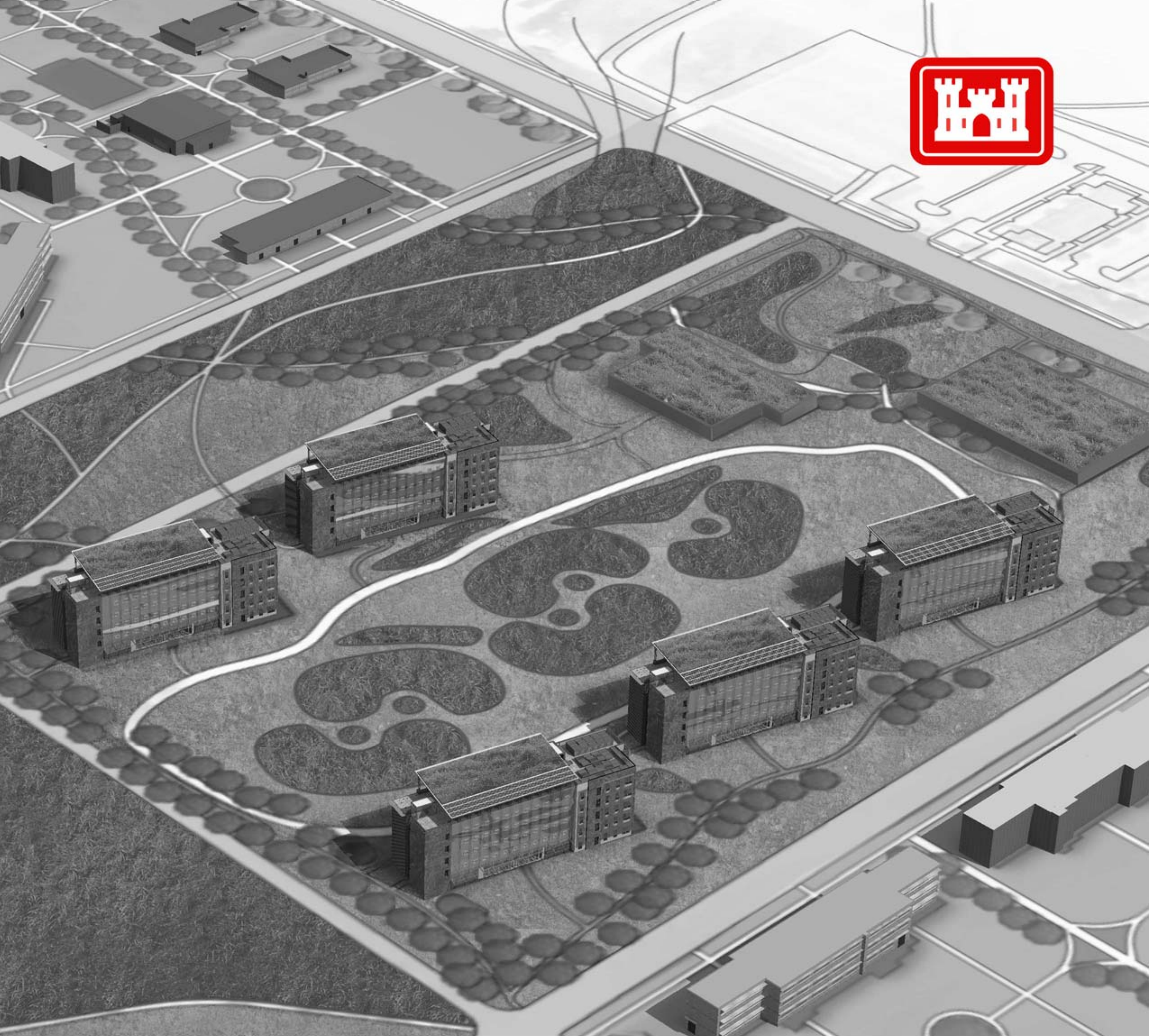

U.S. ARMY CORPS OF ENGINEER'S

THE 2030 PROJECT

Developing Fort Leonard Wood into a NET ZERO Energy, Water, and Waste Installation

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November 2012 Edition

0.1 FOREWORD

20 October 2011

As we implement the many energy independence and security mandates placed upon us today we can not underestimate the power of our contribution in making our Army installations more resilient. The 2030 Project team shows us just what that contribution can be. The team demonstrates that we do not have to wait for new technologies or that silver-bullet solution to realize a new or different outcome. We have the tools and that special ingenuity already embedded within us. The team, twenty-six of our brightest from eighteen districts, submitted the concepts enclosed within to an international design competition and came out on top competing against over six thousand entries. The energy and sustainable design practices applied to Fort Leonard Wood were judged by the best and brightest in academia and industry throughout the world. We made them believers in us, now we turn to ourselves.

Winston Churchill on 12th January 1946 onboard Queen Elizabeth addressing homeward bound Canadian Troops said in his speech.....

> *"Yesterday I was on the bridge, watching the mountainous waves and this ship - which is no pup - cutting through them and mocking their anger.*
>
> *I asked myself, why it is the ship beats the waves when there is so many and the ship is one. The reason is the ship has a purpose and the waves none."*

It is my hope that when reading this report you become inspired as I have, to do more and to do it with the same level of passion as displayed by this team. Only by passion and commitment can great things happen. Let us find our purpose and stay on course.

George O. Lea Jr. PE, CCM, FCMAA,
Chief Military Branch
Engineering and Construction
U.S. Army Corps of Engineers

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0.3 Executive Summary

Recent events have made the U.S. Army aware of the susceptibility of installations to a myriad of environmental and terrorist threats. Given the Army's task of responding during times of need, the necessity of developing self-sufficient installations has come to the forefront of the Army's mission. A Net Zero Installation that internally manages energy, water, and waste utilities is independent from regional resource conflicts and environmental concerns. The installation becomes agile and responsive to its needs and the needs of the surrounding community. While impending mandates require net zero as a target for 2030, this study is the first approach to develop a comprehensive net zero master plan for an American military installation: Fort Leonard Wood, MO.

This plan establishes an energy, water, and waste baseline at three scales: the building unit, the community scale, and the master planning level, and recommends appropriate social and technological solutions to reduce and/or eliminate those resource streams. In this plan, two case-study facilities are redesigned to exploit the building unit scale, two case-study area development plans (ADP) are reprogrammed to address the community scale, and comprehensive solutions are applied to the installation as a whole. The conclusions are phased into an implementation timeline that will guide the Fort Leonard Wood Garrison in becoming the first U.S. Army installation to be net zero energy, water, and waste by 2030. The research focuses on building systems, life cycle cost, safety, and infrastructure, in order to assure that practical applications of sustainable goals can be addressed and improved. However, the spirit of the plan is to foster the ultimate goals of an enduring Army force that is enabled by secure and sustainable operations, systems, and communities.

With a compressed schedule, the team chose to focus efforts on two "slices" of the installation at all three aforementioned scales. A slice is composed of the redesign of one building and one area development plan then integrated with the master planning study. The two slices were analyzed for commonalities and unique attributes. The commonalities are believed to apply to most facilities and area developments on the installation. The unique solutions are considered to be site or function specific. It was only through the abstraction of the two slices that the team was able to develop a conversion process for the installation in its entirety. The installation was combed through with stakeholders to determine the most effective abstractions based on diverse geography, diverse program (multiple space types), and the number of times the facility-type was programmed in the Department of Defense Programmed Objective Memorandum (POM) for FY12-FY16. Additionally, it was deemed most applicable to make use of the U.S. Army Corps of Engineers' (USACE) Center of Standardization (COS) Program that consolidates facilities programmatic relationship by user and function. By analyzing COS facilities that were scheduled frequently in the POM, the project team was able to maximize the impact of the design solutions.

The two facility types chosen were individual buildings from a COS complex that includes multiple facilities. While only one building out of the complex was redesigned, the integration of the facilities in the complex and how those facilities interacted with the master plan was also analyzed.

1. Basic Training (BT) Barracks Company Operations Facility (BCOF) for approximately 1200 trainees (five barracks). A Basic Training complex typically includes the following with square footages approximated:

Open-Bay Barracks (each)	65,000	SF
Dining Facility (2 BN)	60,000	SF
Storage Facility	2,000	SF
Battalion HQ + Classrooms	25,000	SF
Running Track	N/A	

2. Advanced Individual Training (AIT) Barracks Company Operations Facility (BCOF) for approximately 1200 trainees (four barracks). An Advanced Individual Training complex typically includes the following with square footages approximated:

Barracks (each)	90,000	SF
Dining Facility	56,000	SF
Battalion HQ + Classrooms	15,000	SF
Storage Facility	2,000	SF
Running Track	N/A	

The project solutions are intended to be utilized as design and planning strategies not as specific numeric data that is usually acquired over vested years of research. The team encourages the application and adaptation of the recommendations to individual projects. A key theme within this book is flexibility and fit. Each project delivery team (PDT) should make every effort to ensure that solutions are adaptable to new leadership, mission requirements, and the economy. Simultaneously, each proposed solution should be tailored to the climate, geography, community, and capacity needed for the optimization. Only when these two ideas work collaboratively will the PDT find efficiency and sustainability at its best.

0.4 Legislation & Directives

Below is a non-exhaustive list of active and historical legislation that is aligned with the intent of this project during its creation. Whether directly referenced or not, these documents provide a context for the direction, incentives, and mandates that support the implementation of the proposed solutions:

Executive Orders associated with building design, construction, and management:

OCT 2009	*EO 13514: Federal Leadership in Environmental, Energy, and Economic Performance*
JAN 2007	*EO 13423: Strengthening Federal Environmental, Energy, & Transportation Management*
MAY 2003	*EO 13302: Amending Executive Order 13212, Actions to Expedite*
JUL 2001	*EO 13221: Energy Efficient Standby Power Devices*
MAY 2001	*EO 13212: Actions to Expedite Energy-Related Projects*
MAY 2001	*EO 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use*
APR 2000	*EO 13149: Greening the Government Through Federal Fleet and Transportation Efficiency*
APR 2000	*EO 13148: Greening the Government Through Leadership in Environmental Management*
AUG 1999	*EO 13134: Developing and Promoting Biobased Products and Bioenergy*

JUN 1999	*EO 13123: Greening the Government through Efficient Energy Management*
SEP 1998	*EO 13101: Greening the Government through Waste Prevention, Recycling and Federal Acquisition*
MAR 1994	*EO 12902: Energy Efficiency and Water Conservation at Federal Facilities*
OCT 1993	*EO 12873: Federal Acquisition, Recycling and Waste Prevention*
Oct 1991	*EO 12777: Implementation of Section 311 of the Federal Water Pollution Control Act of October 18, 1972, as Amended, and the Oil Pollution Act of 1990*

JAN 1987 EO 12580: Superfund Implementation

JUL 1977 EO 12003: Relating to Energy Policy and Conservation

MAR 1970	*EO 11514: Protection and Enhancement of Environmental Quality*

Code of Federal Regulations relating to building design, construction, and management:

2004	*10 CFR Part 435 Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings*
2004	*10 CFR Part 436 Federal Energy Management and Planning Programs*
2004	*24 CFR Part 51 Environmental Criteria and Standards*
2004	*48 CFR Part 23 Environment, Energy and Water Efficiency, Renewable Energy Technologies, Occupational Safety, and Drug-Free Workplace*

Laws associated with building design, construction, and management:

OCT 2009	*National Defense Authorization Act FY10*
DEC 2007	*Energy Independence and Security Act 2007*

FEB 2006	*Federal Leadership in High Performance Sustainable Buildings MOU*
AUG 2005	*Energy Policy Act 2005*
1992	*Energy Policy Act 1992*
1990	*Montreal Protocol*
1978	*National Energy Conservation Policy Act + Amendments*
1970	*Clean Air Act (Amendments of 1990)*

U.S. Codes associated with building design, construction, and management:

Clean Air Act (CAA) of 1970 (42 USC §7401)

Department Authorization Amendments and Base Closure and Realignment Act (42 USC §2749)

Energy Policy and Conservation Act (EPACT) (42 USC §6201)

Federal Water Pollution Control Act of 1972 (33 USC §1251)

Department of Defense (DoD) & Tri Services:

Guiding Principles (Whole Building Design Guide)

Unified Facilities Guide Specifications

Unified Facilities Criteria Technical Publications

Army Policy:

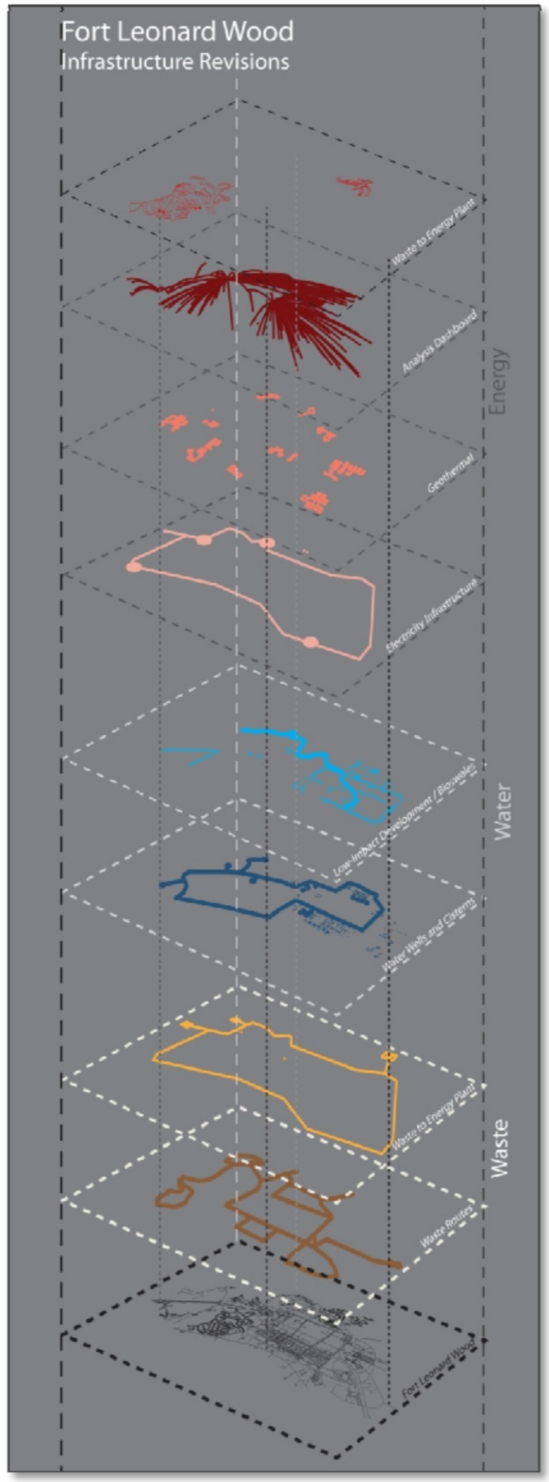
OCT 2010	*ASA I&E Memo, Sustainable Design & Development Policy*
JUL 2004	*Under Secretary of Defense Memo, DoD Environmental Management System (EMS) Self-Declaration Policy*
JUL 2003	*ACSIM memo, Army Environmental Management System Policy*
JUN 2003	*Under Secretary of Defense Memo, Guidance for Fiscal Years 2006-2011 Sustainable Ranges Programs*

JUN 2002	*ASA I&E memo, DoD/EPA Region 4 Pollution Prevention (P2) Partnership Grants Initiative for Environmental Management Systems (EMS)*
JUL 2001	*ASA I&E Memo, Army Environmental Management Systems*

USACE Engineering Construction Bulletins (ECB) related to sustainable and energy efficient design:

ECB 2012 -16	*Building Air Tightness and Air Barrier Continuity Requirements*
ECB 2011 -10	*Sustainable Features Integration*
ECB 2011-01	*High Performance Energy & Sustainability Policy*
ECB 2010-14	*Energy Savings and Enhanced Commissioning*
ECB 2009-24	*Communicating Sustainability in Construction*

1.0 The Project: Fort Leonard Wood



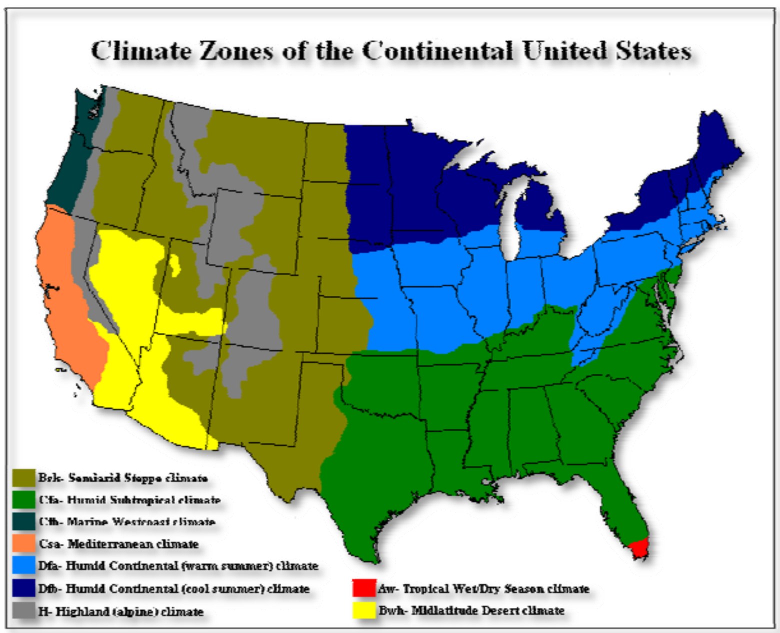
1.1 Introduction & Background

In January of 2011, the Assistant Secretary of the Army for Installations, Energy and the Environment, Ms. Katherine Hammack, unveiled a challenge for sixteen installations to become net zero: "five net zero water, five net zero energy, five net zero waste, and one installation to achieve all three by 2020. The Army goal is to have twenty-five installations achieve Net Zero (EWW) by 2030" (HQDA website). The installation chosen for the pilot study applied for Ms. Hammack's challenge to be net zero energy and net zero water using the phased plan recommended in the study. While Fort Leonard Wood was not one of the sixteen installations selected to participate, they have advocated interest in striving to meet the net zero energy and net zero water goals by 2030.

This forward momentum to realize the challenge has catalyzed the U.S. Army Corps of Engineers' pilot study for a phased net zero installation. The 2030 Project was developed prior to the ASA IE&E releasing the 2020 challenge and thus developed an independent selection metric for determining the best installation to support in the 2030 challenge. The 2030 Project selection criteria depended on the installation's construction program, the planned facilities types, and the attitude of the key stakeholders that managed the installation. Of considerable importance was the desire of the 2030 Project team to work with an installation that was neither wholly supportive of the ambitious 2030 goal nor wholly objectionable; but rather, an installation that would provide relevant feedback in both directions so the project might overcome perceived obstacles for neighboring installations.

In coordination with the Army's Installation Management Command (IMCOM), the team reviewed the Program Objective Memorandum (POM), which lists the construction projects scheduled for funding in FY12 - FY16, to highlight installations that cumulatively had over $300,000,000.00 worth of construction. This short-list was vetted for diversity of facility types and facilities that were part of the Center of Standardization (COS) Program. The pilot study sought holistic design integration and sought an installation that had infrastructure, renovation, new residential, and mission facilities scheduled for construction in tight geographic vicinity. Lastly, the pilot study required installation stakeholders to apply and nominate what, if any, support the study would receive if selected. This ensured the installation was fully invested in the study, that they took ownership and would implement the principles and design strategies recommended by the 2030 Project team.

Six installations: Fort Drum (NY), Joint Base Lewis-McChord (WA), Schofield Barracks (HI), Fort Leonard Wood (MO), Fort Jackson (SC), and Fort Meade (MD) met the initial criteria. Three additional factors were considered when making the final selection: transferability (climatic relevance to other installations), coordination (attitude of the on-site Department of Public Works), and overall need. More than 200 continental United States Army installations were plotted on a commonly used climate map to determine the climate zone that was most common to U.S. Army installations which determined the relevance of the short-listed installations climate zones.



CLIMATE MAP - IMAGE IS IN THE PUBLIC DOMAIN; OBTAINED FROM WIKIMEDIA COMMONS.

Over 60-percent of U.S. Army installations fall in the "mixed-humid" climate zone, with the next highest in the "cold" category (CND, 2009). Thus, Joint Base Lewis-McChord and the Schofield Barracks were dropped from consideration because they did not represent common climates. The study was to be conducted during the second quarter of the fiscal calendar (January through March) which made access to surveying the buildings at Fort Drum difficult. Of the remaining three installations, Fort Leonard Wood had the largest construction program of COS facilities in close proximity. Additionally, the installation Master Planner, Bryan Parker, and Mark Premont, the Director for Plans, Analysis, and Integration Office (PAIO), reached out to the 2030 Project team with a high degree of support for the project.

As explained by the installation staff, Fort Leonard Wood had dire need to immediately implement a net zero energy plan because the current electrical supplier had increased the cost (by kWh) of power by 50-percent from 2006-2008 resulting in a fiscal increase of approximately $23M in 2008 alone (Show-Me, 2010). The Army legally responded to the local power provider, Show-Me Power, arguing that the original 1989 contract stipulated that the Army's Contracting Officer could set its own rate for power and the Federal Acquisition Regulations (FARs) allows the Army to have indefinite term contracts. Show-Me Power was able to gain favor in a ruling with the Armed Services Court of Appeals citing 1949 Federal Property and Administrative Services Act (FPASA) which limited utility contracts to a maximum of ten years. Thus, the court released Show-Me Power of any obligation to supply the installation with power. Fort Leonard Wood and Show-Me Power agreed to terms of a contract that terminates in 2012, but could extend to 2016 pending the Army's discretion.

Fort Leonard Wood sources at least 40-percent of its total energy profile from electricity from Sho-Me Power. Thus, the 2030 Project team invested in Fort Leonard Wood as an installation of opportunity and foresight.

1.2 Purpose & Goals

On resilience by ASA Hammack:

> *"Today the Army faces significant threats to our energy and water supply requirements both home and abroad. Addressing energy security and sustainability is operationally necessary, financially prudent, and essential to mission accomplishment. The goal is to manage our installations not only on a net zero energy basis, but net zero water and waste as well. We are creating a culture that recognizes the value of sustainability measured not just in terms of financial benefits, but benefits to maintaining mission capability, quality of life, relationships with local communities, and the preservation of options for the Army's future.*
>
> *The net zero vision is a holistic approach to addressing energy, water, and waste at Army installations. An approach that is a force multiplier enabling the Army to appropriately steward available resources, manage costs and provide our Soldiers, Families and Civilians with a sustainable future. In an era of persistent conflict, with a mission of stabilizing war-torn nations, a true stabilizing factor can be that of appropriate resource management.*
>
> *The Net zero vision ensures that sustainable practices will be instilled and managed throughout the appropriate levels of the Army, while also maximizing operational capability, resource availability and well-being (Hammack, 2010)."*

Our military forces have historically been opposition forces seeking to eliminate security risks on foreign soil. In the last fifty years, the United States has developed into a global power with a society that has the perception of invincibility. Our communities and neighborhoods have become relaxed, envisioning war and terrorism as external threats plaguing developing nations. On 9/11, that paradigm shifted. Law makers began to remove the veil of false security and realize that the underbelly of our society, the neighborhoods and communities of America, were (and still are) susceptible to attack. Our focus needed realignment to include developing the core of the country into a resilient society. Since those 2001 attacks, eyes on Capitol Hill have been drawn to the concept of homeland security – not just the protection of our borders and the prevention of aircraft hijackings, but the ability of our communities to withstand threats. The science of security is complex. It includes the features and processes to ensure that the object in question has planned for prevention, is fortified against the threat, and has the ability to quickly and with little effort return to normal operations. These can be boiled down to the concepts of prevention, endurance, and resilience (Kasthurirangan & Srinivas, 2010).

Most prepare and stop there. Preparedness is advanced planning – as with hurricane evacuation routes and the Occupational Safety and Health Administration (OSHA) requirements to prevent a work accident. It attempts to determine the likelihood of a risk and assess which preventative measures should be taken. The Department of Homeland Security has taken this measure seriously and in the past decade implemented laws and requirements, such as body scans in airports, to mitigate risks. Equally apt is the endurance of the United States; seismic building codes, fire suppression systems, and egress requirements are all ways in which the built environment can endure during a disaster. The weakest point in the security chain is resilience. If a disaster occurred, how long would it take to resume business as usual? The most detrimental impact a disaster has on the community is not the initial collateral damage, but rather the long term economic consequences that evolve because the businesses are not able to function and thus slowly collapse the surrounding economies (OASD HDASA, 2007). The commerce of a community is essentially the backbone that drives all other functions. If the entity does not have a plan for temporary operations or steps in place to resume functionality, the drivers of its economy are irrevocably devastated.

The concept of developing a resilient community, one which withstands the disaster and is then able to return quickly to the original operating capacity, is the new accepted cause of policy-makers and in turn, the United States military.

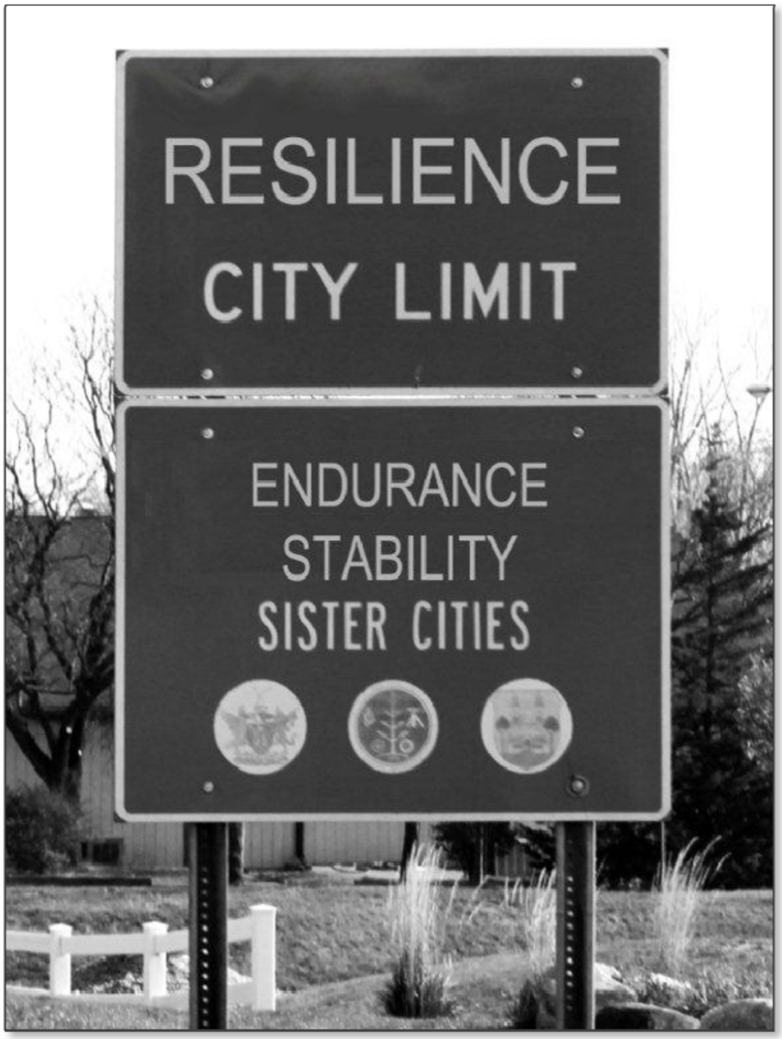
Traditionally, the American military has focused on external threats and deployable forces. In developing resilient overseas bases, the issue of logistics becomes a dominant factor. Many services in the military are contracted out, including many logistics operations. A leading factor in casualties for defense contractors is attack during logistics missions (convoys). In recent contingency operations during Operation Iraqi Freedom and Operation Enduring Freedom, these ground resupply missions have accounted for approximately 20-percent of our military lives lost. Thus, every effort has been made to decrease the number of logistics missions. The military's first step in reducing convoys is to decrease the dependence on resources and simultaneously increase efficiency. This has evolved into practices of self sufficiency and sustainability founded on resources existing within the confines of the base perimeter. This second evolution of self sufficiency is prevention, endurance, and resilience (Coyle, 2011). It lowers casualties by significantly decreasing the need for logistics operations. It transforms the base into an agile and light installation that can react to any threat.

Self sufficiency is the key to supporting the Mission. "The Army's Mission is to fight and win (the American) Nation's wars by providing prompt, sustained land dominance across the full range of military operations and spectrum of conflict in support of combatant commanders" (U.S. Army). This is done through many duty assignments by soldiers referred to as missions. Research reveals a disparity in resource demands between missions and the base operation.

Each mission requires variable resources that constantly change depending on the target and end-goal. The return on effort for planning and supporting missions solely with local means is negligible. However, base operations are planned in advance. For example, the 2005 Base Realignment and Closure (BRAC) Act planned the population fluctuation for most installations for the succeeding decade. Additionally, the process for allocating funds for facilities and infrastructure construction starts a minimum of five years in advance under normal circumstances.

Through advanced planning, it is possible to phase out the dependence on external water, waste, and energy services for the daily operation of the base; only utilizing the external services for short term mission-related functions. The ability to sustain on internally generated services is referred to as net zero (energy, water, waste) in this study.

While the idea of the self-sufficient installation emerged during war time operations for overseas bases commonly referred to as forward operating bases (FOBs), the benefits can be realized on continental bases and reinforce the principles of resilience for the neighboring community (MacDermid Wadworth & Rigges, 2010). Thus, the development of U.S. continental installations that are self-sustaining in their base operations equals a secure network of installations dispersed across America that can endure disasters and quickly eradicate threats such that the surrounding community is quickly restored to its original state.



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1.3 Project Approach

1.3.1 Developing a Baseline

Simply put, achieving net zero should be a simple equation:

$$(\text{Baseline}) - (\text{Baseline}) = 0$$

However, Fort Leonard Wood, like most Army installations, meters utilities as an entire installation and does not meter individual buildings. This is changing due to mandated Army policy that requires all new construction to implement wireless metering devices. As of FY11, due to congressional budget cuts, the Army was not able to retrofit existing buildings with metering devices. The existing building program accounts for approximately 70-80-percent of the building program. Further, metering for the DoD is a sticky subject as a security concern. Armed with the utility profile and the location of the facility, a threat could potentially deduce the deployment schedule and thus, the war plan. For this reason, USACE is developing security measures to ensure that metering data is not intercepted. Until the language parameters and security measures are officially defined, the new construction program will be equipped with wireless broadcasting metering devices, but the devices are unable to transmit.

Therefore, drawing simple conclusions about energy and water use become more difficult (Parker, 2011). In developing the approach for the project, it was crucial to first define problems and then grasp the magnitude of solutions. The team collected metered data from the power providers (electricity, natural gas, propane, and fuel) and worked with the water treatment plant to develop an understanding of total water usage.

Once the installation scale was determined, the team worked backwards with the predictive information used in standard military planning to conclude the output for individual facilities. For planning purposes, the Army calculates the energy use per square foot by facility type to develop a programmatic cost. The team chose to sort this data, apply it to the existing facility types, and then scale it to congruence with the total metered results captured from the utility providers. While approximate, the figures provided enough data to develop a phased plan at the installation scale with highlights on two area development plans (community scale). For the building scale, computer generated energy models using Green Building Studio, Energy Plus, Climate Zone, and Carrier HAP software programs were applied to a Revit Model. These were manipulated to achieve the maximum efficiency for both the Basic Training (BT) Barracks Company Operations Facility (BCOF) and the Advanced Individual Training (AIT) BCOF. The water data was also divided out by using the full-time equivalent calculation in the U.S. Green Building Council's (USGBC) Leadership for Energy and Environmental Design (LEED) manual. This calculation estimates water usage by gender and the amount of people working in the building (USGBC, 2009). This information was applied to the total water metering data for verification. Waste was divided into two categories: liquid waste and solid waste. Liquid waste was a direct function of the total building water use. This data was interpolated based on the conclusions drawn on building water use combined with research on average waste water use per building function. The solid waste was made easier to conclude due to a previously developed tool. The Army is under mandate to report solid waste in the Solid Waste Annual Reporting System (SWARS) database. While this data is not based on individuals or facilities, the team predicted early-on in the project that solid waste reduction measures for this project were best addressed at the installation-scale and thus individual solid waste data was redundant.

The baseline results are shown below. Note that the results are intended to imply an order of magnitude as this study is a peripheral exercise in the strategies and solutions that are appropriate for Fort Leonard Wood. The units were selected based on industry standard as appropriate for the scale.

