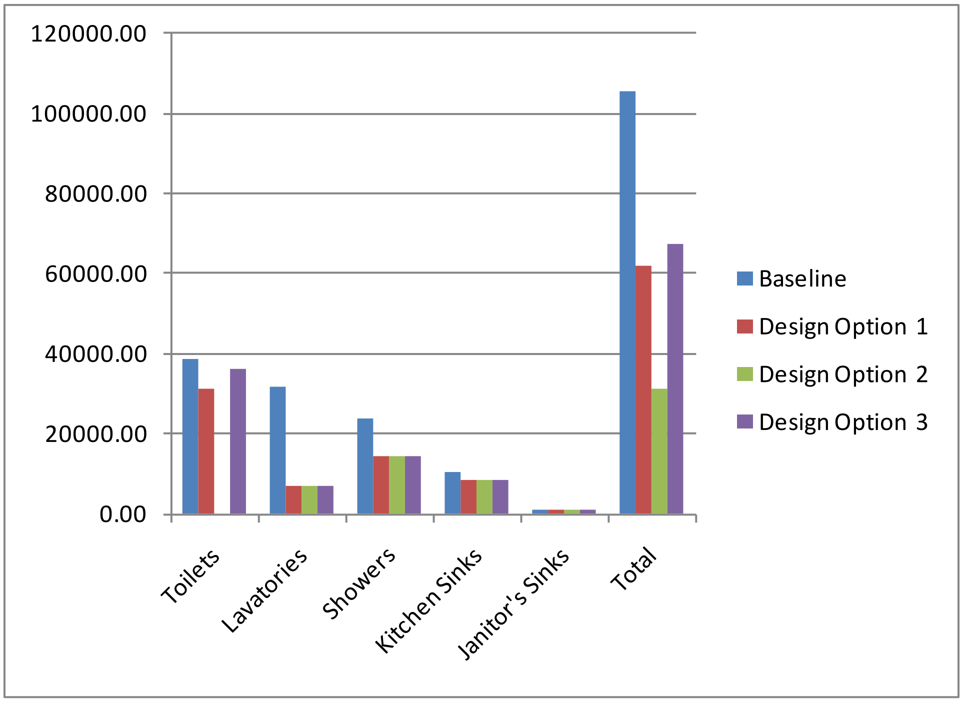


Figure 20. TEMF water consumption by design option.

Table 22 below summarizes a comparison between the baseline and three design options and each respective model's water consumption by water fixture.

Table 22. TEMF water consumption.



5.2.5.5 BDEHQ

The BDEHQ water consumption break-down by fixture is shown in Figure 21 below:

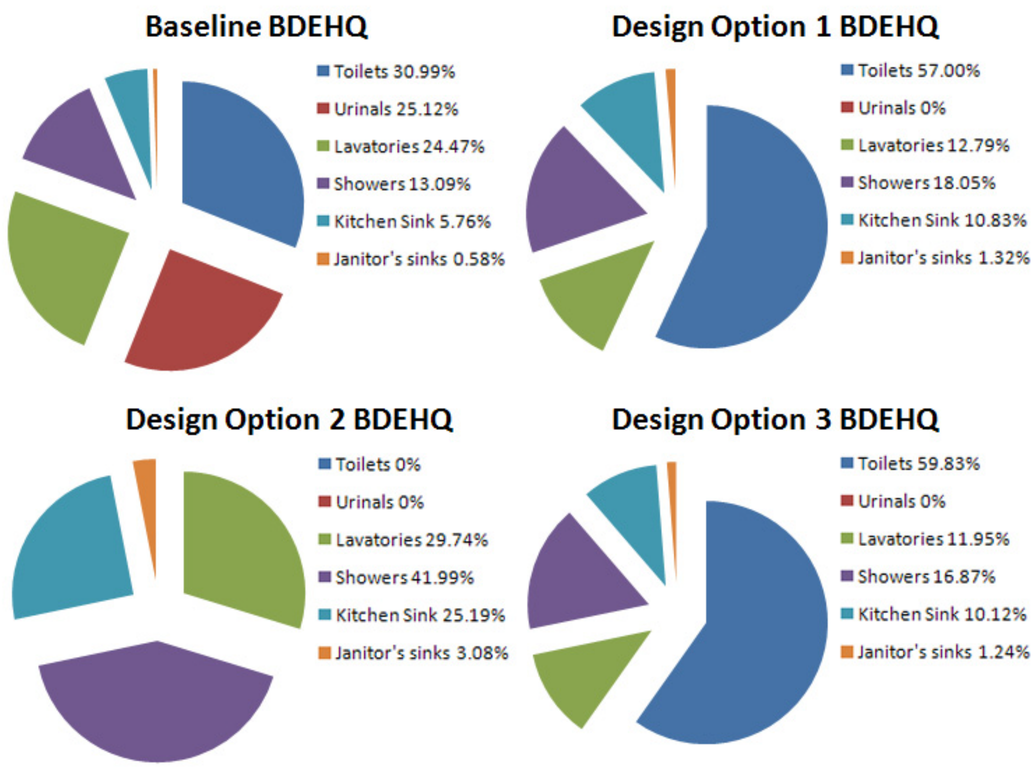
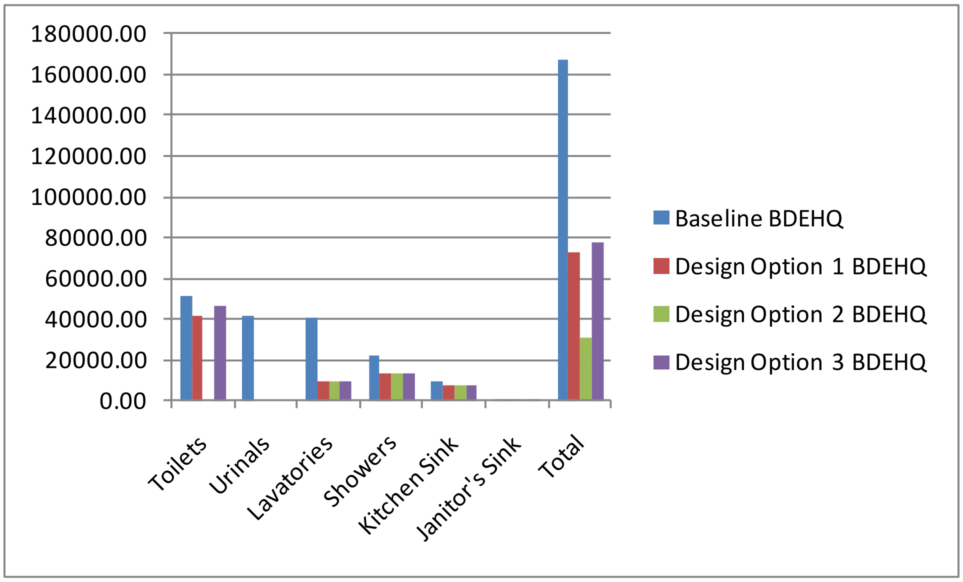


Figure 21. BDEHQ water consumption by design option.

Table 23 below summarizes a comparison between the baseline and three design options and each respective model's water consumption by water fixture.

Table 23. BDEHQ water consumption.



5.2.6 Summary of findings

Annual water consumption volumes are summarized in Table 24 through Table 28.

Table 24. Summary of annual water consumption volumes for UEPH.

Building Type	Annual Volume		Gallons	Savings (%)
UEPH	**Baseline**	Flush Fixtures	339888.00	-
		Flow Fixtures	1274222.30	-
		Total	1614110.30	-
	Design	Flush Fixtures		
		Option 1	271910.40	20.00
		Option 2	0.00	100.00
		Option 3	276013.00	18.79
		Flow Fixtures	765923.30	39.89
		Total		
		Option 1	1037833.70	35.70
		Option 2	765923.30	52.55
		Option 3	1041936.30	35.45

Table 25. Summary of annual water consumption volumes for DFAC.

Building Type	Annual Volume		Gallons	Savings (%)
DFAC	**Baseline**	Flush Fixtures	5890662.00	-
		Flow Fixtures	8692099.05	-
		Total	14582761.05	-
	Design	Flush Fixtures		
		Option 1	3330201.60	43.47
		Option 2	0.00	100.00
		Option 3	3583497.00	39.17
		Flow Fixtures	4436708.55	48.96
		Total		
		Option 1	7766910.15	46.74
		Option 2	4436708.55	69.58
		Option 3	8020205.55	45.00

Table 26. Summary of annual water consumption volumes for COF.

Building Type	Annual Volume		Gallons	Savings (%)
COF	**Baseline**	Flush Fixtures	324380.00	-
		Flow Fixtures	245540.00	-
		Total	569920.00	-
	Design	Flush Fixtures		
		Option 1	159744.00	50.75
		Option 2	0.00	100.00
		Option 3	178830.00	44.87
		Flow Fixtures	98002.50	82.80
		Total		
		Option 1	257746.50	54.77
		Option 2	98002.50	82.80
		Option 3	276832.50	51.43

Table 27. Summary of annual water consumption volumes for TEMF.

Building Type	Annual Volume		Gallons	Savings (%)
TEMF	Baseline	Flush Fixtures	72044.00	-
		Flow Fixtures	72285.00	-
		Total	144329.00	-
	Design	Flush Fixtures		
		Option 1	31027.20	56.93
		Option 2	0.00	100.00
		Option 3	36214.00	49.73
		Flow Fixtures	36447.50	74.75
		Total		
		Option 1	67474.70	53.25
		Option 2	36447.50	74.75
		Option 3	72661.50	49.66

Table 28. Summary of annual water consumption volumes for BDEHQ.

Building Type	Annual Volume		Gallons	Savings (%)
BDEHQ	Baseline	Flush Fixtures	93800.00	-
		Flow Fixtures	72406.25	-
		Total	166206.25	-
	Design	Flush Fixtures		
		Option 1	41440.00	55.82
		Option 2	0.00	100.00
		Option 3	46550.00	50.37
		Flow Fixtures	31259.38	56.83
		Total		
		Option 1	72699.38	56.26
		Option 2	31259.38	81.19
		Option 3	77809.38	53.19

5.3 WEc1—Water efficient landscaping

Gray water reuse for landscape application has been demonstrated at several Army sites. These include the use of gray water at Fort Huachuca, AZ and Fort Carson, CO for golf course irrigation. A similar project is in the planning stages at Fort Hood, TX. Rainwater reuse has been retrofit at Fort Bragg, NC and Fort Lewis, WA. Additionally, new construction efforts at Fort Belvoir, VA and Fort Lewis, WA incorporated rainwater collection in the building design.

5.4 WEc2—Innovative wastewater technologies

The goal of LEED WE credit 2 is to reduce wastewater generation and potable water demand through the implementation of innovative wastewater technologies. This can be accomplished through the use of water-conserving fixtures, as described previously in Section 3.2.1 of this report, by using treated recycled water, or by using alternative water sources, (i.e., graywater, rainwater, and/or condensate water) as indicated in Section 3.5 of this report.[105] The Army SDD Validation team visited several buildings that achieved this credit due to the percentage of men occupying the buildings and the use of non-water urinals.

5.5 Alternate sources

Local regulations often limit the types of water re-use allowed and should be checked before any serious investigation into alternate sources. Other regulations on the usage of alternate sources include EPA regulations on drinking water and backflow prevention, International Plumbing Code (IPC), and the IAPMO's codes regarding non-potable water reuse systems.[106,107]

5.5.1 Gray water

The general definition of gray water is used wash water – the byproduct of most indoor water uses including showers, clothes washers, and most sinks, but excluding toilets, and sometimes kitchen sinks and dishwashers (which produce wastewater containing food particles). Gray water needs some amount of treatment before reuse, except when being used for subsurface irrigation. However, even then, it needs to be used relatively quickly (if untreated). Otherwise, it will become septic.[108]

Water reuse, such as at Fort Carson, and future installation of graywater systems, is currently most common in the semi-arid regions of the south-

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[105] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council. Washington, D.C. P 193.

[106] The International Association of Plumbing and Mechanical Officials. Chapter sixteen of IAPMO uniform plumbing code is devoted to non-potable water reuse systems.

[107] Hoffman, H. (2008). Capturing the water you already have: Using alternate onsite sources. Journal—American Water Works Association, 100(5), 112-116.

[108] Hoffman, H. (2008). Capturing the water you already have: Using alternate onsite sources. Journal—American Water Works Association, 100(5), 112-116.

ern and western United States;[109] however, often in these water-scarce regions water is strictly controlled by legislation that may hinder the expansion of graywater reuse. Major conflicts can arise if substantial amounts of graywater is used consumptively and not returned to the original source for credit. Fort Carson pays a penalty for unreturned groundwater. Las Vegas Valley, Nevada, provides another example where wastewater return to Lake Meade is carefully monitored since it comprises a 190,000 acre-foot-per-year (AF) credit that is applied towards southern Nevada's 300,000-AF Colorado River Allocation.

5.5.1.1 Collection techniques

Systems for gray water reuse generally have to be tailored to the facility from which the water will be collected. For new construction, wash water can simply be collected separately from other water; whereas, in existing construction, gray water is typically run through the same pipes and sewage as other wastewater. Consequently, a separate collection system would generally have to be retrofitted to the facility in accord with local regulations and code requirements. Nonetheless, a variety of gray water systems, with and without water treatment, are available for both new and existing buildings. The amount of gray water generated in a building will decrease as other water usage becomes more efficient. Even so, a significant portion of waste water on site is typically gray water.[110] Thus, especially for larger sites (such as Army installations), gray water has the potential to play an important role in water-use efficiency.

A simpler form of gray water reuse can be implemented in washrooms. The water from the lavatory can be collected under the sink and transported to the flush fixture's tank to be used for flushing. This technique could be retrofitted to the UEPH bathrooms.

5.5.1.2 Feasibility

Graywater should be viewed as a resource that is distinct from black water as it contains little or no pathogens and 90 percent less nitrogen than blackwater, making it ideal for toilet flushing, irrigation, and exterior

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[109] Sheikh, Baham, White Paper on Graywater. American Water Works Association, Water Environment Federation, and the WateReuse Association, 2010.

[110] Madungwe, E., & Sakuringwa, S. (2007). Greywater reuse: A strategy for water demand management in Harare? PHYSICS AND CHEMISTRY OF THE EARTH, PARTS A B C, 32(15-18), 1231-1236.

washing. Because of this difference in composition, graywater requires far less intensive treatment processes than black water does, making on-site treatment possible.

5.5.1.3 Treatment

Systems are generally simple, consisting of a three-way diverter valve, a treatment assembly such as a sand filter, a holding tank, a bilge pump, and irrigation or leaching system.[111] Large scale industrial systems are still in the development phase but are receiving considerable attention from organizations such as the International Water Association (IWA).

Two types of disinfection units that are commercially available now are calcium hypochlorite tablet chlorination and ultraviolet disinfection. In each of these units performance is measured through counts of MS2 coliphage, total coliform, and fecal coliform inactivation. Although both units provided comparable results, both were also subject to breakthrough events, in which design or material flaws resulted in unacceptable levels of the measured substances. In addition to correcting these flaws, proper maintenance routines must be established and mandated in order to ensure the reliability of disinfection units.[112,113]

5.5.2 Atmospheric water

Naturally occurring water in the form of rainwater, stormwater, and condensate from water vapor are all available for non-potable use. Rainwater is typically collected from roof runoff into gutters and stored in rain barrels and cisterns, as discussed previously in Section 4.1.2.6 of this report.

Harvested water is generally clean and therefore has many applications. This may include cooling tower make-up supply, which otherwise has an increasing salinity problem. The high level of purity also enables longer

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[111] NAHB Research Center. 2010. "Greywater Reuse." <http://www.toolbase.org/Techinventory/TechDetails.aspx?ContentDetailID=907&BucketID=6&CategoryID=11>

[112] Leverenz, Harold, Darby, Jeannie, and Tchobanoglous, George. 2010. NOWRA Onsite Journal. "Evaluation of Disinfection Units for Onsite Wastewater Treatment Systems." PDF. http://www.nowra.org/journal/spring2010journal.pdf

[113] Otis, Richard J. 2010. NOWRA Onsite Journal. "What Do You Think? Do Prescribed Design Flows Compromise Treatment?" PDF. <http://www.nowra.org/journal/spring2010journal.pdf

storage times before use. Harvesting technology selection is dependent on climate and building type.

While relatively clean when falling, rainwater can pick up roof debris and organic material en route that needs to be filtered before entering storage. Bacteria levels in untreated rainwater should be tested routinely, and if too high, the water should be tested before being put to (even non-potable) use. If organic material and bacteria do enter the storage area, rainwater has the potential to become unusable (although on a slower time scale than graywater). Additional treatment of rainwater, using ultraviolet (UV) radiation or ozone, for example, can usually achieve levels of water quality high enough to be potable.[114]

Stormwater differs from rainwater in that is collected from storm drains or other areas set aside to collect stormwater, as opposed to directly from the roofs on which the water falls. Stormwater tends to gather more debris and is exposed to different pollutants (such as oil from roads, pesticides, trash, etc.). Consequently, stormwater is more likely to need treatment before use than rainwater.[115] More on stormwater and collection techniques proceed in Section 4.1.2 of this report.

Condensate water is water that condenses on a surface that holds a temperature below dew point. Condensate from water vapor is regularly collected in air-conditioning and refrigeration units that operate in warm, moist places. The water has the advantage of being reliably available in humid places over the hottest months when landscape irrigation and/or cooling tower make-up water is most needed. In addition, condensate water is generally clean enough to be put to either of these uses without treatment. In larger commercial and industrial buildings, the amount of condensate produced can be in the thousands of gallons. Retrofits for the collection of condensate water are normally relatively simple, as most air-conditioning systems collect and/or discharge condensate at a single location. While condensate reuse and recovery systems do not generate a great

[114] Texas Commission on Environmental Quality. (2007). Harvesting, Storing, and Treating Rainwater for Domestic Indoor Use. TCEQ. Retrieved July 24, 2009, from http://www.tceq.state.tx.us/files/gi-366.pdf_4445350.pdf

[115] Hoffman, H. (2008). Capturing the water you already have: Using alternate onsite sources. Journal—American Water Works Association, 100(5), 112-116.

deal of water in dry locations, such systems can save considerable amounts of potable water in humid areas.[116,117]

5.5.2.1 Quantities calculations

As indicated previously in Section 4.1.2 on stormwater collection techniques, rainwater and stormwater may be harvested and stored in rain barrels or cisterns.

Table 29 through Table 33 below summarize the amount of rain water that could be collected from each building type based on its roof area. The design options are consistent with those that were previously described in the calculations for each building type. Design option 1 uses low-flow toilets, design option 2 uses composting toilets, and the third design option uses dual-flush toilets. All three of these design options use non-water urinals.

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[116] Hoffman, H. (2008). Capturing the water you already have: Using alternate onsite sources. Journal—American Water Works Association, 100(5), 112-116; Wilson, A. (2008, May 1). Alternative Water Sources: Supply-Side Solutions for Green Buildings. Environmental Building News. Retrieved July 24, 2009, from http://www.buildinggreen.com/auth/article.cfm/ID/3903/

[117] Chesnutt, T., Fiske, G., and Feecher, J. 2007. Water Efficiency Programs for Integrated Water Management. American Water Works Association.

Table 29. Rainwater harvesting for UEPH.[118]

UEPH	Fort Leavenworth, KS								
				Toilet Demand (gal.)			Cumulative Water Storage Demand (gal.)		
Month	Rainfall (in.)	Roof Area (sqft.)	Potential PWH (gal.)	DO1	DO2	DO3	DO1	DO2	DO3
Jan	1.07	15,200	10,084	3453.33	0.00	3879.17	6,630.35	10,083.68	6,204.51
Feb	1.25	15,200	11,780	3453.33	0.00	3879.17	14,957.01	21,863.68	14,105.35
Mar	2.83	15,200	26,670	3453.33	0.00	3879.17	38,173.60	48,533.60	36,896.10
Apr	3.7	15,200	34,869	3453.33	0.00	3879.17	69,589.07	83,402.40	67,885.73
May	5.38	15,200	50,701	3453.33	0.00	3879.17	116,836.85	134,103.52	114,707.69
Jun	5.02	15,200	47,308	3453.33	0.00	3879.17	160,692.00	181,412.00	158,137.00
Jul	4.73	15,200	44,576	3453.33	0.00	3879.17	201,814.19	225,987.52	198,833.35
Aug	4.03	15,200	37,979	3453.33	0.00	3879.17	236,339.57	263,966.24	232,932.91
Sep	4.93	15,200	46,460	3453.33	0.00	3879.17	279,346.56	310,426.56	275,514.06
Oct	3.72	15,200	35,057	3453.33	0.00	3879.17	310,950.51	345,483.84	306,692.17
Nov	2.74	15,200	25,822	3453.33	0.00	3879.17	333,318.93	371,305.60	328,634.77
Dec	1.54	15,200	14,513	3453.33	0.00	3879.17	344,378.56	385,818.56	339,268.56

Table 30. Rainwater harvesting for DFAC.

DFAC	Fort Bragg, NC								
				Toilet Demand (gal.)			Cumulative Water Storage Demand (gal.)		
Month	Rainfall (in.)	Roof Area (sqft.)	Potential PWH (gal.)	DO1	DO2	DO3	DO1	DO2	DO3
Jan	4.16	28,350	73,120	3453.3	0.00	3879.2	69,667	73,120.32	69,241
Feb	3.43	28,350	60,289	3453.3	0.00	3879.2	126,503	133,409.43	125,651
Mar	4.38	28,350	76,987	3453.3	0.00	3879.2	200,037	210,396.69	198,759
Apr	3.06	28,350	53,786	3453.3	0.00	3879.2	250,369	264,182.31	248,666
May	3.29	28,350	57,828	3453.3	0.00	3879.2	304,744	322,010.64	302,615
Jun	4.18	28,350	73,472	3453.3	0.00	3879.2	374,763	395,482.50	372,207
Jul	5.21	28,350	91,576	3453.3	0.00	3879.2	462,885	487,058.67	459,904
Aug	5.21	28,350	91,576	3453.3	0.00	3879.2	551,008	578,634.84	547,601
Sep	4.78	28,350	84,018	3453.3	0.00	3879.2	631,573	662,652.90	627,740
Oct	3.05	28,350	53,610	3453.3	0.00	3879.2	681,729	716,262.75	677,471
Nov	2.85	28,350	50,094	3453.3	0.00	3879.2	728,371	766,357.20	723,686
Dec	3.18	28,350	55,895	3453.3	0.00	3879.2	780,812	822,252.06	775,702

[118] Design Option (DO) 1 uses low-flow toilets; DO 2 uses composting toilets; DO 3 uses dual-flush toilets

Table 31. Rainwater harvesting for COF.

COF	Fort Stewart, GA								
				Toilet Demand (gal.)			Cumulative Water Storage Demand (gal.)		
Month	Rainfall (in.)	Roof Area (sqft.)	Potential PWH (gal.)	DO1	DO2	DO3	DO1	DO2	DO3
Jan	4.28	71,290	189,175	3453.3	0.00	3879.2	185,722	189,175.14	185,296
Feb	3.32	71,290	146,743	3453.3	0.00	3879.2	329,012	332,465.15	328,160
Mar	3.76	71,290	166,191	3453.3	0.00	3879.2	491,750	495,203.07	490,472
Apr	2.98	71,290	131,715	3453.3	0.00	3879.2	620,012	623,465.14	618,308
May	3.45	71,290	152,489	3453.3	0.00	3879.2	769,048	772,501.12	766,919
Jun	5.06	71,290	223,651	3453.3	0.00	3879.2	989,245	992,698.78	986,690
Jul	5.92	71,290	261,663	3453.3	0.00	3879.2	1,247,455	1,250,908.27	1,244,474
Aug	5.84	71,290	258,127	3453.3	0.00	3879.2	1,502,128	1,505,581.77	1,498,722
Sep	4.79	71,290	211,717	3453.3	0.00	3879.2	1,710,392	1,713,845.48	1,706,560
Oct	3.17	71,290	140,113	3453.3	0.00	3879.2	1,847,052	1,850,505.52	1,842,794
Nov	2.69	71,290	118,897	3453.3	0.00	3879.2	1,962,496	1,965,949.65	1,957,812
Dec	3.06	71,290	135,251	3453.3	0.00	3879.2	2,094,294	2,097,747.71	2,089,184

Table 32. Rainwater harvesting for TEMF.

TEMF	Fort Bragg,NC								
				Toilet Demand (gal.)			Cumulative Water Storage Demand (gal.)		
Month	Rainfall (in.)	Roof Area (sqft.)	Potential PWH (gal.)	DO1	DO2	DO3	DO1	DO2	DO3
Jan	4.16	13,248	34,169	3453.3	0.00	3879.2	30,716	34,169.24	30,290.07
Feb	3.43	13,248	28,173	3453.3	0.00	3879.2	55,436	62,342.44	54,584.10
Mar	4.38	13,248	35,976	3453.3	0.00	3879.2	87,959	98,318.71	86,681.20
Apr	3.06	13,248	25,134	3453.3	0.00	3879.2	109,639	123,452.81	107,936.13
May	3.29	13,248	27,023	3453.3	0.00	3879.2	133,209	150,476.08	131,080.23
Jun	4.18	13,248	34,334	3453.3	0.00	3879.2	164,090	184,809.60	161,534.58
Jul	5.21	13,248	42,794	3453.3	0.00	3879.2	203,430	227,603.29	200,449.10
Aug	5.21	13,248	42,794	3453.3	0.00	3879.2	242,770	270,396.98	239,363.62
Sep	4.78	13,248	39,262	3453.3	0.00	3879.2	278,579	309,658.75	274,746.22
Oct	3.05	13,248	25,052	3453.3	0.00	3879.2	300,177	334,710.72	295,919.02
Nov	2.85	13,248	23,409	3453.3	0.00	3879.2	320,133	358,119.94	315,449.07
Dec	3.18	13,248	26,120	3453.3	0.00	3879.2	342,800	384,239.69	337,689.65

Table 33. Rainwater harvesting for BDE-HQ.

BDE-HQ	Fort Stewart, GA								
				Toilet Demand (gal.)			Cumulative Water Storage Demand (gal.)		
Month	Rainfall (in.)	Roof Area (sqft.)	Potential PWH (gal.)	DO1	DO2	DO3	DO1	DO2	DO3
Jan	4.28	19,895	52,793	3453.33	0.00	3879.17	49340.04	52793.37	48,914.21
Feb	3.32	19,895	40,952	3453.33	0.00	3879.17	86838.57	93745.24	85,986.91
Mar	3.76	19,895	46,379	3453.33	0.00	3879.17	129764.46	140124.46	128,486.96
Apr	2.98	19,895	36,758	3453.33	0.00	3879.17	163069.13	176882.47	161,365.80
May	3.45	19,895	42,555	3453.33	0.00	3879.17	202171.20	219437.87	200,042.04
Jun	5.06	19,895	62,415	3453.33	0.00	3879.17	261132.47	281852.47	258,577.47
Jul	5.92	19,895	73,023	3453.33	0.00	3879.17	330701.74	354875.07	327,720.91
Aug	5.84	19,895	72,036	3453.33	0.00	3879.17	399284.22	426910.89	395,877.56
Sep	4.79	19,895	59,084	3453.33	0.00	3879.17	454915.06	485995.06	451,082.56
Oct	3.17	19,895	39,102	3453.33	0.00	3879.17	490563.36	525096.69	486,305.03
Nov	2.69	19,895	33,181	3453.33	0.00	3879.17	520290.91	558277.57	515,606.74
Dec	3.06	19,895	37,745	3453.33	0.00	3879.17	554582.37	596022.37	549,472.37

5.5.2.2 Feasibility

The storage of collected rainwater was discussed previously in Section 4.1.2.6. Once the water is collected, it may require a disinfectant system to treat the water before use. Although the water is treated, there are limited applications for collected rainwater. At this time, it is proposed that the water be used for toilet flushing and TEMF equipment washing only.

5.6 Recommendations for water efficiency

Recommendations are made on the basis of regional appropriateness, availability of technology, and ease of implementation.

Recommendations for the near term include:

- Expanded use of composting toilets in remote locations where traditional water and sewage infrastructure is not available or practical.
- Consideration of WaterSense approved fixtures when replacement of fixtures is necessary.
- Water reuse for all car washing facilities and for irrigation where practical. The recycle treatment systems used at the more than 25 existing

CVWF now save approximately 2.5 billion gallons of water every year.[119]

Recommendations for the mid-term (5-7 years) include:

- Mandating WaterSense fixtures in all new construction and remodeling projects.
- Implementing on-site graywater systems for outdoor washing activities and as a primary means for irrigation.
- Mandating rainwater harvesting at installations receiving sufficient annual rainfall in states that allow for rainwater harvesting.

Recommendations for the long term include:

- Implementation of large-scale graywater systems as they become commercially available and achieve significant market penetration.
- Cooperation with local utilities to develop large-scale community shared graywater systems within the utility infrastructure.

[119] Update to UFC 4-214-03, Central Vehicle Wash Facilities, Public Works Technical Bulletin 200-1-55, 1 April 2008, published by USACE.

6 Daylighting

The goals of an effective daylighting scheme are to provide enough daylighting without the undesired effects of glare and overheating, and to distribute daylight evenly throughout the space.

According to the Energy Information Administration and Green Econometrics Researchers, indoor electric lighting is the biggest consumer of electricity in commercial buildings, as illustrated in Figure 22 below.[120]

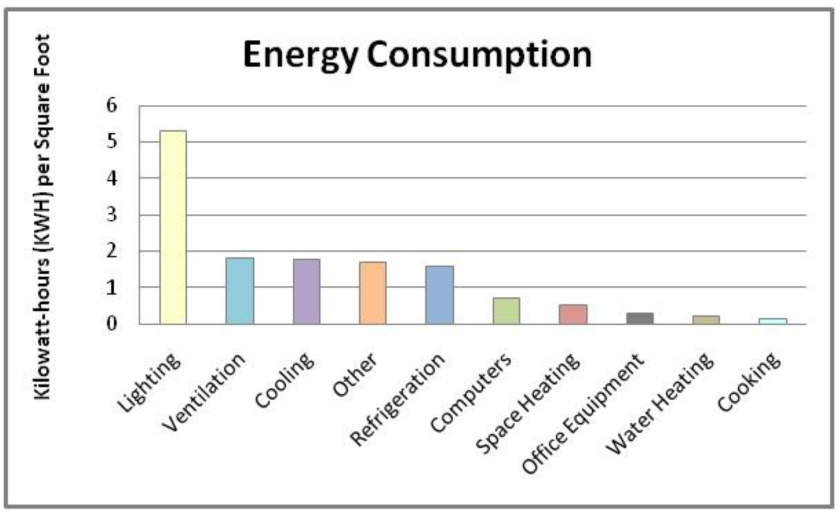

Figure 22. Energy consumption in buildings.[121]

Electrical lighting represents 40 – 50 percent of the energy consumption in commercial buildings and contributes 25 – 30 percent of the emission of greenhouse gases generated.[122] An effective and efficient daylighting scheme holds the potential to dramatically reduce the building's energy costs and the emission of greenhouse gases. Moreover, daylighting establishes a more pleasing and productive atmosphere for people. Studies show that in a corporate facility, an effective daylighting scheme can improve employee productivity, health, and morale.

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[120] Lighting Consumes Most Energy. http://greenecon.net/wp-content/uploads/2009/01/lighting.jpg

[121] Ibid.

[122] Ibid.

Different spectrums of light affect people both psychologically and physiologically. Once the human eye encounters natural light, the hormone melatonin is produced. Melatonin affects body clock synchronization, sleep, body temperature, mood, and tumor development.[123] In addition, sunlight offers improved visibility, better color rendering, and eliminates the flickering associated with electrical lighting. Consequently, studies show that when natural light is added to a workplace, productivity increases 20 percent and absences are cut nearly in half.[124]

According to Romm and Browning, increased productivity has financial implications as well. Based on a national survey, electricity costs $1.53 per square foot, repairs and maintenance typically cost $1.37 per square foot, and office rent costs $21 per square foot, whereas office workers' salaries cost $130 per square foot, 72 times as much as the energy costs. This means that approximately 1 percent gain in productivity is equivalent to the entire annual energy cost.[125] Therefore, an effective daylighting scheme would improve workability, productivity, and would ultimately result in cost savings.

In addition to lessening electrical lighting demand, daylighting strategies also have a positive effect on the heating, ventilating, and air conditioning (HVAC) system. In the winter, the sun is positioned at a lower azimuth angle, thus allowing light to enter the building through windows. The daylight enters the space and heats it, lessening the required heating loads. This has a positive effect on the heating demand; however, the sun is positioned at a higher azimuth angle during the summer months. Consequently, horizontal overhangs and louvers should be used on southern facades to block direct rays from entering the building and overheating the interior space.

123 Edwards, L. and Torcellini, P. July 2002. National Renewable Energy Laboratory. NREL/TP-550-30769. "A Literature Review of the Effects of Natural Light on Building Occupants." [PDF]. Pp. 4-6. With direct reference to: Salares, V.; Russell, P. (1996). "Low-E Windows: Lighting Considerations." A Sustainable Energy Future: How do we get there from here?

124 Edwards, L. and Torcellini, P. July 2002. National Renewable Energy Laboratory. NREL/TP-550-30769. "A Literature Review of the Effects of Natural Light on Building Occupants." [PDF]. P. 11.

125 Edwards, L. and Torcellini, P. July 2002. National Renewable Energy Laboratory. NREL/TP-550-30769. "A Literature Review of the Effects of Natural Light on Building Occupants." [PDF]. Pp. 4-6. With direct reference to: Romm, J.J; Browning, W.D. (1994). "Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design," Snowmass, CO: Rocky Mountain Institute.

Regional climate, building orientation, space-specific lighting requirements, and cooling loads all help to determine the type of daylighting system appropriate for a building.[126] Various strategies including overhangs, light shelves, and louvers can help reduce glare, avoid excessive heat gain, or help the light penetrate deeper into the space. Skylights, light tubes, and clerestories can help distribute the light to the interior from above. In some cases where large openings and penetrations are not desired, fiber optics could be used.[127] Alternatively, various materials and finishes can be applied to interior surfaces to reflect light within the space.

In addition to playing an important role in sustainability, daylighting is important to 'passive survivability.' This concept pertains to the ability of a building to maintain critical life-support conditions for its occupants if services such as power, heating fuel, or water are lost for an extended period.[128]

6.1 Federal building criteria

EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management, effective January 24, 2007, stipulates that all new construction projects must comply with the "Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings," established in the Federal Leadership in High Performance and Sustainable Buildings MOU.[129]

The MOU, effective March 2, 2006, requires buildings to obtain a minimum 2 percent daylight factor—within 75 percent of all occupied spaces that house critical visual tasks.[130] The daylight factor is determined based on the sizes of windows or skylights, the use of overhangs on the building's exterior or light shelves within, the type of glazing used, and reflectance

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[126] LEEDuser — Help for LEED Projects | LEED Credit Forum. N.p., n.d. Web. 28 July 2010. <http://www.leeduser.com/>.

[127] See Appendix B, Section 11.10 on Hybrid Solar Lighting for more information on fiber optics.

[128] Alex Wilson, "Passive Survivability," Environmental Building News, December 1, 2005.

[129] Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management, 01-24-2007 (EO 13423).

[130] The term "critical" refers to lighting being in critical need in order for the task to be completed (offices, meetings, maintenance), not necessarily that the task itself is critical.

levels of materials and finishes.[131] For an approximation of the daylight factor, the following formula can be used:[132]

[Formula 1]: Daylight Factor: $DF = 0.1 * PG$

Where, PG is the percentage of glass to floor area.

Additionally, the MOU—requires either automatic dimming controls or accessible manual lighting controls. Automatic or manual dimming controls allow building occupants to adjust the lighting density output. When natural light supplies sufficient lighting for tasks, electrical lighting can be reduced. ASHRAE Standard 189.1, Energy Efficiency 7.4.6.5,[133] also states that automatic controls should be used within daylighting zones in order to limit daylighting exposure when light levels are too high and glare may become an issue. Automatic controls may also dim or shut off electrical lighting fixtures when daylighting provides sufficient lighting levels for tasks to be performed. Further, the MOU requires a glare control system that is appropriate for the space conditions.[134] ASHRAE Standard 189.1, Indoor Environmental Quality 8.3.4 supports the use of top-lighting and skylights within daylighting zones to further enhance the use of free, natural light.

6.2 Technical criteria

Light levels or densities are measured in foot-candles or Lux. Lighting power densities (LPD) are determined light levels based on the needs of specific spaces. Table 34 below shows the lighting requirements for various spaces within the BDEHQ, COF, DFAC, TEMF, and UEPH.[135] These spaces could be supplemented with natural daylighting, which would result in lower LPDs. For more information on LPD, see Appendix F con-

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[131] Ibid.

[132] National Institute of Building Sciences. 2010. "Federal High Performance and Sustainable Buildings; Supporting Technical Guidance." Whole Building Design Guide. <http://www.wbdg.org/references/fhpsb_guidance.php>. Accessed 22 December 2010.

[133] ASHRAE 189.1.

[134] FedCenter.gov. 2006. Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding. [PDF Online]. <http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=4713&destination=ShowItem>. Accessed 22 December, 2010.

[135] Standards for UEPH and DFAC designs are currently unavailable for updates. As a result, the target density values for some zones of these buildings may not be shown in Table 34.

taining Atelier Ten's report in the MILCON Energy Enhancement and Sustainability Study of Five Army Buildings project report.

Table 34. Space-specific lighting target densities.[136,137,138,139]

Zone	Baseline	Min. Requirements
Arms (x4)	1.40 W/sqft	1.10 W/sqft
Break Room	0.73 W/sqft	--
Classroom/training	1.25 W/sqft	0.75 W/sqft
Conference Room	1.23 W/sqft	0.80 W/sqft
Consolidated Bench Repair	1.90 W/sqft	1.30 W/sqft
Corridor	0.50 W/sqft	0.40 W/sqft
Dining	0.65 W/sqft	0.60 W/sqft
Dishwasher/ Tray Return	--	0.65 W/sqft
File Room	0.72 W/sqft	--
Kitchen/Food Prep	0.99 W/sqft	0.65 W/sqft
Living Quarters	0.61 W/sqft	0.60 W/sqft
Lobby	0.90 W/sqft	--
Lockers	0.75 W/sqft	0.50 W/sqft
Mechanical/ Electrical	0.95 W/sqft	0.70 W/sqft
Office	1.00 W/sqft	0.90 W/sqft
Open Workstation	0.98 W/sqft	0.90 W/sqft
Readiness Bay (x4)	0.90 W/sqft	0.70 W/sqft
Repair Bay	1.70 W/sqft	1.30 W/sqft
Restroom/Showers	0.98 W/sqft	0.60 W/sqft
Server Room	0.99 W/sqft	0.85 W/sqft
Serving Area	0.82 W/sqft	0.70 W/sqft
Stair	0.69 W/sqft	0.50 W/sqft
Storage	0.63 W/sqft	0.90 W/sqft
Storage (x4)	0.90 W/sqft	0.70 W/sqft
Telecom/Siprnet	--	1.20 W/sqft
Utilities	1.50 W/sqft	1.00 W/sqft
Vault	1.38 W/sqft	0.70 W/sqft
Vehicle Corridor	0.70 W/sqft	0.70 W/sqft
Workshop	1.59 W/sqft	0.70 W/sqft

136 US Army Corps of Engineers. 25 October 2010. Department of the Army Facilities Standardization Program. Tactical Equipment Maintenance Facility (TEMF). UFC 4-214-02. Revision 3.6. PDF Online. <https://eportal.usace.army.mil/sites/COS/TEMF/Shared%20Documents/TEMF_Std_Dgn_Revision-3.6.pdf>. P. 54. Accessed 5 January 2011.

137 US Army Corps of Engineers. 21 October 2010. Department of the Army Facilities Standardization Program. Company Operations Facility (COF). Revision 3.6. PDF Online. <https://eportal.usace.army.mil/sites/COS/COF/Shared%20Documents/COF_Std_Dgn_REV_3.6.pdf>. P. 28. Accessed 5 January 2011.

138 US Army Corps of Engineers. 20 October 2010. Department of the Army Facilities Standardization Program. Brigade Operations Complex, Brigade and Battalion Headquarters Standard Design. Revision 3.9. PDF Online <https://eportal.usace.army.mil/sites/COS/BNBDEHQ/Shared%20Documents/Bde-Bn_Std_Dgn_Rev_3.9.pdf>. Accessed 5 January 2011.

139 American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 2010. ASHRAE Standard 90.1-2010: Energy Standard for Buildings Except Low-Rise Residential Buildings. I-P Edition. Atlanta, GA. P 81 Table 9.5.1, Pp 83-4 Table 9.6.1. PDF Online. <http://www.madcad.com/library/ASHRAE-90.1-10/?view=pdf>. Accessed 11 January 2011.

6.3 IEQ (Indoor Environmental Quality) c8.1, Daylight and views—daylight

LEED 2009 modifies and improves the daylighting requirements set forth by LEED 2.2. Building occupants desire connections to the outdoors. IEQ Credit 8.1 stipulates that 75 percent of regularly occupied spaces[140] must meet this goal through daylighting and views to the outdoors. This can be achieved through one of four options: simulation, prescriptive, measurement, or any combination thereof.[141] Table 35 below indicates the advantages and limitations of each of these options.

Note that ECB 2011-1 High Performance Energy and Sustainability Policy directs project teams to earn IEQ 8.1 Daylight & Views – Daylight 75% of Spaces. It also permits project teams to 1) increase vertical glazing by 50% over standard designs; and 2) increase skylight to floor area (SFA) fraction to 3% over corridors, administrative areas, and office areas.

Table 35. Advantages and limitations of the four daylighting options.

Option	Advantages	Limitations
Simulation	Most effective design tool; design can be modified	Costs of hiring a modeler; time-consuming
Prescriptive	Similar to LEED 2.2 Glazing Factor; does not require expert assistance	Not as accurate as Simulation option; time-consuming for large buildings; shading devices are not factored into calculation
Measurement	Lighting meters are inexpensive	Measurement is done after construciton; results can not inform the design
Combination	Allows shading devices to be factored in with the Prescriptive option; takes into account an optimal design	

140 For a workplace, "regularly occupied space" is defined at spaces where people sit/stand while they work. For a residence, "regularly occupied space" is defined as all living areas. This excludes bathrooms and utility/storage space. This definition applies to the UEPH; all other building types use the previous definition.

141 LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council, Inc. Washington, D.C. P 549.

Figure 23 outlines the proper steps that a designer might take throughout the design process when determining daylighting options.

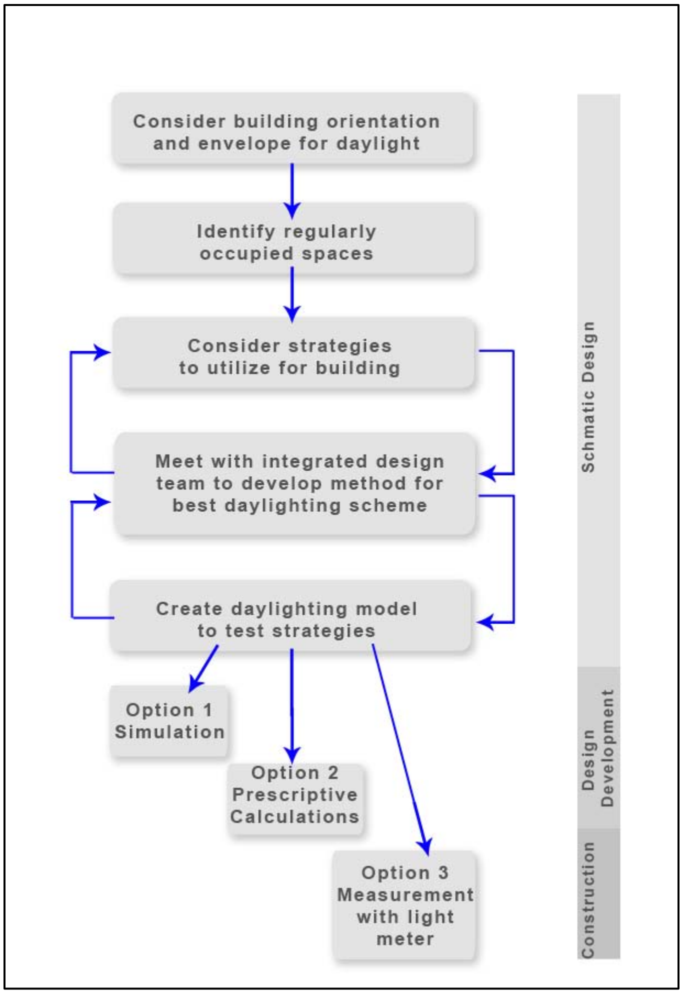

Figure 23. The daylighting design process.[142]

6.3.1 Simulation option

The first option uses computer simulations to demonstrate that the project meets the minimum requirements set forth in IEQ Credit 8.1. The Simulation option was updated in LEED 2009. Previously in LEED 2.2, this option required computer simulation to prove at least 75 percent of all occupied spaces achieved a minimum of 25 foot-candles (fc) during clear sky conditions.[143] LEED 2009 modifies this option to include a maximum of

[142] Redrawn by Justine Kane based on a graphic from LEED User Online.

[143] LEED-NC for New Construction: Reference Guide, Version 2.2. October 2005. First Edition. U.S. Green Building Council, Inc. Washington, D.C. P373.

500 fc on the fall equinox at 09:00 and 15:00 in order to minimize excessive solar heat gain; however, the use of automated shades, used for glare control, exempts the project from this requirement.[144]

Acceptable software tools include RADIANCE plug-in, and AGi32.[145] The program ECOTECT may be used in combination with another lighting software program, but is not acceptable on its own because of its limited sky condition settings. RADIANCE is recommended for its wide acceptance in the lighting industry; however, the program has a high learning curve and must be used with another software program. One of the newest daylighting modeling programs, AGi32, provides lighting calculations and renderings of daylighting systems and electric lighting. It is a stand-alone program and does not require additional plug-ins.

6.3.2 Prescriptive option

Previously, the Army pursued the Glazing Factor Calculation in order to obtain the daylighting credit for LEED 2.2.[146]

[Formula 2]: Glazing Factor =

(Window Area/Floor Area) * Window Geometry Factor * (Actual Tvis/Minimum Tvis) * Window Height Factor

The USGBC replaced the Glazing Factor Calculation with the Prescriptive Method in LEED 2009. The Prescriptive Method resembles its predecessor; however, key improvements, including added and more prescriptive factors, make the calculation more accurate.[147] Table 36 highlights the key differences between these two methods.

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[144] LEED Reference Guide for Green Building Design and Construction. 2009. Pp 555-6.

[145] LEEDuser – Help for LEED Projects | LEED Credit Forum. N.p., n.d. Online. 28 July 2010. <http://www.leeduser.com/>.

[146] LEED-NC for New Construction: Reference Guide, Version 2.2. October 2005. First Edition. U.S. Green Building Council, Inc. Washington, D.C. P373.

[147] LEED Reference Guide for Green Building Design and Construction. 2009. U.S. Green Building Council, Inc. Washington, D.C. P 549.

Table 36. Calculation requirements for LEED Versions 2.2 and 2009.

Version 2.2 Glazing Factor Calculation	Version 2009 Perscriptive Option
Window Area (SF)	Window Head Height
Floor Area (SF)	Window Sill Height
Window Geometry Factor	Window Width (per bay)
Actual Tvis	Bay Width
Minimum Tvis	Bay Depth to Core
Window Height Factor	Tvis
	Floor area (per bay)

For interior spaces with side-lighting (windows), the calculation requires that the visible light transmittance (Tvis) and the window-to-floor area ration (WFR) of a daylit zone ranges from 0.150 to 0.180.

[Formula 3] Daylit Zone Ranges: $0.150 < \text{Tvis} \times \text{WFR} < 0.180$

Note, that the calculated area must be a minimum of 30 inches above the floor.[148] Figure 24 below indicates the applicable window area.

Figure 24. Applicable window area.[149]

[148] Ibid.

[149] Drawn by Justine Kane, ERDC-CERL, 2010. AutoDesk. Revit.

In addition, an imaginary triangle[150] defines a non-buildable ceiling zone. The ceiling must remain outside of the hypotenuse created, as shown in Figure 25.[151]

Figure 25. Ceiling boundary triangle.