ENERGY

INSTALLATION	140* MBTU / KSF
*60 MBTU NATURAL GAS	
05 MBTU FUEL OIL	
12 MBTU PROPANE	
61 MBTU ELECTRICITY	
BT BCOF	575,000 KWH / YR
AIT BCOF	900,000 KWH / YR

WATER

INSTALLATION	90 GAL/ SF
BT BCOF	36,000 GAL/ DAY
AIT BCOF	45,000 GAL / DAY

WASTE (LIQUID)

INSTALLATION	2.5 MGAL / DAY

BT BCOF*	36,000 GAL/ DAY
AIT BCOF*	45,000 GAL/ DAY
*LESS PROCESS LOADS	

WASTE (SOLID)	
INSTALLATION	30,000 TONS / YR

1.3.2 Team Assimilation

Equally important to developing a baseline was the establishment of a project methodology. The project sought innovative solutions that were not restricted to one field. Additionally, the integration of disciplines and diversity has proven to strengthen the constitution of a project and validate the results (Smyth, Fredeen, & Booth, 2010).

The project was funded as the second phase of a sustainability study on Center of Standardization designs. In 2009, the U.S. Army Corps of Engineers (USACE) sponsored a study to look at the energy foot print of five standard facility types: Dining Facility (DFAC), Company Operations Facility (COF), Tactical Equipment Maintenance Facility (TEMF), Unaccompanied Enlisted Personnel Housing (UEPH), and Brigade Headquarters (HQBGD). The military uses design standards, a series of required programmatic relationships, to ensure consistency and maximize the building program. The USACE hired the Pacific Northwest National Laboratory (PNNL) and the Construction Engineering Research Laboratory (CERL) to carry out the study to determine what changes could be made to the standard design to reduce the energy demands of the facility, specifically paying attention to passive design strategies. The study determined that it was possible to reduce the energy consumption of these facilities by approximately 20- to 30-percent through implementation of these strategies in the standard design. However, the study determined that it is not possible to meet the reductions mandated by recent energy policy (65-percent and higher) solely though changes to the building standard.

For higher levels of energy reduction, the study pointed to the following factors that must be addressed (Carpio, 2010):

- Climate Design
- Site Design
- Integrated Design

The Corps implemented the 2030 Project as a pilot study to analyze the *process* by which a net zero installation could be developed through focusing on the aforementioned factors of climate, site, and integrated design. The intention was to create a tailored approach that addressed site and climatic conditions. The solution was to plan for implementation at multiple scales: the cantonment area (master plan), the community (area development plan), and the building. By designing beyond the site boundary of a building and planning for the area development and the cantonment, net gains are achieved. These net gains evolve into cogeneration opportunities that can address infrastructure, water, and waste (Ward & Davis, 2010). Additionally, the study pushed beyond maximizing reductions and sought strategies to increase efficiency as well as phase technology to replace the current dependencies thus resulting in a completely self-sustaining installation that operates on internal services.

A call for team applications was sent to all districts within USACE in late 2010. Over seventy-five applications were received during the one-week deadline proving an intense interest in pursuing excellence in design and construction. The applicant pool was narrowed down to twenty-six USACE employees and one soldier who volunteered from Fort Leonard Wood based on the rating criteria below.

- **(50 PTS) PASSION FOR THE MISSION:** the level of desire to participate; the ability and willingness to dedicate oneself to the 2030 USACE Integration Project and learn about new technology / software.

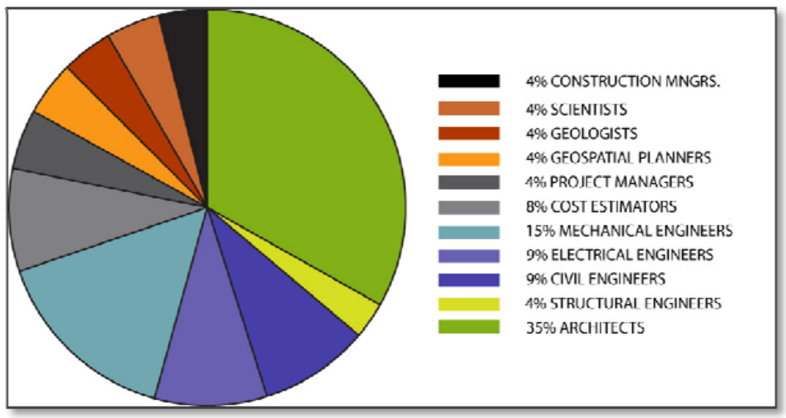
- **(20 PTS) TIME COMMITMENT:** includes the amount and type of hours the applicant is willing to commit. The willingness and the availability of the applicant to attend on-site charrettes.

- **(15 PTS) DIVERSITY:** the USACE intends to impact the largest geographic area possible by selecting a team from a variety of districts and divisions, including overseas.

- **(15 PTS) EXPERIENCE:** includes research, work, and competition experience both from within the Corps of Engineers and in the private and education sectors. Experience provided should highlight the applicant's ambition, embracement of technology, and ability to hunt creative results.

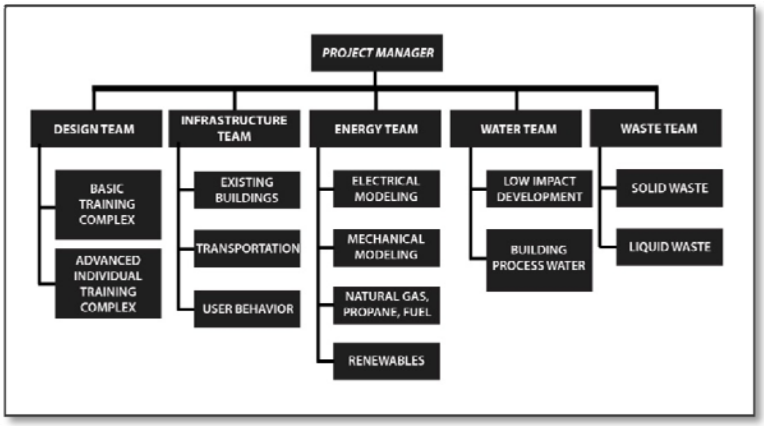
It was crucial to the success of the team that the most important factor in consideration was passion. This is atypical of government project teams but contributed to the intense pace, breadth of information, and success of the project. Passion was a qualitative concept that was evaluated along with the other three criteria on a two-page application that was vetted by a panel of esteemed professionals.

The chosen team spans eighteen states, three continents and nine pay-grades to develop a diverse talent pool. The diversity of the team was the foundation upon which the solutions were developed, however, the geographic disparity created functional challenges. The solutions to successful remote working are addressed in section *4.0 The Future: Strategies Toward a Net Zero Built Environment*.



THIS GRAPHIC ILLUSTRUATES THE PROFESSIONAL MAKEUP OF THE PROJECT TEAM - IMAGE COURTESY OF HQ USACE.

The team underwent several morphological adjustments as the project scope evolved. Initially, the team was intended to organically assimilate based on expertise and interest; the team was intended to be horizontally structured so that each member had an equal voice. However, due to the challenges of schedule and distance, the horizontal structure quickly led to chaos and the team collectively agreed to nominate individuals to leadership positions and establish a hierarchy.



ORGANIZATIONAL CHART ILLUSTRATING DIVISION OF STUDY - IMAGE COURTESY OF HQ USACE.

The project members were structured to work in teams based on utility service with the goal to take the baseline to zero as shown above. The Design Team focused on redesigning the BT and AIT BCOFs for minimized footprint, connectivity to the site, and passive design strategies while still meeting the programmatic relationship guidelines required in the Army Standard Design.

This organized team of twenty-six Corps employees was responsible for the submission of the project to the Holcim Awards for Sustainable Construction as well as the development of the Technology Notes found in the Appendix. However, it should be noted that working after-hours and remotely on an intense project with twenty-six individuals proved to be exhausting. After the competition entry was submitted, the team pushed on, deciding to add to the list of deliverables – an implementation guide of the study to share the project process. This secondary action was deemed Phase II. Prior to the initiation of Phase II, an anonymous survey was collected from all twenty-six applicants. The survey evaluated the performance of the team as a whole, the strengths and weaknesses, and the performance of leadership. Additionally, the survey announced that the Phase II team would only have eight members. The survey asked for nominations of those eight members to establish the Phase II team.

The three main strengths and weaknesses that are applicable to future endeavors, as collected by the survey, are listed below. The eight members that advanced to Phase II along with the competition (Phase I) team can be found in more detail in section 5.0 *The Authors: Integrated Project Team.*

STRENGTHS:

1. The focus on passion generated a motivational atmosphere that dominated the frequent and abundant obstacles the team encountered. The team had a sense of community that only intensified over the course of the project.

2. Organizing the sub-teams by quantitative goals with a defined product assisted the members in developing a project timeline and back planning their role.

3. The diversity in members allowed for individuals to be experts as well as students. It assisted members in understanding the tangential concerns associated with their field and connected them to experts in other fields for future endeavors.

CONCERNS & SOLUTIONS:

1. The team eventually requested weekly communication and recorded reports of sub-committee progress that was read at the weekly meeting. This helped with communication and comprehension so as to avoid overlaps in effort.

2. In a remote team, where members had never worked with each other before, voicing concerns and vulnerabilities was difficult. The team requested an anonymous feed-back mechanism with leadership to report on items of significance.

3. The abundance of passion for the project led many of the participants to volunteer to work on multiple sub-teams. While impressive, this created confusion and too much overlap. The team requested that members prioritize one sub-team and only play an assisting role on additional sub-teams.

1.3.3 Methodology

The Army's business process currently handles master planning and facility programming at a micro or facility scale, treating each building like a separate island on a sea that is the installation. This is counterintuitive as our buildings are connected by utilities, by site, by function, and by use (Coker, McGinley, & Lyell, 2010). These synergies are specific to each installation and must be considered on a case by case basis to align with the installation's goals and mission. It is the process by which the solutions are developed that must be transferrable to other installations.

Thus, a project methodology was produced that is easily transferrable and considers the main factors of user integration, building life cycle, scalable systems, and diversity in utilities.

Essentially the project methodology replicates the scientific community with three iterative steps.

1.4 Research

The process for conducting design research involves understanding multiple perspectives. The design team should budget and account for the collective of a diversity of paradigms. It was concluded by the project delivery team (PDT) that deleterious effects are produced when the research function is outsourced from the project delivery team. While efficiencies in budget and potentially schedule may be seen up-front, this is counterproductive to the project delivery process. As the team vets solutions, new information comes into play and the PDT is unable to accurately score the results. This typically is exposed in solutions that are short-sighted or do not consider maintenance concerns, climatic effects, and user needs. Only through the exposure of the PDT to the research process, was the team able to both suggest solutions but also analyze the effects, quickly and with the holistic perspective needed to develop a strategic plan.

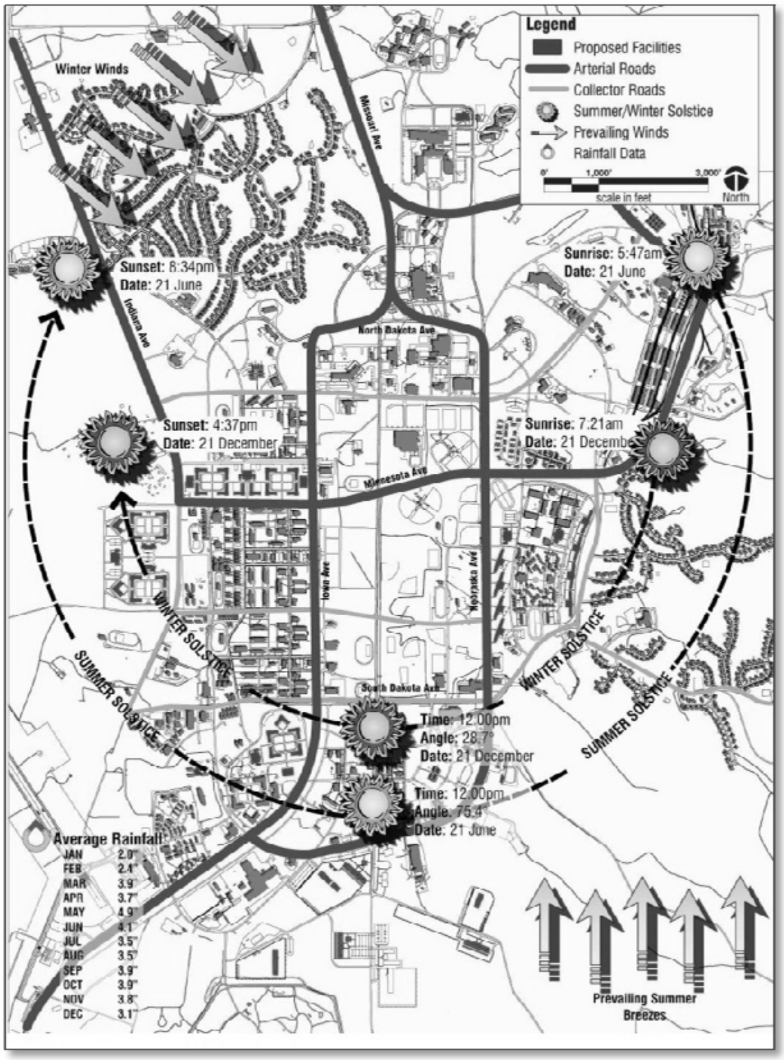
The types of research identified in this study are by no means exclusive but intended to provide a perspective of the diversity sought with direct ties to the results recommended.

1.4.1 Identify & Interview Key Stakeholders

The project kicked off with a site visit to interview the key stakeholders during a planning workshop. The stakeholders identified were: the Deputy to the Commanding General, the Garrison Commander, the Chief of the DPW, the Installation Master Planner, and the Director of the Plans Analysis and Integration Office (PAIO). This step documented the intentions of the key stakeholders and briefed the team on previous attempts or lessons learned.

1.4.2 Analyze Cantonment Area & Design Guide

Following the interviews, the installation cantonment area was documented through photography and site walks. This provided the much needed insight into the identity of the installation which proved to be predominantly an educational machine. As the home of the Chemical School, Military Police School, and the Engineer School, Fort Leonard Wood has a large transient population that lives off-post and commutes daily. The installation design guide explained the requirements for brick and black glazed facades. While aesthetically pleasing, this treatment is not always energy efficient. A detailed climate analysis of the installation as a whole was run to frame the problem. The analysis is used to show the optimum orientation of any facility on the installation based on the latitude and longitude.



THIS GRAPHIC ILLUSTRATES SOME OF THE MANY CLIMATIC FORCES INTERACTING WITH FORT LEONARD WOOD AS A WHOLE - IMAGE COURTESY OF THE FORT LEONARD WOOD DIRECTORATE OF PUBLIC WORKS.

Fort Leonard Wood is not an ideal candidate for renewable energy from wind, as the wind is steady but multidirectional. For profitable wind to energy generation, the wind should have high velocity and come from a singular direction (Wiser & Bolinger, 2010). Additionally, Fort Leonard Wood has a history of violent weather, including tornados and hail.

TECHNOTE wind turbines

1.4.3 Establish a Building Life Cycle & Construction Program

While the Army has an established building life cycle of 50 years, if working on a tenant facility it would be necessary to determine the expected life cycle of the existing and programmed facilities. The life cycle of the built environment on the installation and the process by which buildings are constructed determines the parameters by which most systems decisions are made. For example, it would not be life cycle cost effective to replace the HVAC system in renovated facilities if the facility is to be torn down in less than fifteen years.

For the Army, the process starts when the Garrison requests a new facility and submits the request to the Army. The Garrison selects a site prior to the design of the facility. With congressional approval, the USACE executes the design and construction of the facility for a targeted thirty years, at which point it is to be renovated for another twenty year life span. Each facility is designed for a fifty year life cycle. At beneficial occupancy, the facility is handed off to the Department of Public Works (DPW) for maintenance and repair. It is returned to the USACE for renovation and then back to the DPW until the building is no longer able to function.

1.4.4 Occupant Practicum

Understanding the needs and requirements of the tenant and integrating them into design are crucial to the design and construction process. An operational order was issued from the Garrison Commander requesting that the BT and AIT commanders send at least eight representatives at the drill sergeant rank and below to an informational meeting. It was important that the representatives did not know why or what would be asked of them so that their responses were not biased. They were brought into a classroom setting and told to first brainstorm on the flaws of the facilities and then to recommend changes for a better facility. As both the BT and AIT facilities are Company Operations Facilities, the answers have been combined below.

RECOMMENDATIONS:

1. Separation from Permanent Party
2. Integrate Maintenance with Training
3. Operable Windows
4. Physical Training Shelter from Weather.

ISSUES:

1. Limited Parking
2. Safety
3. Sick Building Syndrome
4. Building Flexibility
5. Control Over Soldiers
6. Lack of Storage

1.4.5 Operator / Maintenance Practicum

Similarly, the Department of Public Works (DPW) was asked to send representatives - maintenance contractors, engineers, and project managers - to a brainstorming session. They were asked general questions about their role in the life cycle of the building. What were the most common issues with buildings? What weather conditions caused the most damage? They were also prompted to respond to specific technology. This was to judge the paradigm and preconceived notions that the DPW had developed over the past 100 years in maintaining the installation. The analysis on whether these notions were ill founded or not was not discussed with the DPW but rather only with the project team. The following list illustrates the sentiments of the DPW and installation staff.

TECHNOLOGY

1. Waterless Urinals – Maintenance contractors not able to properly maintain because these fixtures are not in their contract.

2. Aluminum Boilers/Tanks – Difficulty maintaining correct pH.

3. Ground Source Heat Pumps – Takes up land. Expensive to maintain, and concern of contamination because of seismic events.

4. Skylights/Roof Penetrations – Leaks. Potential conflicts with design guide requirements for standing seam metal roofs.

5. Solar Shading – Must be made of sturdy material or may be damaged by hail.

6. Incinerator – To be cost effective, would have to burn recyclables.

7. Wall Mounted Water Closets – No Issue.

8. Parking for Carpools – Soldiers disregard after occupying facility.

9. Green Roofs – Design guide violation. Not beneficial in rural area. Funding concerns.

10. Pervious Pavement – Difficult to remove snow. Doesn't work well with clay-based soils.

1.4.6 Consult with Experts

TECHNOTE form based code

Although the team had diverse knowledge, bringing in subject matter experts to vet solutions is always beneficial. The USACE Construction Engineering Research Laboratory (CERL) offered research to support conclusions on renewable energy and water (Curvey, Hessel, & Holmes, 2010). The senior master planner at USACE (Andrea Kuhn) led a two day workshop on planning principles, highlighting complete streets and form based code.

Form based coding is a revolutionary development for planning. It identifies the qualities and attributes that create a space and generates codes based on those qualities. For example, typical zoning would dedicate specific areas of the installation to a function like residential or commercial developments. Form based code incites the planner to evolve the traffic pattern (round-a-bouts, grid style, boulevard, etc.) based on the needs of the surrounding communities. Then, after proper differentiation has been made between pedestrian, bike, mass transit, and vehicular traffic, the community can evolve code requirements. The code is not based on the function but rather the qualities, like wide or tree lined streets, or streets with sidewalks. Once street qualities and the pattern of transit have been established, the function can be applied to a district, an area identified by function. The function can be mixed-use, residential, industrial, commercial, or a number of other categories to assist a developer in keeping with the vision. The function may also have occupancy or glazing requirements based on the quality the street is to produce (Kuhn, 2011). It was through this interaction that the solution for a diversified street network evolved which will be described in detail in the section on infrastructure.

1.4.7 Tour Well-Planned Neighborhoods & Buildings

Touring successful buildings and communities is equally as important as consulting with experts. The team toured the Brewery Blocks community in the Pearl District and the new OHSU Medical Center on the South Waterfront of Portland, OR. Following this site visit, the team toured two facilities in St. Louis, MO – a climate similar to that at Fort Leonard Wood.

"Alberici Constructors converted a 50-year old manufacturing facility into Class-A office space for its parent company, Alberici Corporation. The property contained a three-story brick office building and a large metal fabrication facility. They deconstructed and recycled the 60,000sf office building, diverting 97-percent of the material from the landfill.

A catchment system will collect rainwater from 60-percent of the garage roof area. The rainwater will be stored in a 38,000-gallon cistern, treated, and then used for sewage conveyance, saving nearly 150,000 gallons of water per year.

The building's HVAC system uses a mix of under floor air distribution and natural ventilation through operable windows. The raised floor system used throughout the building enables employees to individually control air flow and temperature through floor vents. A 65-kilowatt wind turbine will generate 20-percent of the building's total energy needs" (Alberici Enterprises, 2011).

1.5 CHARRETTE PROCESS

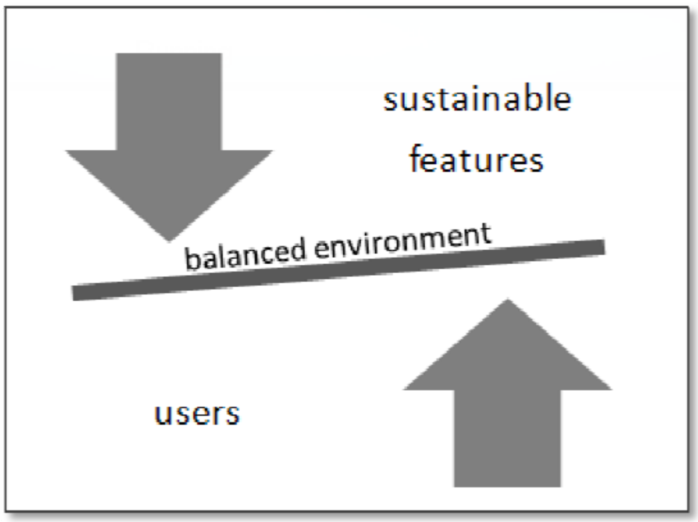
With the knowledge that the 2030 Project attempted management goals far beyond those the military has established in the past, the team took a close look at the Army Center of Standardization (COS) Program, the Master Planning Process, and the U.S. Army Corps' charrette process. While these formalities are well established and have yielded many successful projects, they do not lend themselves to the future goals of net zero which require intense integration of projects with both qualitative and quantitative factors. The 2030 Project team harnessed insight from industry sources that lent directly to addressing and achieving these goals. A few of the newly applied strategies are described further below as they directly relate to the implementation and approach for the 2030 Project on Fort Leonard Wood. Principles regarding the project team's functionality and strategies for non-specific application can be found in section *4.0 The Future: Strategies toward a Net Zero Built Environment*.

1.5.1 The Eco-Charrette Process

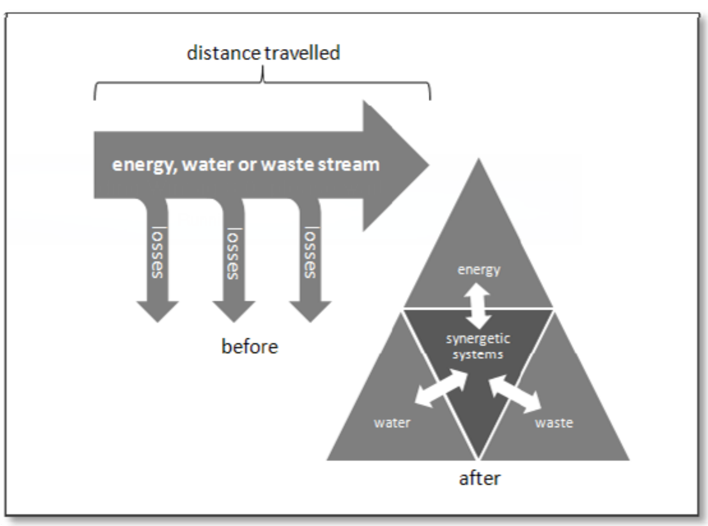
While the eco-charrette process does not differ entirely from the typical charrette, the main difference is the establishment and agreement by all stakeholders on sustainable and efficiency targets for a given project early in the project delivery process. The 2030 Project team agreed to the goal of net zero energy, net zero water, and net zero waste as measured at the installation level by 2030. The team chose to define net zero for this application as having a time period of fifty-years; meaning, that if a theoretical wall were to be drawn around the base perimeter, virtually enclosing the base from any outside force, the installation could survive on resources from the sun, rain, wind, and soil for fifty years without replenishment.

The 2030 Project team met with a variety of stakeholders to develop the guiding criteria for this project; from the direct users (soldiers) to funding sources (IMCOM) and policy makers (HQ USACE). All of this information was brought to the site charrette held in St. Louis, MO from 30 Jan 2011 to 4 Feb 2011. The first day of the charrette was focused on setting goals and expectations for the design team and the project as a whole. A dominant portion of time was spent developing concept validation statements. These are short statements or diagrams that illustrate the cumulative goals of the entire study. After consensus and discussion of these statements, they can be used to validate design decisions at every level of investigation. An additional benefit for developing concept validation statements is that they ensure the project meets the intentions set forth regardless of turnover in stakeholders. This is a common issue in military construction, where projects often extend past the term of an officer.

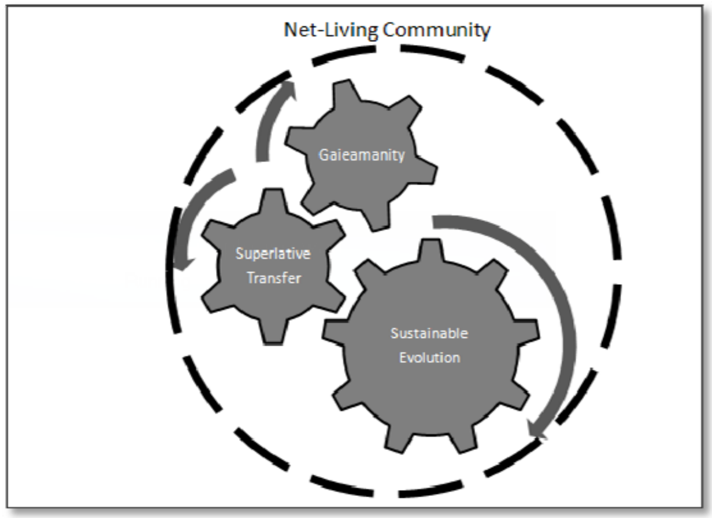
Some concept validation statements and graphics that were generated as part of the think-tank charrette for the 2030 Project on Fort Leonard Wood are listed below:



GAIANIMINITY - USER INTERACTION WITH SUSTAINABLE FEATURES AND THE ENVIRONMENT IN A SYMBIOTIC WAY – IMAGE COURTESY OF HQ USACE.



SUPERLATIVE TRANSFER - MINIMIZING LOSSES & MAXIMIZING EFFICIENCIES IN WATER, WASTE, AND ENERGY STREAMS – IMAGE COURTESY OF HQ USACE.



BATTALION OPTIMIZED SYMBIOTIC SYSTEMS - PROVIDES A LEVEL OF GRANULARITY BY WHICH PERFORMANCE CAN BE MEASURED AND COMPARED – IMAGE COURTESY OF HQ USACE.

Following the development of the think-tank the 2030 Project team evolved the concept validation phrases and diagrams to become guiding principles that account for the larger themes. Those generated for Fort Leonard Wood's Net Zero Installation are listed below:

- PRINCIPLE OF ADAPTABILITY:
  Structures should be constructed to meet the needs of the tenant while not jeopardizing their ability to quickly, inexpensively, and with minimal waste be transformed to meet the needs of the future.

- **PRINCIPLE OF DURABILITY:**
  The application of new technology should be vetted against availability of local adept service technicians, maintenance contracts, longevity, and integrity of materials and construction in the Fort Leonard Wood environment.

- PRINCIPLE OF OPERATIONS:
  The modification of user behavior is critical to the final levels of utility reduction required to achieve net zero.

- **Principle of Flexibility:**
  The implementation plan is only feasible if malleable toward changes in leadership, funding, and program but rigid in vision and principle. Thus, the structure should be built with the most applicable and recommended ideas at the forefront followed by the less researched strategies. The plan should maintain aggressive time objectives but allow replacement of strategies to accommodate needs.

- **Principle of Net Gains:**
  Higher levels of efficiency are best achieved when programmatic needs are met through existing measures. Solutions for adapting or consolidating existing projects should be sought prior to the initiation of a new project.

- **Principle of Scalable Systems:**
  Each strategy should be analyzed for the appropriate scale for maximum efficiency and functionality. Some technologies are best implemented at the master planning scale, community scale, building scale, or individual scale.

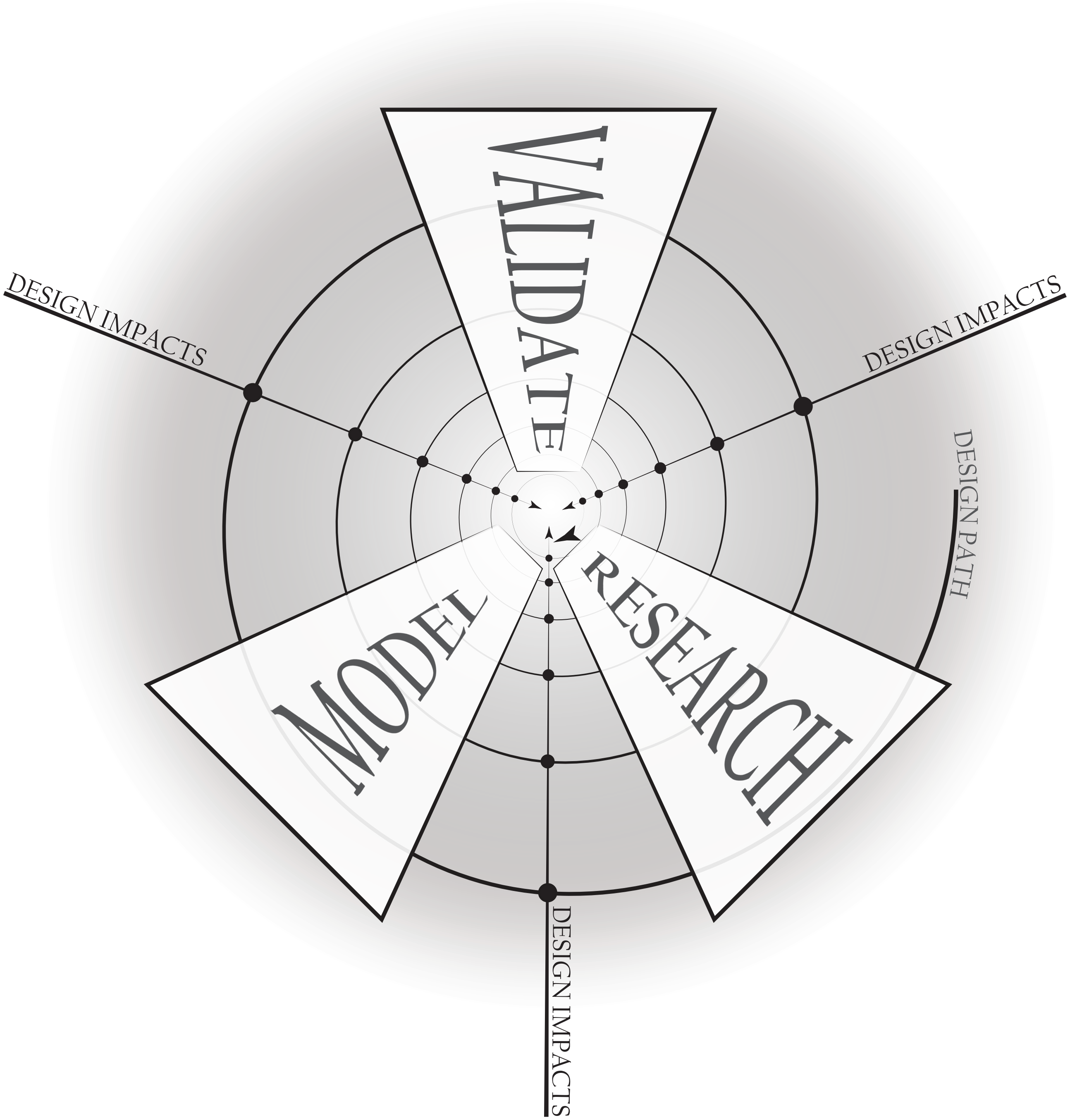
1.5.2 Iterative Design

Following the development of the guiding principles and the think-tank exercise the project delivery team underwent an exercise of iterative design. The twenty-six person team was divided into several multidisciplinary teams. Each sub-team was assigned to resolve a specific task at a given scale for an appropriated length of time. For example, sub-team Alpha was given the Basic Training Area Development Plan (ADP) as a boundary. The team was given the objective to quickly determine a method for calculating the baseline utility usage for the ADP. Another sub-team, Beta, was asked to develop the maximum renewable energy solution for the Advanced Individual Training ADP.

All solutions were presented to the larger group and evaluated for concerns and potential strategies. Armed with this knowledge, the designers were then mixed and divided into different groups to explore another design task (in most cases, a new task at a different scale). Over the course of the week, each of the approximately twenty-six designers had addressed multiple design problems (some addressed the same issue from different angles), vetted them, and presented them to the rest of the team. By creating different iterations of similar or the same problems and presenting them to the collective group, trends and synergies become apparent. Those synergies were then exploited on a variety of scales to create a comprehensive network of design solutions.

This iterative design process diverges significantly from standard charrette practices and as a result yields distinctly different results that typically are more thorough and innovative. Each designer gains a more holistic vision of the entire project and how that project relates to and touches the community. This allows them to implement design decisions that benefit others just as much as they benefit their given task. Further, the team as a whole gains a collective grasp on which issues need more information to determine solutions. All design decisions become open to critique from other design disciplines producing a diverse perspective and helping to account for risks and potential gaps / overlaps. For example, instead of an Architect deciding on a thermal resistance (R-value) for a wall, the Mechanical and Electrical Engineers can work with the Architect to determine an appropriately balanced R-value given internal and external building loads. The 2030 Project designers left the site charrette not only with an idea of where their specific task was going but also with an idea of how it is intended to fit into the integrated plan. With that knowledge, as the plan changed they could anticipate much more accurately how their design would respond as the requirements progressed.

Given the project goal of resiliency, this iterative design process produced multiple design solutions. The team did not want to create a plan that equated to a "house of cards", a self-destructing plan when one piece was removed or hampered. In fact, decisions were made knowing that change is always a certainty. In order for the installation to become more resilient, the implementation plan had to be flexible and adjustable. Design solutions were selected for their modularity and ability to be replaced or eliminated depending upon political, environmental, and economic conditions.



DESIGN PROCESS

THE INTEGRATED PROCESS IS ITERATIVE. BY MAKING DESIGN DECISIONS AND VALIDATING THEM REPEATEDLY, THE INTEGRITY OF THE DESIGN IS MAINTAINED THROUGH THE EVOLUTION OF THE PROJECT - FROM IDEA TO END-PRODUCT.

DESIGN DECISIONS SHOULD BE CONTINUALLY EVALUATED WITH RESPECT TO OTHER. A CONSTANT ISSUE WITH HISTORICAL DESIGN PRACTICES IS THE POTENTIAL LACK OF COORDINATION OF BUILDING SYSTEMS WITH OTHERS. INTEGRATED DESIGN PRACTICES MAKE THOSE COORDINATION EFFORTS A FIRST PRIORITY.

IN THE PAST, INDIVIDUAL DESIGNERS MODELED THEIR DESIGNS INDEPENDENTLY AND FORMALLY COORDINATED ONLY AT KEY POINTS IN THE DESIGN PROCESS. ADVANCES IN TECHNOLOGY HAVE ALLOWED THOSE COORDINATION POINTS TO BE INFINITE AND IN REAL-TIME. BY HARNESSING THE BENEFITS PRESENTED IN THESE PROCESSES, COORDINATION ISSUES CAN BE REDUCED DRASTICALLY.

ONE REALITY OF THIS PROCESS IS THAT IT TENDS TO FORCE DESIGNERS TO MAKE LARGE SCALE DECISIONS FIRST. IT ALSO TENDS TO FRONT-LOAD EFFORT IN THE DESIGN PROCESS. IF PROJECT TEAMS CAN ESTABLISH COMMON DESIGN GOALS BASED UPON SIMILAR FUNDAMENTAL CHANGES, THIS DESIGN PROCESS WILL YIELD HIGHER PERFORMING PROJECTS WITH FEWER DESIGN DEFICIENCIES.

INTEGRATED DESIGN PRACTICES ALSO SHIFT WORKING RELATIONSHIPS FROM A DISCIPLINE-CENTRIC EMPHASIS TO A PROJECT-CENTRIC EMPHASIS. PROJECT TEAMS WILL FIND THEMSELVES COORDINATING MUCH MORE FREQUENTLY WITH OTHER DISCIPLINES IN ORDER TO MITIGATE DESIGN DEFICIENCIES FURTHER DOWN THE DESIGN PATH.

1.6 Model / Evaluate

Analysis tools used in this study include Autodesk Revit Architecture, Autodesk Ecotect Analysis, Relux, Autodesk Green Building Studio, and Carrier HAP. A wide variety of tools are available to facilitate this process; those utilized were selected based on availability, reviews, and market trends. The software selected is not an endorsement by the U.S. Army or USACE.

1.6.1 Conceptual Energy Modeling (CEM)

Energy modeling is a popular topic in the design and construction realms recently due to its ability to project the energy consumption of a project long before it is constructed. This technology allows a team of designers to "see" the energy repercussions of their design decisions throughout the design process. It also allows project owners and stakeholders to understand the magnitude and evaluate energy data on a facility long before they ever get their first energy bills.

Conceptual energy modeling refers to software intended to be used in schematic and design development phases for comparative decision making by design experts. As design decisions are made, the living model is updated with the new information and the adjusted results are utilized in the next round of design.

For the pilot study, budgetary restrictions prevented modeling each area development and facility on the installation. To adequately represent all three scales, it was deemed acceptable to analyze the entire cantonment area for master planning implementation, two area developments (the Basic Training Complex and the Advanced Individual Training Complex) and two facilities (the Company Operations Facilities) from within each area development. To realize the cumulative effects, it would be necessary to apply this methodology to the remaining facilities and area developments.

The analyses and calculations produced by the models can be time consuming and thus only selections of critical importance to support conclusions are shown and discussed.

In developing the baseline facility model four things are critical: how daylight infiltrates the design, how the sun affects the building skin and develops shadows, the energy load, and the ability of the site to capture renewable energy from radiation or wind. The team chose to utilize the Army Center of Standardization floor plan for the BT BCOF and the AIT BCOF at the onset of schematic design. These models would be used to analyze the climatic and site factors of the programmed facilities and guide on opportunities for improvement.

After the baseline buildings were modeled, each building form was manipulated on the site so that several iterations of the buildings were vetted through a precursory program, in this case Green Building Studio. Each alternative was analyzed for cost implications, energy use, daylighting, and renovation potential. The alternatives were also viewed at the area development scale in consideration of factors such as social connectivity, access, and human scale. Once each alternative was maximized for potential, the buildings were taken into another program for refinement.

Ecotect is a software program that analyzes shading, solar path, and radiation among other climatic factors. The results showed sunlight's reach into the interior space on multiple floors. This type of analysis is used to determine when, where, and how to design windows based on the orientation to the site. Glazing is expensive, especially when it is used incorrectly, as in an area of a building in shadow for most of the year. In this way, architects can appropriately design and size glazing as well as coordinate with mechanical engineers to effectively balance the heating and cooling loads.

TECHNOTE building orientation

The daylighting simulation allowed the design team to understand the infiltration of daylight in the standard design as programmed on the site. An orthographic projection was developed for each Company Operations Facility. As a type of cylindrical diagram, the orthographic projection shows the Sun's apparent path for an observer who is looking due south. It was used to verify shading calculations and further the understanding of the building's application to the site.

An equidistant projection is a type of polar diagram in which the sky dome is projected onto a horizontal plane with the observer in the center. It is ideal for visualizing the compass direction of the Sun at any point in time.

The daylight analysis diagram was another useful tool; it gave the cumulative shadow range of the facility. The AIT BCOF is essentially a type of barracks with residential rooms along a double loaded corridor. The daylight analysis showed that one side of the building would be in constant shadow, while the opposite side, in constant sunlight. This was augmented by the occupancy schedule of the building. As a strictly regimented barracks facility, most soldiers only occupy the space at night. During the day, they are in common areas elsewhere in the building or away from site at the range. Their absence of body heat means that the cooling or heating load is a direct effect of the external temperatures. This disparity between the side of the building in the sun and the side of the building in shadow will generate irregular cooling and heating demand and strain the HVAC system. By reorienting the building on the site, it was possible to lower the energy demand without moving any interior walls.

Conceptual energy modeling (CEM) is a crucial step that is often skipped due to process or budgetary restrictions however it is also the most influential step in reducing overall utility use, accounting for net gains and lowering life-cycle cost. The 2030 Team passionately encourages future project teams to include this seminal step in the design process with an interdisciplinary team. Application of CEM as a design tool is elaborated on in section *4.1 Energy Modeling in Practice.*

	CONCEPTUAL						DEVELOPMENTAL				FINAL DESIGN				
	WEATHER DATA	SOLAR DATA	SOLAR/SHADOW ANALYSIS	FACILITY TYPE/LOAD COMPARISON	BUILDING ORIENTATION	LOCAL ENVIRONMENT ANALYSIS	ENERGY USAGE INTENSITY CALCULATION	RAPID PROTOTYPING	DAYLIGHT ANALYSIS	DESIGN DEVELOPMENT	LOAD DISTRIBUTION ANALYSIS	GEOMETRIC MODELING	RENDERING	ENERGY COST ESTIMATING	DATA INPUT/INTERPOLATION/SORTING
CLIMATE CONSULTANT 5	High	High													
AUTODESK WEATHER TOOL	High	High	Moderate												
ENERGY STAR TARGET FINDER				High											
GOOGLE SKETCHUP		Minimal	Minimal		Moderate	Minimal		High	Minimal	Minimal		High	Moderate		
REVIT ARCHITECTURE	Minimal	Minimal	Minimal		Moderate		Moderate	Moderate		High	Minimal	High	Moderate	Minimal	
AUTODESK ECOTECT	Moderate	Moderate	High		High	High		Moderate	Moderate	Moderate		Minimal			
AUTODESK GREEN BUILDING STUDIO	Moderate	Moderate		High	Moderate		High	Moderate		Moderate	Minimal			Moderate	Minimal
CARRIER HAP	Moderate	Moderate			Minimal		High	Minimal						High	
RELUX									High		High		Minimal		Minimal
KERKYTHEA									Minimal				High		
MICROSOFT EXCEL															High

USAGE LEGEND: ○ MINIMAL USE ◍ MODERATE USE ● HIGH USE

SOFTWARE UTILIZATION MATRIX

THIS GRAPHIC ILLUSTRATES SOME OF THE MANY PIECES OF SOFTWARE THAT WERE UTILIZED OVER THE DURATION OF THIS STUDY. THIS MATRIX ILLUSTRATES SOME OF THE MANY TASKS THAT THESE SOFTWARE PRODUCTS ARE CAPABLE OF ANALYZING. THIS MATRIX ALSO INDICATES THE FREQUENCY BY WHICH THESE PIECES OF SOFTWARE WERE USED FOR A GIVEN TYPE OF ANALYSIS.

THE INTENT OF THIS GRAPHIC IS TO INDICATE THE WIDE RANGE OF ANALYSIS SOFTWARE AND THEIR RANGE OF USES. MANY OF THESE TOOLS MAY BE OF BENEFIT AT MULTIPLE STAGES OF DESIGN AND SHOULD BE USED THROUGHOUT THE DESIGN PROCESS FOR MAXIMUM BENEFIT.

NOTE: THIS GRAPHIC IS INDICATIVE OF THE DESIGN PROCESS UTILIZED BY THE 2030 TEAM. BRAND NAMES AND PRODUCTS INDICATED HERE-IN ARE PROPERTY OF THEIR RESPECTIVE OWNERS AND COMPANIES. THIS GRAPHIC SHOULD NOT BE CONSTRUED AS A REFLECTION OF THE WORTH OR VALUE OF ANY SOFTWARE PRODUCT CAPABLE OF DOING THESE TYPES OF ANALYSIS. THE INTENT OF THIS GRAPHIC IS TO SIMPLY DOCUMENT THE TOOLS USED AND THE PHASES OF DESIGN IN WHICH THEY WERE UTILIZED FOR THIS SPECIFIC STUDY.

1.6.2 Systems Modeling (SM)

After the design team had completed several iterations of design with conceptual energy modeling tools, the designs were taken to another level of analysis. The more exhaustive level of analysis is referred to as systems modeling because it typically produces targeted results of a particular system at a high level of accuracy. However, the results of systems modeling are wholly dependent on the value of the input information. Systems models are detailed and lengthy requiring many input measures. Therefore, systems modeling should only be carried out on a few scenarios within predetermined limitations.

Daylighting systems models were run on the BT and AIT BCOF. Detailed modeling calculations representing every room were run for each quarter (MAR, JUN, SEP, and DEC) and three times during daylight hours (8am, 12am, 5pm). This analysis was performed for each enclosed space on both facilities to determine the lighting demands. An electrical engineer used this information to program a lighting schedule (which is a significant contributor to the energy demand). Thus, by passively lighting the building the lighting demand is decreased and in turn, the energy load is reduced.

Relux, the light simulation tool utilized here, requires specific information about the wall types, window size, and the exact location and orientation of the building. It is not practical to do this level of analysis on multiple building designs for comparison; systems models should be used at the final stages of design for fine detail changes.

Another type of common systems model is the HVAC systems model. The study elaborates on the design decisions made for each building in section *3.0 Building Specific Solutions*.

1.7 Installation Concerns (2011)

It is important to understand the context under which this study was conducted. There were several key factors that drove decision making at the time, and any changes in those circumstances can and will necessitate the evaluation (or re-evaluation) of the recommendations made in this document. The team intends that as this plan is implemented it is also updated and revised to include the most relevant conditions and stakeholder values. The project team has done its best to incorporate flexibility, but unforeseen and future events will certainly have an impact on the reasonability and feasibility of the suggestions made herein.

Given the emphasis on site specific design and optimization, the 2030 team intends for this plan and analysis to be a "living document." Recommendations made at the time of this study may or may not make sense in the context of its targeted implementation five or ten years into the future. Even so, every effort is given to make the recommendations as flexible as possible. The intention is to avoid a "house-of-cards scenario" in which failure to meet a certain benchmark will cause the plan to collapse.

Some significant events and realities were documented at the time of this study. It should be recognized that these events had a direct impact upon some of the suggestions made in the following pages. As the installation evolves and learns from the implementation of said strategies, it is important to reference these items to determine the weight and intent of these concerns. A brief (but not exhaustive) list of concerns and said influences are provided below.

The Mission Support Center of Excellence (MSCOE)

1.7.1 Installation Purpose & TRADOC

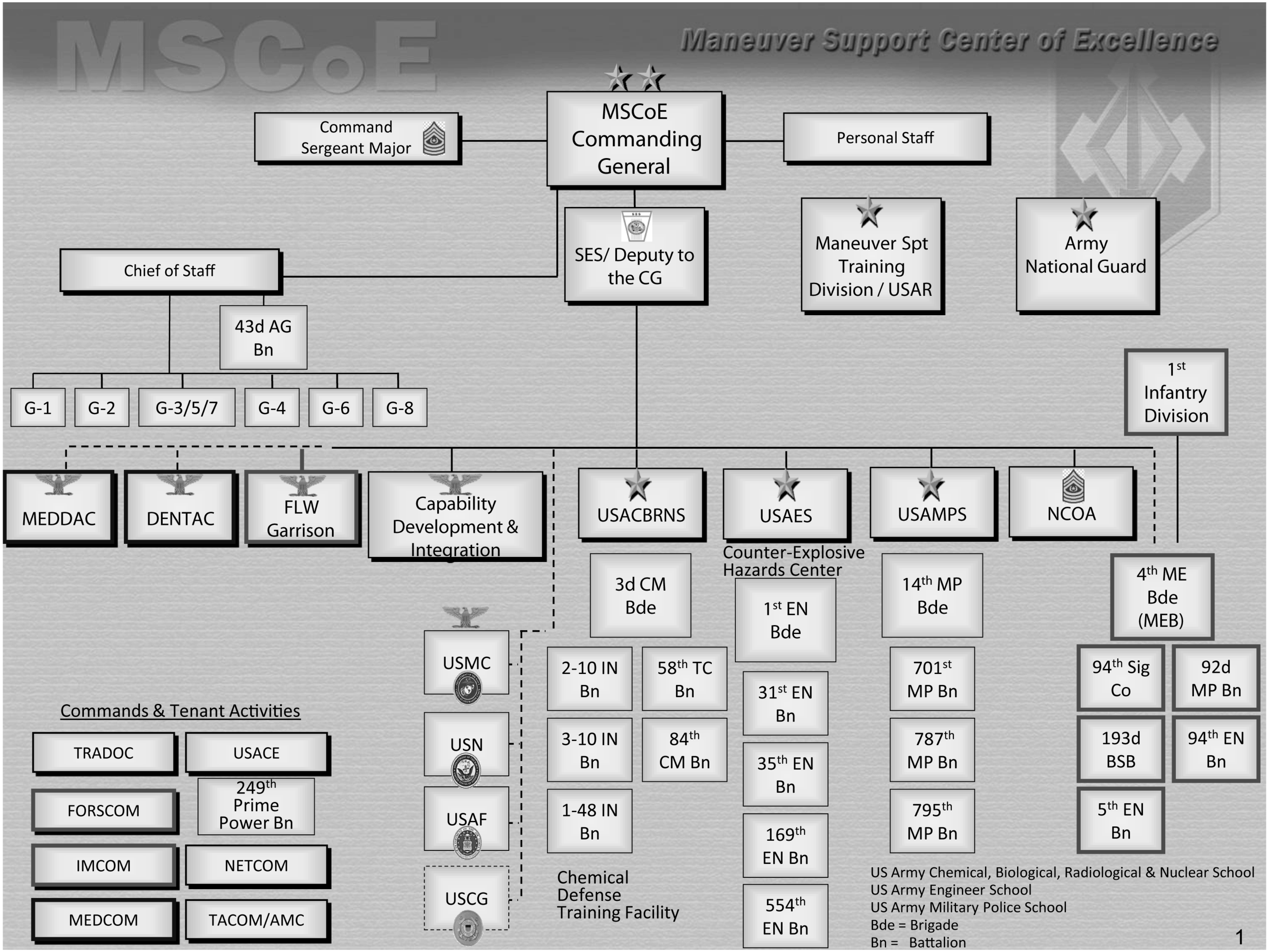
Fort Leonard Wood is a thriving and prosperous installation that has evolved from a small basic training post approximately seventy years ago to a premier Army Center of Excellence that annually trains between 80,000 to 90,000 military troops and civil servants.

Fort Leonard Wood currently operates under the United States Army Training and Doctrine Command (TRADOC). As a TRADOC installation, Fort Leonard Wood is home to the Maneuver Support Center of Excellence (MSCoE). Fort Leonard Wood now trains and educates service members and develops doctrine and capabilities for the Training and Doctrine Command's U.S. Army Chemical, Biological, Radiological, and Nuclear School (CBRN), U.S. Army Engineer School (USAES), and U.S. Army Military Police School (USAMPS), three gender integrated Initial Military Training brigades, one of only five reception stations in the Army, and the Army's largest Non-Commissioned Officers (NCO) Academy.

As a part of the U.S. Armed Forces Base Realignment and Closure (BRAC) 2005 stationing action, Fort Leonard Wood has received numerous additional responsibilities to include supporting the 4th Maneuver Enhancement Brigade, a large Forces Command (FORSCOM) unit that is responsible for all deployable capabilities at Fort Leonard Wood.

A colonel-commanded Marine Corps Detachment and an Air Force Detachment, which are both the largest on any Army installation, are located on Fort Leonard Wood. The post is also home to a large Navy Seabee Detachment and elements of the Coast Guard that use facilities for training purposes. All Department of Defense truck-driver training and a large international student detachment that has representation from over 120 different countries is sited on Fort Leonard Wood.

All of this can be somewhat summarized in the statistic that even though the 2000 census indicated a permanent population in the neighborhood of 14,000 – over 100,000 individuals either live or pass though this installation for a wide variety of education, training, or FORSCOM activities.


MSCoE
Maneuver Support Center of Excellence
MSCoE Commanding General
Command Sergeant Major
Personal Staff
SES/ Deputy to the CG
Maneuver Spt Training Division / USAR
Army National Guard
Chief of Staff
43d AG Bn
G-1
G-2
G-3/5/7
G-4
G-6
G-8
1st Infantry Division
MEDDAC
DENTAC
FLW Garrison
Capability Development & Integration
USACBRNS
USAES
USAMPS
NCOA
Counter-Explosive Hazards Center
3d CM Bde
1st EN Bde
14th MP Bde
4th ME Bde (MEB)
USMC
USN
USAF
USCG
2-10 IN Bn
58th TC Bn
3-10 IN Bn
84th CM Bn
1-48 IN Bn
31st EN Bn
35th EN Bn
169th EN Bn
554th EN Bn
701st MP Bn
787th MP Bn
795th MP Bn
94th Sig Co
92d MP Bn
193d BSB
94th EN Bn
5th EN Bn
Chemical Defense Training Facility
Commands & Tenant Activities
TRADOC
USACE
FORSCOM
249th Prime Power Bn
IMCOM
NETCOM
MEDCOM
TACOM/AMC
US Army Chemical, Biological, Radiological & Nuclear School
US Army Engineer School
US Army Military Police School
Bde = Brigade
Bn = Battalion
1

1.7.2 Adjacent Communities

AREA MAP OF ST. ROBERT, WAYNESVILLE, AND FORT LEONARD WOOD - IMAGE COURTESY OF GOOGLE MAPS (© 2011 GOOGLE).

A very high percentage of military personnel that operate out of this installation live off post in surrounding communities. St. Robert and Waynesville hold the highest contingent of such personnel – as they are the largest and lie closest to post. Outlying communities such as Richland, Crocker, Dixon, Big Piney, Devil's Elbow, and others are also comprised of a large percentage of active-duty and retired military personnel that maintain a variety of links with Fort Leonard Wood.

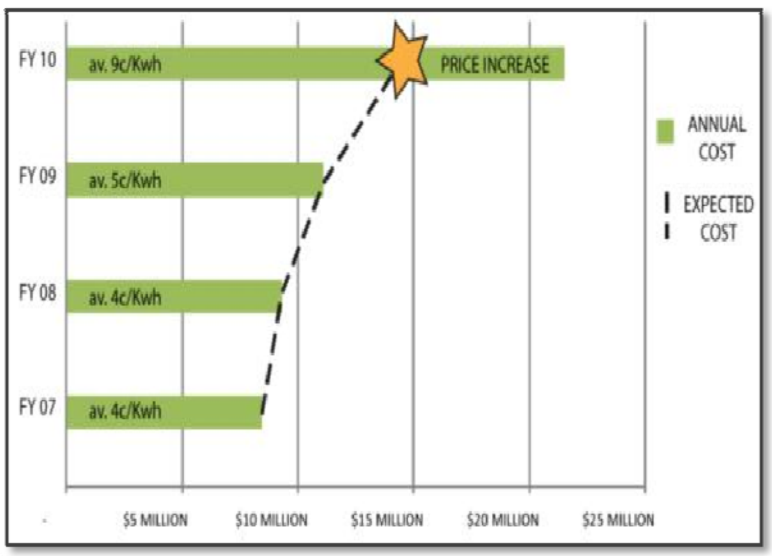
These demographics present several potential opportunities and challenges. These two communities represent the most permanent contingent of personnel that operate in and around Fort Leonard Wood. All of these communities rely heavily upon the economic benefits presented by the jobs and capital passing through this installation. By acknowledging and accommodating this reality, there is potential to pool resources in approaching utility, infrastructure, and transit concerns.

Certainly, this study advocates a high level of cooperation with these surrounding communities. Without a strong working relationship in implementing many of the goals presented in this document, achieving prescribed benchmarks will be significantly more difficult, if not impossible.

1.7.3 Soldier & Occupant Education

User education is a difficult challenge on military installations. Traditionally, Army Posts have elevated turnover rates. That reality is even higher at a training facility like Fort Leonard Wood. The concern is the time it takes to educate users on proper sustainability strategies and techniques. DPW and Army representatives indicated during preliminary meetings that this must be taken into account when considering technologies that require direct user input or response. On one level, education strategies must be simple and quick to learn. On another, any "menial" tasks that can be delegated by drill sergeants to instill a sense of responsibility, work ethic, and stewardship in new recruits can be seen as a valuable teaching tool during BT and AIT exercises.

1.7.4 Installation Power Supply



PROJECTIONS OF ENERGY COST - IMAGE COURTESY OF HQ USACE.

Fort Leonard Wood's energy crisis was a critical factor for selecting this installation. The electricity on Fort Leonard Wood is supplied by the Sho-Me Power Electric Cooperative. In recent years, the cooperative has doubled the price of electricity. This has resulted in a large demand on installation operational funds, not to mention increased vulnerability from an operational and security standpoint. Recently, Sho-Me Power and the Army formally disagreed on the ability of the power co-op to vastly increase the cost of electricity. The result was not only the ability of the power co-op to increase the rate but also to terminate the existing contract. As of the publication of this document, the power co-op and Fort Leonard Wood were entered into an agreement for power through 2012 with the Army's option to extend to 2016.

The supply problem is real enough in itself, but this is combined with two other nagging realities: failing power infrastructure and single source dependency; Fort Leonard Wood's energy crisis is becoming insurmountable without drastic re-evaluation of its energy systems.

First is the single-sourced nature of the installation's energy supply. Fort Leonard Wood receives 100-percent of its electricity through five transformers located on post. Without these transformers feeding electricity on post, the installation is left, literally, in the dark. As previously mentioned, resilience is a key motivator between many of the proposed recommendations and required mandates. The single-sourced method of supplying energy is not resilient. In fact, it is a giant weakness in any installation's ability to withstand or respond to disaster situations.

The most recent concern coming to light is the reality of Fort Leonard Wood's aging infrastructure. The existing five transformers serving the installation in 2011 were at or are very near maximum capacity. When combined with the large construction program scheduled, this becomes a recipe for disaster. The 2030 Project team was advised by the installation energy manager that the lead time for the type of transformer equipment needed was approximately six to nine months. If Fort Leonard Wood either continues its electrical consumption as planned, and / or if the installation does not order a newer, larger transformer by the summer of 2012, they will not have the capacity to connect the buildings they are programmed to construct in FY13. Now, all of a sudden, energy concerns are not a goal for 2030, they are a necessity for getting through the next decade.

Fort Leonard Wood is not alone in its energy crisis. Most of our nation's installation utility and transportation infrastructure was constructed in the 1940s to 1950s. The infrastructure was not intended to survive without significant retrofit and repair for more than sixty years. Many installations have not had sufficient budgets to maintain and retrofit the infrastructure as needed. Thus, Fort Leonard Wood's crisis is shared by many throughout the country.

1.7.5 Building Materials & Durability Concerns

EXAMPLE OF FASTENER, CORROSION, AND FAILURE ON ARCHITECTURAL SUN SHADES. - IMAGE COURTESY OF USACE, OMAHA DISTRICT.

Over the years, Fort Leonard Wood has developed a distinct aesthetic identity. DPW expressed their desire that the 2030 designs do their best to integrate with the surrounding community to include compliance with Fort Leonard Wood's Installation Design Guide (IDG).

Many of the strategies, systems, and materials slated for implementation were selected for a variety of reasons and their inherent benefits. While they were selected with the IDG and the character of the installation in mind, it is important to note that many of the systems and strategies presented in this document may have unforeseen aesthetic and organizational consequences. Concepts such as passive systems integration, walk-able communities, renewable energy systems, and low impact development will certainly impact the massing, density, and aesthetic of the installation and its communities over time.

That being said, not all tenets established by the current IDG need to be abolished. Close coordination with and evaluation of the existing IDG should be mediated with the net zero goals that Fort Leonard Wood has set out to achieve. Priorities should be set and established for the continuity of the post's historic and functional identity – integrated with its current and future operational and environmental goals.

1.7.6 Geothermal Systems, Ground Water, & Caves

During preliminary meetings, DPW expressed concerns over the installation of geothermal systems on post. There were many reasons for the anxiety over the installation of these systems, mostly over maintenance and longevity concerns. The 2030 project revealed an additional concern relating to the composition of the erosive properties of the bedrock in the area and how certain open-loop systems may cause sinkhole concerns if not designed properly.

Additionally, the DPW raised issues with the seismic nature of the area and concerns that closed-loop systems could contaminate the water table. As a predominately rural community, Fort Leonard Wood's neighbors rely heavily on sourced ground water for industrial and residential needs.

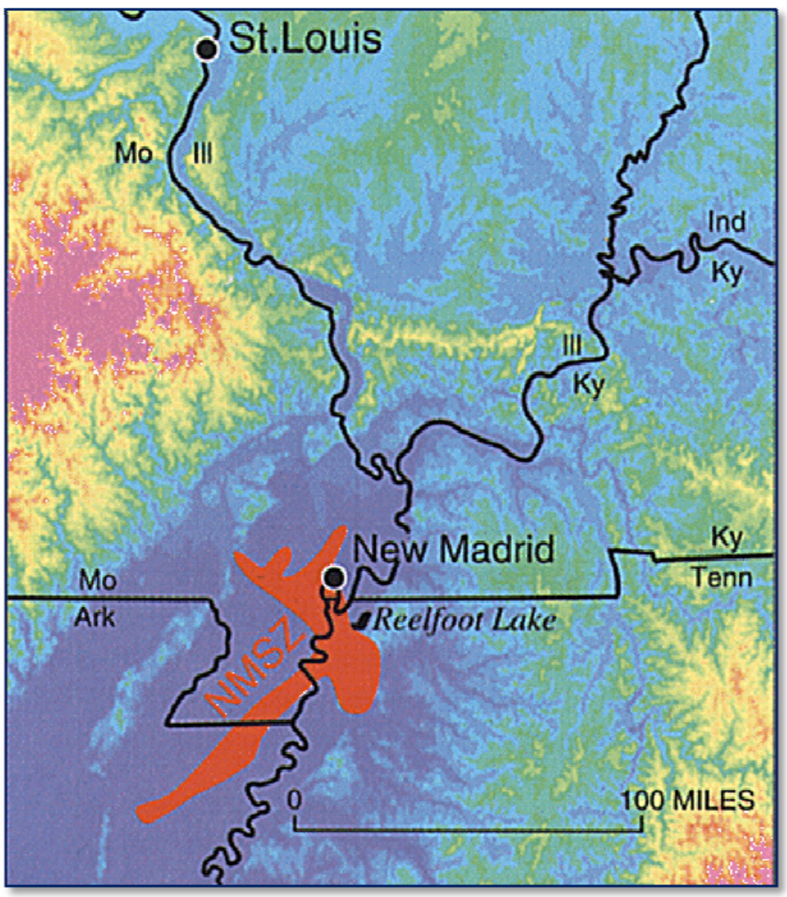
1.7.7 Natural Disasters

PHOTO OF TORNADO DAMAGE AT FORT LEONARD WOOD. - IMAGE COURTESY OF USACE, KANSAS CITY DISTRICT.

An EF3 tornado ripped through portions of Fort Leonard Wood on the morning of 31 December 2010. The event was primarily centered in the base training and cantonment area on the eastern portions of the installation. While there were only minor injuries, significant damage occurred to government buildings, residential housing, and infrastructure. This included the near incapacitation of the water treatment plant due to roof failure.

Since this event occurred in the very early stages of this study, a heavy emphasis was put on designing facilities to acknowledge the fact that storms of this magnitude do occur in the area. Care should be given in designing facilities that will not be significantly impacted by the occurrence of moderate weather events. Of specific concern was the durability of roof systems under high wind and hail storms, the resistance of sunshades and renewable energy systems to hail, and the acknowledgement of temperature extremes in the design of all systems and facilities.

1.7.8 Seismic Concerns (New Madrid Fault)



MAP SHOWING LOCATION OF NEW MADRID SEISMIC ZONE. - IMAGE COURTESY OF USGS.

Fort Leonard Wood lies within close proximity to the New Madrid Seismic Zone. While it is a lesser-known fault line in the United States, it is the site of four of the largest North American earthquakes in recorded history. The most recent major event occurred in late 1811 and 1812 when a series of earthquakes and aftershocks occurred with magnitudes reaching an estimated 7.5-8.0 on the Richter Scale. Given the geologic makeup of this portion of the country, these events are reportedly felt over a much larger area than those occurring on the much more well-known San Andreas fault running along the western coast of North America. Even today, the New Madrid Seismic Zone averages one event per year that is strong enough to be felt, with thousands events of lesser magnitude that are recognized by seismic analysis equipment.