For top-lighting, the daylight zone includes the area directly beneath the penetration as well as a defined area beyond. This defined area is governed by the lesser of three calculations: 70 percent of the ceiling height (H), half the distance to another skylight, if one exists, or the distance to an opaque partition. Skylights must provide 3-6 percent of the total roof area, with a minimum Tvis of 0.5. The distance between any two skylights shall not exceed 1.4 times the height of the ceiling (H). Further, optional skylight diffusers must exceed a 90 percent haze value, in accord with ASTM D1003 standards, and should be placed out of direct lines of sight.[152]

6.3.3 Measurement

Option 3, measurement, saw no change in LEED 2009 from the LEED 2.2 version. Measurements are taken on a 10-foot grid, where spaces achieve the minimum illumination levels set forth. Daylight redirection and glare control devices must be provided.[153] Unfortunately, measurement is per-

[150] The triangle is created by lines that connect the window-head (wH) to a position on the floor whose distance from the window is two times the floor-to-ceiling height (2H).

[151] LEED Reference Guide for Green Building Design and Construction. 2009. P 550.

[152] Ibid.

[153] LEED Reference Guide. 2009. Pp 559.

formed after construction is complete. Consequently, modifications can only take place afterwards, often resulting in missed credits.

6.3.4 Combination

Due to the limitations of the preceding three options, LEED 2009 introduces a fourth option: combination. This allows projects to combine any of the options together in order to obtain the daylighting credit. For example, a large space may use the prescriptive option to take into account window openings and the measurement option to account for other strategies, like louvers.

Finally, LEED 2009 requires that submittal forms are uploaded and submitted online in order to save paper and time in the review process.

6.4 Daylighting strategies

A building's passive daylighting scheme must account for various factors including potential solar heat gain, glare, and sky conditions expected at the building's location throughout the day and throughout the year. Several key strategies can dramatically increase the daylighting potential, without causing excessive heat gain or solar glare.

6.4.1 Building orientation

The building's orientation is the most important design strategy when trying to maximize daylight potential or minimize overheating. North-south oriented buildings are the most effective for daylighting design. South-facing facades can provide up to 50 percent of the daylighting requirements (Figure 26)[154]; however, they frequently require external shading devices in order to reduce glare and excessive solar heating. North facades rarely experience direct sunlight in the northern hemisphere. Consequently, little to no shading is required on these facades in order to prevent excessive sunlight, glare, or solar heat gain. Interior shading may be used when greater darkness is desired by the building occupants. East-west oriented buildings experience morning and evening sun rays. During these times of day, the sun is at a lower angle in the sky, resulting in direct sun

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[154] FedCenter.gov. 2006. Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding. [PDF Online]. <http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=4713&destination=ShowItem>. Accessed 22 December, 2010.

penetration. Consequently, these buildings often experience excessive heat gain and glare.

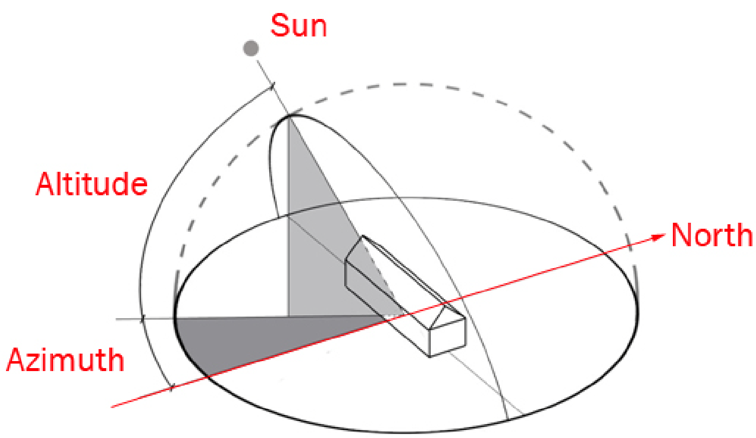

Figure 26. Building orientation to maximize daylighting.[155]

6.4.2 Shading devices

Shading devices may be located on the building's exterior or interior. The exterior devices act as a first line of defense and are more effective because they prevent solar heat from entering the building; however, such devices may alter the aesthetics of the building. Interior shading devices serve as a second line of defense. While they do not prevent solar heat from entering the building, they have a minimal effect on the building's exterior appearance, are less expensive, are easily changed or altered, and they allow the building occupants to maintain control of the interior environment.

Exterior shading devices include fixed or automated louvers or fins, external window shades, overhangs, exterior light shelves,[156] and dynamic tracking or reflecting systems. In addition, natural vegetation may help to shade the building. The orientation of louvers or fins, horizontal or vertical, depends on which wall the device is located. On a south façade, horizontal devices work best to control high angle sunlight; whereas, vertical

[155] "Federal High Performance and Sustainable Buildings (FHPSB): Daylighting," 2010. Whole Building Design Guide. Supporting Technical Guidance. http://www.wbdg.org/references/mou_daylight.php

[156] UFC 3-530-01, effective 22 August 2006, discourages the use of external light shelves in high-threat areas because of potential blast threats.

devices better control low-angle sunlight on the east and west facades.[157] Figure 27 below shows various overhang and louver/fin design techniques.

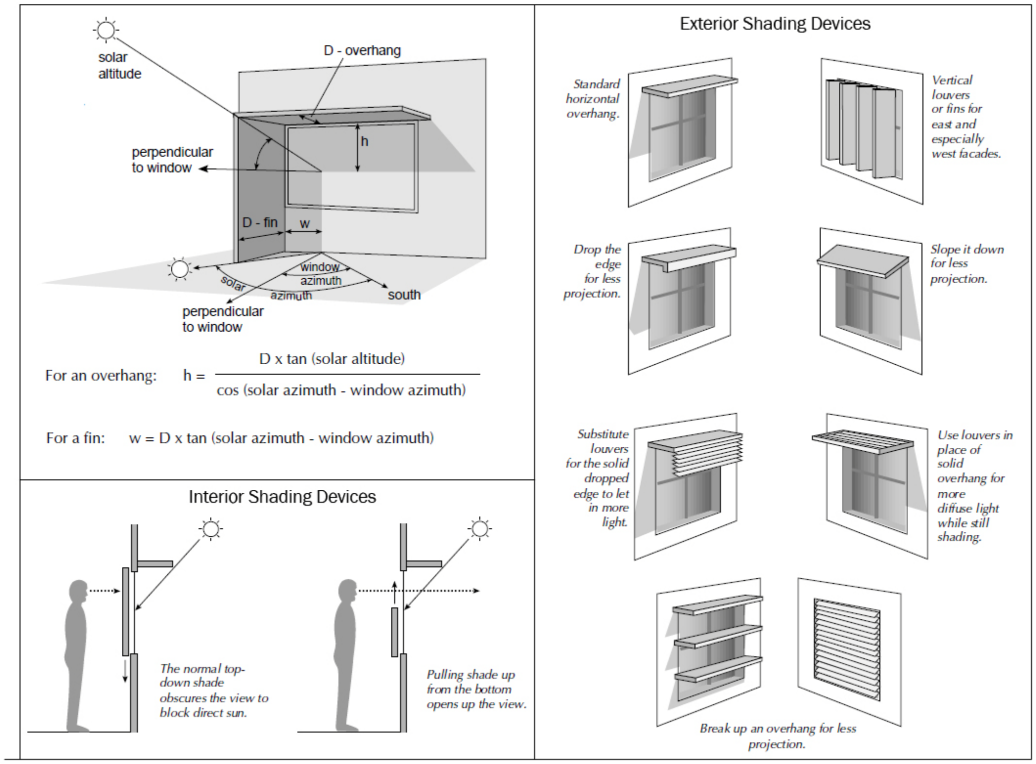

Figure 27. Overhangs and louvers/fins.[158]

Interior shading devices include Venetian[159] or horizontal blinds, roller shades, drapery, and interior light shelves. Like exterior shading devices, horizontal devices are recommended on south-facing walls and vertical devices are recommended on east and west facades. It is often recommended that blinds and shades commission automated controls to optimize sunlight penetration or shading, as necessary or desired. In addition, drapery can be used to block out the sun when greater darkness is desired by the building occupants. Further, interior light shelves can be used to reflect incoming sunlight onto ceilings. The light can bounce off surfaces and penetrate deeper into the space. Moreover, such devices can help re-

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[157] LEED Reference Guide. 2009. P 554.

[158] International Energy Agency. *Task 21: Daylight in Buildings*. Section 5: Shading Strategy-Tips for Daylighting with Windows. PDF Online. <http://windows.lbl.gov/daylighting/designguide/section5.pdf>. Accessed 7 January 2011.

[159] Vertical blinds.

duce glare, shade clerestory windows,[160] and create uniform lighting.[161] Figure 28 below shows how light bounces off a light shelf.

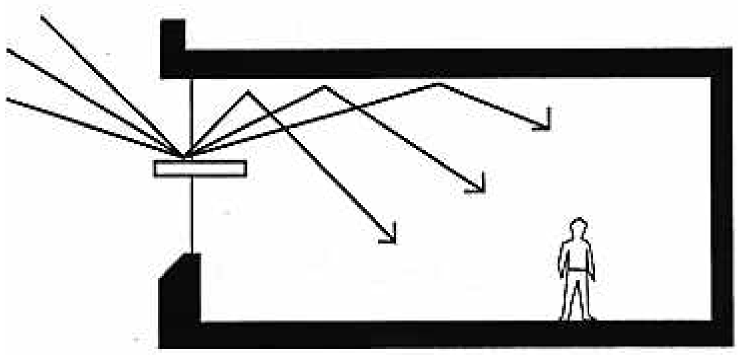

Figure 28. Light shelf.[162]

6.4.3 Building configuration

A narrow, elongated building has more surface area for windows and light penetration than a perfectly square building. In addition, shallower floor-to-ceiling enables light to bounce off the ceiling and penetrate deeper into the building's interior. When taller floor-to-ceiling heights are required, overhead clerestory windows, atriums, skylights,[163] or light-tubes may be considered; however, providing daylight from above is more costly than side-lighting. Despite the cost increase, tall ceilings have daylighting advantages. Clerestory windows may be positioned higher than interior partitions, thus allowing light to pass over these partitions and deeper into the space. In addition, clerestories reduce direct sunlight at eye level, thus reducing potential glare.[164] Sawtooth roof forms or roof monitors may also effectively bring top-lighting into a space (see Figure 29 below).

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[160] Clerestories are windows placed at the top of a wall.

[161] LEED Reference Guide. 2009. Pp 554, 562.

[162] Public Technology Inc. and U.S. Green Building Council. Sponsored by U.S. Department of Energy and U.S. Environmental Protection Agency. 1996. Sustainable Building Technical Manual: Green Building Design, Construction, and Operations. P. 96. PDF Online. <http://www.wbdg.org/ccb/EPA/sbtm.pdf>.

[163] Overhead skylights require unwanted solar heat gain and water leakage prevention techniques.

[164] LEED Reference Guide. 2009. Pp 554-8.

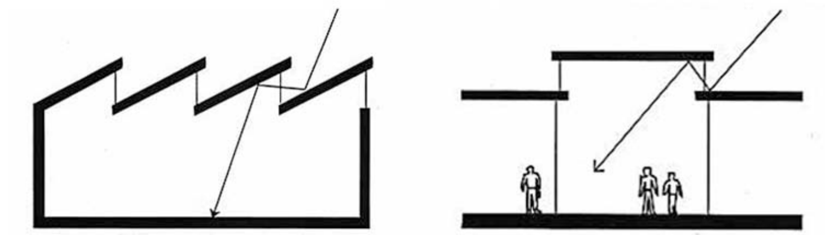

Figure 29. Sawtooth roof and roof monitors.[165]

6.4.4 Interior layouts and finishes

An appropriate arrangement of people in a space can do much to help manage and avoid direct and indirect glare that could annoy building occupants. Occupants should be arranged so they are sitting perpendicular to the window wall. A person or computer screen that faces a window wall would experience excessive direct glare or reflected glare, respectively. Partitions in open office spaces can also help reduce glare, but could block the light penetration. Placing partitions perpendicular to window walls will help prevent light blockage.[166]

Finishes can further help light bounce into the space. Lighter paint colors and higher sheens enable this to happen and also give the illusion of brightness and openness. The minimum reflectance values for interior surfaces are as follows: ceiling—80 percent, walls—50 percent, floors—20 percent.[167]

6.4.5 Complementary electrical lighting and lighting controls

A successful lighting design integrates a complementary electrical lighting system with daylighting. Lighting controls respond to daylight levels and turn on or off the electrical lighting system as needed. When daylighting is sufficient, electrical lighting can be dimmed or turned off.[168] Further, mul-

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165 Public Technology Inc. and U.S. Green Building Council. Sponsored by U.S. Department of Energy and U.S. Environmental Protection Agency. 1996. Sustainable Building Technical Manual: Green Building Design, Construction, and Operations. P. 96. PDF Online. <http://www.wbdg.org/ccb/EPA/sbtm.pdf>.

166 "FHPSB Daylighting, Whole Building Design Guide." WBDG - The Whole Building Design Guide. N.p., n.d. Web. 28 July 2010. <http://www.wbdg.org/references/mou_daylight.php>.

167 LEED User Online.

168 FedCenter.gov. 2006. Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding. [PDF Online]. <http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=4713&destination=ShowItem>. Accessed 22 December, 2010.

tiple lighting controls can be used within a space to control separate lighting zones. Therefore, electrical lighting can be restricted to the zone where tasks are being completed, rather than lighting up an entire interior space. There are three types of commercially-used controls: switching controls, stepped controls, and dimming controls.

Switching controls are automated or manually-controlled on/off switches. Automatic switching controls may disturb occupants because they lack a gradual change in powered lighting; however, manually-controlled switches are frequently ignored by occupants. Often occupants leave electrical light switches on, even when natural lighting is sufficient to light the interior space. For spaces such as corridors, restrooms, conference rooms, and warehouses, motion sensor switching controls are the best solution.[169] The location of these sensors should be carefully selected to adequately sense occupants.

Stepped controls provide various levels of electric lighting throughout the day according to when daylighting is high or low. Dimming controls automatically adjust the electric lighting by adjusting the power input to the lamps based on the available levels of the daylight. The best applications for dimming controls are continuously occupied spaces, like offices or classrooms.

6.4.6 Glazing considerations

Glazing should be selected to optimize transmittance and minimize infrared penetration.

Tvis values may vary in accord with the window type. Clerestories would benefit from Tvis values of 0.70 or greater; whereas, view windows would benefit from Tvis values of 0.40. Tints or mirrored coatings are not recommended.[170]

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169 "FHPSB Daylighting, Whole Building Design Guide." WBDG - The Whole Building Design Guide. N.p., n.d. Web. 28 July 2010. <http://www.wbdg.org/references/mou_daylight.php>.

170 U.S. Department of Defense. 10 December 2010. Unified Facilities Criteria (UFC). “Design: Interior, Exterior Lighting and Controls.” UFC 3-530-01. PDF. Online. <http://www.wbdg.org/ccb/DOD/UFC/ufc_3_530_01.pdf>. Pp 43.

Glazing with moderate to low shading coefficients (SC) and/or low solar heat gain coefficients (SHGC) help to minimize infrared transmittance.[171]

Table 37 compares glass types. Note the Tvis and solar heat gain coefficient values.

Table 37. Comparison of glass types.[172]

Glass Type	Glass Thickness (inches)	Tvis %	U-Factor (Winter)	Solar Heat Gain Coefficient
Single Pane (standard clear)	0.250	89	1.09	0.81
Single White Laminated w/ Heat Rejecting Coating	0.250	73	1.06	0.46
Double Pane Insulating (standard Clear)	0.250	79	0.48	0.70
Double Bronze Reflective Glass	0.250	21	0.48	0.35
Triple Pane Insulating (standard clear)	0.125	74	0.36	0.67
Pyrolitic Low-e Double Glass	0.125	75	0.33	0.71
Soft-coat Low-e Double w/ Argon gas fill	0.250	73	0.26	0.57
High-Efficiency Low-e	0.250	70	0.29	0.37
Suspended Coated Film	0.125	55	0.25	0.35
Suspended Coated Film w/ Argon gas fill	0.125	53	0.19	0.27
Double Suspended Coated Films w/ Krypton	0.125	55	0.10	0.34

High-performance glazing maximizes Tvis and minimizes solar radiation;[173] however, these systems are often cost-prohibitive. Various films can be applied to glazing to reduce solar gain through reflection or absorption instead. Bear in mind that these can negatively affect the transmit-

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171 U.S. Department of Defense. 10 December 2010. Unified Facilities Criteria (UFC). “Design: Interior, Exterior Lighting and Controls.” UFC 3-530-01. PDF. Online. <http://www.wbdg.org/ccb/DOD/UFC/ufc_3_530_01.pdf>. Pp 43.

172 Ander, Gregg D. 18 June 2010. Whole Building Design Guide. ”Windows and Glazing.” <http://www.wbdg.org/resources/windows.php>. Accessed 7 January 2011.

173 FedCenter.gov. 2006. Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding. [PDF Online]. <http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=4713&destination=ShowItem>. Accessed 22 December, 2010.

tance of sunlight into the interior of the building. Therefore, designers must balance the effects of solar heat gain with light penetration.

Fritted glass may be used in areas where light penetration is not required, such as interstitial spaces between floors.[174] Just as not enough window area results in inadequate daylighting levels, too many windows and large amounts of glazing will produce excessive light levels. The window quantity, size, and spacing may be altered in order to mitigate this effect.

Electrochromatic glass shades interior spaces by automatically tinting when it absorbs sunlight. As seen in the Oakland GSA Federal Building in Figure 30 below, the glass has different degrees of tint throughout the day.

Figure 30. Electrochromatic windows at the Oakland GSA Federal Building.[175]

6.4.7 Active daylighting

Active daylighting strategies use mechanical devices that track the sun to collect light. These devices then distribute the daylight to a building's interior. Although these devices have higher initial and maintenance costs, tracking devices enable earlier morning and later evening sunlight capture.[176]

Hybrid solar lighting (HSL) is another technique that allows for daylight to enter interior, potentially secure, spaces without direct ceiling or wall pe-

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[174] LEEDuser — Help for LEED Projects, LEED Credit Forum. N.p., n.d. Web. 28 July 2010. <http://www.leeduser.com/>.

[175] Selkowitz. Stephen. 15 December 2009. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory. ARPA-E Advanced Building Energy Technologies Workshop. "Buildings as Testbeds? Testbeds as Buildings? Needs, Opportunities, Challenges." Arlington, VA. PDF Online. <http://arpa-e.energy.gov/portals/0/Documents/ConferencesandEvents/Pastworkshops/BuildingTechnologies/BuildingTechnologies2/bt_selkowitz.pdf>.

[176] U.S. Department of Defense. 10 December 2010. Unified Facilities Criteria (UFC): Design: Interior, Exterior Lighting and Controls. UFC 3-530-01. 4-10-10.1.

netrations. The HSL section in Appendix B on Alternative Technologies discusses this option further.

6.5 Unsuccessful daylighting and recommendations for success

Few Army projects achieved the daylighting credit in LEED Version 2.2, under the Glazing Factor Calculation option. To meet the requirements of the High Performance and Sustainable Buildings MOU, ASHRAE 189.1, and ECB 2011-1, Army projects must implement daylighting design strategies that respond to LEED 2009 requirements.

All LEED daylighting calculations call for light level requirements for 'regularly occupied spaces,' or areas where individuals sit or stand to complete a task or work.[177] These spaces must be defined before any calculations may take place. The floor plans for the five COS standards are shown in the sections that follow. Regularly occupied space is indicated in green on each plan.

6.5.1 BDEHQ

The BDEHQ standard design shown in Figure 31 and Figure 32 failed to successfully incorporate a sufficient daylighting scheme into the building. The distance from one exterior wall to the opposite exceeds 60 feet.[178] Therefore, the calculated interior spaces did not receive sufficient daylight.[179] Consequently, this particular design could not receive LEED credit for daylighting. Several strategies, including narrowing the building's footprint and using reflective finishes on surfaces, could have enabled the building to achieve the daylighting credit.

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[177] LEED Reference Guide for Green Building Design and Construction, 2009.

[178] This is a pre-determined maximum distance that allows for sufficient daylighting penetration (Lechner, N. 2009. Heating, Cooling, Lighting. Hoboken, New Jersey: John Wiley & Sons, Inc. P 380).

[179] Secure rooms were excluded from all daylighting calculations due to the nature of the work that takes place in these spaces. It is likely that said spaces would be exempt from the LEED daylighting requirements.

Figure 31. BDEHQ first floor plan showing regularly occupied spaces.

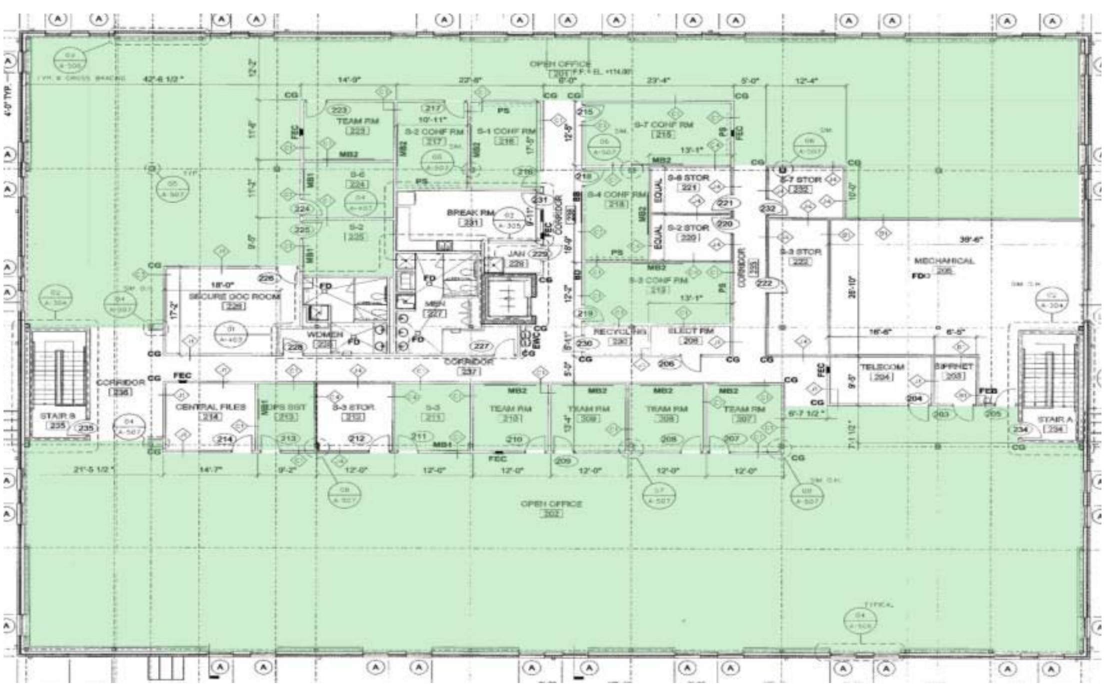

Figure 32. BDEHQ second floor plan showing regularly occupied spaces.

In addition, standard BDEHQs generally have window shades drawn throughout the day in order to prevent glare on computer screens. Proper arrangement of workstations can easily mitigate the effects of excessive glare, as discussed previously in Section 6.4.4.

6.5.2 COF

Figure 33 and Figure 34 show the layouts of the COF standard design. Regularly occupied spaces are indicated in green.

Figure 33. COF first floor plan showing regularly occupied spaces.

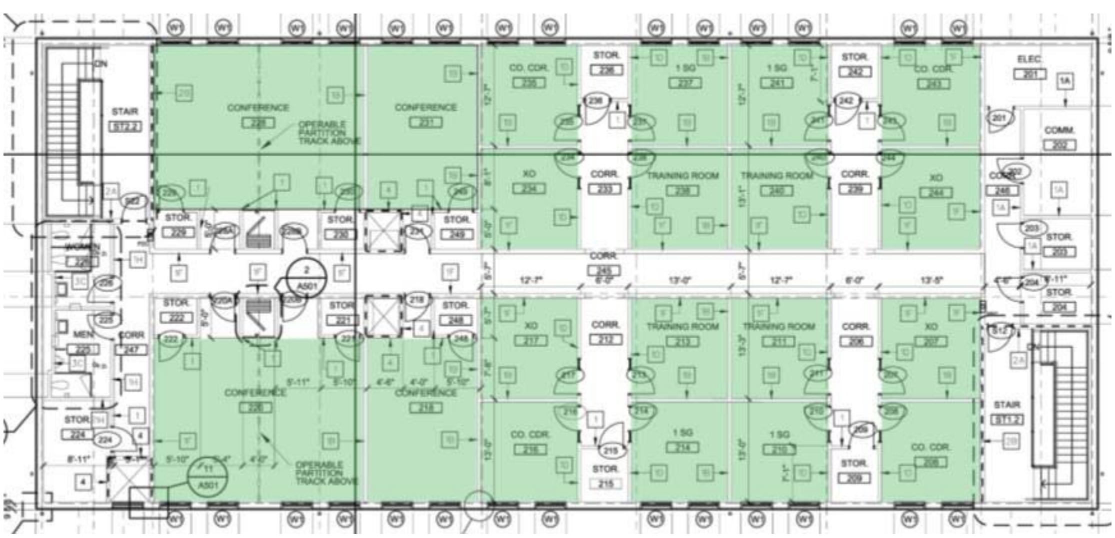

Figure 34. COF second floor plan showing regularly occupied spaces.

The current COF building standard does not supply adequate daylight to the interior office spaces. Storage areas that do not require daylighting are located along the building's perimeter. Alternatively, these spaces should be placed towards the building's center, thus allowing regularly occupied spaces to benefit from window walls. Figure 35 indicates in purple the areas that could be rearranged to better address daylighting concerns.

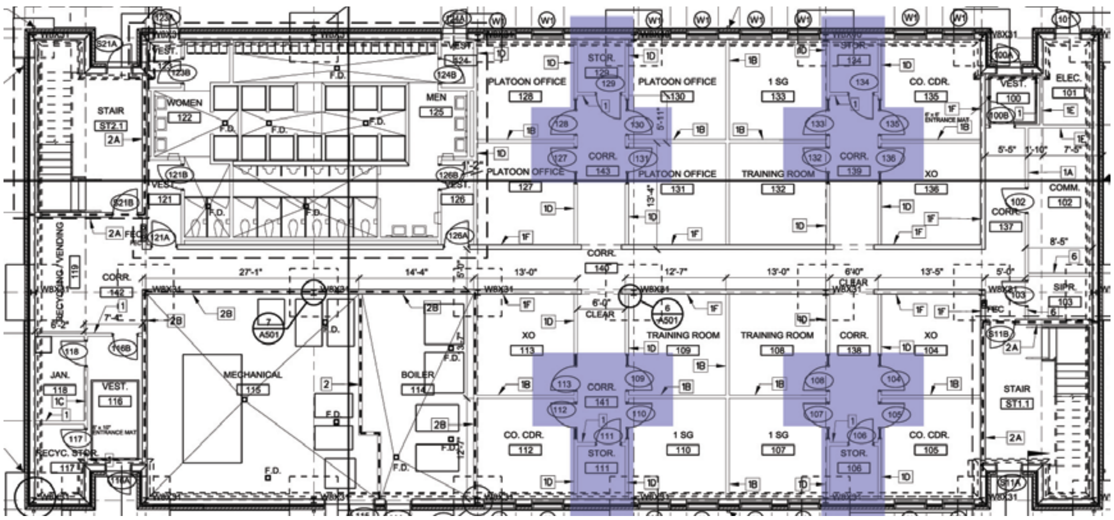

Figure 35. COF areas of suggested rearrangement.

Figure 36 is a plan showing a suggested rearrangement of the COF plan that helps to increase the availability of daylighting to required spaces.

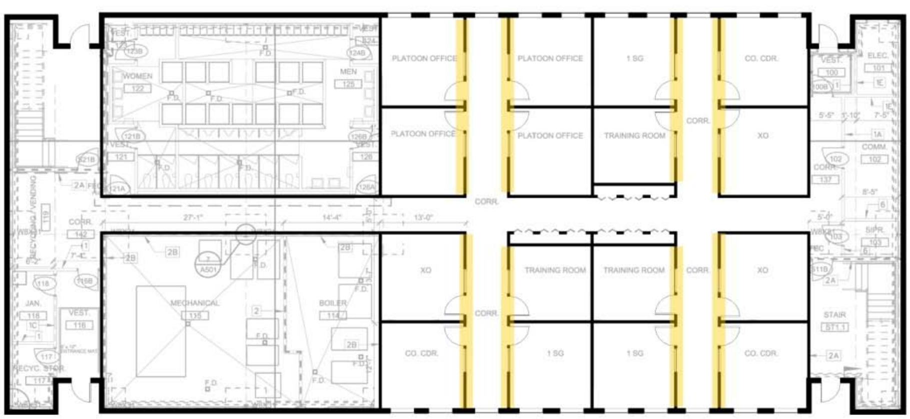
Figure 36. Suggested COF plan for effective daylighting design; note interior transom windows along halls shown in tan (similar design for both floors).

In addition, windows could provide daylight within corridors, where they currently do not. The use of glazed transoms above interior office doors and windows would allow light to penetrate into offices, even when doors are closed.

6.5.3 DFAC

Figure 37 shows the layout of the DFAC standard design. Regularly occupied spaces are indicated in green.

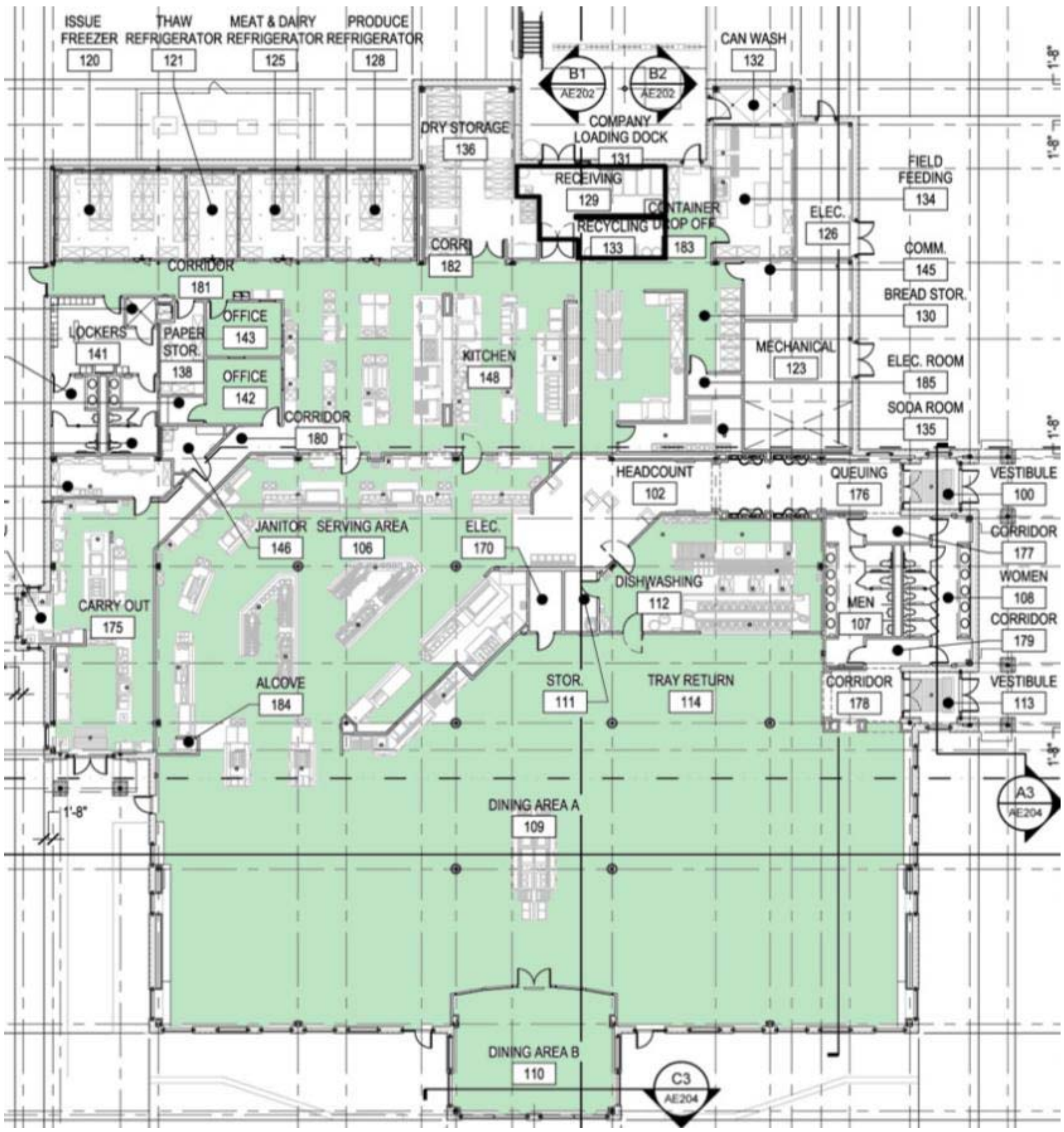

Figure 37. DFAC regularly occupied spaces.

Currently, the standard DFAC design provides sufficient daylighting to the dining area; however, both the kitchen/preparation area and the dishwashing area lack daylighting. The standard design features clerestories and skylights in the dining area as shown in Figure 38.

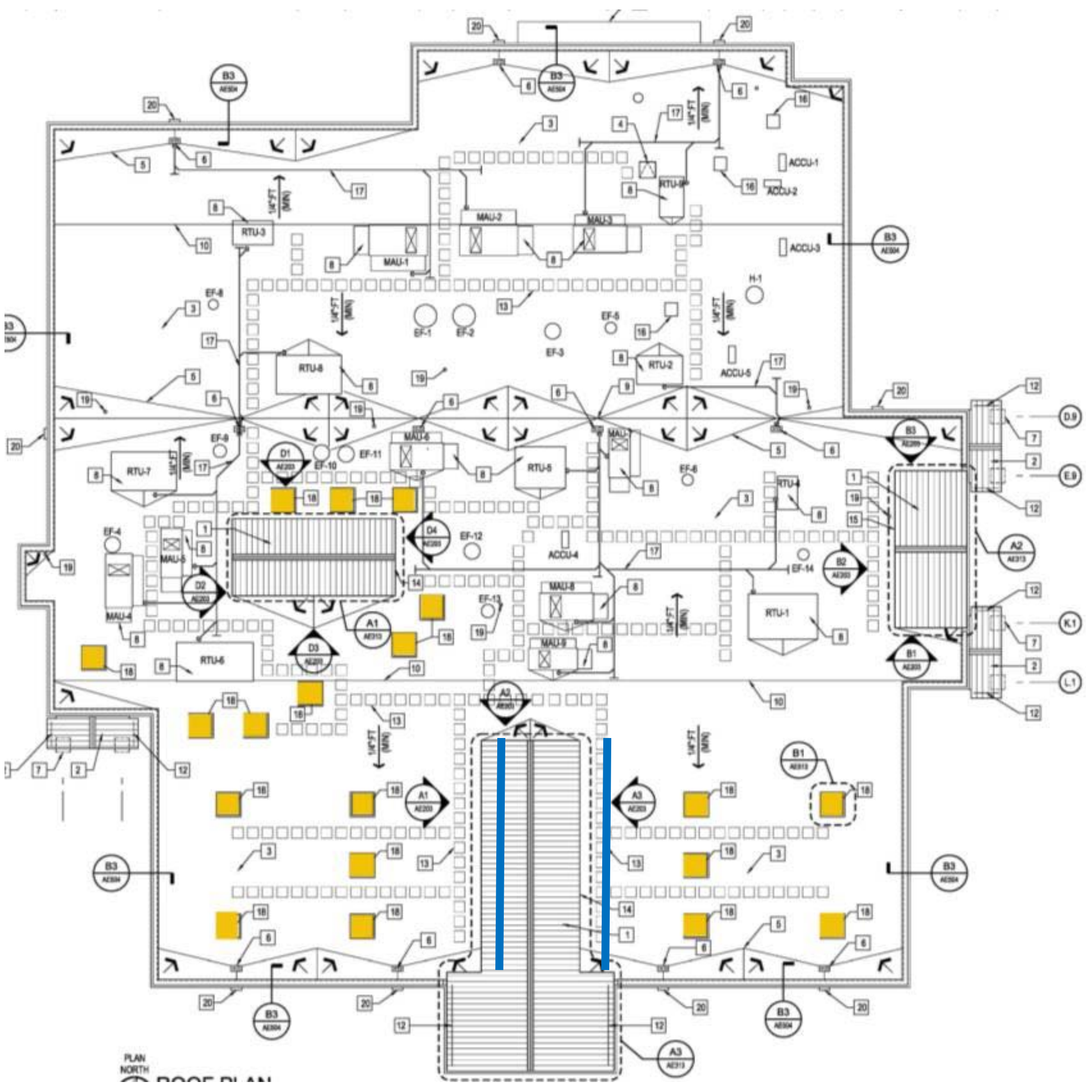

Figure 38. DFAC roof plan.[180]

Notably, the DFAC is a single story building. Therefore, the use of light tubes or additional skylights would provide enough natural light into spaces that are currently lacking daylighting.[181]

6.5.4 TEMF

Figure 39 and Figure 40 show the layouts of the TEMF standard designs. Regularly occupied spaces are indicated in green.

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[180] Blue lines represent clerestories; yellow squares indicate skylights.

[181] It is understood that any additional apertures introduced in the kitchen and dishwashing areas would have to be placed around numerous hoods, vents, and other equipment.

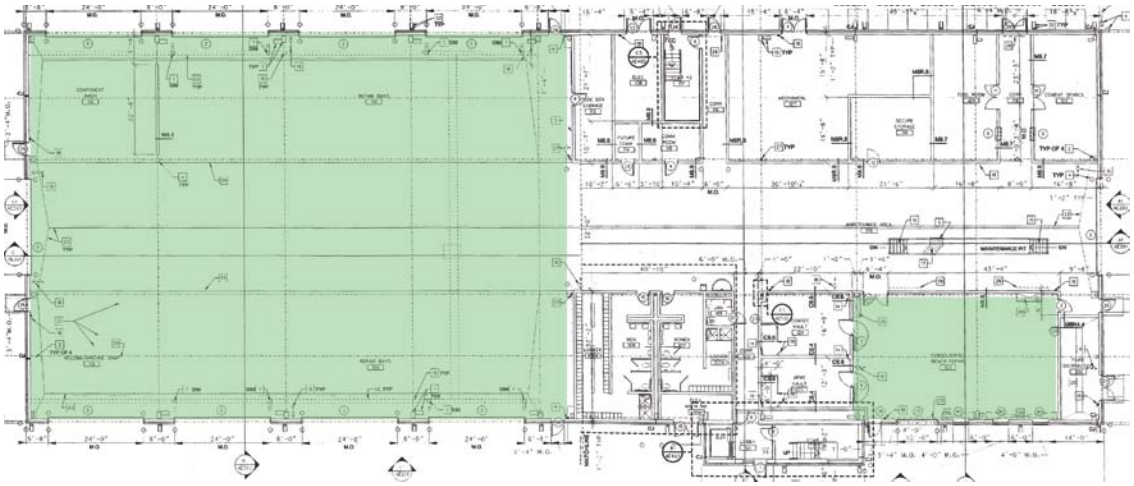

Figure 39. TEMF first floor plan showing regularly occupied spaces.

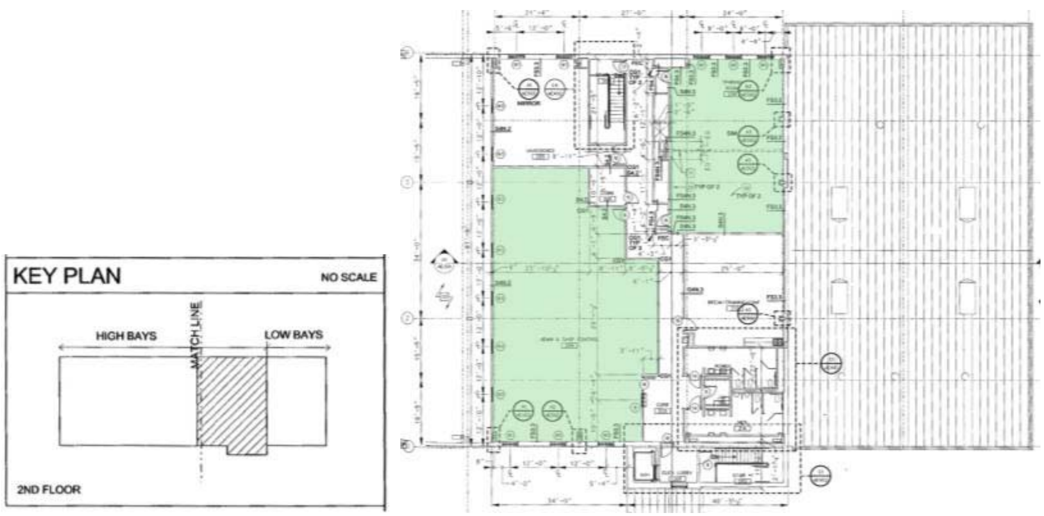

Figure 40. TEMF second floor plan showing regularly occupied spaces.

The TEMF standard design could receive the daylighting credit without rearranging the existing plan. Skylights or light tubes could provide sufficient daylight to the interior space of the high bay; however, these technologies must be placed carefully to prevent blocking from the high bay's large overhead doors.

6.5.5 UEPH

Figure 41 shows the layout of the UEPH standard design. Regularly occupied spaces are indicated in green.

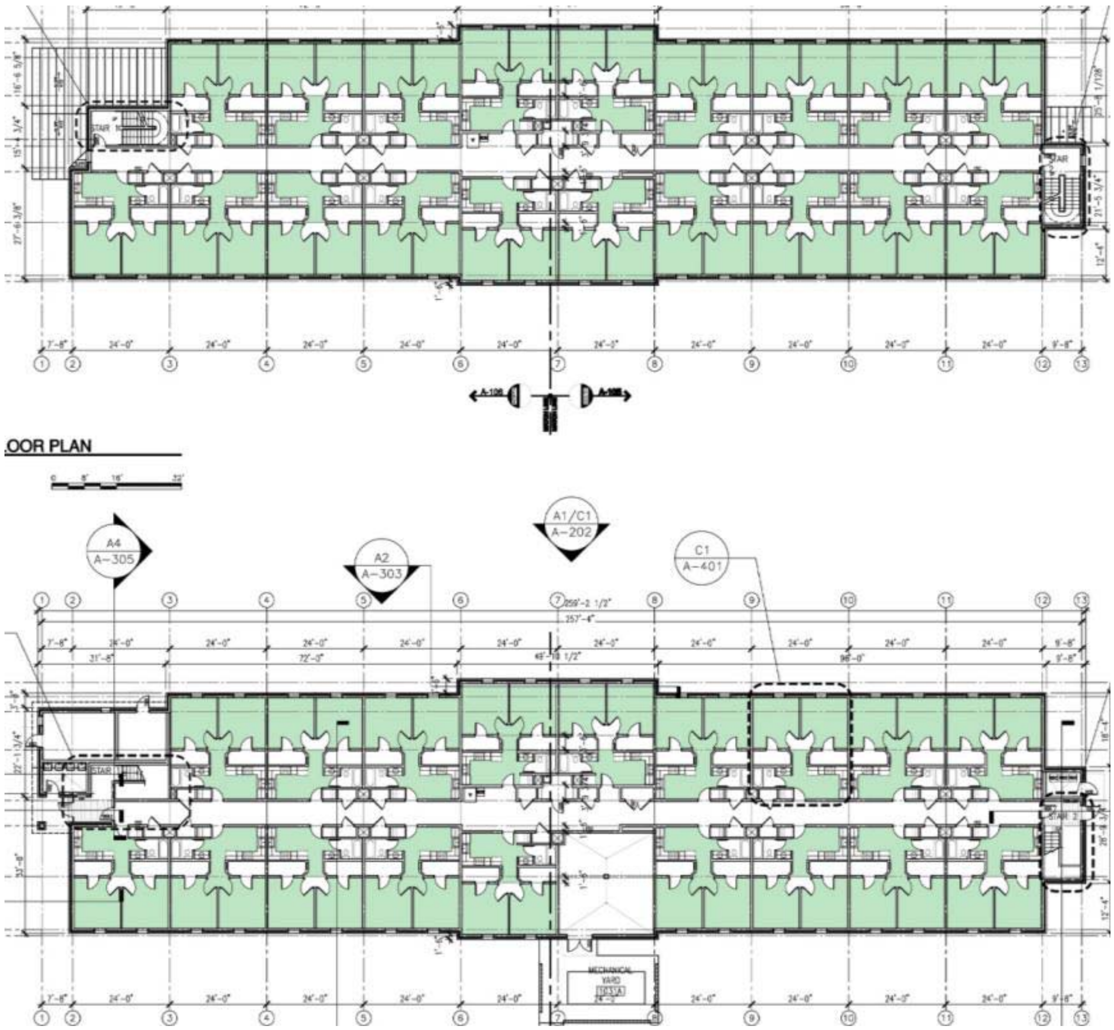

Figure 41. UEPH first and second floors showing regularly occupied spaces.

The current design of the UEPH provides adequate natural light in the perimeter bedrooms; however, interior spaces are blocked by the bedrooms. Light does not reach the kitchen or dining area. However, transom windows[182] can be placed over bedroom doors and high on bedroom interior walls to provide sufficient daylighting without compromising privacy. To achieve this, closets must be substituted with wardrobes to minimize walls and partitions. This would also allow for rearrangement and flexibility of room layouts. Moreover, the use of wardrobes would lower construction and material costs, as wardrobes are considered furniture, fixtures, and equipment (FFE) rather than built fixtures.

182 A transom window is a glazed light above a door or wall panel.

7 Innovation and Design (ID)

Under LEED Innovation in Design, projects can achieve points in three ways: 1) for exemplary performance for existing LEED credits stated as eligible in the LEED Reference Guide, generally for doubling the requirement; 2) for innovative performance not addressed in LEED where significant, measurable environmental benefits can be demonstrated and documented; and 3) having a LEED accredited professional on the project team. Army projects have ample opportunity to achieve all possible points under Innovation in Design.

7.1 Army achieved ID credits

Experience of the FY10 SDD Validation Review was that projects typically achieved 3 of the possible 5 LEED-NC v 2.2 points. The most common credits were for exemplary performance:

- Water Use Reduction – Exemplary Performance 40 Percent Water Savings (WE 3) – most projects employed multiple strategies for saving potable water saving and achieved this credit.
- Site Development, Maximize Open Space– Exemplary Performance (SS 5.2) -- Given setback requirements typical for Army projects, most were able to achieve this credit.
- Heat Island Effect (Non Roof) - Exemplary Performance (SSc7.1).

Other typical credits achieved included:

- Site Development, Protect or Restore Habitat – Exemplary Performance (SS 5.1);
- Green Power – Exemplary Performance (EA 6);
- Certified Wood – Exemplary Performance (MR 7); and
- Educational Programs – Educational, Educational Signage, and Education and Outreach Programs.

Less typically, the following credits were sought:

- Enhanced Building Envelope Performance/Air Leakage Testing and
- Low Mercury Fixtures.

Some projects developed or discussed the possibility for additional credits but did not pursue them and/or they were claimed but not validated. These included:

- Thermo Graphic Inspection Report;
- Blower Door Test Report (as means of thermal envelope commissioning);
- Off Peak Thermal Energy Ice Storage System; and
- Low-Emitting Systems Furniture.

A good source to identify candidate innovation credits for all projects registered under LEED-NC v2.2 is the USGBC's Innovation in Design Credit Catalog. The last published version contains ID credits submitted by projects before the summer of 2007. The catalog is intended as a brainstorming tool only to assist project teams in the development of new ID credits. It does guarantee that a credit will be accepted in a certification review, but it is the only means to establish certifiability by the SDD Validation Team review. For official rulings in advance of LEED Certification Review, projects must adhere to the LEED Credit Interpretation Ruling (CIR) procedure. While the catalog remains a valid source of potential ID credits Army projects registered under LEED 2009, v2.2 or earlier CIRs will not apply. The catalog is available at: http://www.usgbc.org/ShowFile.aspx?DocumentID=3569.