According to the U.S. Geological Survey (USGS), there is a broad consensus that the possibility of major earthquakes in the New Madrid Seismic Zone remains a concern. The agency recently issued a fact sheet reiterating the estimate of a 10-percent chance of a New Madrid earthquake of magnitude comparable to those of 1811–1812 within the next fifty years, and a greater chance of a magnitude 6.0 earthquake in the same time frame (USGS, 2009). Combined with a report filed in November 2008, the U.S. Federal Emergency Management Agency (FEMA) warned that a serious earthquake in the New Madrid Seismic Zone could result in "the highest economic losses due to a natural disaster in the United States," further predicting "widespread and catastrophic" damage across Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, Oklahoma, Texas, and particularly Tennessee, where a 7.7 magnitude quake or greater would cause damage to tens of thousands of structures affecting water distribution, transportation systems, and other vital infrastructure.

If an event were to occur, many of the active and training units (prime-power, bridging engineers, combat engineering, etc.) established at Fort Leonard Wood would be extremely valuable in restoring infrastructural integrity to the region. Attention should be paid to the potential value that Fort Leonard Wood troops would play in recovery efforts if an event were to occur. Many of the systems suggested for implementation in this study could aid in the installation’s resilience to a major seismic event and in turn, aid in troop’s ability to respond to a major seismic or other natural disaster.

1.8 Design Strategies

As previously mentioned, a guiding principle during the 2030 Project's St. Louis charrette was to work with the installation to develop a concept or process statement that would drive design decisions at all scales and yield the most efficient transition from current state to a net zero future.

This process statement evolved into a logical and obvious three step strategy:

1. **Optimize existing systems.**

   This should be done immediately and with the lowest amount of initial investment. It will ensure the integrity of existing utility systems and infrastructure. Stakeholder education, the installation of measurement and verification systems, utility repair projects, and existing building energy-efficiency upgrades (as deemed reasonable) should be included.

2. **New projects shall be constructed as efficiently as practicable under current cost and legislative constraints.**

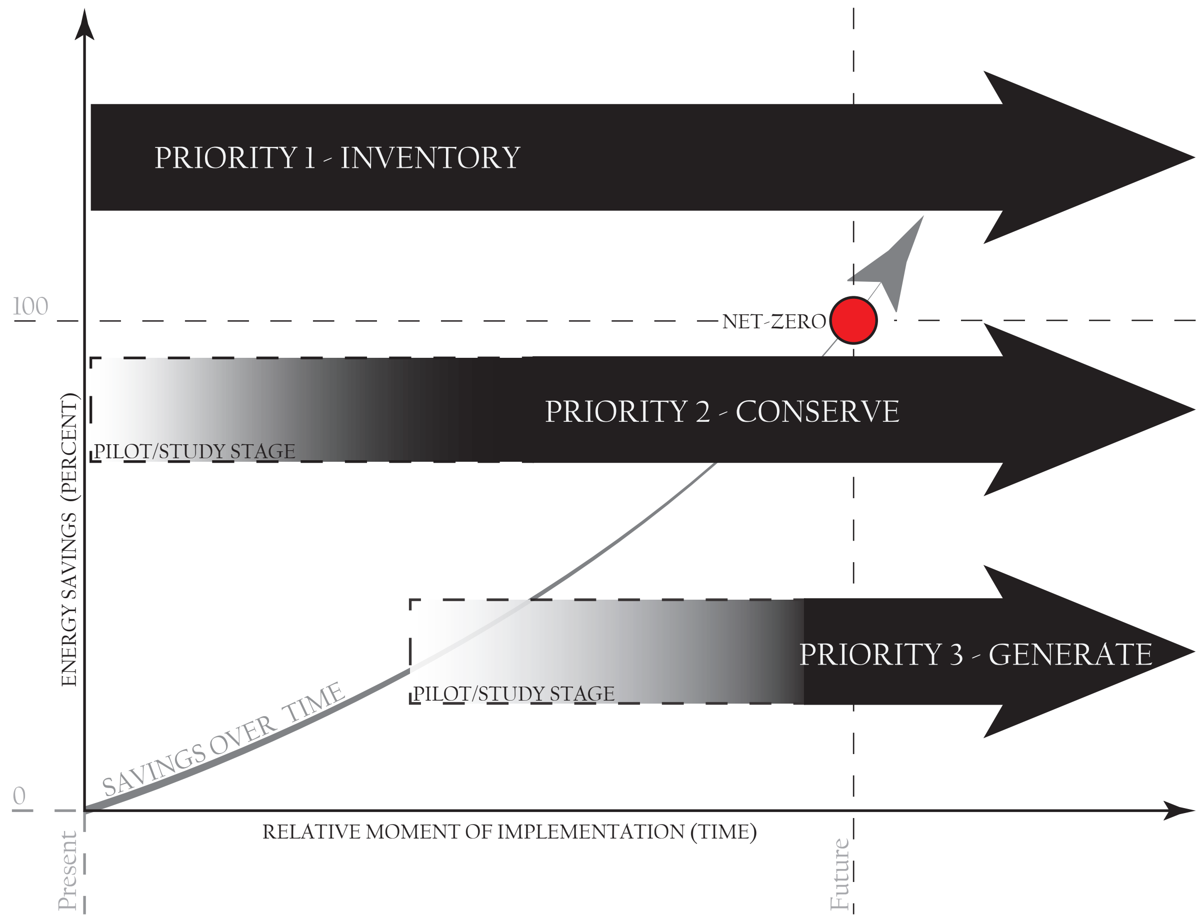
   Building upon the efficiency improvements made to infrastructure in step one, new projects shall be constructed to the highest performance standards possible given budgetary and legislative restrictions. Even at an early stage, infrastructure improvements shall be given priority. This includes the development of smart infrastructure networks, utilization of passive design strategies, and other passive improvements that can be incorporated into site and facility designs. Implementation of small-scale active systems such as daylighting controls and building or community scale energy generation devices as reasonable within budget restrictions may also be considered. Cost implications shall be measured using holistic strategies to account for second tier costs such as transportation of materials and flexibility of design.

3. **Implement large-scale active systems to supplement residual energy and utility flows.**

   Leaving this step until last ensures that the entire installation is optimized to the extent possible prior to implementing often costly and resource-intensive systems (but potentially efficient in comparison to smaller installations). This shall necessitate the smallest active systems since all existing features are optimized. In addition, many renewable and sustainable energy systems are relatively new to the market, keeping this step as the last option allows time for technology to mature, de-bug, and become more cost competitive.

The 2030 Project Team referenced this three-step process continually over the development of these documents. Improvements in step one catalyze the improvements in step two and in turn, lessen the loads required by step three. Further, improvements in step three will help supplement needs far beyond those projected in this document. In doing so, a highly-efficient method for ramping down utility consumption at Fort Leonard Wood with an eye at becoming net zero by 2030 is developed.

PRIORITIZING NET-ZERO AND ENERGY CONSERVATION STRATEGIES



THIS DIAGRAM ILLUSTRATES THE NEED TO PRIORITIZE IMPLEMENTATION OF NET-ZERO GOALS OVER THE LIFE OF THE PROJECT. INITIAL EFFORTS SHOULD BE SHIFTED TO INVENTORYING EXISTING ENERGY, WATER AND WASTE STREAMS. BY DOING THIS, YOU CAN ESTABLISH BASELINE USAGES IN YOUR BUILDING STOCK AND DEVELOP A DATA RESOURCE BY WHICH YOU CAN BEGIN TO ANALYZE CONSERVATION EFFORTS IN THE FUTURE. INVENTORYING CAN BE DONE WITH MEASUREMENT AND VERIFICATION (M&V) SYSTEMS, DASHBOARDS, PERFORMANCE MANAGEMENT SYSTEMS, ETC.

ONCE YOU HAVE DEVELOPED THAT ROBUST DATA RESOURCE, YOU CAN BEGIN TO RESPOND TO IT. THIS MAY BE THROUGH USER AND STAKEHOLDER EDUCATION, FACILITY RENOVATION, NEW FACILITY DESIGN OPTIMIZATION AND ANY OTHER EFFORTS THAT HELP TO CONSERVE THOSE EXISTING ENERGY, WATER AND WASTE STREAMS. THESE EFFORTS CAN BE FURTHER INVENTORIED TO ENSURE PROPER PERFORMANCE AND TO BEGIN PROJECTING (AND MINIMIZING) ENERGY, WATER AND WASTE NEEDS INTO THE FUTURE.

THE TERM "GENERATE" REFERS TO ANY DEDICATED PROJECT SINGULARLY PROGRAMED TO MINIMIZE OR MITIGATE AN ENERGY, WATER OR WASTE STREAM. DO THESE LAST TO ENSURE THAT THEY ARE SIZED PROPERLY, ARE SUFFICIENTLY COMPATIBLE, AND COST THE LEAST. THIS ALSO ALLOWS FOR NEW TECHNOLOGIES TO MATURE OVER TIME OR ALLOW NEW TECHNOLOGIES TO BE DEVELOPED. EITHER WAY, THIS ENSURES THE EFFICIENCY OF THE SYSTEM OF THE WHOLE AND CREATES AN INTEGRATED NETWORK OF SYSTEMS THAT CAN CONTINUE TO BE OPTIMIZED OVER TIME.

1.8.1 Site Optimization versus Standardization

This study takes a definitive stance that in order to most effectively and efficiently increase building performance, buildings must be directly designed for their intended sites. The USACE study referenced in section *1.3 Project Approach* resulted in similar conclusions. The study conducted by USACE analyzed five Army standard designs in multiple climate zones with help from CERL and PNNL to demonstrate that energy efficiency measures (EEMs) were specific to facility type and site. In order to push energy savings thresholds beyond what is currently achieved, the incorporation of passive design strategies is increasingly important. This includes investigation of proper building orientation, fenestration, building envelope, mechanical systems, and more.

The idea of facility standardization in the army is not new. Facility standardization programs have been implemented several times in the past and have had varying degrees of success. The intent of a standardization initiative (among other goals) is to save time, money, and resources in the design of many of the most common facilities found in the military.

Interestingly, these are some of the same goals that are intended by the presentation of this document and the pursuit of a Net Zero Installation. A certain amount of criticism has been made to the affect that facility standardization prohibits site-specific and contextual design – and therefore prohibits designers from achieving energy and resource conservation goals. While this could be true in certain contexts, it is not a certainty. In fact, standardization has the potential to play a key role in the success of these projects now and in the years to come with some adjustments to the process to allow for regional flexibility to reach energy, water, and waste goals.

The Center of Standardization (COS) program holds key responsibilities beyond enforcing building floor plans and elevations. They maintain an integral connection with stakeholders for a wide variety of facility types and attempt to balance the task of creating reasonable standards for facilities as used today and as Army leaders shape their forces for the future. The COS maintains a substantial and potentially irreplaceable knowledge base that is arguably more forward-thinking than many local or regional stakeholders can afford to entertain. By leveraging this knowledge base, the COS has a distinct advantage in establishing standards for not only useable (programmatically sound), but also sustainable (now and into the future) and energy efficient (using both passive and active strategies) buildings on an unprecedented scale. Furthermore, they can utilize lessons learned as stepping stones in improving facility performance into the future. The key is how this tool is used and the magnitude of their role.

What must be further investigated is the degree of rigidity (or flexibility) that these standards must carry, followed by a process to consider warranted deviations from the standard(s) on environmental grounds. It is interesting to note that the 2030 Project team found the standard AIT BCOF design to have very high performance potential at Fort Leonard Wood – had it been able to fit in its optimal orientation on its very long and narrow site. It should also be noted that the team was able to find a large amount of potential in re-evaluating the massing of the BT BCOF structure, even though the site was flexible enough to allow almost any orientation of the facilities. This study recommends the evaluation of how the COS can help maintain and regulate processes that balance all of the following:

1. PROGRAMMATIC NEEDS OF ARMY LEADERSHIP AND FUTURE PROGRAMS.
2. PROGRAMMATIC NEEDS OF SPECIFIC USERS AND USER-GROUPS NOW AND INTO THE FUTURE.
3. SITE SPECIFIC NEEDS IN OPTIMIZING THE FACILITY SITE ON POST.
4. SITE SPECIFIC NEEDS IN OPTIMIZING THE FACILITY ORIENTATION ON SITE.

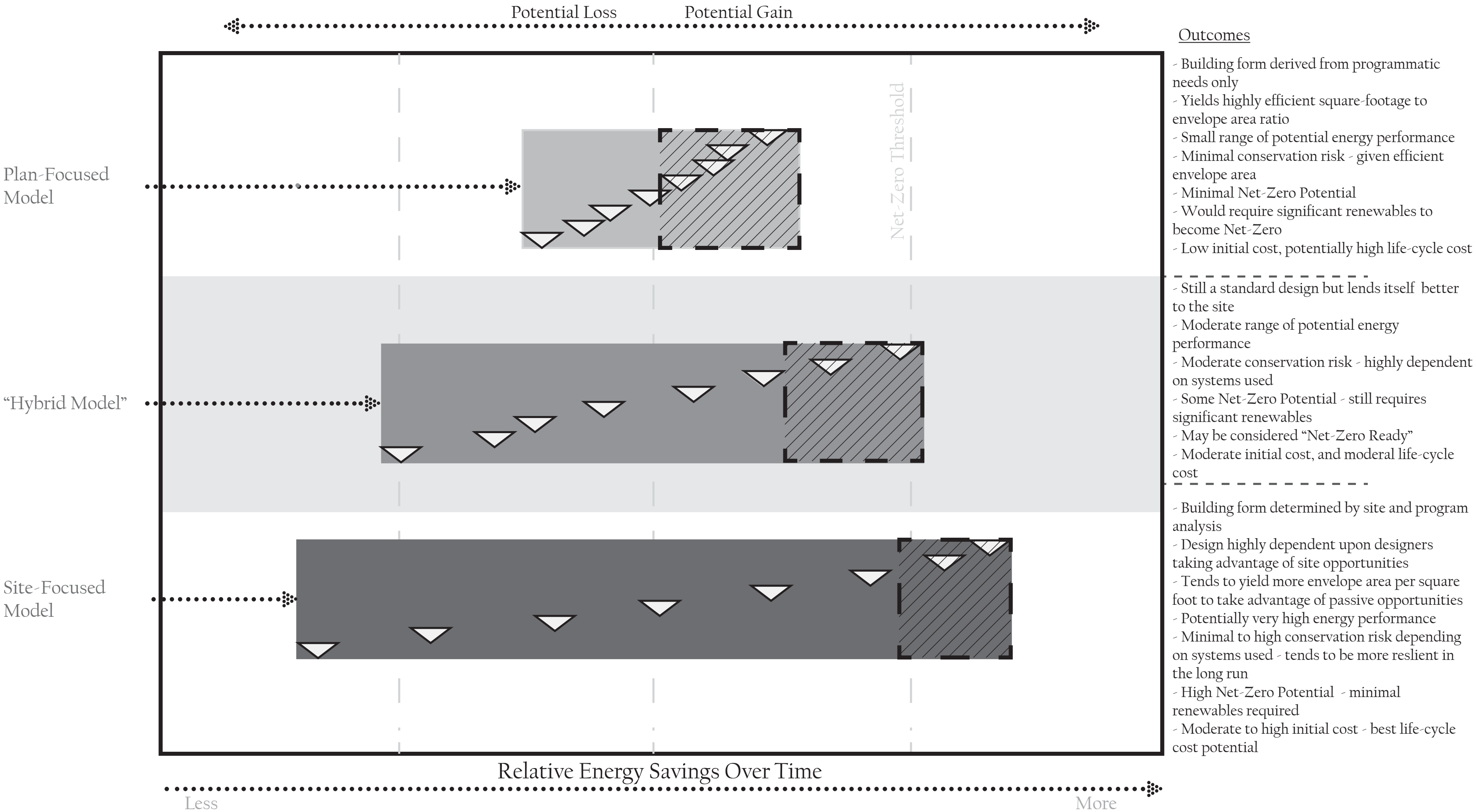
This study dictates that failure to accommodate any one of these needs will yield less than optimal results for stakeholders and the pursuit of a Net Zero Installation by 2030. Under current practice, there is a disconnection between planning and design. This study recommends that the COS develop a more active role during the programming phase as the technical experts in order to provide preliminary site selection input aimed at ensuring proper facility orientation before the DD1391 form (programming document that locks funding) is finalized. This preliminary analysis can be further validated in the ENG FORM 3086 (system selection document, etc.) stage with additional energy modeling to confirm that the goals set for the project can be realistically met. If done correctly, this should significantly improve the reliability of the DD1391 and help manage risk to PDTs that receive project sites which do not consider facility orientation for energy goals, possible net gains, and social connectivity.

Furthermore, this study recommends a certain amount of flexibility in established standards to allow for balancing those aforementioned needs. Potential options to accomplish this are:

1. NARRATIVE BASED DESIGN STANDARDS.
2. MODULAR OR "KIT-OF-PARTS" STYLE FLOOR PLANS.
3. BLOCK AND ADJACENCY DIAGRAMS AS OPPOSED TO RIGID FLOOR PLANS.
4. HIERARCHICAL APPROACH TO DESIGN SOLUTIONS.
5. DEVELOPMENT, MAINTENANCE, AND DESIGN TEAM ACCESS TO AN ARCHIVE OF ACCEPTABLE FACILITY DESIGN SOLUTIONS.

Without this flexibility, stakeholders often become bound and bogged down by criteria and design challenges that have very little to do with the functional operability, cost, or performance of the building. Conveying requirements on a programmatic level removes the possibility that involved parties focus on unimportant details and assists designers in making reasonable choices during the conceptual energy modeling process for optimization of the facility on-site while still garnering buy-in from stakeholders. The 2030 Project team not only sees this flexibility as an imperative step in reaching Net zero energy goals, but also as a risk management tool for teams to stay on schedule and within budget for delivery of these standard facilities.

RISK-BENEFIT ANALYSIS MODEL OF SITE-SPECIFIC FACILITY OPTIMIZATION TECHNIQUES



Representative Energy Model "Run" or Design Solution

Potential performance assuming proper design, operations and maintenance

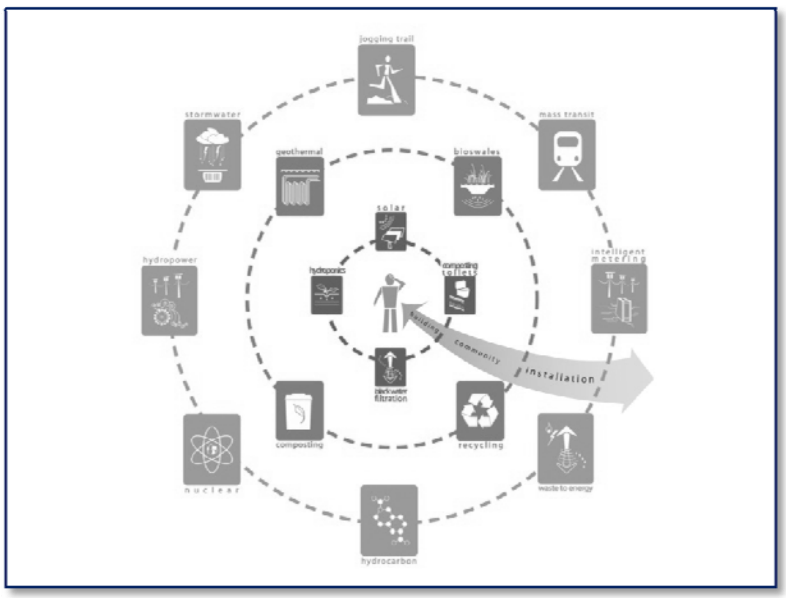
THIS DIAGRAM ILLUSTRATES THE RISK-REWARD DICHOTOMY OF SITE SPECIFIC AND SUSTAINABLE DESIGN. THE PLAN-FOCUSED MODEL IS THE "DESIGN IN A VACCUUM" APPROACH. EVERYTHING IS DONE TO ISOLATE THE INTERIOR DESIGN CONDITION FROM THE OUTSIDE WORLD. THIS YIELDS A DESIGN WITH A VERY PREDICTABLE PERFORMANCE, BUT WITH RELATIVELY HIGH ANTICIPATED ENERGY CONSUMPTION, AND LITTLE OR NO OPPORTUNITIES FOR SITE INTEGRATION. SUSTAINABLE DESIGN STRATEGIES ATTEMPT TO HARNESS ON-SITE NATURAL ENERGY SOURCES (WIND, SOLAR RADIATION, ETC.). SINCE THESE OPPORTUNITIES ARE VARIABLE, THIS YIELDS A HIGH RANGE OF POTENTIAL DESIGN PERFORMANCE. TO MITIGATE THE RISK OF POOR PERFOMANCE, SYSTEMS AND OPERATIONS PROCEDURES MUST BE IN PLACE TO HARNESS THE BENEFITS, BUT MITGATE THE DRAWBACKS OF THOSE NATURAL ENERGY SOURCES. IF THE DESIGN IS EXECUTED WELL ENOUGH - FOLLOWED BY PROPER OPERATIONS AND MAINTENANCE - THE POTENTIAL RISK OF HARNESSING THAT SITE ENERGY CAN BE DESIGNED OUT OF THE EQUATION.

2.0 The Solution: Net Zero by 2030

2.1 ORGANIZATION & USE

The 2030 Fort Leonard Wood Net Zero Implementation Plan has been developed to incrementally provide tailored means and methods by which Fort Leonard Wood may begin taking stock of and eliminating energy and resource consumption at multiple scales in order to effectively eliminate energy, water, and waste draws from outside the installation by the year 2030.

The 2030 Fort Leonard Wood Net Zero Implementation Plan is organized on several levels. There is a distinct hierarchical pattern by which suggestions and recommendations are made for implementation. This was done for several reasons, but the primary goal was flexibility. The project team holds the opinion that the greater the flexibility, the greater the chance that the plan will be executed and, therefore, the greater the chance to achieve the end goal of Net zero (energy, water, and waste) by 2030.



THREE SCALES SURROUND THE USER: MASTER PLANNING, AREA DEVELOPMENT, AND BUILDING. - IMAGE COURTESY OF HQ USACE.

First, this plan contains a chronological timeline. The timeline is organized in five year increments. This unit of time was chosen for several reasons while it provides a measureable increment of time for the purposes of planning. In the military, projections for facilities and funding look five to ten years into the future. The five year increment is short enough to provide firmly grounding resolution and anticipate challenges, but long enough to allow time to redirect resources in other directions if an initiative is hampered.

This timeline is written in a narrative manner to the greatest extent possible. The intent of this style is to comprehensively convey a holistic image of how the installation should evolve over time. It is not reasonable to anticipate each and every need to achieve this goal twenty years before the critical date, but by painting a gestural image, the installation's implementation team will have a better idea of the overarching goals of this study rather than segmented, individual, performance-based criteria that are certain to become flawed or obsolete over time.

Benchmarks described in the timeline include pre-2015, 2015, 2020, 2025, and 2030 and beyond. Each benchmark is organized as a chapter and describes master planning, energy, water, and waste efforts to be executed within each step. An initial fear in the development of this plan is the division of labor within the Army and supporting entities. The 2030 Project team expressed concern that this plan would be divided into discipline-based tasks and that there would be little overlap or integration of efforts. The perceived success of this plan is by virtue its integrated nature. Arguably, there is little to no chance that this initiative will succeed without an extremely high degree of coordination and integrated effort expressed by all stakeholders. For maximum benefit, each chapter shall be read in its entirety so that the installation implementation team can begin to identify synergies in the plan as it evolves.

Identified throughout this plan are technologies, systems, and practices that are crucial to achieving Fort Leonard Wood's net zero goals. These items are referenced in the document and elaborated on in section 8.0 *Reviewed Technology & Concepts (Tech Notes)*.

The Tech Notes supplement the gestural timeline by providing detailed descriptions of technologies and systems followed by tailored analysis for implementation at Fort Leonard Wood. This includes a cost of implementation, rough life-cycle cost analysis, and references to important outside resources. The list of Tech Notes includes a wide range of technologies including items that are underutilized at the installation and cutting edge technologies that are emerging from research to be installed in real-world applications. Again, each Tech Note was selected, written, and tailored specifically for consideration at Fort Leonard Wood, but that by no means indicates that the inventory of Tech Notes is exhaustive. Additionally, with some minor effort, the Tech Notes may be adjusted for other installations, industry, and private use.

Case studies of the AIT and BT Complexes are included in section *3.0 Building Specific Solutions*. These are intended to be detailed investigations and applications of the practices and technologies identified in the first two parts of this plan. It is the 2030 Project team's belief that these case studies offer a series of reasonable approaches to integrating plans and technologies at every level. These case studies may be referenced to infer reasonable approaches and applications to net zero design and construction at Fort Leonard Wood. The team attempted to accommodate both existing and projected aesthetic, programmatic, economic, and performance concerns in order to present only two of many options by which this complex problem may be approached. It should be made clear that the two designs presented are not the only solutions for the BT BCOF and AIT BCOF, but simply individual examples of integrated research and design.

All suggestions made in this plan are intended leeway for "plug and play." If a proposal does not seem reasonable at its given time, replace it with a more ideal strategy or system of strategies that accomplishes a similar task. If funding is not available a for a certain task or technology, the plan may be adjusted to delay the task a year or more with the knowledge of its impacts and that key benchmarks may need to be altered to accomplish the overall goal of being net zero by 2030. This document should be treated as a shared resource. It must be updated as strategic and design decisions are made, and kept as current as possible. By maintaining this living document, Fort Leonard Wood has a holistic strategy with incremental goals, suggestions, and identified incentives for becoming a net zero and resilient installation as it leads the Army into the future.

2.2 Pre–2015

Pre 2015 – Master Planning

The overarching solution for Fort Leonard Wood's infrastructure is to enforce the existing area developments through the development of a form based code that would lower traffic and increase safety. Initial efforts to move Fort Leonard Wood towards a highly efficient sustainable community shall enhance previously existing elements. Master planning schemes shall be coordinated as soon as possible and concurrently with planned utility infrastructure. The implementation of sustainability strategies, at any scale, affects all utility realms and strategies. Therefore, master planning initiatives shall have second order goals to synergize with other advanced systems planning and building design. It is up to the master planning team to ensure integration and facilitate the intent of the installation as a whole.

The major issues and vulnerabilities targeted at the master planning scale are:

Traffic Congestion:

"Rush hour" caused by high densities of privately owned vehicles entering or exiting the installation at the same time. Traffic is channelized into high-use intersections and access control points. The massive influx of people coming on base for graduations who must drive from ceremony, to parade ground, to the Post Exchange (PX), to restaurants, etc. creates bottle necks. Additionally, the aging infrastructure of the existing roadways are a safety concern due to limited sight distances, inadequate signalization, adjacent culverts, and heavy pedestrian use areas without sidewalks. Programmatically, the training centers being located on opposite peripheries of the installation with military traffic convoying to and from these centers several times a day creates unnecessary volume.

ENDLESS PARKING LOTS:

The parking lots are built to parking ratios much higher than private industry. The City of Portland typically allows 2.5 parking spaces per 1000 square foot of building area. However, the installation uses a ratio of 8 parking spaces per 1000 square foot of building area. This "design for the maximum" mentality created a sea of parking lots with spaces that are rarely used and encourage driving.

NOT ENOUGH PARKING WHERE IT IS NEEDED:

Ironically, because these large parking lots take up so much site area, they are isolated and spread out. This means that smaller buildings, whose programs do not warrant a large parking lot, become combined with a neighboring building. The occupants are thus forced to walk long distances across parking lots to reach their destination. The 2030 team witnessed several occasions where tenants would drive across the parking lot rather than walk.

DYNAMIC WEATHER CONDITIONS:

The tendency is that the weather conditions discourage alternative methods of movement such as walking, biking, and jogging. The weather fluctuation means that the occupants drive to each destination within the installation in case of a major storm system or change in temperature. Designing canopies or tree cover for protection alleviates congestion and supports alternatives.

INVENTORY OF EXISTING FACILITIES:

Over 600 existing facilities totaling approximately 10 Million SF of facility space (excluding range support, warehouses, and single family housing) that require substantial upgrades and resource consumption reduction to contribute to net zero goals.

DIVERSE SET OF POPULATIONS SUPPORTED BY THE INSTALLATION:

Fort Leonard Wood is at its core a training installation. The Maneuver Support Center of Excellence provides basic and advanced training for all of the Army's Engineer, Transportation, Chemical, and Military Police soldiers, NCOs, and Officers. As such, a large percentage of the installation's population is transient, staying between four to nine months. This poses challenges for occupant training. Another consideration is the fact that many of these soldiers do not have privately owned vehicles, so consideration must be given to ensure they are within walking distance to the needed services.

The next set of residents is the permanent party and families who are assigned to MANSCEN and FORSCOM units. They are typically on the installation for three to five years and pose their own requirements for proximity to services.

Additionally, Fort Leonard Wood is home to several Department of Defense (DoD) and Non-appropriated fund (NAF) civilians, as well as a large military retiree population who are accustomed to the rural lifestyle where "sustainability" may be a significant cultural shift. In some cases, these individuals are the most permanent contingent on Fort Leonard Wood and at times the most resistant to change.

However, the installation is set up by functional area to include a community center, shopping center, recreation center, work centers (BT, AIT, FORSCOM, MANSCEN, industrial area, etc), and residential centers (single soldier, enlisted family housing, officer family housing) which is leverage in the proposed solution.

2.2.1 Master Planning Instance Initiatives

The goal of the *Pre-2015* master planning initiative is centered on maximizing existing networks and introducing tested strategies. The Basic Training (BT) and Advanced Individual Training (AIT) programs at Fort Leonard Wood utilize a mass transit system (bus) to move large numbers of soldiers from one place to another. Although a by-product of a less than ideal sprawl of training locations, the use of mass transit prevents traffic congestion and positively impacts the installation by demonstrating that a large population at Fort Leonard Wood can effectively live, learn, and train without the use of a personally owned vehicle (POV).

TECHNOTE mass transit

Fort Leonard Wood is home to very distinct communities of both military personnel and civilians. The simple implementation of a civilian mass transit bus route should be introduced immediately, and can be achieved with minimal cost implications. The bus route is an opportunity for a public-private partnership (PPP) contract. It is recommended that the parameters of the contract require a private organization to provide buses, maintenance, fuel, and staff. The installation shall provide civil servants and troops with rider cards that act as vouchers for bus trips. The installation also pays for a pre-negotiated rate for rider cards. Visitors to the installation, friends, and families pay a market rate per trip.

It is recommended that bus operating staff members are trained in security protocol and can “clear” off-installation bus riders as they enter the bus. This would allow for an express entry to the installation through the access control point.

It is recommended that the installation partner with the St. Robert Wal-Mart and request joint use of the facility’s parking lot for installation commuters. The Wal-Mart is located directly at the intersection of Interstate 44 and Missouri Avenue (the main gate access road to the installation). The partnership is symbiotic because the parking lot is designed over capacity and is regularly empty during working hours. Commuters, by association, are likely to shop at the Wal-Mart due to convenience. This will increase the customer base and allow the installation to make use of an existing under-utilized resource.

Once on the installation, stops should be placed approximately ¼ to ½ mile apart at the nearest community or residential center. Studies show that pedestrians are likely to walk a 5-10 minute walk comfortably. Additionally, closer stops lead to longer ride times which discourage ridership.

It is of utmost importance that the attention paid towards mass transit be equally intended to produce high quality pedestrian zones that link communities.

2.2.2 Master Planning Area Initiatives

Specific implementations listed above must be supported by the completion of area development plans and studies on the existing status quo at Fort Leonard Wood. To effectively lay the ground work for this type of development and to improve upon existing conditions, a *Visioning Workshop* must be held to update and refresh Fort Leonard Wood's visioning statement. With a realignment of the vision for Fort Leonard Wood, areas may then be identified by the Garrison with consideration given for grouping communities and transportation routes into area development plans that utilize techniques commonly established by the Congress for New Urbanism.

It is recommended to adapt the existing master plan to account for the principles and requirements found in the Unified Facility Criteria (UFC) for Master Planning. Support for this effort can be found at the DoD Master Planning Institute (www.dodmpi.org).

Currently, heavy traffic cripples vehicular flows when soldiers must cross the densest cantonment areas which are served by the most restrictive streets. Master planners must be careful to consider how future relocations of soldier housing and training areas might adversely affect a "quick fix" of placing mass transit along existing high density traffic routes. Implement a mass transit route that easily loops the cantonment area such that future branches split off when dense areas are moved. Although the shortest route between officer housing and training areas is across the cantonment moving from east to west, the safest and most flexible long term route loops north and south to pass by future high density soldier areas. By planning for simple modifications in the future, master planners will provide a much easier transition for the users of the mass transit system.

The strategies mentioned for *Pre-2015* implementation address traffic and transportation. Once the installation initiates the bus system, pedestrians will populate the sidewalks creating a more desirable outdoor environment.

The installation must also diverge from the temptation to start with a clean slate on a new site on the edge of sprawling development; infill strategies must be considered for future development. Infill will make use of existing infrastructure and increase the density of the installation (which will develop synergies among buildings and increase the walk-ability of the community).

Aging utility infrastructure at Fort Leonard Wood must be modernized or replaced on an installation-wide scale. Similar to pedestrian zone implementation, what is currently a daunting task of massive utility reconstruction could be eased by incremental projects funded by infill development. When planning ahead for future development, using sites with buildings to be demolished and sites near existing infrastructure must be recognized as priorities.

Pre 2015 – Energy

2.2.3 Energy Instance Initiatives

At the instance level, immediate energy impacts can be realized by incorporating energy saving equipment and strategies into all current building projects including renovations and new construction. The retrofit of existing building equipment will reduce the energy use of the current stock of buildings while prioritizing energy performance in new buildings will position the installation to achieve net zero energy use. Each current project should also include provisions to install energy usage monitors in buildings to aid in data collection, benchmarking, and identification of waste.

Various energy conservation measures should be implemented in this phase, including occupancy / daylighting sensors, LED lighting, drain water heat recovery, glazing type, and solar hot water heating.

Interior lighting makes up approximately 20- to 30-percent of electrical energy usage in buildings. Installation of occupancy sensors in occasionally occupied spaces such as restrooms, storage rooms, and utility rooms, and installation of daylighting sensors in office spaces can significantly reduce a building's energy use. Additionally, reducing the lighting power usage reduces the amount of cooling required to remove the heat dissipated by light fixtures during the cooling season. New buildings should be designed to take advantage of daylighting.

Light-emitting diodes (LEDs) use a semiconductor diode to generate energy in the form of light. Current LED lighting packages can be used for various indoor and outdoor applications. However, the current range of products varies widely in light output and efficiency. Exit signs and outdoor area lighting are instances where LEDs can provide performance equal to conventional lighting at reduced energy and maintenance costs. Exit signs should be replaced with LED exit signs in existing buildings and designed for LED exit signs in new buildings. Outdoor lighting should also be retrofit or designed for LED lights. Lights should only be replaced when they expire; replacing capable lighting is wasteful and demands greater cradle-to-cradle energy.

Domestic hot water is heated from the groundwater temperature, usually 45-65°F up to a storage temperature of 140°F. The hot water is used (in showers and kitchen fixtures) and then discarded to the sanitary sewer system, taking the heat energy with it. Between 25- and 90-percent of the waste heat can be reclaimed through the use of drain water heat recovery coils to preheat supply water. This technology would be most effective in barracks buildings where hot water use is sustained over several minutes. Several shower drains can be combined to run through a single heat exchanger to reduce initial costs.

Minimum performance requirements for building glazing can be found for each climate zone in ASHRAE 189.1 Standard for the Design of High-Performance Green Buildings. Glazing size, location, and performance ratings should be specified to maximize daylighting, views, and winter solar heat gain while minimizing summer solar heat gain to support the integrated design of an energy efficient building. Shading features such as fins or eyebrows should be sized and placed to shade glazing from high angle summer sun while allowing low angle winter sun to warm the building.

Solar hot water heaters collect radiant energy from the sun to heat water for domestic or process uses. Evacuated-tube collectors are constructed of parallel assemblies of absorber tubes within glass tubes with a vacuum between to minimize heat losses. When freezing is a concern, a freeze-proof heat transfer fluid is circulated through the absorber tubes and moves heat from the panel to the domestic water system using a heat exchanger. Solar hot water heating systems can be retrofit on existing buildings and should be included in all new building projects where life cycle cost effective.

There are a few mandatory energy criteria with which new buildings must comply. Military Construction – Army (MCA) projects are required to meet the provisions of USACE Engineering and Construction Bulletin (ECB) No. 2011-01. The bulletin requires that MCA projects, depending on fiscal year program, achieve energy performance of 40-percent better than the baseline ASHRAE 90.1-2007 building and compliance with ASHRAE 189.1.

The installation should evaluate additional energy saving strategies that exceed the requirements of ECB 2011-01 to meet net zero energy goals. Such strategies include:

- Using integrated design to coordinate building envelope, fenestration, orientation, and electrical / mechanical design to optimize performance of energy saving features.
- Sizing and placing fenestrations and shading to use daylighting throughout the year while minimizing solar heat load in the summer and maximizing it in the winter for free heating.
- Using a solar hot water system to reduce water heating loads.
- Considering under-floor heating systems to increase comfort in the occupied zone while reducing energy used to heat stratified air near the ceiling.

The installation shall include provisions for installation of smart monitoring equipment with renovation and new construction projects. Tracking the amount of energy that each building uses will allow the installation to identify the best and worst performing buildings. Energy use data can be compared to design models to determine if the building is operating efficiently and as expected. Corrective action may include sealing the building envelope or replacing equipment but additional evaluation of energy conserving measures will also be needed.

2.2.4 Energy Area Initiatives

The *Pre-2015* stage should be a time that strides are made to take advantage of the most "convenient" energy conservation measures. In order to accurately assess current energy usage intensity, data must be collected and analyzed to establish energy consumption baselines. The implementation of Smart Monitoring Systems that compile energy consumption data gathered at the building level and transmit it to a central monitoring location would be vital in attaining these baseline figures. From a macroscopic view, energy baseline numbers from the entire installation would provide the opportunity for Fort Leonard Wood to analyze their power grid. Fort Leonard Wood's current utility situation places it in a vulnerable state and considerable analysis is needed to develop solutions. The relationship with their current utility provider in conjunction with the two substations slated to reach their capacities in the near future, makes the need for diversifying Fort Leonard Wood's utility infrastructure more apparent than ever. The power plant studies previously conducted size the plant based on the current needs of the military installation without considering any energy conservation methods that would be implemented at this phase. Utilizing the outputs from the Smart Monitoring System, energy needs of the base could be constantly tracked and the system could be sized more appropriately to account for measures of sustainability employed. The implementation of the analysis must occur at a time when the data collected would provide meaningful results. These results will aid in determining the installation's course of action when planning to incorporate elements of the upcoming phases.

Pre 2015 – Water

2.2.5 Water Instance Initiatives

The *Pre-2015* holds two distinct water issues to address: water efficiency with regard to potable water and stormwater management. For potable water efficiency on new construction, systems have been integrated into design through the use of the USGBC LEED rating scale that meet 30-percent or more potable water savings from baseline standards. New technology will continue to be used and implemented on all projects *Pre-2015* to ensure that water savings can be achieved through installing efficient fixtures in new construction.

With regard to potable water usage and greywater usage in *Pre-2015*, metering should be completed at all new construction and pilot greywater systems should be implemented. As of 2011 on Fort Leonard Wood, the only metering for potable water is a measure of how much water leaves the water treatment facility each day. Individual buildings do not have meters making it impossible to see the efficiency (or inefficiency) of the water system. All new buildings should have water meters installed as early as possible to begin tracking water usage. The water infrastructure is assumed to have some leaks, but without having data to show where water is being lost, leaks are nearly impossible to find unless significant damage occurs. Fort Leonard Wood should begin implementing greywater systems (example: Living Machines) as pilot projects in selected new construction. The difficulties and challenges derived from the pilot projects shall be resolved before the systems are implemented at full scale to all new buildings and retrofits beyond 2015.

Stormwater is a significant challenge on Fort Leonard Wood. As of 2011, under the Energy Independence & Security Act (EISA) Section 438, new and more restrictive stormwater laws have been adopted which require all new federal projects to retain the 95^{th} percentile stormwater. In order to meet these mandates, low impact development (LID) shall be required on all new projects as part of the *Pre-2015* stage of the project. This is a sustainable approach to stormwater management, designed to mimic the natural hydrology of the site and to increase water infiltration to plantings.

low impact development

TECHNOTE

2.2.6 Water Area Initiatives

During this phase, stormwater management should be designed in site layouts and incorporated as part of area development plans establishing larger stormwater features. These stormwater areas or “regions” should be in the design / planning stages before 2015. With this early planning, Fort Leonard Wood will be able to quickly move toward a more unified stormwater infrastructure that works cohesively as a full system as opposed to sites that all operate separately. The goals of stormwater management are to have systems working together to slow runoff rates and to provide cleaner water for downstream infiltration. A move toward more effective and more stringent erosion control plans and stormwater management during construction would begin in this stage. Fort Leonard Wood personnel must receive adequate training on erosion control to ensure that construction sites meet these standards at all times.

Pre 2015 – Waste

In general, waste has two primary characteristics of measurement: solid and liquid. Liquid waste is essentially tied to water use on the installation. Thus, the reduction strategies for liquid waste align with many water reduction strategies, such as low flow fixtures and behavioral use campaigns. Solid waste considers organic and non-organic waste from residential and mission sources. The *Pre-2015* Phase includes strategies that require the least amount of fiscal and infrastructure support, minimal time impact, and minor changes to policies, guidelines, and practices that return significant results. This stage will lay the foundation of future sustainable growth and, though some sustainable regulations have already been adopted, drastic steps must be taken beyond these comfortable levels to achieve a completely net zero waste installation by 2030.

2.2.7 Waste Instance Initiatives

The U.S. Army Corps of Engineers (USACE) has implemented sustainable building policy with increasing intensity. USACE Engineering and Construction Bulletin (ECB) 2010-14 mandated the application of select LEED credits for all Army construction. One of the required credits calls for 100-percent adaptive plant landscaping with zero potable water use. While integrated into FY11 contracts and beyond, inclusion of this requirement should be a fundamental principle of the installation design guide (IDG). As of 2011, the Fort Leonard Wood IDG allows various types of landscaping to be utilized on the installation. The IDG must adopt advantageously direct criteria, requiring all landscaping to be 100-percent native species. As areas around the installation continue to develop and change, this approach to each site should be employed, affecting non-USACE managed construction as well as renovation and infrastructure projects. Utilizing xeriscaping strategies and planting native flora will reduce erosion, maintain groundwater levels, increase water retention, naturally filter and absorb waste, and provide an inherently beautiful environment without the need for additional funding for landscaping maintenance. These efforts help to reduce primarily the liquid waste profile.

For individual facilities, requiring all new construction to have sustainable solid and liquid waste systems and components, such as high efficiency or dual flush toilets and waterless urinals, will maximize the efficiency of each building's waste system and provide precedence for future construction. Providing these high efficiency fixtures in new construction is already a requirement of ECB 2010-14 mentioned above. However, Fort Leonard Wood should enhance this requirement by employing these systems in all renovation projects as well, to systematically transition the installation's inventory. Establishing these standards now will increase opportunities to implement future sustainable practices, such as blackwater composting and harvesting.

Another basic physical change during this stage for solid waste mitigation will be that waste receptacles, trash containers, and recycling bins should be relocated to more accessible sites. Today, Fort Leonard Wood has only one location on post for recycling drop off. The new multi-waste units should be placed in strategic, convenient, and obvious locations, along circulation corridors, in residential areas, and near mass-consumption districts to provide ample opportunities to establish habitual use. Office complexes, residential neighborhoods, and similar structures which could be classified as heavy-consumption areas must have obvious opportunities to deposit their solid waste in the most efficient capacity. At a minimum, offices, medical complexes, each Post Exchange (PX), the warehouse district, the tenant district, and the garrison headquarters should all be fully equipped with waste and recycling containers. This effort can be easily combined with a recycling campaign (see *Pre-2015* Area Initiatives) as funding allows.

For Dining Facilities (DFACs) in particular, along with other complexes, composting systems should be initiated at this early stage. A common myth is that composting produces odor while, in fact, composting piles absorb odor when properly maintained and can be used as fertilizers for the installation. Though this is a relatively new operation for Fort Leonard Wood, developing the system at this time will ease policies and personnel into the process. All types of organic waste (including food scraps, biosolids, and meat) will be processed at each facility, making DFACs primary locations to instigate composting operations now, with other structures will be added in the future. A new contract should be developed to define and explain how the

various types of waste will be managed, who will be involved, their responsibilities, and the overall process to implement a base-wide composting program, put into practice at each DFAC. Standard Operating Procedures (SOPs) would also be generated in conjunction with the creation, design, and initiation of this program. The SOPs should be molded and solidified as each facility learns the process mandated by the installation.

2.2.8 Waste Area Initiatives

In the *Pre-2015* phase, an installation-wide recycling awareness campaign should be developed to begin to address the installation's solid waste load. This campaign will serve as a catalyst to jump-start Fort Leonard Wood's ultimate target of net zero waste. When polled, families Fort Leonard Wood did not know on-base recycling facilities existed. All individuals working and living on post should have ample exposure to recycling locations, policies, guidelines, and systems, and how following these guidelines aids them on individual and global levels. Educational training for all soldiers, civilians, and families on recycling, composting, and reuse programs should be created and implemented. Visibly promoting opportunities for recycling and challenging citizens to meet specific waste limitation goals may serve as another aspect of Fort Leonard Wood's approach. In more densely populated or high-use areas (i.e. heavy waste-consumption areas), adoption of this concept is a vital step toward waste mitigation success. As part of this campaign, the Fort Leonard Wood Department of Public Works (DPW) should conduct an initial study to determine the existing waste stream content and waste diversion rates to establish a baseline for future recycling and waste program modifications. It is expected that reduction will account for 26.9-percent and reuse will account for 2.7-percent of the total solid waste profile.

The reduction strategies for liquid waste mirror the reduction strategies for water. It is projected that combined with the water reduction factors mentioned, the total reduction from present day to 2030 will be 35-percent.

Fort Leonard Wood should also partner with the outside community to increase the efficiency of each existing, albeit limited, recycling program. Fostering this relationship and maintaining a dialog further opens the door to negotiating future changes to the entire network's recycling program and bettering both the installation and the community at large.

2.3 2015

2015 – Master Planning

Preliminary master planning initiatives must constantly be revisited and refined based on lessons learned and relationships to variables that have changed since initial development. Earlier strategies must be massaged at each phase to provide maximum benefit while new strategies are introduced into the community.

2.3.1 Master Planning Instance Initiatives

Fort Leonard Wood master planners will review the performance and implementation of *Pre-2015* initiatives. The interdisciplinary working group should review strengths and weaknesses and adjust the implementation plan to account for the lessons learned. The installation should use this opportunity to introduce the Common Army Master Planning System (CAMPS) for modeling future facility utilization. Despite ever-changing Army mission requirements and subsequently in training paradigms, general resource needs for a U.S. Army Training and Doctrine Command (TRADOC) installation are consistent. Considering the current needs of training programs and growth strategies for their curriculums, master planners will map future facility requirements for existing, planned, and potential facilities. As more bases implement CAMPS, the database will be loaded with data displaying how similar training advances affect facility usage. Many installations, particularly Fort Benning, GA, may provide examples, such as the Base-4D system developed in conjunction with HNTB that tracks facility occupancy and traffic concerns with GIS data.

The previously completed traffic study (2005) shall be updated in conjunction with the mass transit and pedestrian zone strategies. Quantitative data shall be gathered to determine how traffic flows have been altered due to the addition of environmentally friendly modes of transit being incorporated with park-and-ride lot locations off post, near the main and west gates, to encourage and help alleviate congestion at entry gates, main intersections, and heavily traveled thoroughfares on the installation. In addition to mapping future mass transit routes, the study will also show which areas of the installation shall be completely converted from vehicular to pedestrian or bike friendly routes due to a sharp decline in motor vehicle usage.

Infill sites that were noted as possible areas for future expansion should already be prepared for new construction projects in the *2015* phase. These sites should be improved with the replacement of old and inefficient utility infrastructure, construction of new rainwater management controls, and planned connections to mass transit and pedestrian networks. As installation stakeholders address functional needs for training and thus new construction, master planners will see areas where connections must be made between newly developed micro-communities.

A new strategy to be tested at this time is the development of self-supporting urban agriculture facilities. The construction of high density greenhouses at various locations across the installation not only provides fresh produce for dining facilities but also educates permanent residents on sustainable food production. As the benefits of urban agriculture are experienced, inhabitants of Fort Leonard Wood will begin to support the production of home grown foods and larger community gardens. Once established, these gardens can become composting centers and reduce the amount of organic waste sent to landfills.

2.3.2 Master Planning Area Initiatives

The visioning workshop held in the *Pre-2015* phase was a precursor to the Master Planning Practicum for the *2015* phase. This workshop will be held with all stakeholders present to create the illustrative and regulating plans for Basic Training ADP and the Advanced Individual Training ADP. The outcome of the practicum will be a tailored form based code, superseding any previous zoning established to provide guidance on development of these areas to most efficiently and effectively lay out available sites and maximize preservation of green space.

Based on the results of an updated traffic study, Fort Leonard Wood master planners and traffic engineers can now begin to modify, and in some cases repurpose existing roadways. It is anticipated that a successful mass transit system, now widely accepted by Fort Leonard Wood inhabitants will replace the need for a dense network of streets. Additional mass transit routes will be added to what should be very popular "MANSCEN" and "FORSCOM" routes which experience a high proportion of ridership. Although ¼ mile to ½ mile walks are traditionally accepted by mass transit riders, the transit system should be expanded such that exposure to extreme climates in the summer and winter are limited by users. While the mass transit system expands, existing roadways should be modified based on results of the traffic study to support one-way traffic in some locations. Each new element of transit, or modification to existing infrastructure, should be modeled to show a net gain in efficiency of traffic flow. The parade grounds in the center of the cantonment area shall serve not only as a functional site for graduations and recreation; but also, as a pedestrian node for direct routes across the installation. As this area becomes an integral part of the community, it must represent Fort Leonard Wood's 2030 net zero waste and net zero water goals. Planning for the urban park must begin in the *2015* phase, and be molded over time based on the results of other water and waste conservation strategies introduced at smaller scales.

2015 – Energy

2.3.3 Energy Instance Initiatives

During the *2015* time frame, energy saving measures that are integrated with master planning area initiatives can be incorporated into retrofit and new building projects. Hybrid solar technology can be used to increase the amount of solar energy harvested by collecting thermal and photovoltaic (PV) energy. Area-scale geothermal wells can be tied into building HVAC systems to provide higher efficiency heating and cooling systems. At the same time, energy saving measures mentioned in the *Pre-2015* stage should continue to be implemented in building retrofits and new building construction.

Two primary energy conservation measures would occur during this phase: hybrid solar and ground source heat pumps (GSHP).Traditional thermal and PV systems fail to capitalize on the total solar energy incident on building rooftops. Hybrid solar systems capture both thermal and PV energy in an integrated package to reduce space requirements and increase the amount of solar energy captured. Since these systems are installed as an integral part of the building roof system, they can only be installed in new buildings. Retrofits may be possible where roof repair or replacement is required.

Heat pump systems function as air conditioning equipment during cooling season and run in reverse to provide heat during the winter. Ground source heat pump (GSHP) systems use the relatively constant temperature of earth and water beneath the surface as a heat source or heat sink by connecting pipes that are placed in a grid of bore holes. The constant temperature allows the system to run more efficiently than systems using air or cooling towers as a heat sink or source. GSHPs must be implemented along with area scale well fields located under parking lots or green space. The GSHP unit could be located within each building or at a central plant to supply chilled or hot water for air conditioning, heating, and domestic hot water. As more well fields are constructed, nearby existing buildings should retrofit their HVAC systems to include GSHP systems.

2.3.4 Energy Area Initiatives

The Power Plant Study conducted by Burns & McDonnell only considered a few types of systems that would still be dependent on finite fossil fuels for electricity, as well as some renewable energy alternatives. In the *2015* phase, the approach will begin to pursue the systems that are considered advantageous to Fort Leonard Wood. These energy alternatives are more invasive but more sustainable than those of the previous phase.

The *2015* phase intends to add resiliency to Fort Leonard Wood's utility infrastructure. Employing power generation technologies, such as geothermal and waste-to-energy plants, reduces dependency on non-renewable resources and sets a higher level of utility versatility. Geothermal harnesses thermal energy from the earth using it for electric power generation while waste-to-energy plants use organic materials for power production.

During this phase, it is important to be cognizant of the effectiveness these systems have on Fort Leonard Wood's overall energy profile. The integration of "green" power sources coupled with the energy conservation methods from the *Pre-2015* phase should prove to be effective, not only in efforts to decrease dependency on utility providers who rely on fossil fuels for electricity generation but also, in efforts to decrease the overall energy consumption of the base. Phasing this implementation plan is vital. It allows Fort Leonard Wood to gradually introduce new technologies that work collectively to achieve their goals, but equally as important, the timing in which the technology is introduced will allow analysis to be conducted to monitor the collective impact of the systems installed. Progression along the implementation timeline is an indication that the deadline for the 2030 net zero mandate is drawing near and that the most aggressive measures for power generation and energy conservation are scheduled to be brought on line. The monitoring systems utilized in the earlier stages will provide the ability to properly identify the specifications of the system to be installed. An accurately sized system that is based on the needs indentified by the installation ensures that the system chosen will operate as efficiently as possible. Selecting a system using real-time data will eliminate possibilities of wasted funds on an oversized system as well as minimize the risk of selecting an under-sized system that will need to be expanded in the future.

2015 – Water

2.3.5 Water Instance Initiatives

The *2015* phase for water should start pushing the envelope with greywater systems. Pilot systems should have proven or be in the final stages of identifying what works best for Fort Leonard Wood. These solutions should be implemented in the majority if not all new construction projects. Water metering systems should be retrofit onto existing buildings and problem areas in the water infrastructure should begin to be identified at this time. Pilot launches of cisterns, green roofs, and rainwater harvesting systems should also be installed and monitored on some new construction. Retrofits of existing water fixtures with more efficient water savings fixtures will also be installed on existing buildings. Rainwater harvesting will help to achieve goals of both water efficiency and stormwater management.

Existing building retrofits include installing impervious disconnections and providing roof drains which flow across pervious areas instead of directly to gutters and out to stormwater conveyance. Privately owned vehicle (POV) retrofit parking areas should be assessed to determine if permeable paving, curb cuts, or bio-retention should be added.

2.3.6 Water Area Initiatives

For stormwater, low impact development (LID) should be implemented on all new construction (sites, buildings, infrastructure, etc.) on Fort Leonard Wood. Roadwork should progress toward expanding existing grass swales into bioswales. A stormwater management study for the entire installation will kick off in this stage. It should be installation-wide, but focus on stormwater in the cantonment area. The study will determine where a stormwater management area can coexist with parks to serve dual purposes as trails for residents and as a stormwater function to retain water on site as well as determine regional areas where water quality ponds and/or wetlands can be utilized to help with stormwater quantity and quality.

Water wells should be studied to determine the appropriate location and the redundancy of the system coordinated with the water treatment plant.

2015 – Waste

2.3.7 Waste Instance Initiatives

As of 2011, some of Fort Leonard Wood's Dining Facilities (DFACs) continuously prepare food that is then disposed of when troops training in the field do not return to post to utilize the contracted meals. Food production is based on a set quantity of meals per day regardless of soldier attendance. During the *2015* Phase, coordinating field training itineraries with DFAC food preparation schedules, ideally through an easily accessible and user-friendly database or network tool, will significantly reduce the frequency of this excessive and avoidable waste. Fort Leonard Wood should acquire and distribute the technology required to successfully track and coordinate field training unit's status with DFACs. Contracts with the companies responsible for operating DFACs must be modified to include requirements for deploying and managing the tracking system and for assisting the base with maximizing the use of this tool.

2.3.8 Waste Area Initiatives

In addition to trash collection service, a contract for recycling service should be activated, possibly in conjunction with community recycling services, in the *2015* Phase. As depositing of solid waste at the various locations throughout Fort Leonard

Wood becomes a habit, these contracts should be combined with the trash collection company, extended to a different business, or collected internally. Regardless, comingled recycling containers are recommended since this would be a new type of waste disposal for Fort Leonard Wood. Continual education of soldiers and civilians on installation recycling practices will increase the program's effectiveness in the future, when material-specific recycling pick-up options could be developed.

To be cognizant of the recommended solid and liquid waste mitigation systems, DPW should work in the next five years on monitoring and studying the waste stream content and waste diversion rates after implementing and expanding the recycling program. This information can be compared to the initial waste study from *Pre-2015* and analyzed as the campaign becomes more effective and regular. The base will have accurate documentation to make informed adjustments to the recycling systems and waste mitigation programs before and during the *2020* phase.

Also during the *2015* phase, a community construction material network should be developed. Potentially chaired by the local Chamber of Commerce, this initiative would be planned to connect local contractors to large construction companies who are contracted for many of the large installation construction projects. These firms are generally capable of being fully bonded for these large-scale projects, making them able to provide an acceptable product but with potentially limited local awareness, and higher costs to their companies and to the environment. As local construction companies are paired or partnered with these large firms, the local connection would greatly reduce CO^2 emissions and increase the economy of the community. Regional materials and labor could be procured by the knowledgeable local workforce and the larger firms would not need to constantly obtain costly travel for each project. The function of this network of contractors should be proposed and accepted by Fort Leonard Wood and the community.

A giant step toward net zero waste before *2020* should be the recycling systems, at all levels of activity, in place, managed, and monitored. Organizing these programs will maximize the initial resourcefulness of Fort Leonard Wood and the installation will be able to focus on more complex and involved opportunities to reverse the waste stream in the coming years.

2.4 2020

2020 – Master Planning

2.4.1 Master Planning Instance Initiatives

To ensure each community (scaled at approximately a 100-person development) is served by an urban agriculture center, greenhouses or landscaping with edible plants shall be added to existing DFACs. Community gardens and associated composting centers shall be planned in residential expansion areas, each serving up to thirty families. These centers shall provide the option to supplement groceries during the growing seasons as well as provide a place for community learning and social interaction on base. From a security perspective, social interaction amongst residents can increase safety through bringing people outside, raising awareness of surroundings, and instigating an informal neighborhood watch. The alternative to grow food on an installation is beneficial for resilience.

Mass transit changes shall be evaluated for effectiveness in reducing privately owned vehicle (POV) use on post. Development should be focused on infill strategies by selecting first brownfield sites followed by greyfield sites with the greatest consideration given to those located along highly traveled mass transit routes for redevelopment.

2.4.2 Master Planning Area Initiatives

The *2020* stage advances the planning charrettes to focus on specific area development plans. In this phase, area development plans should be designed via community stakeholders for the Community Core ADP, Fields ADP, and Graduation ADP. Again, stakeholders should come together for input and development of the illustrative and regulating plans that will inform the Form

Based Code deliverable. This is an important step as projects in the core of the cantonment area affect the connection and improvement to infrastructure across the installation with secondary impacts to energy, water, and waste goals.

Green street development should be introduced at Fort Leonard Wood during this phase as a combined stormwater management strategy that shall improve / create pedestrian and bike access, foster social interaction, and increase operability of mass transit. The first phase of green street development will occur at "The Loop" originating at the corner of Iowa Avenue and 4th Street, continuing east along 4th (Replacement Avenue) to Nebraska, south on Nebraska to South Dakota, and north on Iowa back to 4th Street. Completing this loop proposal is contingent upon Iowa Avenue changing to a one-way, south-bound street.

Green streets at Fort Leonard Wood are proposed to slow vehicular traffic, add bike lanes, and improve stormwater management with permeable materials and bio-retention cells, providing safe, walk-able sidewalks connecting pedestrian traffic between frequently visited areas. Bio-retention cells along green street development consist of low-maintenance native vegetation that collect and treat stormwater runoff and rainwater where it falls to recharge the groundwater and support delivery of cleaner water to the Big Piney River. This is a sustainable, natural systems approach to managing stormwater, reducing flows, improving water quality, and enhancing watershed health which mimics local hydrology prior to development.

TECHNOTE green streets

The urban park shall be further developed in this phase along with the stormwater overflow stream that runs through the recreation fields in the core of the cantonment. Further, the native plantings and trees shall be completed to improve the initial *2015* phase and help mitigate any erosion that may develop after removing the existing culvert system. This development will strengthen the core of the installation, providing connections to tie pedestrian and bike traffic from the converted green streets at "The Loop" perimeter through the central cantonment area. This park will encourage pedestrian traffic (as opposed to POVs used for travel on the installation during the day) and promote social activity in the central recreation area.

Mass transit systems in place shall be evaluated regularly for continual redevelopment and expansion when area development plans create changes in density throughout the installation. Bus stops should be positioned where supported by ridership.

2020 – Energy

2.4.3 Energy Instance Initiatives

In previous intervals, the standard of building construction has been raised to include many of the cost effective energy saving technologies that are available today. During the *2020* time frame, the process of retrofitting existing buildings to become more efficient and reduce the amount of energy used shall continue. Analysis of the building energy use data collected for the past five to seven years will help to identify which buildings are the least efficient and to identify them for renovation or replacement. In addition, new energy conserving technologies shall continue to be evaluated for use as they become available and, through economies of scale, less expensive.

2.4.4 Energy Area Initiatives

TECHNOTE nuclear RX

The *2020* phase is a period planned to deploy more on-site renewable energy system alternatives. Centrally located solar farms and a centrally located nuclear power plant will serve to add yet another layer of resilience to Fort Leonard Wood's utility infrastructure and will eventually decrease the dependency on external electricity (Sho-Me Power). With the installation of a "grid-tied" solar photovoltaic system, the electric utility is still engaged as the alternate source of power when the photovoltaic and other forms of renewable / stored energy are exhausted. In addition, the *2020* phase should be programmed to incorporate the use of a single modular light-water nuclear reactor. As currently planned, the nuclear power plant would serve as a primary source of electricity generation with the existing commercial utility grid remaining in place for redundancy (periods of downtime and maintenance) and to sell power back to the grid with the option of becoming net positive energy. The installation of the light-water reactor would serve as a conduit to provide Fort Leonard Wood the option to completely detach from the commercial power grid. The utilization of a nuclear plant and solar photovoltaic farms would require an intense amount of planning and coordination. During the planning phases, it is important to consider factors such as location, availability of land, environmental impact, and community education and acceptance.

2020 – Water

2.4.5 Water Instance Initiatives

During the *2020* phase, all greywater technologies and water reuse strategies, such as cisterns and green roofs, should be fully implemented on all new construction on Fort Leonard Wood. Existing buildings should transition to install water reuse and greywater retrofit technologies. Areas of concern for the water infrastructure on Fort Leonard Wood should be mitigated, and leaking lines identified and replaced. Water metering on all buildings should also be fully operational and effective to allow Fort Leonard Wood to monitor water usage per building and easily account for any issues. In *2020*, the installation should have the capacity to build new facilities with on-site water treatment capable of not using any potable water for any application in which greywater serves as an alternative.

2.4.6 Water Area Initiatives

The area development plans from *Pre-2015* should be under initial execution and the stormwater management study should be complete. Stormwater management for the initial ADPs will implement the recommended LID strategies. These new area developments should include the retrofit of all stormwater management features on existing sites to produce a more sustainable overall solution. These retrofits should range from impervious disconnections to demolishing existing concrete stormwater conveyance methods to much less invasive, natural conveyance using low impact development strategies.

2020 – Waste

2.4.7 Waste Instance Initiatives

The *2020* phase continues the progression of the *2015* implementation of the trash collection and recycling service. Education of soldiers and civilians on installation recycling practice shall increase the program's effectiveness in the future, where material specific recycling pick-up options should be developed. These education programs should be maximized with early childhood education to develop responsible students on the installation.

The community construction material network should be in early operability and require the review and adjustment to its process. Campaigns for increasing membership in the network as well as community reviews of the projected future building program should be held at regular intervals.

2.4.8 Waste Area Initiatives

In the *2020* phase, the integration of constructed wetlands shall be planned simultaneously with the blackwater harvesting systems. Typically, constructed wetlands are located on bounding sides or privacy sites of area development plans, but should be established for permanent use regardless of location. These will be placed throughout the installation to provide the most effective result with the least interference of prime real estate. Their primary purpose is to filter and clean the non-potable water (liquid waste) collected from blackwater systems for aquifer recharge. Wetlands contribute significantly to both the net zero water and net zero waste goals.

Since Fort Leonard Wood established a partnership with the local community for recycling in the *2015* phase, the installation should have strengthened the partnering bonds with the community. This intentionally positions the installation to partner with the surrounding community for a forest harvesting program in conjunction with a Waste to Energy (W2E) system. Waste to Energy utilizes pelletized or compressed feedstock (solid waste) for gasification, converting waste into energy or electricity. Since several hectares of potential forested land are available on or near the base, this plan must allow for both the consumption and generation of forests, where tree pulp would be used as a Waste to Energy fuel source in addition to waste produced on Fort Leonard Wood. This system will not only reduce the volume of waste and cost for its removal, but will also help the installation achieve net zero energy.