Another recent additional source to identify potential LEED ID credits is the LEED Pilot Credit Library. The library contains credits that are currently being tested for all rating system types, and all credit categories, including the proposed LEED 2012 Rating System. Project teams may attempt any credit listed in the library for Innovation and Design credit. Credits from the library are not currently acceptable as certifiable by the SDD Validation Team. These credits are available for a limited time only as they are being tested. LEED Pilot Credit Library may be found at: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2104.

7.2 Project example LEED innovation in design credits

The project example below is from FY10 LEED validation activity.

7.2.1 ID Credit Title: Water Use Reduction [Exemplary Performance 40% Water Savings (WEc3)]

Statement of Intent: LEED Intent: Maximize water efficiency within buildings by specifying and installing water-saving fixtures with high-efficiency flow rates to reduce the burden on municipal water supply and wastewater systems, beyond the thresholds established in WEc 3.
Statement of Credit Requirements: Employ strategies that use in aggregate at least 40% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements.
Approach to Credit: The [Project Name] has employed [Description of the water-saving strategies/fixtures specified in the project, their flow rates]. The project has achieved [Value]% water savings, which exceeds the requirements of 40% water savings for exemplary performance. Please refer to WEc3 Template for calculations.

7.2.2 ID Credit Title: Site Development, Maximize Open Space [Exemplary Performance (SSc5.2)]

Statement of Intent: Provide a high ratio of open space to development footprint to promote biodiversity, above the prescribed levels established in SSc5.2 Maximize Open Space.
Statement of Credit Requirements: Provide a high ratio of open space to development footprint to promote biodiversity, above the prescribed levels established in SSc5.2 Maximize Open Space. For areas with no local zoning requirements (e.g., some university campuses, military bases), provide vegetated open space area adjacent to the building that is equal to the building footprint. Exemplary performance is achieved when the open space is two times the building footprint.
Approach to Credit: The [Project Name] has demonstrated exemplary performance in site design by providing [Area] SF of open space which is [Value] times the building footprint. The proposed open space is vegetative open space is [Area] SF and the building footprint is [Area] SF. [Description of the open spaces, references to back-up documentation/drawings, and the landscaping feature/planting materials to be provided] [Reference LEED Templates/Forms for SSc5.2].

7.2.3 ID Credit Title: Heat Island Effect (Non Roof) [Exemplary Performance (SSc7.1)]

Statement of Intent: Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.
Statement of Credit Requirements: Demonstrate that either, a minimum of 100% of non-roof impervious surfaces have been constructed with high-albedo materials and/or will be shaded in five years OR 2) 100% of the on-site parking spaces have been located under cover.
Approach to Credit: The [Project Name] [Description of the non-roof impervious elements, areas and SRI ratings, and shading features]. Please refer to SSc7.1 for a complete listing of non-roof impervious, shading, and covered on-site parking spaces.

7.2.4 ID Credit Title: Site Development, Protect or Restore Habitat [Exemplary Performance (SS 5.1)]

Statement of Intent: Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Statement of Credit Requirements: On previously developed or graded sites, restore or protect a minimum of 75% of the site area (excluding the building footprint) with native or adapted vegetation. Native/adapted plants are plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds. Projects earning SS Credit 2 and using vegetated roof surfaces may apply the vegetated roof surface to this calculation if the plants meet the definition of native/adapted.
Approach to Credit: The [Project Name] site will be planted with [Area] SF of vegetation which is [Value] % of the total site. All of the plant material is native or vegetation adapted to the project site environment. Please refer to WEc1 for a complete listing of plant materials selected.

7.2.5 ID Credit Title: Green Power [Exemplary Performance (EA 6)]

Statement of Intent: To encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.
Statement of Credit Requirements: Engage in at least a two-year renewable energy contract to provide 100% of the building's electricity from renewable sources, as defined by the Center for Resource Solutions (CRS) Green-e products certification requirements.
Approach to Credit: The Green Tags were purchased through a one-time purchase agreement with Renewable Choice Energy (a Green-e certified clean source). The amount of green power purchased was equal to 100% of the annual electricity usage as determined by EAc1 Optimize Energy Performance. A quote was provided by Renewable Choice Energy, and a purchase agreement for the green tags was signed by [the project contractor].

7.2.6 ID Credit Title: Certified Wood [Exemplary Performance (MR 7)]

Statement of Intent: To encourage environmentally responsible forest management.
Statement of Credit Requirements: Achieve an FSC-Certified Wood content of 95% or more of the project's total new wood.
Approach to Credit: The [Project Name] has achieved an FSC-Certified Wood content of [percent %] of the project's total new wood. Please refer to documentation provided under MRc7 demonstrating that [percent %] of the wood products on the project were FSC-certified.

7.2.7 ID Credit Title: Educational Program (Educational, Educational Signage, and Education and Outreach Programs).

Statement of Intent: To educate the building users, designers of new facilities, and the public about the sustainable features of the [Project Name] and its environmental achievements. To provide public education focusing on green building strategies and solutions.
Statement of Credit Requirements: Establish an educational program that is actively instructional. Two of the following three elements must be included in the educational program: 1) A comprehensive signage program built into the building's spaces to educate the occupants and visitors of the benefits of green buildings. This program may include windows to view energy saving mechanical equipment or signs to call attention to water conserving landscape features. 2) The development of a manual, guideline or case study to inform the design of other buildings based on the successes of this project. This manual, guideline or case study will be made available to the USGBC, USACE, and/or the Army for sharing with other project teams/installations and the public as desired. 3) An educational outreach program or guided tour could be developed to focus on sustainable living, using the project as an example.
Approach to Credit: The [Project Name] is using elements [# and #] to comply with the credit intent and

requirements. Element 1: Educational signs have been located throughout the project space, as shown on the uploaded floor plans. The signs are provided for facility occupants, employees and visitors to learn about the sustainable features inside the building. The signage text has been uploaded as supporting documentation. Element 2: A case study has been created to inform the design of other buildings based on the successes of this project. This case study has been uploaded to the Department of Energy's (DOE) High Performance Federal Buildings (HPFB) Database to inform other project teams of lessons learned. Element 3: The Installation DPW Environmental Branch has an on-going environmental educational outreach program operated in conjunction with [The installation Department of Defense Education Activity (DoDEA) School/the U. S. Army Community and Family Support Center (CFSC) Child, Youth & School Services/etc.]. The [Project Name] will be used as an example of sustainable facility features and sustainable living in the educational program.

7.2.8 ID Credit Title: Building Envelope Commissioning (Enhanced Building Envelope Performance[183] and Air Leakage Testing[184])

Statement of Intent: Provide high performance building envelope to reduce energy consumption and increase occupant comfort and indoor air quality through verification that the building exterior enclosure systems are designed, installed, and perform according to the OPR, BOD, and construction documents.
Statement of Credit Requirements: 1) Design and construct building envelopes with a continuous air barrier to control air leakage into (or out of) conditioned space. a. Identify air barrier components, joint and details, air barrier interconnections and component penetrations, air barrier boundary limits, and zones to be air tightness tested on construction documents; b. Provide a continuous plane of air tightness throughout the building envelope with flexible and sealed moving joints; c. Provide an air barrier with permeance not to exceed 0.004 CFM/sq ft at 0.3 iwg [0.02 L/s.m2 @ 75 Pa] when tested in accordance with ASTM E 2178; d. Provide support to the air barrier so as to withstand the maximum positive and negative air pressure without displacement, or damage;

[183] USGBC LEED Credit Interpretation Request/Ruling (CIR) 10/3/2008 Building Envelope Commissioning. This Credit Interpretation Request is from a project that sought an ID Credit for using to NIBS Guideline 3-2006, Exterior Enclosure Tech. Requirements for the Cx Process, to direct the envelope commissioning process. The intent was to achieve a high performing building envelope which would provide for occupant comfort, improve energy performance, indoor air quality control, maintainability, rain penetration control, mold prevention, building longevity, and ultimately building sustainability through effective building envelope commissioning metrics including documentation, performance criteria, test procedures, and checklists. The Credit Interpretation Request outlines the ID Credit intent, and requirements as required for LEED documentation. The Credit Interpretation Ruling (CIR) indicated that the approach would likely be rewarded an ID credit provided the submittal documentation meets the requirements of EAp1 – Fundamental Commissioning. The complete CIR is available on the USGBC website at: http://www.usgbc.org/LEED/Credit/CIRDetails.aspx?CIID=2363

[184] ECB No. 2009-29: Building Air Tightness Requirements, 30 October 2009. ECB 2009-29 directs compliance for building air tightness and building air leakage testing for new and renovation construction projects for all new Army construction projects and all renovation projects in or after Fiscal Year 2010 in or after Fiscal Year 2010. While no Army project's have achieved certification of an Enhanced Building Envelope Performance and Air Leakage Testing ID credit, adherence to building air tightness design and testing requirements of Army policy as prescribed by ECB 2009-29 should meet GBCI requirements for certification as evidenced by the following Credit Interpretation Ruling (CIR) [CIR 10/3/2008 Building Envelope Commissioning]. The ECB is available at: http://www.wbdg.org/ccb/ARMYCOE/COEECB/ecb_2009_29.pdf

e. Provide sealing for all unavoidable penetrations of the of the air barrier sufficiently durable to last the anticipated service life of the assembly; f. Damper and control to close all ventilation or make-up air intakes and exhausts, atrium smoke exhausts and intakes, etc. when leakage can occur during inactive periods. g. Provide air-tight vestibules at building entrances with high traffic and compartmentalize garages under buildings. h. Compartmentalize spaces under negative pressure such as boiler rooms and provide make-up air for combustion. 2) Adhere to commissioning requirements and activities including building envelope quality assurance criteria and documentation addressing continuity of air barrier system/components, constructability, maintainability, durability, rain penetration control, and visual comfort and indoor air quality. 3) Periodically monitor installation of air barrier system/components during construction, especially during roof transition/ roof termination installations, initial installation of sealants, and the specific project interfacing conditions. 4) Demonstrate performance of the building envelope by testing. a. Demonstrate that the air leakage rate for the completed building does not exceed 0.25CFM/sq ft at a pressure differential of 0.3 iwg (75 Pa) in accordance with ASTM E 779 or ASTM E 1827 using both pressurization and depressurization.. b. Perform pressure testing on the completed building following verification that the continuous air barrier is in place and installed with any necessary repairs to the continuous air barrier, if needed to comply with the required air leakage rate. c. Perform Infrared Thermography Testing on the completed building using infrared cameras with a resolution of 0.1 °C or better in accordance with International Organization for Standardization (ISO) 6781 and ASTM C 1060. Determine air leakage pathways using ASTM E 1186, and perform corrective work as necessary to achieve the specified whole building air leakage rate.
Approach to Credit: Adherence to ECB No. 2009-29: Building Air Tightness Requirements.

7.2.9 ID Credit Title: Low Mercury Fixtures[185],[186],[187],[188]

Statement of Intent: Provide low or no mercury lamps for light fixtures to reduce the potential for environmental contamination.
Statement of Credit Requirements: Demonstrate Toxic Material Reduction via reduced mercury in light bulbs. Specify maximum levels of mercury permitted in mercury-containing lamps for the building and associated grounds, including lamps for both indoor and outdoor fixtures. Specified lamps must establish a target for the overall average of mercury content in lamps of 90 picograms per lumen-hour (90pg/(lm*hour) or less. At least 90% of the lamps must comply with the target (as measured by the number of lamps). Lamps containing no mercury may be counted toward compliance only if they have energy efficiency at least as good as their mercury-containing counterparts.
Approach to Credit: Comply with the language and requirements of LEED 2009 EBOM MRc4, Sustainable Purchasing—Reduced Mercury in Lamps.

7.3 PDT considered LEED ID credits but not project developed

The ID credits below are partially developed from Project Documentation, CIRs, and the ID Credit Catalog.

7.3.1 ID Credit Title: Thermo Graphic Inspection Report

See Building Envelope Commissioning above.

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[185] This potential Innovation & Design Credit is derived from the Innovation & Design Credit Catalog and based on credits/language contained in LEED-EB. LEED-NC/BD&C projects implementing LEED for Existing Buildings Upgrades, Operations and Maintenance (LEED-EB) strategies for the reduction of mercury brought into buildings through purchases of light bulbs have been granted ID credits. This LEED-EB credit continues to evolve, however, and it may become a credit in LEED BD&C or dropped from LEED-EB in the future.

[186] LEED for Green Building Rating System for Existing Buildings Upgrades, Operations and Maintenance (LEED-EB), Version 2, July 2005, (a) MR-Pr2 Toxic Material Source Reduction: Reduced Mercury in Light Bulbs – Intent: Establish and maintain a toxic material source reduction program to reduce the amount of mercury brought into buildings through purchases of light bulbs, (b) MR-Cr6 Additional Toxic Material Source Reduction: Reduced Mercury in Light Bulbs – Intent: Establish and maintain a toxic material source reduction program to reduce the amount of mercury brought into buildings through purchases of light bulbs.

[187] LEED 2009 for Existing Buildings: Operations & Maintenance Rating System (LEED 2009 EBOM), July 2010, (a) MR-Pr1 Sustainable Purchasing Policy – Intent: To reduce the environmental impacts of materials acquired for use in the operations, maintenance and upgrades of buildings (The sustainable purchasing policy must include requirements for MR Cr4: Sustainable Purchasing—Reduced Mercury in Lamps), (b) MR Pr2 Solid Waste Management Policy – Intent: To facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills or incineration facilities (The solid waste management policy must include requirements for the recycling of all mercury-containing lamps), (c) MR Cr4 Sustainable Purchasing—Reduced Mercury in Lamps – Intent: To establish and maintain a toxic material source reduction program to reduce the amount of mercury brought onto the building site through purchases of lamps.

[188] LEED 2009 for Existing Buildings: Operations & Maintenance Rating System (Current Draft still contains the same provisions as LEED 2009 EBOM for the reduction of mercury brought into buildings through purchases of light bulbs).

7.3.2 ID Credit Title: Blower Door Test Report

See Building Envelope Commissioning above.

7.3.3 ID Credit Title: Off Peak Thermal Energy Ice Storage System

The Armed Forces Reserve Center at Fort Sheridan installed this type of system but did not complete the ID credit template.

7.3.4 ID Credit Title: Low-Emitting Systems Furniture (Furniture - Greenguard Certified and Environmentally Friendly) (from the ID Credit Catalog)

Statement of Intent: Reduce indoor air contaminants that are odorous, potentially irritating and/or harmful to the comfort and wellbeing of installers and occupants
Statement of Credit Requirements: In the absence of any Greenguard certified laboratory-grade furniture, specify environmentally-friendly laboratory furniture
Approach to Credit: Provide list of systems furniture and associated low-emitting attributes including: 1) Low formaldehyde in the MDF wood products for the wood casework 2) No VOC powder coat paint finish on the steel casework 3) No VOC Expanded Polystyrene insulation in the steel casework 4) No VOC powder coat finish on the casework fixtures 5) No VOC content

7.4 LEED ID credits related to ASHRAE 189.1, HPSB GP, EO & ECB requirements

The ID credits below were developed from CIRs, ID Credit Catalog, High Performance Sustainable Building Guiding Principles (HPSB GP), Executive Orders, Engineering Construction Bulletins and ASHRAE 189.1.

7.4.1 ID Credit Title: Green Cleaning Plan (Required by ASHRAE 189.1) (From ID Credit Catalog)[189]

Statement of Intent: Reduce exposure of building occupants to contaminants that adversely impact the indoor environment.
Statement of Credit Requirements: Implement three green cleaning strategies after construction completion and prior to building occupancy: 1) Implement a Construction IAQ Management Plan; 2) Conduct a Two-week flush-out and replacement of filters with MERV 13 filtration media; 3) Conduct a final clean-up by independent green cleaning service using cleaning products that meet the Green Seal GS -37 standard, floor cleaners complying with CA Code of Regulations maximum VOC content, and

[189] American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 189.1, Section 10.3.2.1.4.6 Building Green Cleaning Plan.

disposable paper products, supplies and trash bags meeting the minimum requirements of US EPA's Comprehensive Procurement Guidelines. 4) Demonstrate that the products used in the project are non-hazardous, have a low environmental impact and are environmentally preferable.
Submittals: 1) Statement of purpose describing health and environmental goals, focusing on cleaning chemicals and custodial training; 2) Description of contractual and procedural requirements for operations staff including training and implementation; 3) A clear set of acceptable performance level standards by which to measure progress or achievement; 4) Documentation of the program's housekeeping policies and environmental cleaning solution specifications, including a list of approved and prohibited chemicals and practices. Concentrated cleaning products should be utilized when available. 5) Description of post-occupancy green cleaning strategies.

7.4.2 ID Credit Title: Transportation Management Plan (Required by ASHRAE 189.1) (From credit catalog)[190]

Statement of Intent: To reduce pollution and land development impacts from automobile use.
Statement of Credit Requirements: Develop a Transportation Management Plan providing building occupants with incentives to telework, adopt flexible work schedules, carpool, rideshare and use alternative transportation in accordance with ASHRAE Standard 189.1, Section 10.3.2.4 Transportation Management Plan (TMP).
Submittals: Detailed narrative describing the transportation management program.

7.4.3 ID Credit Title: Energy Star Appliances & Equipment (Required by ASHRAE 189.1) (From ID Credit Catalog)[191]

Statement of Intent: Reduce energy consumption through use of highly efficient appliances and equipment.
Statement of Credit Requirements: Purchase Energy Star compliant appliances and equipment and calculate the associated % energy savings and resulting cooling systems downsizing according to the anticipated heat load savings.
Submittals: 1) Narrative describing purchasing decisions 2) Calculation of energy savings 3) Copies of purchase orders and payment invoices

7.5 Recommended LEED pilot credit library potential ID credits

Below is the current listing as of 01 December 2010. For the complete list, the LEED Pilot Credit Library may be found at: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2104)

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[190] ASHRAE Standard 189.1, Section 10.3.2.4 Transportation Management Plan (TMP).

[191] ASHRAE Standard 189.1, Sections 6.3.2.2, 6.4.2.2, 7.4.3.1, and 7.4.7.3.

- Pilot Credit 1: Life Cycle Assessment of Building Assemblies/Materials
- Pilot Credit 4: Innovative Ventilation
- Pilot Credit 5 & 6: Preliminary Integrative Project Planning & Design (Required by HPSB GP)
- Pilot Credit 7: Light Pollution Reduction
- Pilot Credit 10: Sustainable Wastewater Management
- Pilot Credit 11: Chemical Avoidance in Building Materials[192]
- Pilot Credit 12: LT - Reduced Automobile Dependence
- Pilot Credit 13: LT - Bicycle Network, Storage and Changing Rooms
- Pilot Credit 14: LT - Walkable Streets
- Pilot Credit 15: LT - Parking Reduction
- Pilot Credit 16: SS Rainwater Management
- Pilot Credit 17: WE - Cooling Tower Makeup Water
- Pilot Credit 18: WE - Appliance and Process Water Use Reduction
- Pilot Credit 20: MR - Recycled Content
- Pilot Credit 21: EQ - Low Emitting Interiors
- Pilot Credit 22: EQ - Quality Interior Lighting - Lighting Quality Only
- Pilot Credit 24: EQ - Acoustics
- Pilot Credit 25: PF - Water Metering and Reporting
- Pilot Credit 26: PF - Advanced Energy Metering
- Pilot Credit 30: LT - Alternative Transportation
- Pilot Credit 31: SS - Heat Island Reduction
- Pilot Credit 37: EQ - Balance Heating/Cooling Distribution Systems
- Pilot Credit 40: GIB: Light Pollution Reduction

[192] A list of chemicals to avoid is included in EPA742-R-99-002, Defending the Environment at the Department of Defense: Using Environmentally Preferable Purchasing Procedures to Maintain the Pentagon and Other DOD Facilities, Washington DC: EPA, July 1999.

8 Regional Priorities (RP)

The USBGC has analyzed all of the zip codes throughout the United States and selected six credits that are considered most important for each zip code. If a project achieves any of the selected credits for the building's particular zip code, the project receives the point for the credit plus a bonus point for achieving a Regional Priority Credit (RPC). Up to four bonus points are possible out of the six priority credits to choose from. Therefore RPCs are designed to encourage achievement of LEED credits of special environmental importance to a particular geographic area.

ERDC-CERL has created a tool called the "Military Installation Regional Priority Credit Database" (http://datacenter.leamgroup.com/leed) designed to act as a central database for military installation LEED 2009 rated buildings and projects. It allows users to search for RPCs by installation name or a 5-digit U.S. zip code. Building projects can be added to an internal project database which allows them to be associated with an installation and its Regional Priority Credits.[193]

[193] LEAMGroup Inc., Military Installation Regional Priority Credit Database, 2010.

9 LEED Lessons Learned

9.1 EAp1/EAc3, Fundamental and enhanced commissioning

9.1.1 LEED commissioning is not traditional commissioning

LEED commissioning extends beyond the traditional focus of HVAC-R systems. EA Prerequisite 1 states that in addition to HVAC-R mechanical and passive systems and their respective controls, lighting and daylighting controls, domestic hot water systems, and renewable energy systems take part in the commissioning process.[194]

9.1.2 Commissioning costs

The cost of fundamental commissioning (Cx) is estimated to be $1.16/sf or 0.4% of the total new construction cost based on information from a recent LBNL study (0.4 percent mean cost with a range from 0.25 percent to 2 percent) for 'total' commissioning.[195] According to GSA, there is an incremental cost of $0.10-$0.15/gross sf on Enhanced Cx (ECx).[196] All costs must be covered in the 1391 regardless of how they will be accomplished (in-house, Cx Authority, or some combination).

9.2 MRc4. Recycled Content

MR credit 4 allows a material total of 10 percent recycled content to earn 1 LEED credit; 20 percent earns 2 LEED credits.[197] Specialty items (mechanical, electrical, and plumbing fixtures and components, elevators) are not included in the calculation of recycled content; however, furniture may be included if it has already been evaluated in MR credit 3: Materials Reuse through MR credit 7: Certified Wood (discussed below in Section 9.3).

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194 LEED Reference Guide. 2009. Pp. 217.

195 Mills, Evan, Ph.D., Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions, Lawrence Berkeley National Laboratory, Berkeley, CA, 21 July 2009.

196 Steven Winter Associates, Inc., GSA LEED Cost Study: Final Report (Washington DC: GSA, October 2004).

197 Recycled content value is determined by weight.

Raw materials often recycled into construction products include: concrete, asphalt, asphalt shingles, gypsum wallboard, wood, and metals. [198,199] Raw materials commonly recycled into architectural products include: ash, glass, mirror, porcelain, stone, and paint. Binding agents often include corn oil-based resins.

The EPA currently considers fly ash to be a nonhazardous solid waste when encapsulated. Therefore, its presence in concrete as a supplementary cementitious material[200] would be appropriate in Army installations. In this application, fly ash can provide material advantages, such as greater workability, higher strength, and increased longevity, in the finished concrete product.[201,202]

9.3 MRc7, Certified Wood

MR credit 7 stipulates that at least 50 percent[203] of wood-based materials and products must be certified based on the criteria set forth by the Forest Stewardship Council (FSC).[204]

This credit has been jeopardized in many Army construction projects. The Directorate of Information Management (DOIM) is responsible for mounting communications equipment in buildings after construction completion. Non-FSC-certified plywood is often installed by request of DOIM in closets and other areas as a mount for communications equipment. Alternatively, fire-rated FSC-certified plywood or fiber cement underlayment/backerboard could be used.

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198 Construction Materials Recycling Association (CMRA) website.

199 To find a recycler in your area, refer to <http://www.cdrecycling.org/find.html>.

200 i.e., a substitute for, or amendment to, Portland cement in concrete mixes.

201 Vancity, Dockside Green Annual Sustainability Report 2008 (Vancouver: Vancity, n.d.), 41.

202 American Coal Ash Association, 2006 Coal Combustion Product (CCP) Production and Use Survey (Aurora: ACAA, 24 August 2007).

203 Percentage is based on cost.

204 LEED Reference Guide 2009.

9.4 IEQc5, Indoor Chemical and Pollutant Source Control—Permanent Entryway Systems

LEED now requires that all regularly used entrances must employ entryway systems to collect and hold dirt from people and equipment entering the building. Recessed collection devices (grills or grates) are most effective and are recommended for Army installations.[205]

Alternatively, IEQ credit 5 stipulates that walk-off floor mats are acceptable when maintained by a contracted service organization on a weekly basis.[206] To avoid issues involving cleaning service contracts, researchers recommend the permanent installation of walk-off carpeting or mats recessed in mat wells at all building entry locations.[207] All carpeting must follow ADA 2010 standards. Accordingly, carpet must be securely attached and have an acceptable cushion or pad, if one is chosen.[208] The entire edge lengths must be fastened and have a trim.[209,210]

Carpeting would be subject to IEQ credits 4.1, Low-Emitting Materials-Adhesives and Sealants, and IEQ credit 4.3, Low-Emitting Materials-Flooring Systems. Indoor carpet and carpet pad adhesives must comply with the volatile organic compound limits (VOCs) set forth by the South Coast Air Quality Management District (SCAQMD) Rule #1168. Carpets and carpet cushions are subject to the requirements of the Carpet and Rug Institute (CRI) Green Label Plus program.[211]

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205 LEED Reference Guide. 2009. P. 513.

206 LEED Reference Guide. 2009. P. 511.

207 Recessed carpets must be ADA compliant. Ramped edging may be required.

208 Carpet and padding increase roll resistance, making it difficult to maneuver wheelchairs. According to the 2010 ADA Standards Section 302.2, a pile thickness of ½ inch or less is allowed (lower pile yields less roll resistance). It is also advisable to omit carpet padding in order to maintain wheelchair maneuverability; however, if one is desired, it should be firm for this purpose.

209 Sin, Jennifer. Correspondence via email. 12 January 2011 to 14 January 2011.

210 Department of Justice. 15 September 2010. *2010 ADA Standards for Accessible Design.* Section 302.2. PDF Online. <http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards_prt.pdf.> Accessed 24 January 2011.

211 LEED Reference Guide. 2009. Pp. 471, 487.

10 LEED Point Assessment of the Five Standard Building Types

10.1 Achieved and projected LEED points by facility type

LEED data was collected (as available) from USACE project delivery teams that had executed LEED projects or currently have projects underway at Army installations. Credit tallies were drawn from LEED validation checklists. Some data was for LEED Version 2.2 and some was projected for LEED 2009.

For each facility type, researchers compiled and reviewed LEED points currently being achieved in construction projects. They then forecasted additional LEED points to be achieved based on a set of assumptions (Table 38).[212] Most site credits and all Regional Priority points were excluded since site constraints and geographical information are typically not available to standard facility designers.

In forecasting the projected LEED point totals, several assumptions were made. Points were given for the following:

- Credits commonly attained for a facility type (3 or more projects attained the credit in the FY09 & FY10 SDD Validation review sample);
- Credits on average achieved by other facility types (same sample);
- Credits now required by statute or policy;
- Credit for meeting energy consumption reduction targets of over 48% for 10 points under LEED EA Cr3 Energy Optimization; and
- Credit for all 6 points under LEED ID.

As mentioned above, LEED Site credits most directly related to site selection (listed below) and location-dependant LEED Regional Priority credits were excluded from the assumptions. These exclusions represent the potential for an additional 17 Points.

- SS Cr1 Site Selection

[212] Note that most Army construction projects now nearing completion are being evaluated under LEED version 2.2. The recommendations and projections in this report are for LEED 2009 which has more stringent credit requirements.

- SS CR2 Development Density & Community Connectivity
- SS Cr3 Brownfield Redevelopment
- SS Cr4.1 Alternative Transportation, Public Transportation Access

Table 38 summarizes attainable LEED credits for the five COS standard designs. The first column within each of the building types indicates points that have already been achieved by the standard design; the second column indicates additional forecasted points. Note that this table has some discrepancies. Two credits (MR4 and MR5) do not realize full potential in any of the standard designs. Some building designs claim neither achieved nor forecasted credits for an assortment of LEED credits.

In this exercise, none of the existing standard designs achieved the required Silver Certification (50-59 points). Moreover, some of the existing standard designs do not qualify for certification at all (Certified 40-49 points). By implementing, where appropriate, the design strategies discussed in this report, all of the standard designs hold the potential to reach beyond the DoD Silver benchmark and earn Gold Certification (60-69 points).

Since the Army seeks to attain “Smart Silver,” once enough points have been earned to obtain the Silver Certification, the credit accumulation process typically ends. This results in some LEED credits receiving little attention and no attempts at implementing design strategies to achieve those credits. Although Silver Certification is the objective, many Army projects hold the potential to reach Gold Certification (as indicated in Table 38).[213]

[213] Platinum Certification could be obtained if *all* LEED credits were considered, not just those listed in Table 38. However, the added expense for this is unknown at this time.

Table 38. Achieved and projected LEED points by building type.[214]

	LEED Credits	Points	BDEHQ		COF		DFAC		TEMF		UEPH	
SS 4.2	Alternative Transportation Bicycle Storage & Changing Rooms	1	1	--	1	--	0	0	1	--	1	--
SS 4.3	Alternative Transportation Low-Emitting & Fuel Efficient Vehicles	3	0	3	3	--	0	3	3	--	3	--
SS 4.4	Alternative Transportation Parking Capacity	2	0	2	0	2	2	--	2	--	2	--
SS 5.2	Site Development Maximize Open Space	1	1	--	0	0	1	--	0	0	1	--
SS 6.1	Stormwater Design Quantity Control	1	0	1	1	--	1	--	0	1	0	1
SS 6.2	Stormwater Design Quality Control	1	0	1	0	1	0	1	0	1	0	1
SS 7.1	Heat Island Effect Non-Roof	1	0	1	0	1	0	1	1	--	0	1
SS 7.2	Heat Island Effect Roof	1	1	--	1	--	0	1	0	1	0	1
SS 8	Light Pollution Reduction	1	1	--	0	1	0	1	1	--	1	--
WE 1	Water Efficient Landscaping	2-4	4	--	4	--	4	--	4	--	4	--
WE 3	Water Use Reduction	2-4	4	--	4	--	4	--	4	--	4	--
EA 1	Optimize Energy Performance 19 points for 48%	19	10	9	10	9	10	9	10	9	10	9
EA 3	Enhanced Commissioning	2	0	2	0	2	0	2	0	2	0	2
EA 4	Enhanced Refrigerant Management	2	0	2	2	--	0	2	0	2	2	--
MR 2	Construction Waste Management	1-2	2	--	2	--	2	--	2	--	2	--
MR 4	Recycled Content	1-2	1	0	1	0	1	0	1	0	1	0
MR 5	Regional Materials	1-2	0	1	1	0	1	0	1	0	1	0
MR 7	Certified Wood	1	0	1	0	1	1	0	1	0	0	1
IEQ 1	Outdoor Air Delivery Monitoring	1	1	--	1	--	1	--	1	--	1	--
IEQ 3.1	Construction IAQ Management Plan During Construcion	1	1	--	1	--	0	1	1	--	1	--
IEQ 3.2	Construction IAQ Management Plan Before Occupancy	1	1	--	1	--	1	--	1	--	1	--
IEQ 4.1	Low-Emitting Materials Adhesives & Sealants	1	1	--	1	--	1	--	1	--	1	--
IEQ 4.2	Low-Emitting Materials Paints & Coatings	1	1	--	1	--	1	--	1	--	1	--
IEQ 4.3	Low-Emitting Materials Flooring Systems	1	1	--	1	--	1	--	0	1	1	--
IEQ 4.4	Low-Emitting Materials Composite Wood & Agrifiber Products	1	1	--	1	--	0	1	1	--	1	--
IEQ 5	Indoor Chemical/Pollutant Source Control	1	1	--	0	1	0	1	0	1	0	1
IEQ 6.1	Controllability of Systems Lighting	1	1	--	1	--	0	0	1	--	1	--
IEQ 6.2	Controllability of Systems Thermal Comfort	1	1	--	0	0	0	1	0	0	1	--
IEQ 7.1	Thermal Comfort Compliance	1	1	--	1	--	1	--	1	--	1	--
IEQ 8.1	Daylight & Views Daylight 75% of spaces	1	0	0	0	0	0	1	0	1	0	1
ID 1	Innovation in Design Innovation, Examplary Perf., Pilot Credit	1-5	2	3	1	4	2	3	1	4	0	5
ID 2	LEED Accredited Professional	1	1	--	1	--	1	--	1	--	1	--
	Total Points	**68**	**39**	**26**	**41**	**22**	**36**	**28**	**41**	**23**	**43**	**23**
	Certification Possible	**110**	**65**	**G**	**63**	**G**	**64**	**G**	**64**	**G**	**66**	**G**

214 First column indicates "achieved"; second column indicates "forecasted"; blue indicates Missed Opportunity Credit (MOC).

10.2 Regional priorities by facility location

Forts Bragg and Stewart share identical regional priorities. Forts Bragg, Leavenworth, and Stewart have WEc3 and EAc2 as common priorities. However, percentage goals differ at Fort Leavenworth where there is less emphasis on water efficiency and more emphasis on energy efficiency (Table 39).

Table 39. Regional priority credits for target installations.[215,216]

Fort Bragg, NC 28307						
(1) DFAC (1) TEMF	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1
Fort Leavenworth, KS 66027						
(1) UEPH	SSc4.3	SSc5.1	WEc1, Opt. 2	WEc3 (30%)	EAc2 (9%)	MRc2 (50%)
Fort Stewart, GA 31314						
(1) BDE HQ (1) COF	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1

[215] Common RPCs among the three sites are highlighted.

[216] Some RPCs are multi-threshold credits. In each case, the bonus point is awarded only when a specific threshold is met. For example, WEc3, Water Use Reduction (in LEED for New Construction) includes three thresholds ranging from 30% water savings to 40% water savings. If an RPC indicates WEc3 (40%), a project must achieve the 40% threshold in order to earn the associated bonus point (USGBC, Regional Priority Credits, Frequently Asked Questions).

11 Conclusions and Recommendations

Building features and construction methods and materials deemed to be viable based on feasibility and life-cycle cost analysis should be incorporated into the appropriate standard design for the FY13 program and beyond. While these standard design updates begin with recommendations from this effort, an intensive follow-on effort by the COS to add feasible, cost-effective ideas to their standards will occur during integrated design charrettes. These charrettes should include the proponent for the applicable standard design. As sustainability strategies are perfected, they should be applied to other Army building types, most notably:

- Child Development Centers (Huntsville COS)
- Starship/Reception Barracks (Fort Worth COS)
- Chapels (Omaha COS)

Engineering and Construction Bulletin (ECB) No. 2011-1, High Performance Energy and Sustainability Policy (CECW-CE, 19 January 2011) captured and codified many of the ideas that were proposed, investigated, and cost estimated during this integrated research effort.

Additional recommendations are discussed in the following sections.

11.1 Consider installation strategic sustainability goals

The article "Today's Choices, Tomorrow's Army: What's Your Bootprint? Fostering a Sustainability Ethic in the Army[217]" by Karen J. Baker discusses so-called Big Hairy Audacious Goals (BHAGs). "Sustainability is a BHAG and the goals set forth in the Army Strategy for the Environment are intentionally big in order to communicate a vision of the future Army we wish to create."

Army installations have been using the 25 year ISSP (Installation Strategic Sustainability Planning) visioning processes to establish long range sustainability goals. To date, 34 installations have developed 25 year sustainability plans, goals, action teams, measurements for goals, and are working towards specific objectives established during the visioning process.

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217 http://www.imcom.army.mil/hq/kd/cache/files/AEA75359698D455896243A4DD010A711.pdf

Figure 42 shows the Army installations that are implementing Sustainably Plans. USACE project delivery teams should engage the installation Sustainability planners to help facilitate acceptance of new ideas within the installation community.

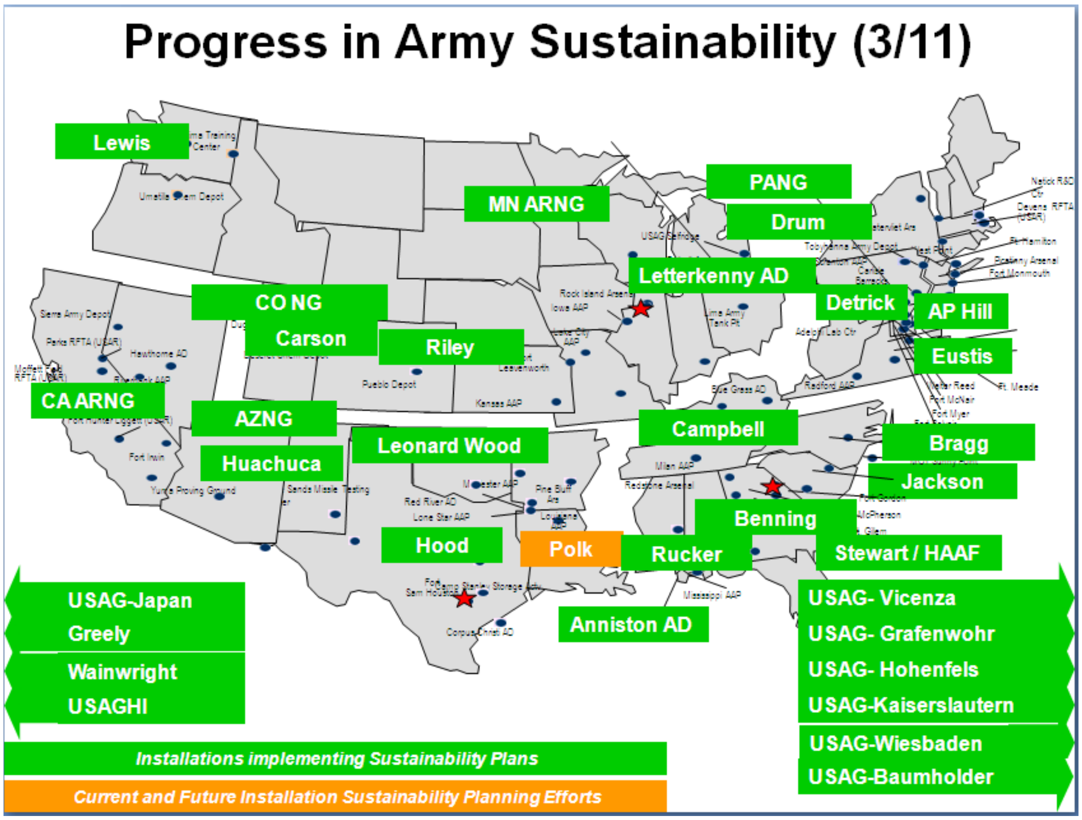

Figure 42. Army installations implementing sustainability plans.

Example infrastructure related goals are shown below:

Fort Bragg

Land Use: Create and enhance sustainable training and urban areas to ensure military readiness and promote compatible growth of the surrounding communities.

Facilities: To become the model sustainable military community of the world by using sustainable principles throughout the life cycle of all facilities and supporting infrastructure (FSI).

Utilities: Supply reliable utility services and infrastructure with no negative impact while aggressively reducing overall demand. Utilities include energy, water, and information technology.

Transportation: Build a sustainable world-class ground transportation network providing seamless transition between multiple modes of travel while reducing harmful emissions.

Anniston Army Depot

Flexible and adaptable facilities: Provide the right buildings at the right time in the right location to support current and future missions.

Utilities: Become capable of 100 percent self-sufficient utility production over 2010 baseline (produced on depot or purchased within the local community). Utilities include water and energy (facility and mobility).

Fort Carson

Energy and water resources: Sustain all facility and mobility systems from renewable sources and reduce total water purchased from outside sources by 75% by 2027.

Sustainable development: Create a community that encourages social, civic, and physical activity while protecting the environment.

US Army Garrison Grafenwoehr

Goal 2: Build and sustain world-class facilities to support deploy, redeploy and reset activities in support of multinational full spectrum missions.

Goal 3: Provide multifunctional, state-of-the-art training facilities and capabilities in support of multinational training to prepare and sustain the force in any operational environment, while preserving our natural resources.

Goal 4: Meet LEED® platinum standard for all new construction and when renovating existing structures.

Goal 5: Acquire and manage resources and maximize processes optimizing sustainability (Mission, Environment and Community).

11.2 Adopt whole building design process and an integrated project delivery process

The American Institute of Architects defines Integrated Project Delivery (IPD) as leveraging early contributions of knowledge and expertise through the utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project lifecycle.[218]

USACE has designed and built innovative projects, and has established challenging energy and sustainability requirements and targets. Arguably, the most successful projects result when an integrated design team establishes challenging targets at the beginning of the project. There are several case studies of LEED Platinum or net zero projects which challenged all team members to excel by setting BHAG[219].

According to the Whole Building Design Guide:[220]

> Whole Building Design consists of two components: an **integrated design approach** and an **integrated team process**. The "integrated" design approach asks all the members of the building stakeholder community, and the technical planning, design, and construction team to look at the project objectives, and building materials, systems, and assemblies from many different perspectives. This approach is a deviation from the typical planning and design process of relying on the expertise of specialists who work in their respective specialties somewhat isolated from each other.
>
> Whole Building design in practice also requires an integrated team process in which the design team and all affected stakeholders work together throughout the project phases and to evaluate the design for cost, quality-of-life, future flexibility, efficiency; overall environmental impact; productivity, creativity; and how the occupants will be enlivened. The 'Whole Buildings' process draws from the knowledge pool of all the stakeholders across the life cycle of the project, from defining the need for a building, through planning, design, construction, building occupancy, and operations.

The whole building design approach was used to design and build the Community Emergency Services Station at Fort Bragg, expected to earn

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[218] http://www.aia.org/contractdocs/AIAS077630 accessed 8 March 2011.
http://images.autodesk.com/adsk/files/ipd_definition_doc_final_with_supplemental_info.pdf

[219] Conversation between Annette Stumpf and Kim Fowler, 8 March 2011.

[220] http://www.wbdg.org/wbdg_approach.php Accessed 9 March 2011.

LEED Platinum[221]. Upon certification, this building will be the first LEED Platinum facility built by USACE.[222]

11.3 Conduct early design energy charrettes or eco charrettes

There is an on-going conversation among the COS about how to conduct eco-charrettes or energy-charrettes at the project definition phase[223]. The output of this phase is a Project Definition Report (PDR) and 3086 (Current Working Estimate for Budget Purposes). This phase is late enough to generate a concept-level design and still get additional funding if needed. Further development of this concept would allow project teams to creatively test ideas and specific system types for feasibility and identify the cost impacts. Building Information Modeling (BIM), energy modeling[224] and other tools are now available to help teams evaluate the building geometry, orientation, massing, layout, daylight, etc. Additionally, LID concepts or higher-cost systems, such as ground source heat pumps (GSHP), can be explored.

11.4 Update RFP Wizard

The Corps of Engineers uses the RFP Wizard to convey project requirements to design/build project teams. Sustainability and energy efficiency criteria and requirements are periodically updated to reflect the current requirements.

- Water and energy efficiency was improved by adding FEMP-designated Energy Star products, Watersense outdoor fixtures, and 2.0- to 1.5-gpm showers.
- Judith Milton (Savannah District) has been systematically updating content in the RFP Wizard to ensure LEED-relevant items represent the current USACE LEED implementation strategies.
- Other important RFP paragraphs include: Applicable Criteria, Paragraph 4, and Design-Build (D-B) Paragraph 5.9.2.

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[221] The Residential Community Initiative (RCI) Fairfax Village Neighborhood Center at Fort Belvoir earned LEED® Platinum; however, it was funded and built by the Clark Realty Capital, Inc. the RCI contractor.

[222] The Residential Community Initiative (RCI) Fairfax Village Neighborhood Center at Fort Belvoir earned LEED® Platinum; however, it was funded and built by the Clark Realty Capital, Inc. the RCI contractor.

[223] Email and phone conversations between Brandon Martin LRL and Annette Stumpf 7 March 2011.

[224] Draft CERL Technical Report: Early Design Energy Analysis Using BIM by Annette Stumpf. Final report available on the CERL website soon: http://www.cecer.army.mil/td/tips/index.cfm

11.5 Update installation design guides (IDG)

Current installation design guides (IDGs) can be problematic for some areas of sustainable design. This study identified the following areas of conflict. Flexibility in these areas would facilitate sustainable design and development efforts to meet Army sustainability and energy mandates.

- Roof forms—Flat roof forms offer opportunities in terms of energy efficiency, yet many installations are required to preserve the architectural character of an installation locale by using sloped roof forms. The roof form may directly affect opportunities for daylighting, photovoltaic, solar hot water or other technologies.
- Roof colors— To reduce solar heat gain and heat island effects, light-colored roofing with higher albedo values has preference over dark roofing with lower albedo values. Despite this, many installations are required to preserve the architectural character of an installation locale by using pre-established darker color palettes. ASHRAE 189.1 requires buildings in climate zones (1-5) to use Cool Roofs. This can be in direct conflict with Installation Design Guides for historic districts. A project delivery team facing this issue would need to research the best available roofing in a suitable colored cool roofing material appropriate for the locale.
- Tinted glazing—Installations often require window glazing to be tinted to reduce glare and sun deflection. Yet these tinting products undermine daylighting attempts by drastically reducing the Visible Transmittance (T_{vis}) value of glazing units. Low T_{vis} values typically increase the amount of artificial lighting (and electricity) needed in buildings.
- Installation planting lists—These lists should contain draught-tolerant, non-invasive, and native or adapted plant material that is sustainable. Many installations still specify water-intensive exotics (i.e., non-native species).
- Stormwater management — IDGs typically contain requirements for hardened surfaces to convey storm water away from the site. Traditional impervious streets and parking lots, gutters, curbs and pipes are used, contrary to the LID principles that are mandated by EISA and the 19 Jan 2010 Memorandum by Dorothy Robyn, Deputy Under Secretary of Defense (Installations and Environment) "Subject: DoD Implementation of Storm Water Requirements under Section 438 of the Energy Independence and Security Act[225]". This is an issue which must be ad-

[225] http://www.p2sustainabilitylibrary.mil/p2_documents/dusd_ie.pdf

dressed by Installations and USACE project delivery teams. LID principles are being introduced in Army projects. However, installation DPW personnel, who are unfamiliar with LID strategies, often resist these efforts. Army installation managers do not want detention and retention ponds because they use precious land area, and may not trust the "new" LID techniques until they are proven to work effectively in the region. Disconnecting installation storm water flow by routing runoff from hard surfaces to pervious areas could help avoid traditional paving and pipe systems.

- Definition of "site" for EISA Storm Water Management — A bigger issue for successfully meeting the EISA requirement is the definition of the "site" boundaries.[226] The size of the site and the soil characteristics are two key factors in determining the difficulty of meeting EISA requirements. The site could be considered to be an entire installation, a watershed or area within an installation, visual themes and zones defined in the IDG, or the site where a building or cluster of buildings is to be constructed. It is more challenging and expensive to manage stormwater on a small site where a building and parking lot will be constructed, yet USACE teams might hear that requirement from their installation customers. A more practical and cost-effective approach would be to collaborate with the installation and look at stormwater management for larger areas. This approach could result in adoption of more innovative strategies for new construction, appropriate retrofits in existing infrastructure, and the ability to use rainwater as a resource to work towards the Army's net zero water goal.

11.6 Update outdated UFCs and UFGSs

A survey is needed to determine which applicable UFC and UFGS address the current DoD and Army sustainability requirements. Out-dated criteria and specifications should be updated to facilitate the Army's energy, sustainability, and construction program goals.

11.7 Coordinate Furniture, Fixtures & Equipment

In order to maximize energy efficiencies and achieve sustainability objectives in Army facilities, it will be necessary to have coordination of some FF&E purchases and use. Examples include the following:

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[226] Note that the LEED® project boundaries must be consistent throughout all project documentation, but the EISA storm water site could be different. This might affect the ability to earn the LEED Stormwater credits.

- Modular walls (to allow for daylight penetration and views)
- Modular furniture (with lighting controls)
- Freestanding furniture (to encourage use of low VOC, formaldehyde-free, certified wood, rapid renewables, and recycled content)[227]
- Appliances, e.g., microwaves, ranges, refrigerators, dishwashers and clothes washers/dryers (for energy use reductions)
- Office appliances, e.g., cordless phones, battery chargers, external power adapters, shredders, imaging equipment[228] (for energy use reductions)
- FEMP-designated ENERGY STAR electronics (top 25 percent of ENERGY STAR products), e.g., televisions, cable boxes, computers, monitors, and audio/video equipment (for energy use reductions).