2.5 2025

2025 – Master Planning

2.5.1 Master Planning Instance Initiatives

Traffic studies shall be conducted again at the *2025* phase to follow up on previous study goals from the *2015* phase, which will account for any strategic growth areas and expansion of mass transit networks implemented in *2015*.

Urban agriculture and composting centers should be expanded to residential zones of similar scale across the installation, if found to be successful at locations shown in the *2020* phase.

2.5.2 Master Planning Area Initiatives

In the *2025* phase, charrettes must be initiated for MANSCEN ADP, Bowling ADP, and Education ADP with stakeholders to develop the Form Based Code for these locations on the perimeter of 'The Loop' to ensure they appropriately integrate the cantonment area and connections to adjacent area developments.

Additionally, green streets should be expanded from 'The Loop' to serve outer residential zones and less frequented areas. Development should be extended by continuing north on Nebraska to the proposed wildlife area and south on Nebraska along the curve to Artillery Circle. Green streets should be extended north on Iowa to North Dakota, looping back to Nebraska. The installation shall add green streets with tree-lined sidewalks and bike lanes on Evans Street, between Frizell and Turner Street, alongside the schools. Adding green streets to outer residential areas, to less traveled areas, and within large complexes should be planned carefully, considering feedback from the initial phase of construction for lessons learned opportunities.

Mass transit shall be continually evaluated and developed to serve ridership and maximize potential to integrate with the St. Robert and Waynesville communities. The focus shall remain on mobility by foot, bike, or bus and not personal vehicles to fully access the installation.

Pedestrian zones will continue to require maintenance, extensions, and updates to the urban park and conversion of streets to pedestrian pathways. This development should be evaluated and reestablished during area development planning to ensure pedestrian connections are utilized as planned and well connected for safety and ease of use.

2025 – Energy

2.5.3 Energy Instance Initiatives

Up to the *2025* time frame, most of the inefficient buildings should have been renovated to include more efficient features such as daylighting and lighting controls, passive and hybrid solar, appropriate insulation, integrated glazing and shading, and high performance HVAC. With the last set of building energy improvement projects taking shape during this phase, the final baseline requirement for installation renewable energy production will come into focus. Reliable energy use data collection over the past ten to twelve years should provide a clear picture of the energy debt that the installation must overcome to achieve net zero energy.

2.5.4 Energy Area Initiatives

The *2025* phase is a period of systems performance review. At this time, the phasing of energy conservation and alternative power generation measures is complete and the deadline for the *2030* net zero mandates is five years out. In year one of this five year period, establishing installation-wide energy use baselines that account for the contributions of all systems is the main priority. The Smart Monitoring Systems implemented in the *Pre-2015* phase will aid in streamlining this process and provide the installation with accurate energy use reports. In the event that Fort Leonard Wood is not a net zero energy military installation at this time, benchmarks should be set and the systems must be optimized to attain the prescribed standards of energy use.

The phasing to incorporate energy conservation and generation technologies into the Fort Leonard Wood utility grid is an iterative process of system deployment and analysis. Therefore, a similar approach should be taken in regard to closing the gap between the current energy standing and achieving net zero energy status. Optimizations shall begin with the systems whose outputs are capable of being modified by simple adjustments to the inputs. Exploring additional techniques to conserve energy and methods to collect more waste (waste to energy conversion process) are examples of simple manipulations of inputs that directly affect the system outputs and create noticeable impacts on system performance.

2025 – Water

2.5.5 Water Instance Initiatives

In *2025*, all new construction shall be net zero water ready, with any ongoing retrofits and developments underway. All construction shall meet the EISA 438 standards with ease due to the thorough stormwater management analysis and implementation deployed in the *2015* and *2020* phases.

2.5.6 Water Area Initiatives

By *2025*, all potable water on the installation that is not for drinking or food production shall be connected to the infrastructure for reuse as greywater. All toilets shall be tied to greywater systems or composting systems and all potable water use on base should have at least one type of reuse feature. Low speed, one-way green streets should begin implementing stormwater management and pedestrian access. These pedestrian hardscapes assist in making Fort Leonard Wood a walk-able installation. Bio-retention should also be planned for and installed on the ranges to help filter water contaminated with lead. LID practices should be retrofit into areas that were not part of area development plans completed as betterments throughout the installation. Grassed swales should be engineered to effectively infiltrate and slow down water by use of soil amendments and check dams. Over the next five years (2025 to 2030), Fort Leonard Wood should continue to move forward with new technologies that will help with stormwater management in unique and effective ways across the installation.

The 2025 phase should see the master planning study of the park area complete. The trail that is planned to follow the stormwater system through the installation should have a final and approved design and construction should be initiated. Parts of this trail / stormwater avenue should have areas designed for flooding during large storms. These areas must have detention volumes that allow for storms that do not meet the EISA requirements or the 10-year storm Army requirement. The detention areas must be designed for 25-year – 100-year storm flood levels. The trail and stormwater system will ultimately serve a dual purpose: as recreational enjoyment and as effective stormwater management.

Regional ponds and/or wetlands shall be constructed as part of the stormwater study. These water quality features will tie into existing stormwater conveyance strategies as well as new systems that will begin to be implemented as part of the study. These ponds shall be strategically located as stormwater management features, but should also exist to be assets to the installation for fishing, trails, parks, etc.

2025 – Waste

2.5.7 Waste Instance Initiatives

Most technologies for liquid waste reduction should have been addressed prior to 2025, primarily at the area development scale. However, in the 2025 Phase, plans for large office facilities (over 50,000 square feet) and high density buildings should begin to integrate on-site greywater filtration into their designs. A Living Machine type of greywater filtration system, if implemented in multiple developments, has the ability to account for 13-percent of the liquid waste profile. These systems will require some training and the costs associated with including these systems into larger buildings must be incorporated in the maintenance contracts. This greywater filtration systems inventory should be successfully implemented by 2030, contributing to both net zero water and net zero waste goals.

TECHNOTE living machine

2.5.8 Waste Area Initiatives

Installing moveable partitions in lieu of permanent, framed walls will reduce the materials and construction waste generated when buildings change purpose and must undergo modification to the layout for user function. This maintains the flexibility of building shells, structure, and systems while accommodating transitioning operations. An installation-wide standard should be created and mandated during the 2025 phase, requiring new facilities to be constructed with moveable partitions for all non-structural spaces. As new buildings are constructed or existing ones retrofit with these partitions, the DPW should develop or contract out an internal system of storing and tracking components. They should also acquire training for personnel to be capable of relocating these modules without assistance from outside expertise on a regular basis. Contracts should be modified to require these components in all new construction, and standard designs should be revised to accommodate this technology. As existing facilities are renovated, they should be updated to comply with this regulation.

Along a similar thread of moveable partitions, transforming Fort Leonard Wood's purchasing platform from buying products to leasing them (such as laundry equipment, cubicle components, and carpeting) maintains the flexibility of the installation while minimizing waste throughout its future evolution. Leasing equipment and products, such as computers, also allows for systems to be continually upgraded as technologies develop without sacrificing the premium costs of buying new materials frequently.

2.6 2030 + Beyond

2030 & Beyond – Master Planning

2.6.1 Master Planning Instance Initiatives

Infill strategies will be fully incorporated into area development plans to target improvements to existing aged infrastructure while also developing brownfields and greyfields with preservation of green space emphasized. Urban agriculture will be in place throughout the installation for sustainable food production in high density greenhouses at DFACs, edible landscaped areas, and community gardens to serve various community scales. Composting centers will also be present at established agriculture areas for diversion of organic wastes from the landfill.

In 2030, roadways converted to green streets throughout the installation shall enhance stormwater management with specified use of permeable materials and bio-retention cells. The low impact development strategy within green streets and urban park development shall imitate the local pre-development hydrology. This implementation will support Fort Leonard Wood's efforts to meet the Energy Independence and Security Act (EISA) of 2007 section 438 mandates that are typically difficult to achieve on a project by project basis. A fully functioning mass transit system shall be in place along highly developed routes with strong ridership verified through continued review and improvements to ensure lower vehicle congestion and reduction of personal-use vehicles and government / military vehicles used on the installation. Pedestrian zones that minimize heat islands and mitigate stormwater shall be in place along green streets, converted roadways, and through the urban park to create safe, walk-able connections across the installation encouraging pedestrian over vehicular flows.

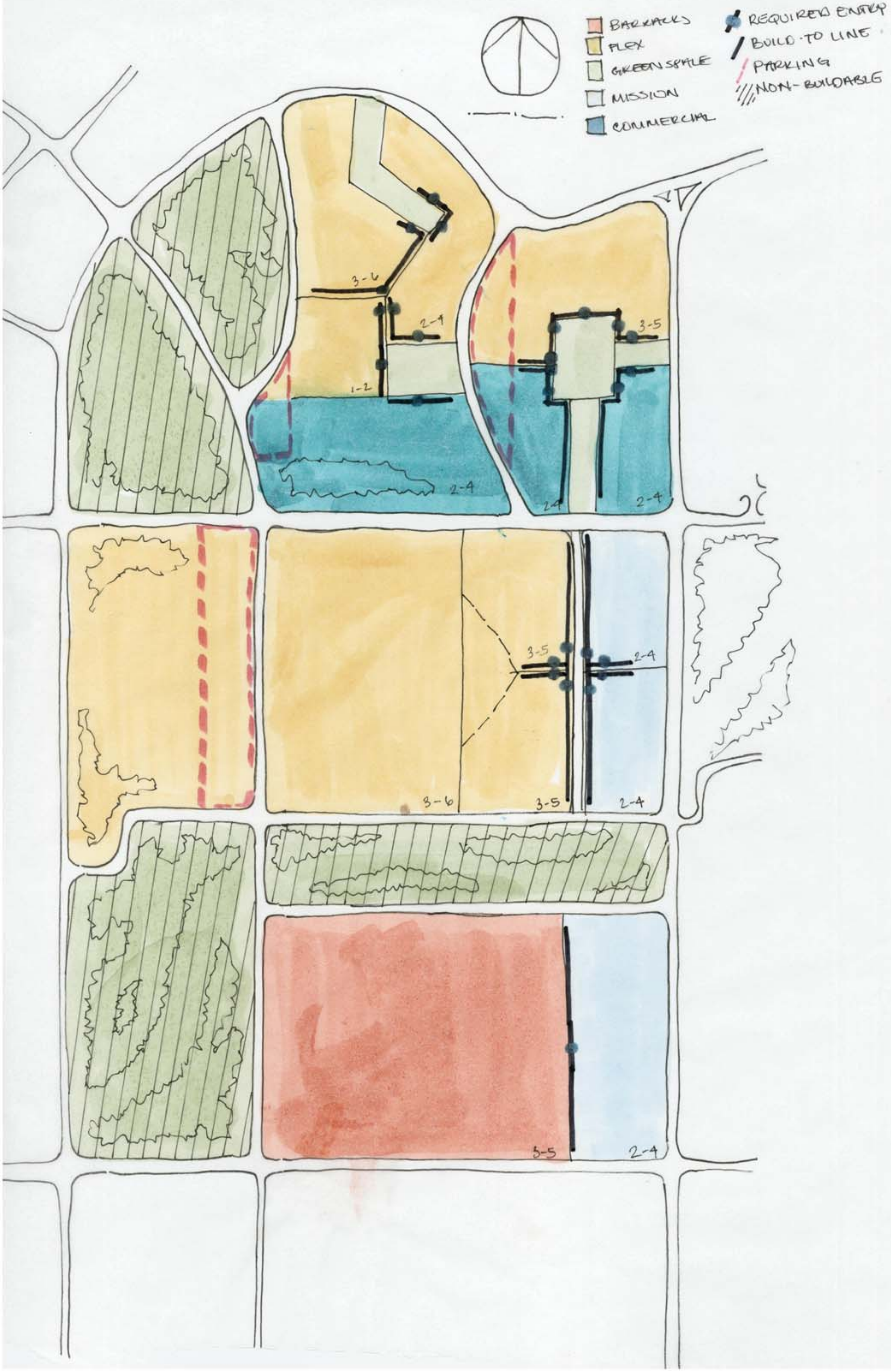
2.6.2 Master Planning Area Initiatives

The 2030 Project Team consulted with the DoD Master Planning Institute to learn the application of great master planning techniques. Through several charrettes, the team developed long-range illustrative plans and regulating plans that begin the discussion to develop a form based code. The intention behind these plans is to address the net gains achieved through infill development and offer a unique opportunity to view the application of the latest strategies that the profession of master planning has to offer on Fort Leonard Wood. Using these ideas as a foundation, the installation is encouraged to contact the Master Planning Institute and set up an area development planning charrette for both the BT and AIT ADP to include the community and installation stakeholders in the practicum.

> "These plans represent the fulfillment of the design vision as a snapshot in time – however, as the Army's needs grow and change the plan will need to change as well. In order to provide a framework for future growth and mission changes, a Form Based Code (FBC) was created as part of each ADP. The FBC provides a framework to examine the siting and massing of each new building and renovation project as they occur and ensures changes support the overall vision." – Fort Lewis Master Plan Digest

The Basic Training ADP Illustrative Plan

As with many rural communities, the typical planning model associated with development is sprawl. Fort Leonard Wood is not an exception. During the practicum with the BT users, a key complaint was the limited amount of parking. Simultaneously, the users argued that the buildings are surrounded by a sea of parking to the extent that the buildings are spread far apart and, thus, the participants admitted that they drove from building to adjacent building. This is a cyclical problem; however, this issue came about and is now perpetuating itself. This pattern is developed around a dependence on the automobile not the human. It is expensive upfront and more expensive in secondary


BARRACKS
FLEX
GREENSPACE
MISSION
COMMERCIAL
REQUIRED ENTRY
BUILD-TO LINE
PARKING
NON-BUILDABLE
3-6
2-4
3-5
1-2
2-4
2-4
2-4
3-5
2-4
3-6
3-5
2-4
3-5
2-4

costs as the process wastes land and consumes extravagant amounts of energy. See page 100 for the BT ADP Illustrative Plan.

The proposed solution develops the surrounding blocks with infill, structured outdoor recreation, or green space. The design strategy is to utilize low impact development as a privacy buffer to protect the BT Complex (BTC) from the distractions of the installation and assist the new soldiers in focusing on their introduction to military life. Across the southern portion of the BTC, an underground stream has been raised into a vegetated swale. This creates an opportunity for a jogging trail that will connect the cantonment area to the west side of the installation which includes residential areas for military personnel. In addition to adjusting the transportation plan to develop a network of one-way and green streets, the ADP stresses the pedestrian experience. This site is a fundamental part of the installation as it connects several BT Complexes with the graduation facility and the parade fields. It is this transition that demands the increase in pedestrian use and the decrease in automobile access for the sake of safety and traffic congestion.

The Basic Training ADP Regulating Plan

The Basic Training regulating plan (page 101) allows for more flexibility than the illustrative plan. It ensures the overarching vision, goals, and design principles remain intact throughout the investment of the stakeholders and in the plan. Thus, through leadership evolutions and changes to mission requirements the regulating plan provides the flexibility to adjust the plan while still holding true to the original values. The regulating plan was instrumental in ensuring the buildings conform to an orientation that maximizes energy efficiency. The BT regulating plan makes use of the following spaces on this site:

- Barracks
- Flexible design
- Green space
- Mission facilities
- Commercial facilities

The plan follows a Savannah-like square motif in the north-eastern plot that connects the smaller partitioned plots with the commercial zone. The mission specific zone is protected by a designated green space. The block north of the BT complex is allocated as flexible design space to accommodate additional BT Complexes in the future or, if needed, can be converted to

TECHNOTE: mixed use development

commercial space. The building setback lines are defined on the east side of the blocks to enforce the definition of the sidewalk and create an intentional pedestrian walkway connecting to the southern graduation facility. This pedestrian walkway extends north to be received by the commercial and mixed use area. The adjacencies have been intentionally set to account for relationships between developments and to encourage walk-ability.

The Advanced Individual Training ADP Illustrative Plan

Safety and separation are concerns when abutting mission essential training facilities with residential neighborhoods. In this version of the illustrative plan, the 2030 Project Team focused on developing natural barriers, making use of the natural cresting of the topography along the south-eastern road and maximizing the potential capacity for the site.

The team emphasized the opportunity in renovating the existing site track rather than demolishing the track and rebuilding a congruent track on the southern tip of the site. Through the adaptation of the building program to account for the correct orientation the team was able to place the buildings at their intended capacity south of the existing track. This places the AIT BCOFs a short five minute walk from the headquarters and classroom facilities as well as parking and the dining facility. This iteration also directs the AIT BCOFs toward the existing AIT BCOFs built in 2012 and uses the parking lot and track as buffers for the residential neighborhood. The northern block of the site is a vegetated swale to account for the tremendous water flow across the site due to the downward slope. The existing framework suggests connecting a stormwater and culvert system to handle the high velocity water. However, concrete piping will only speed up the water and a retention pond would need to be developed to account for the quantity. By opening the area and developing a rain garden that structurally and naturally slows down the water, the site can diverge and store the water in rainwater cisterns for landscaping thus allowing the remaining water to infiltrate the soil to the aquifer below. The central development is intended to evolve into a pedestrian campus. Many of the parking lots have been designed for controlled access which will increase security in an area that is concentrated for military training. The southern two blocks have been reserved for green space as a privacy buffer and restoration area for wildlife. See page 104 for the AIT ADP Illustrative Plan.


EXISTING BUILDINGS
NEW CONSTRUCTION
GREEN SPACE

2-4
2-4
3-5
3-5
2-4
2-4
1-2
Barraks
Flex
Mission
Park/Square
REQUIRED ENTRY
BUILD-TO LINE
PARKING
NON-BUILDABLE

The Advanced Individual Training ADP Regulating Plan

The regulating plan (page 105) defines the boundaries of the pedestrian mall. The facilities are designed to face centrally with parking in the rear. This deliberate use of parking means that it takes longer to go back to the car and drive around to the next building rather than walk across the courtyard. This type of behavior modification makes the energy efficient behavior, like walking, easy and makes the inefficient behavior, like driving, difficult. The regulating plan addresses the following spaces on the site:

- Barracks
- Flexible design
- Green space
- Mission facilities

The installation should note that the 2030 Project Team determined that the AIT ADP was not an ideal location and efforts should be made to relocate the AIT Complexes, through phases, to the south-west portion of the installation nearer to the training areas. This site is best designed for an expansion of the commercial and residential sections. Thus, when strategically envisioning this area in twenty to thirty years, the area could easily be converted to a town center. The buildings should then be designed with a pedestrian scale in mind to ease renovation and limit the amount of construction waste placed on the community.

2030 & Beyond – Energy

2.6.3 Energy Instance Initiatives

In *2030*, the installation should own a stock of high-performing buildings, each of which use a fraction of the energy that standard buildings use today. Buildings that were built after *2015* should have been designed and constructed to integrate site, envelope, lighting, plumbing, and HVAC to take advantage of natural features and renewable energy sources while using minimal energy. Each building's energy use shall be monitored to identify potential areas of improvement including malfunctioning controls or equipment and possible targets of repair or retrofit. Energy shall be collected or produced at both the instance and area scales to offset the energy used by buildings, resulting in a net zero energy installation.

2.6.4 Energy Area Initiatives

In the *2030* phase, Fort Leonard Wood should be a military installation equipped with high energy performance buildings and own a utility infrastructure comprised of a vast array of "green" energy solutions. The *Pre-2015* stage included the introduction of a variety of different energy conservation methods as well as the implementation of Smart Monitoring Systems that monitor performance. The *2015-2020* stages were designed to deploy alternative sustainable power generation systems. The *2025* time frame was designed as a period of data analysis, adjustment, and system optimizations. Finally in *2030*, a holistic view results in the collective contributions of the various energy conservation techniques. The following energy production technologies employed should be realized: waste to energy conversion facilities, solar farms, and the nuclear power plant. These systems working in cohort will offset the total energy consumption of the base. With these efforts, Fort Leonard Wood shall be a net zero energy military installation in *2030*.

2030 & Beyond – Water

2.6.5 Water Instance Initiatives

All potable water use on site should be thoroughly monitored and all potable water used should be reused by a variety of greywater systems. At this point, only greywater reuse (no potable water) shall be used for flushing toilets, washing trucks, and irrigating the landscape.

2.6.6 Water Area Initiatives

By *2030*, the concrete channels and grassed swales on the installation should have been naturalized into low flow streams and bioswales. These sustainable water conveyance systems will slow stormwater, filter stormwater, and provide better flood management. All building areas should have low impact development features to direct stormwater and in most cases, multiple LID features to encounter the stormwater prior to leaving the installation. In turn, this shall produce water with a higher quality leaving the installation than previously discharged. All ranges should have been retrofit to combat potential lead contamination of stormwater heading to the Big

Piney River. Regional ponds and wetlands should be implemented on the installation, providing recreation areas that are also useful as stormwater features.

Through master planning, green streets should now be part of the installation, which also provides stormwater management as well as a more pedestrian friendly installation. The stormwater trail shall run through the post, which allows residents, civilians, and soldiers to jog or walk in a safe environment away from cars while also detaining large storms to ensure that flows leaving the installation do not overpower receiving streams.

2030 & Beyond – Waste

2.6.7 Waste Instance & Area Initiatives

By *2030*, individual buildings shall work in concert with the larger components of the installation to succinctly operate a planned and organized "reduce, reuse, recycle" process. Fort Leonard Wood shall be self-sustaining, with the strong capability of continuing to enhance waste mitigation strategies and technologies.

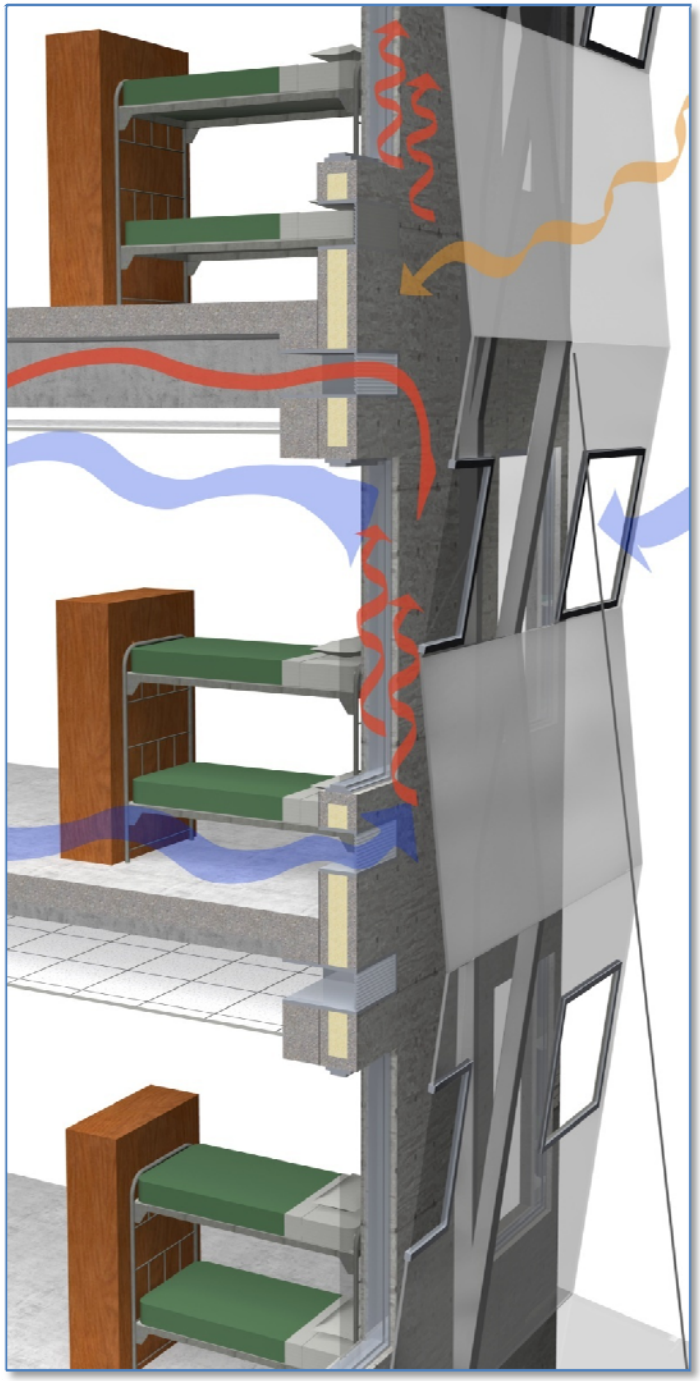
In the *2030* phase, all new and existing buildings should have been renovated or built with high efficiency fixtures, moveable interior partitions (in lieu of permanent interior walls), and other building type specific measures to fully mitigate waste production. In particular, dining facilities shall schedule food preparation to efficiently provide accurate amounts of food for soldiers, with any minimal extra portions composted on the installation. Nearly all temporary and/or flexible building materials (carpet, equipment, appliances, etc.) in all facilities shall be managed under lease contracts rather than purchased. This ensures the installation stays out of the business of storing furniture and equipment while simultaneously staying current with technology. Whether around structures or in open terrain, all landscaping shall be native vegetation, requiring little or no maintenance and ensuring waterborne contaminants are filtered naturally on each site. Also, greywater filtration systems similar to Living Machines will be located in larger facilities or building complexes, constantly increasing Fort Leonard Wood's ability to process waste and create usable products from waste. This will further reduce demand on a strained waste-water treatment plant.

By this point a very regular and practiced recycling program shall be in place. All possible materials on the installation (with very few exceptions), including everything from biodegradable flatware to construction debris, shall be either composted or recycled. All organic waste shall be composted on base, with fertilizer from the compost process used in installation gardening locations. Growing plants, as well as a portion of the food supply on sites throughout Fort Leonard Wood, shall be an inherent practice, providing potential employment opportunities for citizens and soldiers alike.

At this stage, a waste to energy program shall be underway, utilizing tree pulp and other waste products from the installation as fuel sources. Planting, growing, and harvesting tree pulp will be a constant cycle, encouraging community and base partnerships as well as providing further potential employment positions. Any true waste that cannot be processed on the installation will be offset by the supplemental efforts of other waste mitigation measures. Additionally, a community construction materials and labor network will be formed, working to ensure large construction companies are efficiently collaborating with local supplies and experts to prevent costly transportation of resources.

These strategies and techniques will continue to change and expand as the installation transforms. After fifteen years of planning, managing, overcoming challenges, and hard work, Fort Leonard Wood shall ultimately become efficient at waste mitigation, creating a net zero waste society.

3.0 Building Specific Solutions



3.1 PROGRAMMATIC BRIEF

Advanced Individual Training (AIT) complexes include living, dining, training, and administrative functions for soldiers who have graduated from Basic Training. These complexes are comprised of several different facilities that support the advanced training of recently enlisted U.S. Army soldiers. The facilities include combined Barracks / Company Operations Facility (BCOF), a Battalion Headquarters (BNHQ), a Dining Facility (DFAC), and additional support facilities. The facilities are generally built around the outdoor training area perimeter to create a micro-community that enables the battalion to live, eat, train, and work together with limited outside interaction.

Basic Training (BT) complexes are required by the Army to include living, dining, training, and administrative functions to properly introduce recently enlisted soldiers to the typical Army training scenarios. The BT complex facilities are very similar to AIT facilities that soldiers will graduate to after Basic Training.

AIT and BT complexes do not host permanent party personnel, but serve as homes to army trainees for the duration of their training program. Basic Training generally lasts ten weeks and provides a foundation on which enlistees will grow to become elite military personnel. At the conclusion of Basic Training, soldiers will rotate out of the BT complex and be replaced with a new group of basic trainees. The advanced individual training duration varies with specialty and is typically completed at the installation that hosts the corresponding army school. For example, Fort Leonard Wood is home to the Chemical, Engineer, and Military Police schools. Basic trainees with other specialties transfer to another base for AIT while some will remain at Fort Leonard Wood for the aforementioned schooling programs.

Compared to similar BT complexes, AIT complexes are more open to adjacent facilities due to the nature of the training program. Soldiers living here are allowed more personal time away from training instructors and are free to visit other locations on post without supervision.

The foci of this case study are on site functions of the AIT and BT complexes as well as the BCOF facilities in each which have the most impact on site development, cost, and energy usage at these complexes. Strategies, designs, processes, and commentary on these facility types should be found to be applicable for other installations, sites, climates, and facilities with similar functions.

3.2 Center of Standardization (COS) Program

The COS program was initiated in a time when the Army was transforming the traditional division-oriented structure of construction into a more brigade-centric, modular force as rapidly as possible while maintaining the war-fighting readiness of its operational units. This change brought unique challenges and opportunities in many areas including military construction (MILCON).

To facilitate the focus on construction, centers of standardization have been identified and serve as the technical and acquisition resources for the districts. These design centers employ contractual vehicles that districts use to fulfill installation standard facility needs. The standardization of facilities and processes has resulted in consistent engineering and construction applications that allow for expanding the use of all types of construction, and benefit the Army by providing a greater pool of capable contractors.

The standardization of facilities has also resulted in more consistent solicitations via standard Requests for Proposal (RFPs). This has reduced contractor uncertainty about requirements for similar facilities from installation to installation as well as provided for more productive time spent on proposals. Further, the standardization of product and facility types allows the Corps to focus more on actual construction and project delivery.

For example, centers are responsible for design refinement and for selecting, in coordination with Corps regions, a design-build contract primarily through regional Indefinite Delivery Indefinite Quantity (IDIQ) single source selections. When an executing district makes a request, the center issues a delivery order for construction to be managed by the district. With the center issuing the delivery order, the Corps expects a greater consistency in the building product. The centers also capture lessons learned and adjust processes based on feedback from the customer, the contractor, and the servicing Corps district.

When combined, these efforts to standardize facilities and processes result in greater consistency in the quality of construction and lessening of the risk to the contractor, which has brought the Corps closer to achieving lower costs in less time. (SWF website)

3.2.1 BT BCOF Standard Design

The BT BCOF is a building sized at approximately 64,700 gross square feet with an additional 10,700 gross square feet of covered training area. The programmatic areas of the building include four individual sixty to seventy-two person sleeping bays, plus latrines, classrooms, miscellaneous storage, and administrative components typically found in a company operations facility.

The standard design layout for a BCOF shows two wings, three stories in height oriented perpendicular to each other to create an 'L' shape with lengths of each wing at approximately 220 feet. This design allows for four individual groups of soldiers to share bunk space, a latrine, and one classroom. All the administrative functions that are used by training instructors are co-located in the core of the building, with direct access to the sleeping bays. Mechanical spaces and other storage areas are also located in the central core of the building while the latrines are placed at the far ends of each wing. The link between the core and ends of each wing is comprised solely of the sleeping area.

BT complexes include several site functions with which trainees interact on a daily basis. The predominant site feature is a quarter mile jogging track that encloses physical training and combat pits and is augmented with additional outdoor areas for pull-up bar sets and minimal hardstand areas. Generally speaking, the preferred site plan uses five BCOFs to enclose the training areas to create a sense of community, security, and to develop a physical complex boundary.

3.2.2 AIT BCOF Standard Design

The AIT BCOF building is sized at approximately 93,000 gross square feet which accommodates separate sleeping units, central laundry areas, educational classrooms, and a few administrative offices. Each sleeping unit is designed to house two soldiers and includes a private bathroom and individual closets for each. At times of peak soldier population, the unit can accommodate one additional soldier.

The standard design for the AIT BCOF is presented as three stories of a double loaded corridor with fifty individual sleeping units per floor, for a total trainee population of 300 during typical training scenarios and a maximum capacity of 450 trainees. The ground floor of the building is comprised of a central administrative core and shared support spaces for the sleeping units, including a day room, laundry area, and computer lab which trainees use regularly. Additional administrative areas and private bathrooms are also on the ground floor but are only used by training instructors. The upper floors reflect a similar layout to the sleeping units and shared spaces of the ground floor, but only provide one small office for instructor use.

Although extremely efficient from a cost perspective, the lengthy double loaded corridor does create issues for optimized site adaption. With a three story massing approximately 60 feet wide by 440 feet long, this building is typically squeezed onto sites with little respect to solar orientation, social connectivity, or human scale. Fort Leonard Wood's first implementation of this standard design placed four AIT BCOFs with the broad side of the building facing almost due east and west, which is extremely inefficient in this climate and severely limits the opportunity to select efficient mechanical systems.

AIT complex site plans are typically driven by the BCOF buildings with the dining facility and battalion headquarters programmed in "leftover" spaces. Conceptual site plans provided by the COS require that shared facilities are centrally located with site boundaries implied by the BCOF structures, but all areas must be within a ten minute walking distance of each other. Physical training pits are typically located within the quarter-mile running track and some parking is provided.

3.2.3 Re-design Goals

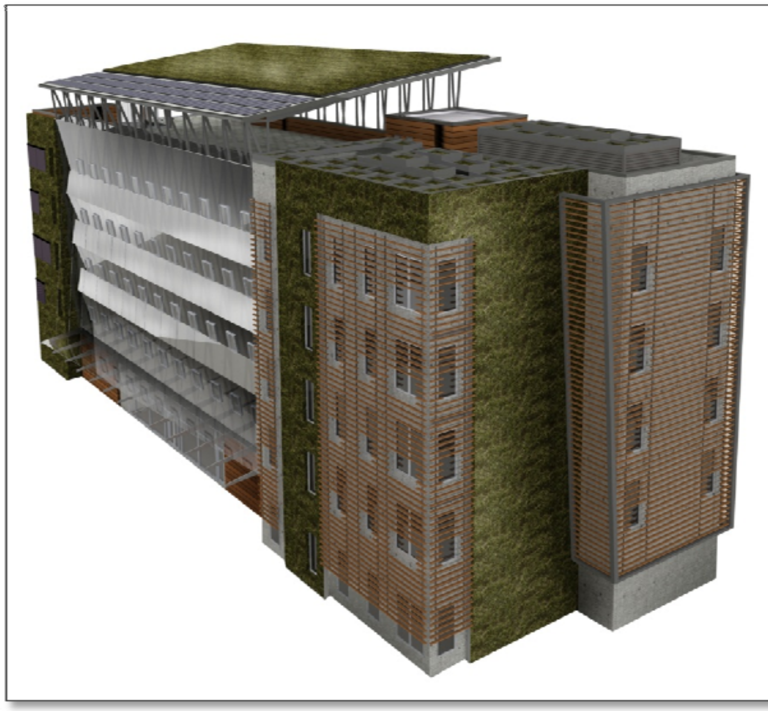
For both the AIT and BT complexes, preliminary analysis of the BCOF standard design floor plans indicate that optimized solar orientation is difficult to achieve given large expanses of exterior walls that may face all cardinal directions. This inefficiency is further compounded by the fact that most installations are investigating infill strategies and have extreme site constraints. These site constraints have led to site plans and building orientations that serve the function of AIT and BT complexes well, but have not engaged in energy and environmentally friendly practices. Unfortunately, current Army master planning policy only allows planners to issue one site to the project delivery team (PDT). Typically, the PDT can only request a new site if the given site is functionally a failure and workarounds are cost prohibitive. There is no comparative analysis done by the project delivery team on the *best* site with consideration given for orientation, scale, and connectivity. One of the overriding goals of the 2030 Project team and the re-design sub-team is to develop conceptual floor plans and building massing that lends itself to adaptation at any latitude for appropriate, and optimized solar orientation. The Army will gain the full benefit of the COS program only when the COS issues malleable design programs (not rigid floor plans) that can be adapted to site constraints and still allow for the greatest energy and environmental efficiency, social connectivity, and opportunity for repurposing. The purpose of the COS is in providing mission essential design intelligence to best serve the customer. Regional design strategies are best left to the district PDT. The marriage of the two entities, with the COS guiding the function and the PDT guiding the form of the building, is a force multiplier.

As previously mentioned, the functions of the current BCOF designs have been rigorously studied and tested in training atmospheres. The buildings' layouts allow for instructors to have direct interaction with trainees at all times. A clear definition of space exists, which builds teamwork among trainees and gives each group a sense of ownership of their space. The Center of Standardization (COS) adjacencies are to be kept to the maximum extent possible for both the AIT and BT BCOFs, with only slight modifications directly related to energy conservation and benefits to the quality of life within the spaces.

Life cycle cost is an important decision making tool when designing facilities to achieve future goals of net zero energy, water, and waste. Rather than apply "known" or "tested" technologies that have been successful on other facility types, this team paid careful attention to applying appropriate sustainable technologies to the BCOF facilities and each specific site. The important key is that there must be a net gain to the design goals and, thus, an energy consumption decrease when selecting any design system or technology. Innovative systems are numerous but synergizing their benefits must be delicately designed and implemented to existing functional programs.

The end state goal of a net zero installation can only be realized through systematic implementation of energy efficient and sustainable technologies. The installation metrics are merely a representation of how each individual facility is performing. Therefore, this re-design intends to immediately reduce energy consumption in facilities before installation-wide initiatives are begun. When the initial necessary energy inputs decrease, the challenge of reducing overall energy use to zero becomes easier.

3.3 BT Complex Re–Design



CONCEPTUAL RENDERING OF BT BCOF REDESIGN. - IMAGE COURTESY OF HQ USACE.

3.3.1 BT Complex Site Design Elements

The proposed BT complex site is on previously developed land with barracks buildings spread across the site. The proposed area is well within the boundaries of the main cantonment area and is traversed on a regular basis by both military and civilian traffic. As the installation moves forward with proposed master planning initiatives and applies the ideas presented in this document, this area development plan shall be in-filled with many upcoming military construction projects. Additionally, building footprints must be minimized to restrict the adverse affects of impermeable surfaces. The construction of new buildings to replace older, inefficient infrastructure will reap cost savings through utility bills. However, erecting long-lasting structures that can be repurposed with minimal renovation dollars is far superior.

The urban park concept that will be applied to the parade grounds of Fort Leonard Wood will be a large-scale project managing rainwater but will also educate Fort Leonard Wood inhabitants. By using vegetated swales, bioswales, and some areas of impervious deconstruction near the BT site, rainwater that carried sediment into potable water supplies is slowed to allow percolation back to the earth. Since the BT complex has covered training areas, it is very likely that training in open areas will not take place during weather events. Therefore, the combat training pits have been design as detention basins that will slowly release water after an event. These detention basins require minimal maintenance and assist in lowering costs by consolidating funding.

To effectively manage rainwater events more intense than the typical two-year design storm, off-site improvements must be made on all new construction projects. For the BT complex, complete redevelopment of rainwater infrastructure on sites to the west should prove costly and too far out of the scope of this project. However, while the adjacent site awaits future construction, the development of the BT complex has provided a bio-retention basin to assist in effective rainwater management.

3.3.2 BT BCOF Architectural Design Elements

CONCEPTUAL RENDERING OF BT BCOF REDESIGN. - IMAGE COURTESY OF HQ USACE.

The BCOF re-design starts with a preliminary concept of maximizing energy savings potential by using passive solar design. The standard design 'L' shaped building is reshaped to be one linear form with multiple stories. By orienting the building along the east / west axis, heat gains are reduced in summer and increased in winter. Functional adjacencies present in the standard design have been maintained with only slight changes to the administrative functions originally found on the first floor.

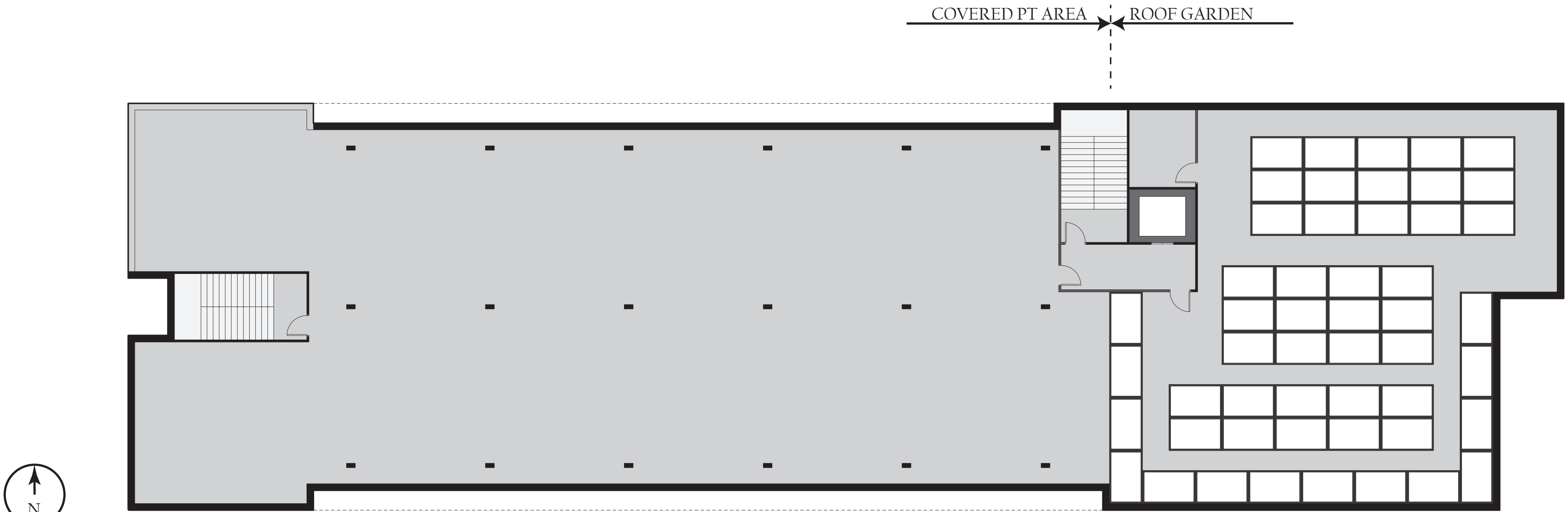
The pre-existing side-by-side relationship between groups of soldiers has been altered to a stacked scenario. The original design has latrines placed as far apart as possible on each floor which required some redundancy in mechanical and plumbing systems stretched several hundred feet away from each other. Stacking the bays allows for similar functions to be much closer together, simplifies the integration of sustainable technologies, and further reduces cost. For example, solar hot water collectors transfer water to one central storage area that is co-located within the stack of latrine spaces. Piping runs are minimized and subsequently so is the heat loss from lengthy pipe runs.

To further enhance the passive solar design, a large trombe wall was placed on the southern façade along the sleeping bays. During hot weather, this feature collects warm air and ventilates the interstitial space to reduce heat transfer into the building. During the cold, the system preheats intake air that reduces the amount of energy consumed to properly heat occupied spaces.

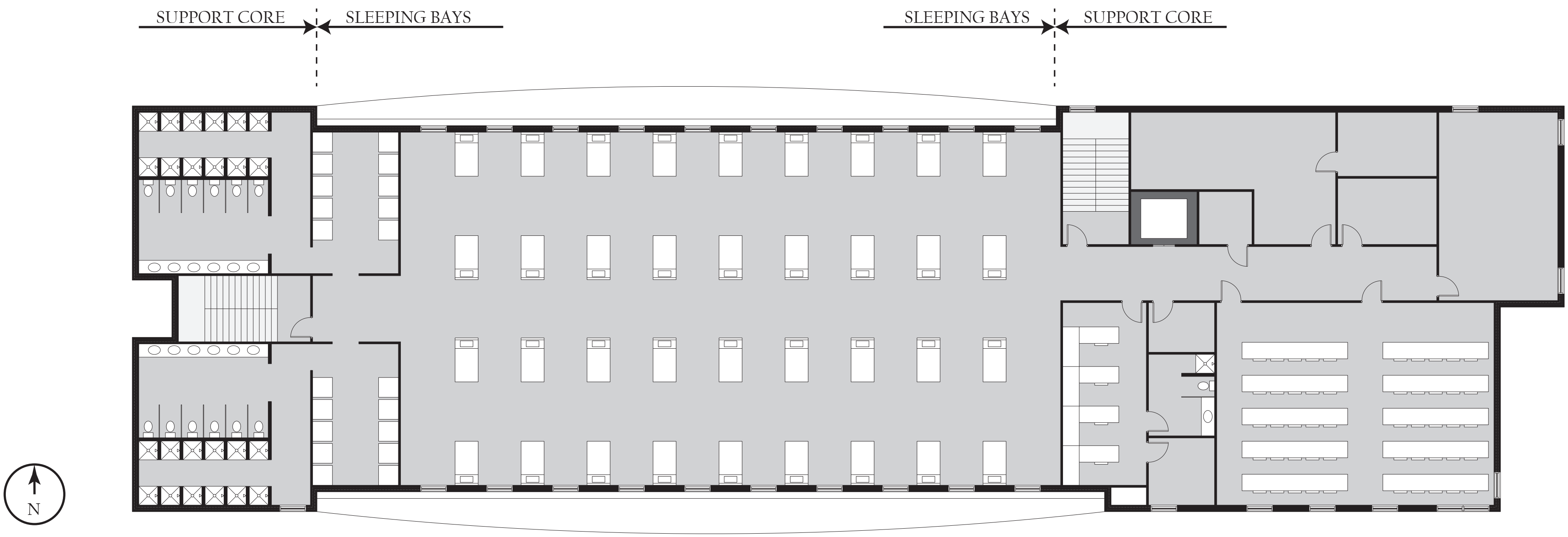
The trombe wall extends above parapets and creates additional covered training space on the roof of the structure. This space operates as half of the programmed covered training area which was removed when the wings were stacked. Additional roof features include solar photovoltaic panels, an accessible green roof, rainwater collection, and an urban agriculture garden.

The design team chose to exploit the function of the BT program and integrate a covered training area as part of the accessible roof space. Adding the two-fold climbing wall reduces the need for an adjacent climbing tower and adds justification for requiring strong, durable cladding. This becomes important in a climate that frequents high velocity winds, tornados, and hail storms. The skin of the building displays terra cotta tubes that shade the building from solar radiation as well as structural green walls that are low maintenance and have a high insulation value further protecting the building from weather damage.

Several additional strategies were applied to push this facility to net zero and possibly a future net positive energy producer. Installations of low flow plumbing fixtures and high efficiency distribution systems are small design decisions with major impacts. It is anticipated at this schematic design level that material procurement of recycled and locally harvested materials will also contribute to the construction of this facility, lowering its ecological impact.

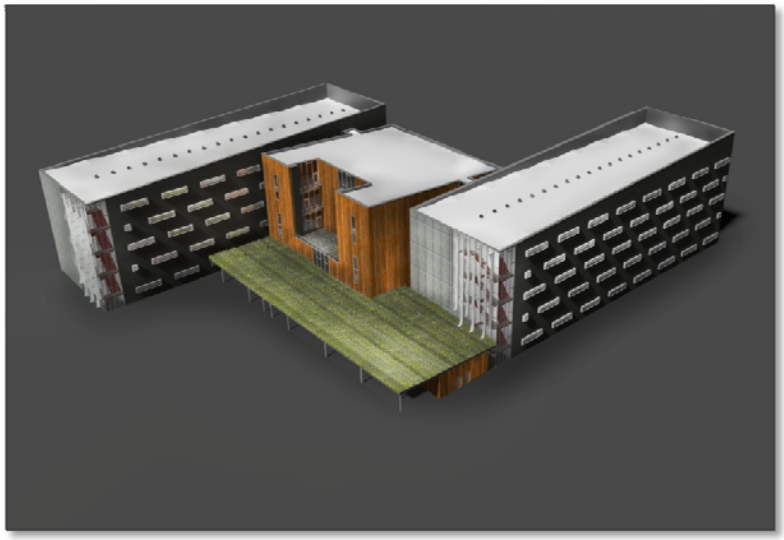


BT COMPLEX - BCOF
PROPOSED ROOF PLAN
SCALE: NTS



BT COMPLEX - BCOF
PROPOSED MAIN FLOOR PLAN
SCALE: NTS

3.4 AIT Complex Re–Design



CONCEPTUAL RENDERING OF AIT BCOF REDESIGN. - IMAGE COURTESY OF HQ USACE.

3.4.1 AIT Complex Site Design Elements

The proposed AIT complex site is just to the east of the Specker Barracks complex which will separate this development from the first phase of AIT redevelopment at Fort Leonard Wood currently under construction. Although the Specker Barracks currently serve as living quarters for many AIT trainees and will be demolished, some of the Specker facilities will remain at the completion of new AIT construction and will see phased replacement over the next decade. The proposed site is also unique in that it is bordered to the east by military family housing and to the north by permanent party housing. The AIT complex area development responds to these adjacencies by focusing on appropriate nodes and paths that will support walk-able and bike-able methods of human movement while acting as a transition zone.

Building footprints have been drastically reduced in this conceptual design. The density of the AIT BCOF has been doubled and leads to the necessity of only two BCOF facilities in contrast to the typical standard site design of four BCOFs. The two BCOF buildings have been clustered near the center of the site and frame a pedestrian corridor that connects family housing to the Specker area along a pedestrian mall. The battalion headquarters is placed to the south and the dining facility has been placed within the existing Specker complex by using an urban infill strategy. As appropriate master planning techniques are followed over time, the Specker complex will be replaced with other facilities and maintain a high density of built environment. These densities create interesting paths and intersections that will encourage pedestrian traffic throughout the site and connect permanent party personnel and their families to community activities along the parade grounds and parks.

The high density strategy also allows for much of the existing site to remain in place and actually provides a net gain in green space compared to a master plan that uses the standard design without alteration. The simple move to retain the existing running track and slightly modify an existing parking lot negates the need for extensive rainwater infrastructure replacement while maintaining the functional integrity of the AIT training concept. This also minimizes upfront costs by reducing the site development requirement of a new track. Additionally, future capital costs are saved in the real property realm because the intended track site remains open for future development. Lastly, by consolidating the site, the density and in turn the walk-ability of the site is increased. The distance from each BCOF to the amenities is reduced making it more likely for pedestrians to utilize the sidewalks.

3.4.2 AIT BCOF Architectural Design Elements

CONCEPTUAL RENDERING OF AIT BCOF REDESIGN. - IMAGE COURTESY OF HQ USACE.

The AIT BCOF re-design has preliminary concepts developed from the site analysis of Fort Leonard Wood. The next phase of previously planned AIT development must be placed on a specific site on the installation, so the design team looked to maximize energy savings potential given robust site constraints.

Rather than continue with the standard design that portrayed one lengthy massing of sleeping units, the early concept increased the density of the footprint by a factor of two, and reduced on-site impacts by offsetting two wings of sleeping units that are separated by a central core of shared spaces. Although exterior wall areas are similar between this concept and the standard design, the use of a more compact, and clustered facility allows for a more adaptive building footprint for use with other sites and climates.

Programmed areas within the AIT BCOF have been maintained but now have greater density and efficiency when it comes to systems integration. In previous designs and planning, four large BCOFs would be spread potentially one quarter mile from each other as seen on the existing AIT site development on the east side of the AIT ADP. By combining the functions of two buildings, the mechanical and electrical distribution becomes less redundant and allows for more efficient systems to support dense facilities, reducing costs. For example, the clustering of laundry facilities can tap into centralized greywater recycling systems or rainwater catchment basins rather than maintaining four individual systems that miss the opportunity to share efficiencies. As seen in the AIT area development plan, this team's conceptual layout allows for the AIT BCOFs to be mirrored against one another allowing for even greater opportunities to share systems and resources. The form of the BCOF was developed to ensure that Drill Sergeants could have maximum purview over Privates with minimal movement. The charge of quarters (CQ) desk, at which the afterhours responsible party resides to watch over the building, is centrally located with a view of both egress stairwells. This was an important feature for the Drill Sergeants who requested that the building have transparency in movement so as to control the actions of the Privates.

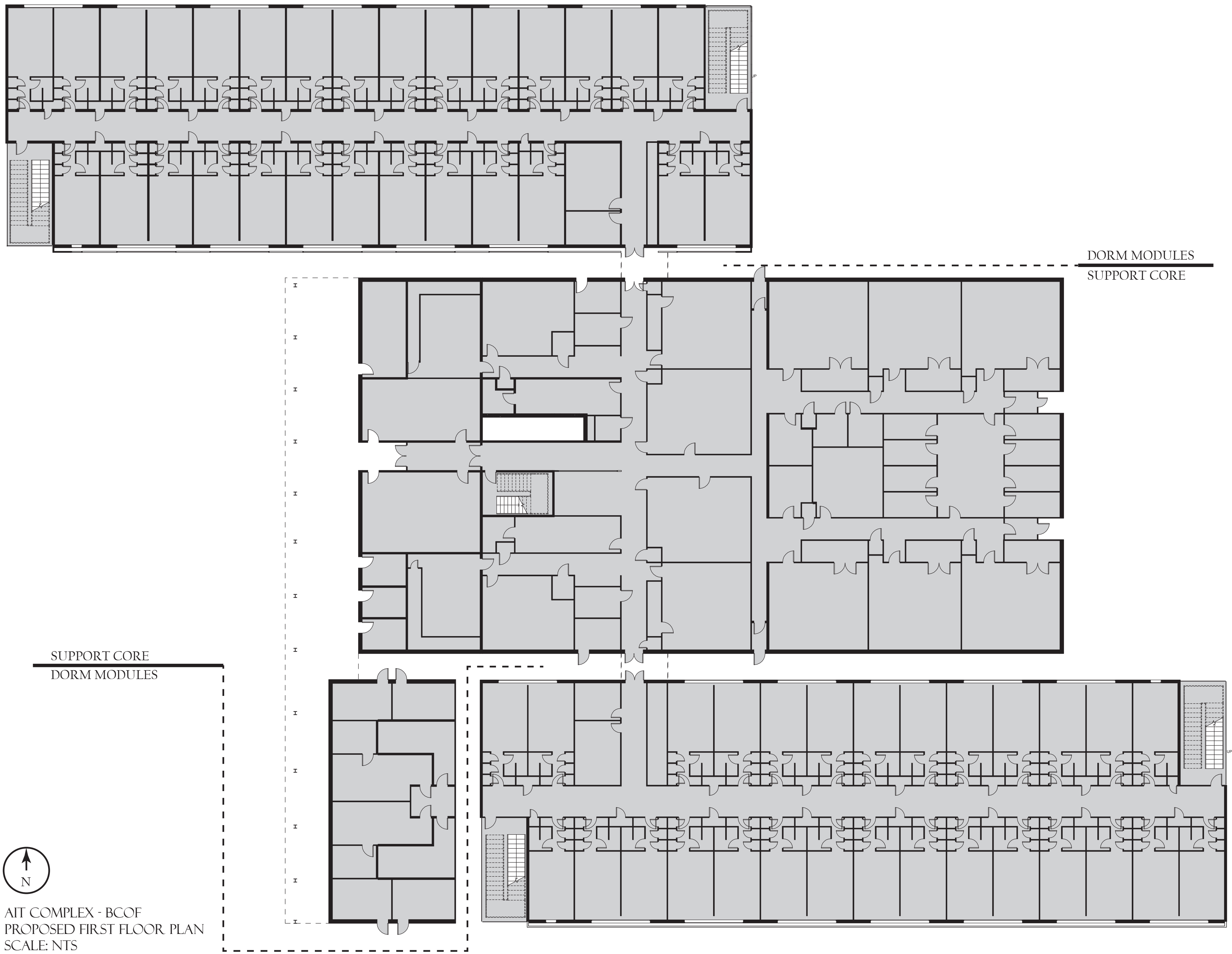
The uniqueness of the AIT BCOF and its layout of individual sleeping areas provide both challenges and opportunities for enhancing the lives of soldiers during training. Mechanical and electrical systems become inherently redundant when points of control are added and may become inefficient. This team's design distributes abundant natural light into all occupied spaces. Window sizing and proportion are determined and allocated in response to solar orientation. Large clerestory windows dance along the façades to allow light to wash the walls of sleeping units. Additionally, solar light tubes line the

TECHNOTE daylight collection

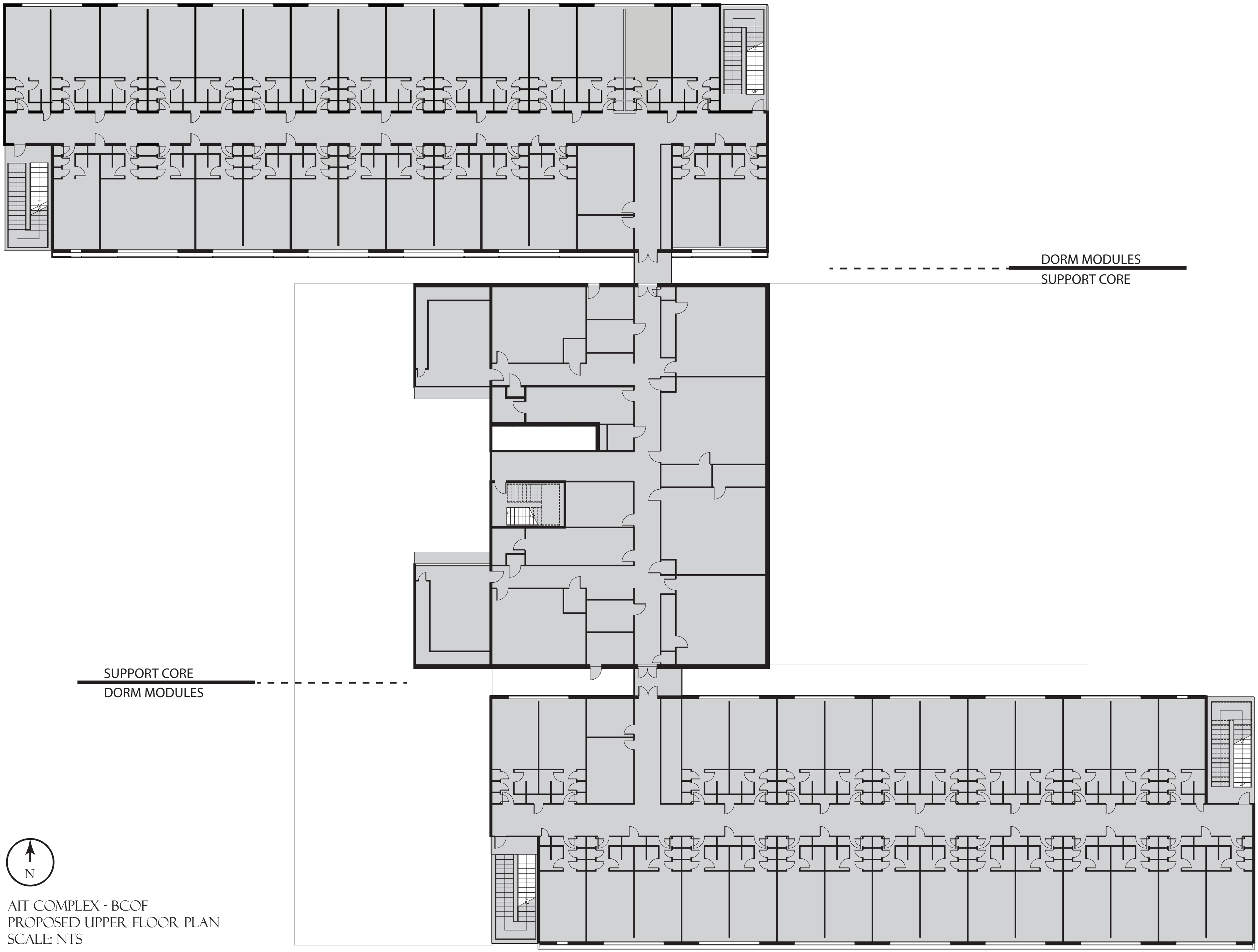
roofs and allow daylight to penetrate deep into enclosed corridors. These light tubes operate in concert with light sensors, further reducing the dependence on artificial light. Each sleeping unit is separated from the corridors by translucent wall panels that allow the lighting from the corridor to bounce between spaces. This strategy also assists in the function of training because Drill Sergeants need an implied connection to trainees despite their deserved privacy. Thus, when a Drill Sergeant enters the floor for the nightly check, the officer will be able to see any light coming from the rooms without walking down the hall; ambient light from the room is projected through the translucent wall panel and into the hallway. This is similar to the inverse relationship of projecting the light from the corridor into the room to assist in reducing the dormitory lighting needs.

To enhance the quality of life for AIT occupants, communal spaces such as the day rooms and laundry rooms have been placed adjacent to large openings in the façade or balconies to create views and connections to the surrounding sites and to maximize the gain from daylight.

The shift from an elongated floor plan to more centralized grouping of spaces requires that exterior walls perform at a higher efficiency given the harsh climate experienced at Fort Leonard Wood. The south-facing wall is intended to act as a thermal wall that collects heat and dissipates it as needed throughout the evening. North-facing walls have been designed using Concrete Structural Insulated Panels (Concrete SIPs) that can have a variety of finishes to work in an array of contexts. Sun shading devices are prevalent on all but the north walls to mitigate the harshness of early morning eastern and late afternoon western sun and glare. The sun shades were not included on the north wall because they are not effective in that location and excluding them equates to a cost savings. The sunshades in this example are fixed, but may be motorized at lower latitudes.



AIT COMPLEX - BCOF
PROPOSED FIRST FLOOR PLAN
SCALE: NTS



AIT COMPLEX - BCOF
PROPOSED UPPER FLOOR PLAN
SCALE: NTS

3.5 Mechanical Design Elements

The BT and AIT BCOFs serve as temporary lodging facilities for soldiers as they undertake their Basic Training and Advanced Individual Training courses at Fort Leonard Wood. The function and usage of these buildings is very similar to commercial motels or university dorms. However, since the occupants are enrolled in a highly regimented training program, the occupancy schedule and specific use of the building spaces is more predictable and specialized than what would be observed in motels or dorms. The predictable occupancy schedule simplifies operation of the mechanical systems and allows for more effective use of energy saving strategies such as temperature and ventilation setbacks. Overall, the mechanical systems were selected to support the overall building goals of providing a comfortable, efficient place for the soldiers to live and train while minimizing the environmental impact with respect to energy consumption, water use, and waste generation.

3.5.1 Mechanical Energy

The HVAC system is highly energy efficient through the use of geothermal wells as a heat source and sinks for the heating and cooling system. Within the building, water source heat pumps use the relatively stable temperature of the geothermal water to attain high Energy Efficiency Ratios (EER) during cooling mode operation and high Coefficients of Performance (COP) during heating operation.

Ventilation air is conditioned by dedicated outdoor air system (DOAS) air handling units (AHU) located on each floor. The AHUs will provide dehumidified tempered air to the spaces in the cooling season and tempered air in the heating season. Decoupling ventilation HVAC loads and supply air volumes allows the system to measure and modulate the amount of ventilation air as required to keep the building occupants comfortable and alert. The DOAS also allows the system to setback the ventilation rate to reduce conditioning loads when the building spaces are unoccupied. During the heating season, outside air will be preheated prior to entering the DOAS AHU through the use of passive solar trombe walls to reduce the heating energy required.

Individual sleeping units in the AIT barracks will be provided with comfort heating and cooling by individual room 2-pipe fan coil units (FCU). Each room will be provided with a thermostat to allow soldiers control of the temperature for their comfort. The 2030 Project team recommends application of a master control system that can be scheduled to override the individual controls at predetermined times each day. For example, the facility technician would be able to digitally and wirelessly lower the heating temperature to sixty-degrees at the end of a training cycle in the winter and re-establish control to the tenants at the onset of a new training cycle. This process will keep the building from being heated and cooled when not occupied. If cost effective, a secondary set of controls should be given to the occupying company to manipulate on days that soldiers will be training on ranges.

The regimentation of the BT and AIT course schedule requires that all of the soldiers in the barracks get ready in the morning and return home at night at the same time. The coordinated movement of building occupants out of and into the building leads to a surge in hot water usage during short periods of time. To recapture some of the energy used to heat the showers and dishwater being used, drain water heat recovery devices will be installed to preheat entering domestic water.

3.5.2 Mechanical Systems & Water

The closed loop geothermal well field being used for heat rejection during the cooling season is water efficient compared to a cooling tower which would be continuously evaporating water into the atmosphere. Since the system has a closed loop, the same water is circulated back and forth between the heat pumps and well field.

Domestic water use within the building is reduced by installing water efficient plumbing fixtures. Toilets that consume 1.28 gallons per flush (gpf) compared to the standard 1.6 gpf, sinks with aerators to reduce flow to 1.0 gallons per minute (gpm) compared to 2.2 gpm, and showerheads that provide 1.8 gallons per minute compared to 2.5 gpm are examples of the fixtures to be installed. Reduced hot water flow from showers and sinks will also reduce the energy required to heat water. The 2030 Project team does not recommend, at this time, the implementation of using solar water for showers in the barracks. Solar water is efficient when used slowly throughout the day. With the uncommon regimented demands of the occupants, the schedule dictates one-time use of hot water early in the morning. This will most likely purge the system of hot water resources instantly. Rather, and especially due to the abundance of geothermal heat, the 2030 Project team recommends solar thermal hot water for secondary uses such as sinks, dishwater, and food preparation and geothermal hot water for barracks showers.