11.8 Partner with USGBC/GBCI to pre-certified prototype credits

11.8.1 Applying USGBC's Volume Certification Program to Army standard construction

The USGBC is piloting a program for volume certification to simplify documentation for volume builders while maintaining LEED's consistent and rigorous quality assurance.[229] As a volume builder, the Army is promoting the development of 'prototype credits' or suites of prototype credits that apply to its Army facility design standards of sufficient uniformity. These prototype credits would then be 'pre-certified' by the USGBC and GBCI so it would not be necessary to petition for each of those credits every time a standard Army building applies for LEED certification.

While the Army construction program seems ideally suited to the USGBC's volume certification program, the latter requires a minimum of 25 buildings to establish a 'volume.' This currently limits use of volume certification. At some point in the future it may be possible to use volume certification for barracks construction. For more information on USGBC's Volume Build Program, see:
http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2267

[227] The Centralized Furnishings Program at the U.S. Army Engineering and Support Center, Huntsville offers GreenGuard furniture for purchase (Allen, teleconference dated 28 April 2010).

[228] Includes copy and fax machines, digital duplicators, printers, scanners, all-in-one devices, mailing machines

[229] USGBC, Portfolio Program.

11.8.2 Applying USGBC's Multiple Building/Campus Program to Army complexes

Using USGBC's Multiple Building/Campus Program, there are features of individual Army buildings that can share credits (e.g., bike racks) and there are cost savings associated with registration (e.g., single registration for multiple buildings). But Army policy requires each building to be rated, documented, and registered separately.[230] Therefore, there would ultimately be no real savings for program participation. Project boundary definition has also been problematic in past Multiple Building/Campus approaches.

11.9 Review LEED 2012 requirements for future Army impacts

For example, in anticipation of the release of LEED 2012, it may be prudent to address 'rainwater management'—soon to be SSc6.1 (2-3 points). The intent of the credit is to "restore or maintain the natural hydrology and water balance of the site based on historic conditions and undeveloped ecosystems in the region." The requirement is to "manage on-site the runoff from the developed site using LID. The minimum runoff volumes for each point threshold are as follows:[231]

Percentile of regional or local rainfall events	Points
95	2
98	3

[230] USACE Army LEED Implementation Guide, January 15, 2008.

[231] USGBC, LEED 2012 for NC, NC Retail, Schools, and CS (unpublished).

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Acronyms

ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BN/BDE HQ	Battalion/Brigade Headquarters
BHAGs	Big Hairy Audacious Goals
CRI	Carpet and Rug Institute
COS	Centers of Standardization
CVWS	Central Vehicle Wash Station
COF	Company Operations Facilities
CCB	Construction Criteria Base
CN	Curve number
DoD	Department of Defense
DOE	Department of Energy
DNR	Department of Natural Resources
DFAC	Dining Facilities
DOIM	Directorate of Information Management
EISA	Energy Independence and Security Act
EPAct 2005	Energy Policy Act of 2005
ECB	Engineering and Construction Bulletin
ET	Evapotranspiration
EO	Executive Order
FSC	Forest Stewardship Council
FFE	Furniture, fixtures, and equipment
HVAC	Heating, ventilating, and air conditioning
HPSB	High performance sustainable building

HETs	High-efficiency toilets
HEUs	High-efficiency urinals
HSL	Hybrid solar lighting
IEQ	Indoor Environmental Quality
ID	Innovation and Design
IDG	Installation design guides
IAPMO	International Associate of Plumbing and Mechanical Officials
ICC	International Code Council
IPC	International Plumbing Code
IWA	International Water Association
ISSP	Installation Strategic Sustainability Planning
LEED	Leadership in Environmental and Energy Design
LCCA	Life cycle cost analysis
LPD	Lighting power densities
LID	Low impact development
MOU	Memorandum of Understanding
MILCON	Military construction
MCA	Military Construction, Army
MPR	Minimum program requirements
NECPA	National Energy Conservation Policy Act
NRCA	National Roofing Contractors Association
NSF	National Sanitation Foundation
NRCS	Natural Resources Conservation Service
OMB	Office of Management and Budget
PRSV	Pre-rinse spray valves
PA	Programmed amount
RPC	Regional Priority Credit

SC	Shading coefficients
SFA	Skylight to floor area
SHGC	Solar heat gain coefficients
SRI	Solar reflectance index
SCAQMD	South Coast Air Quality Management District
SDD	Sustainable Design and Development
SS	Sustainable Sites
SRM	Sustainment, Restoration and Modernization
TEMF	Tactical Equipment Maintenance Facilities TEMF
TSS	Total suspended solids
UEPH	Unaccompanied Enlisted Personnel Housing
UFC	Unified Facilities Criteria
UFGS	Unified Facility Guide Specifications
USACE	United States Army Corps of Engineers
USGBC	United States Green Building Council
VOCs	Volatile organic compounds
WBDG	Whole Building Design Guide
WFR	Window-to-floor area ration

Appendix A: Sample Implementation Strategies

Table 40 is a matrix of implementation strategies for achieving the energy and sustainability objectives set forth in this study. Methods of implementation can be via contract, design, and/or product modes. Average unit costs are included (as available) for use in calculating lifecycle costs, payback periods, and deltas between old and new standard facility design costs. Sources for all unit prices appear at the end of this appendix.

Note that the costs provided in Table 40 are estimates based on researchers' data; said costs are not official estimates that were established as part of the MILCON Energy Enhancement and Sustainability Study of Five Army Buildings Report[1]. Sources for these cost estimates are provided at the end of this appendix.

Table 40. Recommended strategies for implementing LEED recommendations.

Credit	Type	Strategy	BDEHQ	COF	DFAC	UEPH	TEMF	Unit Price
SSc.61	P	Vegetated Roofs						$14-$25/SF (extensive); $25-$40/SF (intensive)
	P	Grid Pavers						$6.50-$11/SF (grass/gravel pavers); $10-$15/SF (interlocking concrete paving blocks)
	P	Porous Paving	X	X	X	X	X	$5.50-$6/SF (permeable asphalt); $7-$11.50/SF (porous concrete)
	D,P	Stormwater reuse						$0.12-$0.50/kgal
SSc6.2	P	Vegetated Roofs						$14-$25/SF (extensive); $25-$40/SF (intensive)
	P	Grid Pavers						$8.50-15/SF
	P	Porous Paving	X	X	X	X	X	$5.50-11.50/SF
	D	Rain Gardens						$18.88/SF
	D	Vegetated Swales						$6600/acre
	D,P	Rainwater						$1.33-2.51/gal; $810-1366/hp
SSc7.1	D,P	Shade Trees/Large Shrubs						$24-$500 ea. (mature); $1.25-$6.50 ea. (sapling)
	P	Vegetated Trellises						$5.65-$87.35/LF
	P	Light-Colored Asphalt Coating/Colorant						$0.25-$2.50/SF

Credit	Type	Strategy	BDEHQ	COF	DFAC	UEPH	TEMF	Unit Price
SSc7.2	D,P	High Albedo (Cool) Roofs	X	X	X	X	X	$0.75-$1.50/sf (coating); $1.50-$3.00/sf (single-ply membrane)
	D,P	Vegetated Roofs						$14-40/SF
SSc8	P	Full Cut-Off Luminaires	X	X	X	X	X	$130-$334 ea.
	P	Low-Angle Spot Lights						$125-$292 ea.
WEp1	P	High-Efficiency Toilets						$400-800 ea.
WEc2	P	Dual-Flush Toilets						$350-600 ea.
WEc4	P	Non-Water Urinals	X	X	X	X	X	$250-650 ea.
	P	Efficient Urinals (> 0.05 gpf)						$190-$1914
	P	Low-Flow Showerheads	X	X	X	X	X	$50-200 ea.
	P	Ultra Low-Flow Faucets	X	X	X	X	X	$100-700 ea.
	P	Commercial Pre-Rinse Spray Valves			X			$300 ea.
	P	Composting Toilets						$1,000 ea. (simpler free-standing units); $10,000+ ea. (centralized, fully-integrated wastewater/ composting systems)
WEp1, WEc1, WEc2, WEc3, WEc4	D,P	Graywater						As low as $280
	D,P	Dual (Graywater/Potable Water Pipe System)						$65-$650/500 gal (new construction); $135-$1250/500 gal (retrofit)
WEc2	P	Wastewater treatment systems						*Treatment Units* : $3,500-$15,000 (buy/install); $200-$700/year (operation & maintenance) *Soil Absorption System* : $10,000-$25,000 (buy/ install); $100-500/year (operation & maintenance)
WEc3		Commercial Flake Ice Machines (Air-Cooled)						$2,700-$3,185 (300 lb); $3,850-$4,665 (600 lb); $4,325-$5,350 (1000 lb); $20,400-$21,600 (2000 lb+)
		Energy Star Commercial Dishwasher (Rack)						$4,650-$5,245 (35-40 racks/hr); $10,100-$10,695 (50-60 racks/hr); $14,300-$16,100 (automatic 190-230 racks/hour); $30,300-$32,825 (automatic 230-275 racks/hr)
		Dish Table (With Trough)						$480-$551
		Garbage Disposal						$1,950-$2,123 (1.5 HP, 100 GPH); $2,075-$2,256 (3 HP, 120 GPH); $3,275-$3,460 (5 HP, 250 GPH)
		Trash Compactor						$22,800-$23,043 (up to 125 lb); $27,900-$28,225 (up to 175 lb)

Credit	Type	Strategy	BDEHQ	COF	DFAC	UEPH	TEMF	Unit Price
EAp1	C,P	Fundamental Commissioning	X	X	X	X	X	$1.16/sf (0.4%) construction cost
EAp2	P	Occupancy Sensors	X	X	X	X	X	$30-$390 ea.
EAc1	P	Triple-paned steel-reinforced fiberglass blast resistant windows	X	X	X	X	X	$80/sf
	P	High Albedo (Cool) Roofs	X	X	X	X	X	$0.75-$1.50/sf (coating); $1.50-$3.00/sf (single-ply membrane)
EAc3	C,P	Enhanced Commissioning						$0.10-$0.15/Gross SF (incremental costs on top of fundamental commissioning)
MRp1	P	Aluminum Can Crushers			X			$16.99-$31.99
	P	Facility Waste Compactors			X			$11,600-$12,570 (115 Volt, 250 lb/hr, chute-fed); $8,450-$8,855 (115 Volt, 250#/hr, hand-fed); $10,500-$11,470 (230 Volt, 600 lb/hr, chute-fed); $9,025-$9,995 (230 Volt, 600 lb/hr, hand-fed)
	P	Shredders & Balers			X			$555,500 (50 ton/day, shred & bale); $278,000 (35 ton/hr, shred only); $592,500 (60 ton/hr, shred only); $87,750-$512,000 (industrial baler)
MRc2	C,P	Require contractors to include their waste removal cost in bids	X	X	X	X	X	N/A
MRc4	C,P	Stipulate Recycled Content in Construction Contract	X	X	X	X	X	N/A
	P	Recycled content surfaces (e.g. countertops)	X	X	X	X	X	$69-$78/sf
MRc2	C,P	Require contractors to include their waste removal cost in bids	X	X	X	X	X	N/A
MRc4	C,P	Stipulate Recycled Content in Construction	X	X	X	X	X	N/A
	P	Recycled content surfaces (e.g. countertops)	X	X	X	X	X	$69-$78/SF
MRc6	C,P	Stipulate rapidly renewable FF&E in						Varies by FF&E
	P	Agriboard						$3.64-$9.95/SF
	P	Rubber Flooring						$0.50-$5.00/SF
	P	Linoleum Flooring						$2.00-$3.00/SF

Credit	Type	Strategy	BDEHQ	COF	DFAC	UEPH	TEMF	Unit Price
MRc7	P	FSC-Certified Plywood	X	X	X	X	X	$25 (4ft x 8ft 3-ply); $27 (4ft x 8ft 4-ply); $32-$36 (4ft x 8ft 5-ply); FSC plywood runs approximately 27-30 percent higher than non-
IEQc4.2	P	Low-VOC Paint	X	X	X	X	X	$18-$62/gal (one gallon of paint covers 250-400 SF)
IEQc5	D,P	Permanent entryway systems	X	X	X	X		$40/sf
IEQc6.1		Manual Electrical Lighting Controls						$2-5 ea.
	P	Manual Daylighting Controls	X	X	X	X	X	$15-$50
IEQc6.2	P	Operable windows	X	X	X	X	X	
	P	Temperature controls for occupants						$50-$200
IEQc8.1	D	Light Wells					X	$432 (2'x2'x2'); $534 (2'x2'x 4'); $667 (2'x4'x 2'); $870 (2'x4'x 4'); $892 (4'x4'x2'); $1,176 (4'x4'x 4'); 4'x8'x OTHER is a custom unit with no standard pricing. All units include: top dome, curb, safety screen, 98% reflective light well, drop ceiling diffuser,
	P	Prismatic Skylights						$450 ea. (typical 4'x8' double glazed with insulated thermal break, curb foam tape, & stainless steel screws)
	P	Light Tubes						$300-$5000 ea.
	P	Light Shelves						$100/window
	P	Light Louvres						$60/LF of window
	P	Sunlight Tracking						$5900 ea.
	P	Photovoltaics (does not include costs of the the following: roof mounting frame, battery & enclosure, low-voltage disconnect, inverter conduit box battery interconn & temp computer probe, digital readout panel)						$106-$157 (10 Watt, 16.3 Volt); $160-$211 (20 Watt, 14.5 Volt); $215-266 (36 Watt, 17 Volt); $298-$349 (55 Watt, 17 Volt); $385-$436 (75 Watt, 17 Volt); $555-$606 (130 Watt, 33 Volt); $580-$631 (140 Watt, 33 Volt); $640-$691 (150 Watt, 33 Volt)
	P	Daylighting Photosensors						$150 - $200 ea. (Dimming photo-sensors are less efficient and
	P	Manual Electrical Lighting Controls						$2-5 ea.
	P	Manual Daylighting Controls						$15-$50
IDc1 (Path 1)								

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Appendix B: Alternative and Underutilized Technologies

There are several daylighting, wastewater and potable water treatment techniques that hold the potential to dramatically reduce energy and water consumption in Army facilities. Note that many of these techniques are underutilized technologies; others are considered “cutting-edge technology” and remain young technological advances. Consequently, these innovations may be cost-prohibitive at this time, but may be of interest in the future upon further development and implementation.

Living machine

The Living Machine aims to reduce wastewater generation and potable water demand, while simultaneously increasing local aquifer recharge. This approach purifies gray and black water through an advanced wetland system.

Technology

The living machine first collects black water from the facility in a buried tank. The water is pumped into a chain of basins or treatment zones. These zones are distinguished by the type of activity, either anaerobic (without oxygen) or aerobic (with oxygen), and the microorganisms residing within that zone.[232] Various forms of life are represented including fungal, bacterial, and plant divisions, and animal phyla, including Mollusca, Annelida, Arthropoda, and Chordata, to name a few.[233]

Each zone along the chain is drained and filled in a similar manner to natural tidal wetlands. The wastewater provides carbon, oxygen and nutrients for the microorganisms that live in the zone. They consume the pollutants and debris, thus naturally treating the wastewater. The final zone has an

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[232] Todd, John. 2010. John Todd Ecological Design: About Eco-Machines. <http://toddecological.com/eco-machines/

[233] Cartage.org. “Animal Morphology.” Online. <http://www.cartage.org.lb/en/themes/sciences/zoology/animalmorphology/listanimalphyla/ listanimalphyla.htm>.

effluent filter that prevents unwanted solids from passing through.[234] The treated water may be recycled for various uses in and around the facility, including landscape irrigation, toilet flushing, equipment washing, etc.

Case study

The Naval Facilities Engineering Command (NAVFAC), in collaboration with the Marine Corps Recruit Depot (MCRD) will be installing and operating this water reclamation technology in San Diego, California through the Environmental Security Technology Certification Program (ESTCP) and the Strategic Environmental Research and Development Program (SERDP).[235] The MCRD base encompasses 377 acres of reclaimed tide lands. The living machine is projected to treat 10,000 gallons per day (gpd) of wastewater. Of that, 9,500 gpd can be reclaimed.[236]

Biodiesel from algae oil

The natural lipids from various species of photosynthetic algae can be refined into a clean biofuel.[237] Additionally, the starch byproduct of algae can be used to feed livestock. Moreover, algae consume carbon dioxide, mitigating greenhouse gases.[238]

Although other fuel sources are already used to create biofuels (soy, corn, sugar cane, and palm), algae germinate faster and produce a larger quantity of oils (Figure 43). Consequently, the initial costs to start the growth of algae is much less than an alternative source because the algae will multiply to desired quantities much sooner. The benefits of constructing a series

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[234] Todd, John. 2010. John Todd Ecological Design: About Eco-Machines. <http://toddecological.com/eco-machines/>

[235] March-Long, Caroline. 8 December, 2010. "Federal Green Building Selects Living Machine." Water and Wastewater.com: Industry News. <http://www.waterandwastewater.com/www_services/news_center/publish/ article_002288.shtml>. Accessed 10 December 2010.

[236] Maga, Sonny, Hatcher, Richard, and Goetz, Fred. 2010. NAVFAC and ESTCP. "Water Conservation: Tertiary Treatment and Recycling of Wastewater ER 201020." [brochure].

[237] Can also be used to create jet fuel.

[238] Ehrenberg, Rachel. 26 January 2010. "Algae as biofuel still rough around the edges." Science News.<http://www.sciencenews.org/view/generic/id/55665/title/Algae_as_biofuel_still_rough_around_the_edges>. Accessed 14 December 2010.

of growing ponds within the landscape or retrofitting an algae tube network onto a facility could be significant.[239]

Biofuel Source	Annual Gallons of Fuel (per acre)
Soy	50
Corn	250
Sugar Cane	450
Palm	650
Algae	2000+

Figure 43. Biofuel output by source.[240]

Condensate collection

Condensate water can be collected by retrofitting Air Handling Units (AHUs). Requirements for water-using systems and condensate collection are outlines in ASHRAE Standard 189.1-2009 Standard for the Design of High Performance Green Buildings Except Low-Rise Residential Buildings and the proposed ASHRAE Standard 191, Standard for the Efficient Use of Water in Building, Site, and Mechanical Systems.[241] Notably, condensate collection can also take place along chilled beams.

Condensate water can be used for toilet flushing, landscape irrigation, or cooling tower makeup. Whether or not such a technique should be retrofitted into a building depends on the location, type, and size of the building.[242]

Buildings in relatively dry climates require mechanical cooling throughout the year are good candidates for condensate collection systems; however, a climate that is has fairly high humidity levels and is relatively cool may not require as much or any mechanical cooling. Facilities in such climates would not benefit from condensate collection systems. A building in a

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239 ExxonMobil Algae Biofuels Research and Development Program. <http://www.exxonmobil.com/Corporate/Files/news_pub_algae_brochure.pdf>. Accessed 14 December 2010.

240 Ibid.

241 Lawrence, Tom, Perry, Jason, and Dempsey, Peter. January 2010. “Capturing Condensate by Retrofitting AHUs.” ASHRAE Journal. P. 48-49.

242 Ibid. P 49.

marginal climate may benefit from such a system if it requires high levels of outdoor air or if it contains higher density spaces.[243]

Currently, drain pipes collect condensate water from the cooling coil's condensate collection pan and disposes the water to the sewer system. Alternatively, the drain pipe could be re-routed to empty into a sump basin. A sump pump would then pump the condensate out of the basin and into pipes that lead to either a rainwater collection cistern or the cooling tower. A meter can also be installed for easy monitoring and reading of collection quantities.[244]

The amount of condensate water that can be collected can be calculated. Assume that air is being supplied at 55 degrees Fahrenheit (12.8 degrees Celsius). Also assume an 85 percent relative humidity (wet bulb temperature is 52.5 degrees Fahrenheit or 11.4 degrees Celsius). Thus, the humidity ratio, or absolute humidity, changes from 0.0141 to 0.0078 pounds water/pounds dry air (kg/kg air). Therefore, the difference, 0.0063 lbs (kg), is the amount of condensed water that is produced for every pound of air supplied. The total amount of condensate can then be determined by the following equation:[245]

[Condensate Collection = Airflow * Density * 60 min/hr * Absolute Humidity]

Assuming that air is supplied at 1000 cubic feet per minute (cfm), 28.8 lb/hr of condensate water could be collected:

[1000 cfm * 1 lb/13.133 cf * 60 min/hr * 0.0063 lb water/lb air = 28.8 lb/hr]

This equates to approximately 3.5 gallons per hour (13.1 L/hr).246

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243 Lawrence, Tom, and Perry, Jason. Fall 2010. "Capturing Condensate." High Performing Buildings. American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. P 57-58.

244 Lawrence, Tom, Perry, Jason, and Dempsey, Peter. January 2010. "Capturing Condensate by Retrofitting AHUs." ASHRAE Journal. P. 53-54.

245 Lawrence, Tom, Perry, Jason, and Dempsey, Peter. January 2010. "Capturing Condensate by Retrofitting AHUs." ASHRAE Journal. P. 50.

246 Ibid.

Dual piping system

Reclaimed water is engineered for safety, reliability, and predictability. Although treated and appropriately-allocated reclaimed water is considered safe, it is not used for drinking water. Reclaimed water can be used in various applications including, but not limited to, ground water recharge, irrigation, industrial cooling/make-up, toilet and/or urinal flushing, and vehicle washing. Reclaimed water is distributed via a dual piping network. This keeps reclaimed water pipes, distinguished by its lavender color, separate from potable water pipes. [247]

Reclaiming water may be used in Army facilities to transport water from a bathroom wash basin to a toilet tank to be used for flushing. Intermediately, the water would be stored under the sink. A dual pipe system would differentiate this water from potable water.

Solar water heating

Solar water heating systems use the sun's heat instead of relying on electricity or gas-powered heaters to heat water. Solar heating is both efficient and inexpensive. A solar water heating system can provide 50-80 percent of a building's hot water needs, has minimal operation and maintenance costs, and helps reduce pollution. In addition, federal tax credits can help pay for the system and installation costs. [248]

[247] Whole Building Design Guide. January 2010. "Water Reuse Systems." Section 44 40 10 (Section 11202). <http://www.wbdg.org/ccb/FEDGREEN/fgs_444010.pdf>. Accessed 4 March 2011.

[248] Energy Star. 2010. "Federal Tax Credits for Energy Efficiency." <http://www.energystar.gov/index.cfm?c=tax_credits.tx_index>. Accessed 14 December 2010.

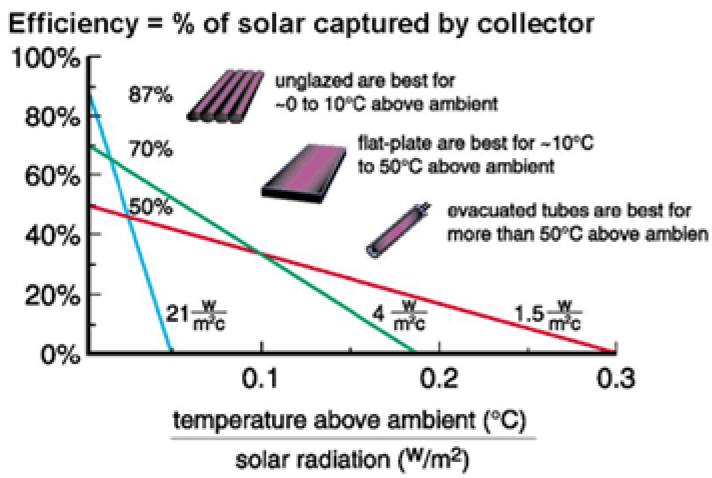

Figure 44. Efficiency of solar water heating.[249]

Solar water heating can either be performed actively or passively. Active solar water heating uses pumps and controls to circulate the water, whereas a passive system does not.

Active solar water heating can either use direct or indirect circulation. Direct circulation uses pumps that circulate pressurized water directly through the collectors. Indirect circulation uses heat exchangers that transfer the heat from glycol fluid to the water. This system is appropriate in freezing temperature climates. Alternatively, a solar water heater in a cold climate could use a drainback system. In this case, the water is pumped through the collector and then drains into a reservoir until used.[250]

Passive solar water heating do not use pumps or other powered means to circulate the water. There are two types of passive solar water heating systems: integral collector-storage and thermosyphon systems.[251]

An integral collector-storage system works best in warmer climates that do not experience freezing winters. These systems consist of insulated storage tanks with a glazed face directed towards the sun. Alternatively, thermosy-

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[249] Walker, Andy. 18 June 2010. National Renewable Energy Laboratory. "Solar Water Heating." *Whole Building Design Guide.* <http://www.wbdg.org/resources/swheating.php>. Accessed 14 December 2010.

[250] Walker, Andy. 18 June 2010. National Renewable Energy Laboratory. "Solar Water Heating." *Whole Building Design Guide.* <http://www.wbdg.org/resources/swheating.php>. Accessed 14 December 2010.

[251] Ibid.

phon systems rely on convection and the natural tendency for heat to rise and cold to sink. The warmed water rises, thus circulates the water through the collectors and into the tanks. The cooler water flows downward, furthering the circulation process. Antifreeze can be installed in heat exchangers, if the building is located in a freeze-prone climate. [252]

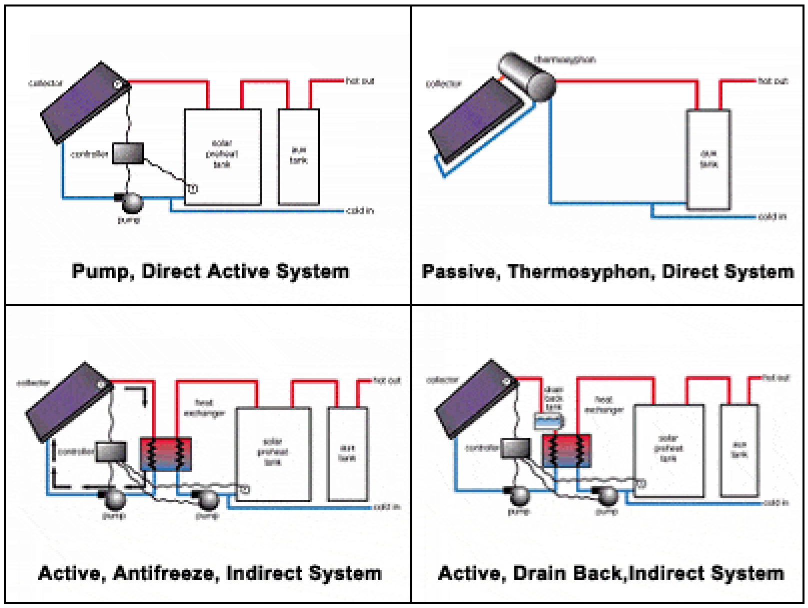

Figure 45. Types of solar water heating systems.[253]

Fog harvesting

Under favorable climactic conditions, water can be condensed and collected from fog. Fogs provide alternative freshwater sources in otherwise dry regions when harvested. Fog collectors are a passive means of collecting the vapor present in certain climactic conditions. They are most effective in along coasts when wind blows the vapor inland. Additionally, mountainous regions[254] could also implement this technology. Water can

[252] Ibid.

[253] Walker, Andy. 18 June 2010. National Renewable Energy Laboratory. "Solar Water Heating." *Whole Building Design Guide.* <http://www.wbdg.org/resources/swheating.php>. Accessed 14 December 2010.

[254] Fog harvesting has been implemented in mountainous, coastal regions of Chile, Ecuador, Mexico, and Peru for over 30 years. It has also been used in San Diego, California.

be harvested from stratocumulus clouds, at altitudes of approximately 400 meters to 1,200 meters. [255]

Technical description

Fog collectors consist of flat, rectangular, fine-mesh nylon or polypropylene netting,[256] tension cables, structural supports at the ends, collection troughs, and storage tanks or cisterns. The thickness, weave, and density of the netting fabric are determined by location and climate. One or more panels could be used to create the net. The net should be placed perpendicular to prevailing winds. As the vapor collects on the net, it condenses. The droplets join and form larger ones that then fall into a gutter or trough, located at the bottom of the panel. The water is then carried to a storage tank or cistern. [257]

Operation and maintenance

Fog nets require little maintenance throughout their operation. Cables must have tension in order for the system to function properly. Therefore, the tension and cable fasteners must be inspected and maintained. Further, the netting itself may tear, grow algae, or become clogged with dust. Torn sections are easily replaced when the netting is formed in separate panels. For cleaning, a soft plastic brush may be used to rid the netting of residue. In addition, the collection troughs, drains, pipelines, and storage drains require regular maintenance in order to ensure the best possible water quality of the system. Filtration, disinfection, and monitoring of dissolved chlorine may be required. [258]

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[255] Unit of Sustainable Development and Environment General Secretariat, Organization of American States Washington, D.C., 1997. “Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean.” Online. <http://www.oas.org/dsd/publications/unit/oea59e/ch12.htm#TopOfPage>. Accessed 4 March 2011.

[256] Also known as “shade cloth”.

[257] Unit of Sustainable Development and Environment General Secretariat, Organization of American States Washington, D.C., 1997. “Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean.” Online. <http://www.oas.org/dsd/publications/unit/oea59e/ch12.htm#TopOfPage>. Accessed 4 March 2011.

[258] Unit of Sustainable Development and Environment General Secretariat, Organization of American States Washington, D.C., 1997. “Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean.” Online. <http://www.oas.org/dsd/publications/unit/oea59e/ch12.htm#TopOfPage>. Accessed 4 March 2011.

Cost and efficiency

Costs of fog harvesting systems vary. In a project in the region of Antofagasta, Chile, the installation cost of a fog collector was estimated to be $90/m^2 of mesh, while, in another project in northern Chile, the cost of a 48 m^2 fog collector was approximately $378 in materials and labor. Maintenance and operating costs for the project in Antofagasta was estimated at $600/year. The system produced 2.5 l/m^2/day. Table 41 below indicates the capital investment costs and life span of the fog harvesting system components for the Antofagasta project.

Table 41. Capital investment costs and life span of fog harvesting system.[259]

Component	Cost ($)	%of Total Cost	Life Span (Years)
Collection	27,680.00	22.70	12.00
Main pipeline	43,787.00	35.90	20.00
Storage (100m^3 tank)	15,632.00	12.80	20.00
Treatment	2,037.00	1.70	10.00
Distribution	32,806.00	26.90	20.00
Total	**121,942.00**	**100.00**	

Hybrid Solar Lighting (HSL)

Fiber optic daylighting, or HSL, systems present an innovative way of bringing natural light into a building without requiring large openings in roofs, as a skylight would. These systems hold the potential to be installed in federal and DoD facilities where penetrations threaten the security of the interior space.

Benefits

Other benefits include increased wellness and productivity of employees (see Chapter 6 on Daylighting) and maintained security.

Moreover, HSL systems to not require large penetrations in the roof or the facades of the building, do not generate heat, and are fast and easy to as-

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259 Unit of Sustainable Development and Environment General Secretariat, Organization of American States Washington, D.C., 1997. “Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean.” Online. <http://www.oas.org/dsd/publications/unit/oea59e/ch12.htm#TopOfPage>. Accessed 4 March 2011.

semble. Cable lengths can reach up to 20 m (65 feet) in length, enabling light from the HSL to penetrate into the building where sunlight could not normally reach. The light would not have to come directly from an exterior surface. This protects and maintains the security of the facility.

Technology

Fiber optics solar lighting technology follows a simple principle. Outdoor solar panels collect solar light, indoor optical cables carry the light into the building, and interior luminaries emit light into interior spaces.[260]

First, sunlight is collected by outdoor solar panels that are mounted on either the roof or facility's façade(s). The panel, approximately one square meter in size, and has an array of optical lenses that collect and concentrate incoming sunlight. Separate Fresnel lenses track the sun as it moves across the sky. This tracking mechanism requires about two watts of electricity to operate and is controlled by a photosensor and microprocessor.[261]

The lenses concentrate the sunlight into an optical fiber. Each fiber is no more than 0.75 mm (3/100ths of an inch) in diameter. Sixteen fibers make up a cable 6mm (¼ inch) in diameter. Cables can run up to 20 meters (65 feet) through interior wall cavities, wiring chases, or ceiling plenums. Longer lengths experience greater light loss. A 10 meter (33 ft) cable delivers 64 percent of the collected light to the facility's interior; a 20 meter (65 ft) cable delivers 40 percent.[262]

Indoors, the sunlight flows out through luminaries. Various fixtures are available, including spotlights, conventional ceiling fixtures, and hybrid fixtures that include both daylighting and high-efficiency fluorescent lighting.[263]

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[260] HUVCO Daylighting Solutions. [Brochure] <www.huvoc.com>

[261] HUVCO Daylighting Solutions. [Brochure] <www.huvoc.com>

[262] Ibid.

[263] Ibid.

Photovoltaic glazing

Photons are the basic unit of light. Each carries energy in correspondence with its solar spectrum wavelength. A photo-voltage is generated when photons are absorbed by photovoltaic (PV) cells. Currents circulate, producing a useful force within the connected external circuit, and electricity is generated.[264]

The following steps must take place for electricity to be generated:

1. Light is absorbed by the PV cell.
2. Currents are generated and migrate to the active zone.
3. Charge is separated in the active zone.
4. Charge carriers are transported to the electrodes.
5. Charge carriers inject the electrodes.

PV cells can be applied to the surface of glazing. The opaque PV cells can be applied on edges or in a pattern so as not to obstruct views to the exterior. Notably, the PV cells, like any coating, may affect the daylighting of the space within. Therefore, the positioning of the cells would have to be optimized for both daylighting and solar electricity.

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[264] Onyx Solar. 2010. "Photovoltaic Building Glass." <http://www.onyxsolar.com/how-is-energy-produced.html>. Accessed 16 December 2010.

Appendix C: TechNotes

TechNotes were developed to provide summary technology information for DoD designers, cost engineers, and installation personnel. Each TechNote follows a standard format that includes a description of the technology or design strategy, potential specific products, a summary of the requirements the strategy could impact, supplemental specification language or resources, and a case study emphasizing the technology. The content of each TechNote is tailored to the information needed to address the specific technology or design strategy. However, they typically follow this standard outline:

- Brief Description
- Applications
- Design Notes
- Related Technologies
- Energy Savings
- Environmental Impact
- Social Benefits
- Guiding Principles (Sustainable Design)
- Associated LEED Credits (NC 2009)
- Product Images (subject to copyright)
- Components
- Cost Range
- Product Types
- Vendors
- Warranty Info
- Code Restrictions
- Specifications (when available)
- Case Study (DoD facility, if available)

TechNotes for the following topics will be made available online at: http://mrsi.usace.army.mil/cos/SitePages/UsaceHQ.aspx. [265]

[265] USACE HQ, Centers of Standardization, Shared Documents, https://eportal.usace.army.mil/sites/COS/HQ/Shared%20Documents/Forms/AllItems.aspx

Table 42. HVAC TechNotes.

Desiccant HVAC. Desiccant HVAC systems remove moisture from outdoor ventilation air before it enters a conditioned space. A wheel that contains a desiccant turns slowly to pick up humidity from incoming air and discharge that humidity to the outdoors. A desiccant system can be combined with a conventional air conditioning system in which the desiccant removes humidity and the air conditioner lowers air temperature. Desiccant materials can be dried, or regenerated, by adding heat supplied by natural gas, waste heat, or the sun.
Overhead Radiant Heating. Unlike conventional heating systems that warm spaces primarily through convection heating, radiant heating systems radiates heat directly to occupants or objects. Radiant heating is especially beneficial in buildings containing large air volumes or with a high infiltration load, such as warehouses, air hangars, and other high bay facilities. Also known as infrared (IR) heaters, overhead radiant heaters can be fueled by natural gas, propane, or electricity.
Radiant Floor Heating – Commercial. Unlike conventional heating systems that warm spaces primarily through convection heating, radiant heating systems heat the floor which in turn radiates heat directly to occupants or objects. Radiant heating is especially beneficial in buildings containing large air volumes or with a high infiltration load, such as warehouses, air hangars, and other high bay facilities. Radiant floor systems provide heat by moving air or hot water through flexible tubing installed in the floor system. “Wet” systems are installed in concrete floors, while “dry” systems are installed under a finished floor system. Commercial applications typically use wet systems.
Radiant Floor Heating and Cooling – Residential. Radiant heating or cooling systems can be installed separately, or can utilize the same infrastructure to provide both heating and cooling. Heating systems are typically most efficient when installed in floors, whereas cooling systems usually operate most effectively when installed in ceilings; thus consideration should be given to the optimum placement for a specific project given the required heating and cooling loads.
Ground Source Heat Pumps. The term ground source heat pumps (also known as GSHPS, geothermal heat pumps, ground-coupled heat pumps, and GeoExchange systems) refers to a family of systems that meet heating, and cooling needs using heat transfer between the earth and the indoor air. High efficiencies are achieved with GSHPs because they take advantage of relatively constant ground or water temperatures.

Table 43. Renewable energy TechNotes.

Solar Collector Wall. [Not online yet.] Solar Walls use a perforated steel wall cladding over the existing wall (usually south-facing), to heat air and recapture heat lost through outside wall. A fan brings the warmed air directly into building or HVAC system. The warmed air is driven by a fan into the building where it can be directly distributed or brought into the building's heating and ventilation system as pre-conditioned air.
Solar Hot Water. Solar hot water systems use a collector to absorb heat from the sun and transfer that heat to water, which is stored for use as needed. A conventional system providing any necessary additional heating is used for backup. Solar hot water systems are best for buildings with high, steady daily volume of hot water use that has greater demand during the summer and later in the day. Per the 2010 Sustainable Design and Development Policy Update, solar hot water heating will be provided for a minimum of 30% of a facility’s hot water demand for all new construction projects with an average daily domestic hot water requirement of 50 gallons or more, located in areas receiving an annual average of 4kWh/m2/day.

Table 44. Water TechNotes.

Dual Flush Toilets. Dual flush toilets provide two options for users to dispose of liquid or solid wastes. Dual flush toilets certified under the Environmental Protection Agency's (EPA) WaterSense program must use no more than an average equivalent flush volume of 1.28 gallons, which is typically achieved through a liquid waste flush of 0.8 gallons of water and a solid waste flush of 1.6 gallons of water. WaterSense certified dual flush toilets must also meet waste removal performance requirements to ensure performance is not compromised with the lower flush volumes.
High Efficiency Toilets. Physically resembling industry standard toilets, high efficiency toilets (HETs) assist in reducing water usage. These toilets average anywhere from 1 to 1.28 gallons of water per flush, using 20% less water than mandated by the U.S. Energy Policy Act of 1992. HETs certified under the Environmental Protection Agency's (EPA) WaterSense program must use no more than an average flush volume of 1.1 gallons. Recent advances in flushing technology allow HETs to remove waste with less water by increasing water velocity.
Low-Flow Showerheads. The U.S. Energy Policy Act of 1992 requires that all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gallons per minute (gpm). Low-flow showerheads are designed to operate within 1.5 gallons of water per minute. To be more efficient, water droplet size and direction is controlled to help reduce and focus the water flow. Low-flow showerheads do not reduce water pressure; instead they restrict flow by forcing water through small apertures which increases the velocity of the water. Low-flow showerheads are designed to be as effective as conventional showerheads.
Ultra Low Flow Faucets. The U.S. Energy Policy Act of 1992 requires that all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gallons per minute (gpm). Ultra low-flow faucets produce 0.5 to 1.5 gallons of water per minute, reducing water usage from 40% to 70%. Ultra low-flow faucets are designed to be as effective as conventional faucets.
Waterless Urinal. Draft Per an Army ECB, waterless urinals are required and since that requirement was put in place they have become more prevalent in commercial, Federal, and DoD facilities. Replacing wall-mounted fixtures with waterless urinals and specifying their use in all new buildings can result in lower water costs, reduced sewage treatment, and less required pumping power. This policy may change in the near future.

Table 45. Lighting TechNotes.

LED – Parking Lot. A light-emitting diode (LED) is a new light source, which uses a semiconductor diode to generate energy in the form of a photon (light). Low power LEDs are fractional wattage devices, typically 0.1 watt. They operate at low current and low voltage, and produce 2 to 4 lumens. High power LEDs are driven at much higher current and can produce 40-80 lumens per 1-watt package. LEDs can be used for various indoor and outdoor applications. However, the currently available LED products vary widely in light output and efficacy and it is important to understand the specific lighting design requirements and the features of different LED products before using them.
Light Pollution Reduction. Light pollution reduction is minimizing light trespass from the building and site and reducing sky-glow and glare. It increases night sky access, improves nighttime visibility, and reduces development impact on nocturnal environments.

Table 46. Daylighting TechNotes.

Dimming Photosensor. Automatic daylight control uses a light sensor to measure the light level in a space and then adjusts the dimming ballast to maintain the desired level of illumination.
Light Shelf. A light shelf is a horizontal light-reflecting overhang that allows daylight to penetrate deep into a building. It is placed above eye-level and has a high reflectance upper surface. It can also shade near the windows and help reduce window glare.
Light Tubes. Light tubes, also called sun/solar pipes, solar light, or tubular skylights, are tubes/pipes used for transport and/or distribution of natural light to another location. A light tube uses highly reflective material or plastic optical fiber to lead the light rays through a building. It can also be a prism light guide distributing light uniformly over its length.
Sunlight Tracking. Sunlight tracking is an active daylighting system, which collects sunlight using a mechanical device to increase the efficiency of light collection. Mirrors within the system rotate based on the direction of the sun or time of day to collect the most possible sunlight, which is directed down to a diffuser box located within the occupied space.

Table 47. Miscellaneous TechNotes.

Enhanced Commissioning. Enhanced Commissioning, as it is described in the LEED documentation is a new requirement for Army buildings. Commissioning is a multi-disciplined process of verifying accurate design, installation and operation of all building systems. The commissioning process should begin in the design phase and continues through occupancy and operation. Enhanced commissioning is a set of best practices that go beyond fundamental commissioning to further ensure proper building function.
Heat Island – Roof. Reduction of the heat island effect can be achieved by selecting cool roof surfaces or installing a vegetative roof. Cool roofs reflect sunlight and emit heat more efficiently. Vegetative roofs installed on top of conventional flat or low sloping roofs are a layered system constructed of with living vegetation.
Permeable Pavement. Permeable Pavement Systems, also referred to as pervious or porous paving, allow stormwater to infiltrate into the soil and eventually into the groundwater. By allowing the water to infiltrate into the ground, the water undergoes absorption, filtration and microbiological degradation; in turn, there is less pollution entering directly into the rivers, creeks, and streams. There are five types of permeable pavement systems: permeable concrete (PC), permeable asphalt (PA), plastic grid pavers (PG), concrete grid pavers (CGP), and interlocking concrete pavers (PICP).

Appendix D: Regional Priorities for all FY13 Army Construction of the Five Building Types

Regional priority credits for all Army FY13 projects involving the five target facility types are shown in Table 47 below.

Table 48. Regional priority credits for Army FY13 construction of five target facility types.[266]

Facility Type/Qty	Credit 1	Credit 2	Credit 3	Credit 4	Credit 5	Credit 6
		Fort Benning, GA 31905				
BDEHQ (1); COF (1); TEMF (1)	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1
		Fort Bliss, TX 79916				
COF (7); TEMF (2); UEPH (7)	SSc6.1	WEc3 (40%)	EAc1 (18%/14%)	EAc2 (7.5%)	MRc2 (75%)	MRc5 (20%)
		Fort Bragg, NC 28307				
DFAC (1); TEMF (1)	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1
		Fort Campbell, KY 42223				
BDEHQ (1); COF (4); TEMF (4); UEPH (1)	SSc6.1	EAc1 (28%/24%)	EAc2 (1%)	WEc3 (40%)	IEQc7.1	MRc2 (50%)
		Fort Carson, CO 80913				
TEMF (2)	SSc1	SSc5.1	WEc1, Option 2	WEc3 (40%)	EAc1 (48%/44%)	EAc2 (13%)
		Fort Drum, NY 13602				
BDEHQ (1); COF (3); TEMF (1)	SSc2	SSc3	SSc6.2	WEc2	EAc2 (1%)	MRc1.1 (75%)
		Fort Hood, TX 76544				
TEMF (2)	SSc5.1	SSc6.1	SSc6.2	WEc2	EAc2 (1%)	MRc2 (75%)

266 Some RPCs are multi-threshold credits. In each case, the bonus point is awarded only when a specific threshold is met. For example, WEc3, Water Use Reduction (in LEED for New Construction) includes three thresholds ranging from 30% water savings to 40% water savings. If an RPC indicates WEc3 (40%), a project must achieve the 40% threshold in order to earn the associated bonus point (USGBC, Regional Priority Credits, Frequently Asked Questions).

Facility Type/Qty	Credit 1	Credit 2	Credit 3	Credit 4	Credit 5	Credit 6
Fort Leavenworth, KS 66027						
UEPH (1)	SSc4.3	SSc5.1	WEc1, Option 2	WEc3 (30%)	EAc2 (9%)	MRc2 (50%)
Fort Lee, NJ 07024						
DFAC (2); UEPH (1)	SSc5.1	SSc6.1	WEc2	EAc1 (40%/36%)	EAc2 (1%)	MRc1.1 (75%)
Fort Leonard Wood, MO 65473						
COF (1); DFAC (1); TEMF (2); UEPH (5)	SSc4 (10%)	SSc6.1	MRc8	EAc4 (7.5%/62%)	MRc5	MRc7
Fort Lewis, WA 98433						
BDEHQ (1); COF (1); DFAC (1); TEMF (2); UEPH (3)	SSc3	SSc4.2	SSc4.4	EAc1 (48%/44%)	EAc2 (13%)	MRc1.1 (75%)
Fort Sam Houston, TX 78234						
UEPH (1)	SSc5.1	SSc6.1	SSc6.2	WEc2	EAc2 (1%)	MRc2 (75%)
Fort Shafter, HI 96858						
TEMF (2)	SSc6.1	WEc2 (25%)	WEc3 (62.5%)	EAc1 (80th percentile)	EAc4 (12%/100%	MRc5 (20%)
Fort Sill, OK 73503						
TEMF (2)	SSc3	SSc5.1	SSc6.2	WEc1 Option 2	WEc2	EAc2 (1%)
Fort Stewart, GA 31314						
BDEHQ (1); COF (1); TEMF (excl.) (1)	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1
Fort Wainwright, AK 99703						
BDEHQ (1); COF (1); UEPH (1)	WEc3 (30%)	EAc1 (12%/8%)	EAc2 (1%)	MRc2 (50%)	MRc3 (5%)	MRc5 (10%)
NWS Charleston, SC 29406						
TEMF (1)	SSc4.1	SSc6.1	WEc3 (40%)	EAc1 (28%/24%)	EAc2 (1%)	IEQc7.1
Wheeler Army Air Field, HI 96854						
DFAC (1)	SSc6.1	SSc6.2	WEc1, Option 2	WEc3 (35%)	EAc1 (28/24%)	EAc2 (1%)

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14. ABSTRACT

The US Army Corps of Engineers (USACE) works to integrate sustainability and energy efficiency into military construction (MILCON) projects. This project originated with an effort to determine funding levels needed for MILCON project budgets to support planning, programming, design, and construction that meets all current and near-term energy and sustainability mandates. The project team assessed current practices and costs, emerging technologies, and performed analyses of five standard designs to develop a set of ideas to help meet net-zero energy, water, and sustainability targets. The objectives of this research were to investigate building features, construction methods, and materials to optimize standard designs for FY13 and beyond MILCON projects for purposes of energy reduction and sustainability, and to ensure that those standard designs meet all the applicable energy reduction and sustainable design policies.

Building features, construction methods, and materials determined viable based on feasibility and life-cycle cost analysis are recommended for inclusion in the appropriate standard design for the FY13 program and beyond. Standard design updates could begin with recommendations from this project, and follow-on effort to add feasible, cost-effective ideas into the standards are recommended. As sustainability strategies are perfected, they should be applied to other Army building types.

15. SUBJECT TERMS

sustainable design, Military Construction (MILCON), life-cycle cost analysis, Leadership in Environmental and Energy Design (LEED), Centers of Standardization (COS)

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