3.5.3 Mechanical Systems & Social Impacts

Providing the soldiers with a comfortable and inviting place to rest and recover increases their ability to complete the training exercises they face each day. Individual control over their room temperature and adequate ventilation rates help soldiers to rest comfortably at night and wake up focused and prepared to face the day's training. A prominent comment in the Drill Sergeant practicum was the request for operable windows to reduce transmission of disease and increase productivity of soldiers.

A Building Management System (BMS) installed in conjunction with the HVAC Direct Digital Controls (DDC) system can be used as an educational piece to increase soldier awareness of their contributions toward energy and water efficiency within the building and the Army. Behavior changes resulting in energy savings can be shown in real time on an energy dashboard which tracks energy use by room or floor. For more information about behavior modification and dashboards, see section *4.7 Occupant Behavior & Dashboards*. Energy savings can be incentivized to change the soldier paradigm regarding energy use and create energy saving habits within the Army's soldier population.

3.6 Electrical Design Elements

3.6.1 Electrical Energy

In a typical energy use profile, building lighting systems will usually contribute 30- to 40-percent of the building's total electricity consumption. The remainder is comprised of HVAC equipment and plug loads. Although the percentages that create the building's energy use profile are not likely to change, the ultimate goal is to reduce the total amount of electricity that the building consumes. Providing a predictable occupancy schedule, installing programmable control systems, and selecting energy efficient lighting fixtures and equipment are elements of the BCOF facilities that will provide a cohesive approach to reduce overall energy consumption.

3.6.2 Luminaries' Selection

The T-8 fixtures selected for use in the AIT BCOF have a high photometric efficiency and a high Luminaries' Efficacy Rating (LER). When matched with high-lumen T-8 lamps and the appropriate energy efficient electronic ballasts, these luminaries can provide up to a 44-percent energy savings over the standard 3-lamp, 18-cell, parabolic fixtures, while maintaining the ability to supply Illuminating Engineering Society of North America (IESNA) recommended luminance levels. The energy savings are even greater when appropriate fixtures that utilize light-emitting diodes (LEDs) are applied. On average, since LED light fixtures are 100-percent efficient and operate at a lower input wattage, the LED fixtures save 5-8 watts of power when compared to the T-5 and T-8 fixtures. However, LEDs at this time may not be cost effective in some applications within the AIT complex.

3.6.3 Programmable Lighting Control Systems

The use of programmable control systems provide the ability to coordinate operation of interior lighting systems with building occupancy schedules and will also allow automated control over the operation of the building lighting system. Devices such as occupancy / vacancy sensors and daylight sensors which are incorporated to enhance system performance will be integrated into the control system and will be programmed to operate in a manner that maximizes reductions in electricity usage. The system can be programmed to dim to appropriate levels when the soldiers are not occupying the facility or when daylight sensors detect adequate amounts of daylight. This system automation will work to reduce and conserve energy on two fronts. The reductions in the number of light fixtures emitting light directly reduce the amount of electricity used to power the fixtures. Additional reductions in electricity consumption will be seen due to the fact that the HVAC system will no longer have to work to remove the resultant heat of those light fixtures.

3.6.4 Electrical Systems & Social Impact

Creating an environment with spaces that have adequate lighting and daylighting can improve the well-being and production of the soldiers and other occupants of the building. Lighting can be used to create inviting areas within the facility, such as the day rooms and lounges, which can promote occupant interaction and further strengthen camaraderie. The science behind using a combination of ambient, circadian rhythm, natural, and direct light is shown to increase attentiveness, happiness, and thus productivity in occupants.

3.7 Summary of Benefits

The BT and AIT complexes serve as a great example of standard, functional, and accepted building designs that can be reshaped to positively affect resource conservation. Whether minimizing the footprint, optimizing solar orientation, or implementing advanced HVAC technologies, all of these suggestions start to harmonize the relationship between the built and natural environments. Design teams must fully understand how these complexes operate when taking these design principles and implementing them at a greater level of detail. When taking into consideration that the occupancy schedules of each BCOF within the complex may vary, there are vast opportunities to have systems that feed each building at peak times, the site during physical training sessions, and the surrounding community after hours.

The conceptual and schematic design strategies mentioned above were analyzed specifically to planned projects that will soon become a reality at Fort Leonard Wood in a future military construction program. The technologies represented in this document all contribute to future net zero goals by reducing ecological impacts through design and construction practices, decreased energy consumption, and effective resource management. At these complexes, there are real opportunities to train and educate U.S. Army soldiers on the importance of energy independence as they join the ranks of the military. Resiliency across Fort Leonard Wood will only be achieved by broadening the goals of this case study and implementing similar processes for sustainable and energy efficient design of all vertical and civil construction projects.

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4.0 The Future: Toward a Net Zero Built Environment

The 2030 Project team spent a large portion of the project researching, soliciting expert opinions, and studying holistic solutions for the Army program. The strategies expressed in *Sections 1.0, 2.0, and 3.0* are intended to address Fort Leonard Wood. The strategies in this section are lessons learned that will assist the Army in addressing its goal of twenty-five Net Zero Installations by the year 2030, a goal initiated by the Assistant Secretary for the Army Installations, Energy, and the Environment, the Honorable Ms. Katherine Hammack.

4.1 Remote Project Delivery Teams

As a revolutionary project, the Corps' first priority in standing up the team was to ensure the highest capacity of talent and ignite a network of motivated individuals to support and champion the cause of developing a higher quality product for our customer, the Army.

It should be noted that the initiation of the 2030 Project team differed greatly from a standard project development team (PDT) because the members had no previous interaction. In fact, the team members had not met each other or the project leader prior to kickoff. This was an unfortunate side effect of having a predominantly entry-level team that was remotely located. The first and only time the entire team met was at the site charrette, occurring at approximately 75-percent project completion.

With budget cuts looming and the refusal by many departments (both within USACE and the greater Army community) to financially support this initiative, the project team needed a way to significantly lower the cost of the project by approximately 30-percent. The final solution came from eliminating all in-person working group meetings except for the single on-site charrette. Other smaller, breakout workshops were held in support of educational objectives that doubled as research for the project team. These educational workshops were framed around prospect courses and were partnered with the employee's district training funds to further lower costs.

4.1.1 Benefits of Remote Working Teams

The decision to work remotely reduced travel costs but also cut secondary costs associated with developing travel orders, coordinating meeting schedules, compensating for travel time (waiting in airports, etc.), and developing travel vouchers. Further, each team member had full-time job duties for his/her Corps position for which they were still responsible to complete 40-hours a week. By reducing the on-site meetings, the team was able to spend the remaining personal time with family and friends. Qualitatively, this reduced the immense strain on the employee's personal lives and, from the perspective of the project team, lowered turnover.

The remote team was also effective in that it gave an opportunity to select team members from a more diverse applicant pool than would a co-located team. This is important if the project has a high valuation on innovation and/or needs a variety of specific expertise. Lastly, the benefit of having a remote team is the ease in standing up and sitting down team members. Because limited resources are expended on each member with regard to travel, the addition or removal of a member is simplified.

4.1.2 Weaknesses of Remote Working Teams

There were negative effects of working remotely along with the positives. The logistics of hosting web meetings using the authorized software is significantly lacking. The project team began by using the Defense Connect Online (webcasting software). This service was riddled with bugs and many times was not operational during the pre-scheduled meeting time. The team attempted to use Google Groups as the project content was not sensitive in nature. However, the limits of ACE-IT (the Corps contractor for computer technology) would not authorize the installation of the free Google Groups software on the Corps machines and thus prohibited the functionality of this industry standard platform. Video teleconference was suggested as each district office has the capability to host a video teleconference. However, because many of the team members were entry-level, they were frequently booted from the meeting space without notice, interrupting the team's ability to remain consistent.

To avoid these issues, the team utilized a teleconference service and shared PowerPoint presentations via a web-share service. This required the team lead to have materials posted well in advance and schedule both the teleconference line and the web-share service individually for each meeting. After over twenty-five meetings in two months, the contractor allowed the team to utilize an open phone line eliminating the need to submit individual requests to schedule the calls.

It took several weeks to determine the needed frequency of meetings and the style of communication that was effective but not redundant. This process was drawn out due to remote working because the team had difficulty giving feedback and communicating over the phone. The team eventually found that a weekly meeting of the entire team plus a weekly sub-team meeting was the best approach. The full-team meetings were kept tightly to one hour with the intention to review the project goals, progress, issues, and solutions. The sub-team meetings were open to the discretion of each sub-team lead to determine the time and focused on development of strategies and discussion. The team meetings became significantly more effective after a posted agenda was available for review for the full-team with attached minutes from the previous meeting.

4.1.3 Recommendations

While it may seem redundant to recommend consistent meetings, the project team found that due to the remote locations and lengthy amount of time it took to coordinate a one-hour meeting between twenty-six people on three continents, it was most effective to have a set meeting time each week regardless of the amount of information to present. This developed a level of consistency that the team relied on. The meeting was never cancelled. It was scheduled for a date that never had a holiday. It never changed times. Attendance was taken and posted on the agenda. This encouraged attendance because a member's reputation was based on productivity and commitment to the team as a whole.

The team lead found two effective strategies for keeping a remote team motivated: selecting quality people followed by a promotion / dismissal system.

Selecting quality employees is difficult when the budget precludes a face-to-face interview. The 2030 Project team recommends requiring a confidential reference by the applicant's supervisor as well as a non-confidential reference of the applicant's choice. This is the closest effective manner to discern commitment, teamwork, and consistency – items difficult to discern from a résumé and application only.

Jack Welch held the idea that a leader owes it to the productive people to dismiss the unproductive people. In the first few months three people were dismissed from the team. It is important to the team as a whole to understand what behavior is acceptable to work through and what actions constitute immediate removal.

For example, two team members had similar issues: one was dismissed and one was re-titled as a consultant with the opportunity to rejoin the team at a later date. Both members had critical family circumstances that affected their ability to work at the Corps, let alone a voluntary team. However, they treated the situation in opposite ways. In one scenario, the member made an appointment with the team lead immediately after the issue occurred. The team lead was able to redirect the member's work load temporarily and advise the entire team of the situation. While inconvenient, the team stayed on schedule and was able to move forward. The member was never able to fully rejoin in the same capacity but did attend the weekly meetings and assist in an advisement capacity that was comfortable to both the member and the team. In the second situation, the member never informed the team, but rather became defensive and hostile. The member was unresponsive in email and phone calls. The member's supervisor had to be contacted to track the progress of the assignments given to the member. The member was immediately dismissed against protest; the members work caused a significant delay in the production and threatened to slow the project.

Accountability is crucial to a remote team, especially one reliant on voluntary efforts. The team's functionality is dependent on advanced communication. Issues will always arise, but ensuring the team is aware that accountability and communication are top priorities will guarantee a remote team that works together. This greatly improved the morale of the team as the remaining members felt that they could count on the productive members and that it enforced their role as top contributors.

In the first month, five of the committed and experienced members were promoted to leadership positions. The sub-team leaders were appointed based on their demonstrated professionalism, experience with the subject matter, and passion for taking on the role. It is here that the 2030 Project team recommends an anonymous feedback loop. In a co-located project team, members would have the ability to discuss issues / disagreements with middle management or senior management. However, because the team had not developed trust and the promotion system encouraged the members to show endurance and solve their own problems, members later confessed to the team lead that they felt unable to convey dissent with middle management decisions. Ultimately, this was the largest road block in the project as it contributed to a design failure in the floor plan of the AIT BCOF for the design competition entry. It proved to be a middle management issue because, once removed, the productivity of the design branch increased tenfold and the passion of the designers was once again restored.

The remote team had significant difficulty with the large team size. The 2030 Project team hypothesizes that this was in part due to the organic nature of the project definition; the first assignment was to define the scope. Potentially, a remote team that has a defined process with individual roles and examples could successfully function. However, the 2030 Project was original in scope as a USACE endeavor. Additionally, the unfamiliarity within the team and the lack of initial definition proved that 26 was too large a team to operate remotely at maximum efficiency. The team lead sent out an anonymous survey to rate the effectiveness of the leadership, the status of the project, possible strengths, and identifiable opportunities. Included in the survey was a nomination form for the second phase of the project. Members were asked to nominate an unlimited number of teammates that they felt would be best on the Phase II team. Ninety-percent of the members recommended a team size of less than ten. The promotions were based on this survey and ten members were asked to stay for the second phase. Of the ten, only eight were able to make the increased time commitment. The functionality of the team increased significantly with only eight members. At this point, the team members had met in person during the charrette, had an established work history, and an unwavering commitment to the end product.

In summary, key principles for a successful remote team include:

1. Established communication medium (free of bugs, tested, and easily accessible)
2. Consistency in decision making & schedule
3. Redundancy in expectations and values
4. Central repository for a live schedule & task list
5. Anonymous feedback loop & feedback ability on all members including the team leader

6. Promote the best employees
7. Dismiss the unproductive or disrespectful employees
8. Offer opportunities for increased passion for the subject matter to motivate team
9. Hold structured opportunities for the team to get to know other members personality (examples include developing subject matter experts, asking members to present to the team, etc)
10. Make meetings fun and safe from public criticism

4.2 Energy Modeling in Practice

Energy modeling technology allows those involved to make better decisions with regards to the proper design and operation of energy systems in a proposed facility. When combined with life cycle cost analysis, energy modeling is an enormous resource in determining the best systems to implement on a project with the lowest possible life cycle cost. Given that energy costs are one of the Army's largest (if not the largest) expense in the annual budget, this forecasting ability has gained attention.

In recent months, however, there has been growing discontent among designers and owners that energy models have evolved to become unrealistic optimized simulations of facilities that reflect energy savings far beyond expectations from the actual building operations. In effect, these models have become "snapshots in time," that only show utopian conditions, ignorant of real-world environmental variables. This has been of particular concern with contracted designs. Typical contracts are set up for a predicted performance base. Thus contractors have been known to game the energy model. Gaming refers to the practice of clicking on and off design features and systems to produce the maximum efficiency without consideration for scale, climate, user needs, and cost. This practice is also used by ignorant technicians who have limited experience with modeling and are encouraged to produce the result with the best numeric value. The team encouraged the Corps and the base to first use in-house labor for modeling and, if not available, to then provide alternative metrics for modeling results and provide experienced professionals to develop the models.

This is not to say that energy models cannot be accurate. There are many cases when energy model predictions are found to be extremely close to the actual performance of the facility. The problem lies in that there is little or no support in ensuring that these models truly reflect realistic conditions by enforcement agencies or internal policies. There is a direct tie to the accurate performance of energy models when used beginning in the early stages of the charrette process as an evolutionary design tool to guide design decisions.

Recent Leadership in Energy and Environmental Design (LEED) energy and sustainability criteria, mandated in 2011 by the Army, gives little to no incentive to verify an energy model's accuracy after design efforts are complete. Designers are pushed by criteria and design limitations to squeeze every bit of energy performance out of the models without any favor being placed in verifying the accuracy of those modeling conditions. While these models output more favorable numbers and may even be accepted by evaluating agencies such as the U.S. Green Building Council, the models are straying further and further from actual building performance (anecdotal evidence indicates that many energy models are showing on average a 30-percent discrepancy with instances of 60-percent error or more). Instead of simultaneously improving model and design performance, trends show that energy model performance is increasing (as designers become more proficient at figuring out which toggles and variables yield the most beneficial results) while actual facility design performance is branching further and further from that path (plateauing and in some cases decreasing).

This study has made an attempt to acknowledge the aforementioned critique of energy modeling trends and identify the strengths and weaknesses of this process. The primary reason for the concern with models is their value in net zero facility design. Instead of comparing a design to a baseline (a dynamic variable), a designer must compare a building to a static energy performance variable – in this case, zero. While most of the 2030 Project team's design work was conceptual in nature and at very preliminary stages of design, the team found that many of the opportunities realized in high-level (highly detailed) energy modeling could be identified in preliminary design decisions as well. In this study this process has been referred to as conceptual energy modeling (CEM).

Conceptual energy modeling should be executed and refined through all stages of design, but it is most beneficial to the later stages if implemented early. By doing this, the team was able to affect early design decisions such as siting, massing, and ratios that had a trickle-down effect (in either good or bad ways) in the way higher-level energy systems operated.

It is important to note that this analysis technique will not produce the reliable "bottom-line" energy consumption data that high-level modeling often touts; but, if done properly, this process will ensure that the project delivery team yields the most efficient project within the design parameters.

The goal of CEM is quite different than that of systems energy modeling, but it utilizes many of the same tools and workflows. The real benefit in this process is that it analyzes multiple model "runs" in order to find trends, consistencies, and opportunities. This multiple run process (while still corruptible) helps to ensure that data is more robust and not just a "snapshot in time." CEM moves away from "bottom line" evaluation practices in that the end product is not a basic thermal unit of consumption or a dollar value energy cost. The trends found by mapping these processes are the items of real value. Creating a "good" model becomes less about finding the most optimized run and more about creating a large volume of runs to establish ranges and trends. Encouragingly, almost all of the information gleaned from this process is reinforced by well-established, sustainable principles such as daylighting, proper building siting, orientation, and passive solar techniques.

As the design develops through schematic, design development, and construction documentation stages, iterative energy modeling analyses of a design feature can give the designer a good idea of the repercussions of implementing each system or feature into the integrated whole. In effect, the model becomes a design tool, not an end product, that helps predict the best life cycle cost of each decision.

In conclusion, CEM helps to encourage accurate high-level energy modeling such as Energy Plus and Trane Trace. Since the model is developed concurrently with the design, both are more accurate. This helps to ensure that the highly coveted "bottom line" energy consumption data is, if nothing else, as realistic as possible within the constraints and variables offered by the energy modeling tools.

4.3 Sustainable Building Renovations, Operations, & Maintenance

One of the many acknowledged realities of energy modeling is that high-performance building systems operate at optimal condition only if properly maintained and managed. The statement that facilities are designed as "snapshots in time" that only show utopian conditions is absolutely correct as it is impossible to comprehensively design for all environmental and occupant load conditions. That is not to say, however, that the systems cannot be tuned to operate near or at those conditions if maintained and optimized correctly.

The built environment is constantly evolving especially when occupied. It is illogical that energy systems tuned for one set of design parameters will efficiently respond to those variations in demand required by the interaction of the building and its occupants, especially as facility use evolves over the life of the structure. Not surprisingly, though, building energy systems are designed with a degree of adjustability. By harnessing the inherent flexibility, energy systems can almost always be tuned to operate more efficiently at different time intervals (hourly, daily, seasonally, annually, etc). Current practice indicates that military facilities are serviced annually on average (depending on building type, mechanical system, usage, etc). Maintenance contractors inspect and maintain systems on that time scale and any glaring inconsistencies may be fixed or reported to the installation. While this practice may be sufficient in maintaining the mechanical life of the system, these practices do not guarantee or maintain design performance. It does not accommodate energy or mechanical system "tweaks" to optimize performance based on built environment realities that were not considered in the original design.

A growing trend on our nation's military installations is the employment of energy and utility managers. While building managers are common in a repair or management capacity, they have been tasked with new challenges in recent years. Fresh mandates have turned their focus from maintenance to an optimization role. They have also been exposed to a growing palette of tools by which they can facilitate their energy and utility management decisions. Descriptions of some of these tools and strategies can be found in the following sections. All of these tools serve to help better inform decision makers in optimizing their facilities on a range of size and time scales.

4.3.1 LEED EBOM (Existing Building Operations & Maintenance

TECHNOTE

LEED EBOM

The Army has achieved great success using USGBC's LEED for New Construction rating system as a tool to teach USACE and the DoD about designing and building high performing and sustainable facilities. When the project is complete and the building is in operation, LEED for New Construction has no jurisdiction or favor over the continual and proper operations and maintenance of the facility. The intent of LEED for Existing Buildings: Operations & Maintenance (LEED EBOM) is to certify the operations and maintenance of the building and create a plan for ensuring high performance over time. The rating system captures both a building's physical systems (equipment, design, land use, etc.) and the way the building is occupied and operated (waste management, temperature monitoring, commuting programs, etc.). The goal of this system is to institutionalize a process of reporting, inspection and review over the lifespan of the building.

This certification system identifies and rewards current best practices and provides an outline for buildings to use less energy, water, and natural resources; improve the indoor environment; and uncover operating inefficiencies over the life of the facility. LEED EBOM helps building owners identify and solve problems, improve building performance, and maintain and enhance this performance over time. LEED EBOM should reduce cost streams associated with building operations and environmental impacts, create healthier and more productive workspaces, and provide public recognition for leadership in sustainability.

It is important to note that LEED EBOM is not an outright analysis tool. It is an evaluation system that rewards owners and users implementing sustainable O&M practices with a relative certification level. While the certification system itself does not necessarily ensure net increased energy performance, the practices and methods prescribed by the rating system provide a solid tool by which to evaluate and measure energy performance.

By requiring certain certification levels or individual credit compliance, the installation may be able to develop a consistent process by which the installation can take stock of their new and existing facilities with respect to energy and utility streams. In effect, LEED EBOM is not the end goal, but a tool by which to measure efforts in getting to that objective.

4.4 Enhanced Commissioning (CX)

Commissioning, as defined by the American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), is the process of ensuring that building systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. Commissioning in general terms is the evaluation and adjustment of building systems to ensure that they are operating as designed. As previously mentioned, buildings are living; they continuously evolve and adjust to the occupants and climatic conditions over time. Changes in energy and utility demand can vary over time, especially if the building use, occupant, or type has changed, and the process of commissioning can help identify and remedy any oversight, discrepancy, error, or inefficiency.

Enhanced commissioning (Enhanced CX) is a term used by the LEED rating system defined as, "a set of best practices that go beyond fundamental commissioning to ensure that building systems perform as intended by the owner. These practices include designating a commissioning authority prior to the construction documents phase, conducting commissioning design reviews, reviewing contractor submittals, developing a systems manual, verifying operator training, and performing a post-occupancy operations review" (USGBC.org). For credentialing purposes, LEED attempts to break commissioning activities into "fundamental" and "enhanced" sets of functions. Fundamental commissioning focuses on developing a basis of design (BOD) and documenting owner requirements while enhanced commissioning (Enhanced CX) places emphasis on verifying those requirements by a third-party entity throughout the design, construction, and initial operation phases. The real value in enhanced commissioning is the degree of enforceability it brings to systems commissioning in comparison to the effective goal-setting measures established by LEED's fundamental commissioning requirements.

THE STAGING EQUIPMENT FOR A BLOWER-DOOR TEST. - IMAGE COURTESY OF USACE, KANSAS CITY DISTRICT.

For the purposes of this study, Enhanced CX is recommended as a "boots-on-the-ground" attempt to ensure that stakeholders (whether they are owners, operators, tenants, or maintenance personnel) are not only informed of the design assumptions by which a facility is planned, but also equipped enough to recognize inconsistencies in building or systems performance. From there, those individuals can, at the least, contact the appropriate entity in order to investigate the issue.

An added benefit of the LEED Enhanced CX process is that the commissioning agent must report directly to the facility owner, an attempt to ensure that the BOD and owner requirements are upheld throughout the entire facility procurement process. This additional level of enforcement helps to ensure that the owner will receive a facility tailored to their unique design criteria.

With the addition of progressive and complex energy management systems in increasingly efficient building designs, the need for commissioning activities will continue to rise. The USACE requires the Enhanced CX credit be pursued in all MCA projects awarded at or after 35-percent design as of June 2010. While the contracting vehicles to exercise this requirement are numerous, many districts have decided to keep the expertise in-house and commission the buildings with a district led commissioning team. This is a benefit to the owner as it ensures an independent party inspects the building and allows for greater transfer of information to the maintenance organization, DPW.

4.5 Operations & Maintenance Training

Stakeholder training is a key part of enhanced commissioning efforts, but it may also be pursued independently from those initiatives. Military maintenance personnel and contractors are faced with the difficult job of cataloguing and performing maintenance on an extremely wide range of facility types usually constructed over decades of time with a wide variety of energy and utility systems and connections.

Obviously, it is an inherent challenge for maintenance personnel and contractors to stay current on each facility's design and operation criteria. This is especially true as systems become more diverse and complex. An acknowledged reality is that over time, maintenance personnel become familiar with certain systems. They become very proficient in maintaining certain systems while they obviously lack the skills to properly maintain systems that are new or are less common.

Given that there are often a handful of employees responsible for the maintenance of the hundreds or thousands of facilities and that their respective systems on an installation have their unique maintenance schedules, time reveals a potentially difficult reality. As time passes, systems begin to operate in a manner directly proportional to the maintenance contractors' knowledge of and ability to service that system. All systems wear with age. Most of them become less efficient with time, but if maintenance personnel have the proper means by which to evaluate or troubleshoot system-specific deficiencies, they become empowered to make the best decisions they can with regards to the performance and longevity of those systems.

Improving building turnover procedures is a step in helping maintenance personnel understand the way in which building systems operate as constructed. Allowing proper amounts of time for contractors to work with maintenance personnel in helping them to learn the intricacies of each system not only allows the personnel to become knowledgeable of the systems as-built but also allows them to respond more appropriately to unforeseen conditions in the future.

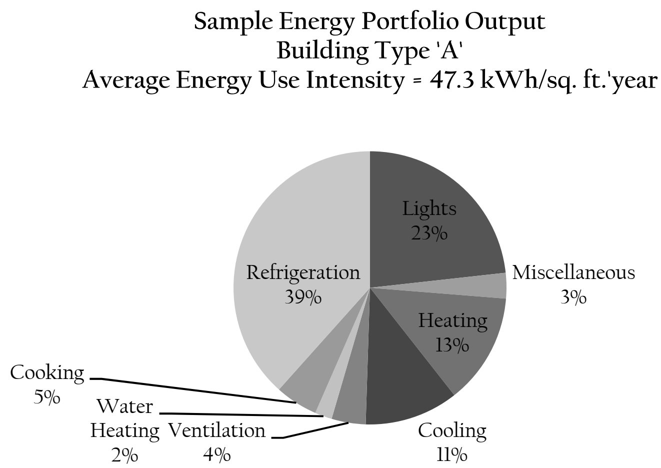
Online Interactive Electronic Manuals (IEM) can increase accessibility of technical information for certain systems to maintenance personnel. Most building turnover procedures include provisions for systems and user manuals to be provided to the owner for archiving. Unfortunately, this is not a seamless process. Manuals get misplaced, sometimes discarded, or become inaccessible under a mountain of other literature. Digital archiving of these items not only facilitates multiple-user access but it also allows maintenance personnel unparalleled access to a vast amount of documentation on something as small as a laptop, tablet device, or smartphone. It allows the contractor or employee to have accurate information when they need it in order to make the best decisions in servicing those systems.

Properly trained staff can further inform facility users on procedures to enhance both their occupant experience and building systems performance. Cumulatively this contributes to an educated occupant and O&M employee force that can arguably make the largest impact in curbing utility demands on a given installation.

4.6 Performance Management Systems

At the very early stages of this study, the 2030 Project team attempted to collect energy conservation data from the installation. While initially surprising, the team concluded the situation to be typical of U.S. military installations. Almost none of the individual facilities had been metered in energy consumption. In general terms, utility companies tend to treat an installation as a single customer and a single bill is charged to the Garrison. As a result, stakeholders have very little understanding of current and historical energy usage patterns at the building and community level. This makes it extremely difficult to spot usage trends, identify problems, and in turn verify impacts of system alterations.

performance management
TECHNOTE



EXAMPLE OUTPUT: ENERGY STAR'S PORTFOLIO MANAGER PROGRAM. – IMAGE COURTESY OF THE US ENVIRONMENTAL PROTECTION AGENCY (EPA), ENERGY STAR PROGRAM.

There are multitudes of measurement and verification (M&V) systems available to facility managers to aid in metering utility and building energy flow. Logically, this study recommends the installation of these types of devices as it assists stakeholders in directly measuring the impacts of their decisions in relation to the overall performance of the facility. As the existing building stock is outfitted with these measurement and verification systems, those concerned will be able to access a wide variety of real-time and historical usage data, all of which can be analyzed and critiqued in order to find the best possible operating conditions for the selected facilities.

This is all done with one end-goal: to facilitate the optimization of utility flows on the installation before more inefficient construction or aggregate systems are initiated to supplement a utility system.

Inherently, analytical performance data is only as valuable as the extent to which it is accessible. While many new military facilities are being outfitted with measurement and verification devices, very few installations have the ability to manage the data. Performance management systems are becoming popular with facility managers in that they provide a portfolio of tools to bring that data together for holistic analysis. This allows managers and their staff to respond to those trends and anomalies proactively.

The 2030 Project team recommends the deployment of a performance management system installation wide, minimizing load before planning capital-intensive infrastructure design, alternative energy source development, and transmission improvements. The Environmental Protection Agency (EPA) and Department of Energy (DOE)'s Energy Star Portfolio Manager (ESPM), is an interactive energy management tool, which allows the tracking and assessment of energy and water consumption across an entire portfolio of buildings, in a secure online environment. ESPM helps set investment priorities, identify underperforming buildings, and verify efficiency improvements.

4.7 Occupant Behavior & Dashboards

Performance management systems bring building performance information to facility managers; but often, that information never makes it to the building user who is flipping the switch or turning on the faucet. Dashboard system technology bridges the gap between user and result without the burden of intense education.

Dashboards are systems (usually equipped with user-friendly graphical interfaces) that display building performance at facilities installation-wide to advance building operation by making live energy and utility use visible to users. Dashboard kiosks at individual buildings will improve conservation behavior in occupants by providing real-time feedback on utilities used (they can be programmed by occupant, room, floor, building, and complex, etc.) which will lead to proven cost savings in building operations through conscious conservation of resources. These dashboard systems will need to be tied into the same performance management system that energy managers are using for continuity and accuracy.

Historic data can be collected through this system and should be compiled for research to inform design teams of post-occupancy status of buildings at Fort Leonard Wood when working on future projects. This data is crucial for understanding the built environment at Fort Leonard Wood and will assist in validating systems that are working and to identify those that are ineffective. Data from this system will lead to improved design decisions for projects at Fort Leonard Wood in the future.

The 2030 Project team noticed that the application of dashboard technology is as important as the availability. While the project team is passionate about building efficiency, there are no preconceived notions that soldiers might retain the same sentiments. Thus, informing the user without forcing the education is a key principle. Among many solutions, the project team recommends tying the dashboard to the installation desktop for every networked computer. Similar to a notification board, the dashboard should tie into an installation level and building level projection that shows the user their comparative status. In following with Army tradition, the dashboard could project a red, amber, green (RAG) chart for various energy, water, and waste metrics. This system compounds effectiveness when tied with user behavior strategies such as competitions. For example, in the BT BCOF, the 2030 Project team recommends having the platoons compete against each other for lowest energy use. As a reward mechanism the installation can incentivize a dollar value to the winner. Another strategy pays the building occupants a percentage of the energy and water savings. For example, if the historical energy bill for a given building is $500 a month and the installation pays 40-percent of the savings, the user would be paid $40 for every $100 saved in energy. This money could go into an account for user betterments such as chairs or a monthly lunch.

The opportunities for motivating the population are endless. However, the first step is monitoring the performance of the building. The user's behavior will begin to transform if minimal changes in daily behavior are required or if the habit can be incentivized during the formation stages.

4.8 Building for Renovation & User Workflow

The 2030 Project team felt it was important to build this future model using some key principles developed by specific sustainability pioneers. Ray Anderson was a revolutionary in the sustainability industry although he would always argue that his end game was business not sustainability. Mr. Anderson was a pioneer in the thought process behind making consumerism sustainable. As the CEO of a leading interior flooring firm, Interface Flor, Mr. Anderson understood the need to develop a business model that made fiscal sense. He deduced that the chronology of the consumer industry was flawed. Consumers purchase a product with no concept of the expiration of the product.

Yet another pioneer in sustainability, Annie Leonard co-director of the Story of Stuff Project, implies that people consume products that disappear after they use them. In her popular and free internet movie, Ms. Leonard draws a timeline showing that people believe they live in a linear world where they pull virgin sources from the ground, manipulate these materials into things they can use, and sell, then trade them, then use them, and then when they are through, they throw them away. To most people, throwing something away is a magical process in which an item is placed in a trashcan and is never seen again. However, travelers to developing countries will attest that the product cycle is not magical. Rather, developed countries keep landfills consolidated and in remote locations because it is a part of society many refuse to participate in let alone see. Ms. Leonard argues that the reality is that our system is sick because it does not fit with the forces of nature. The system is intended to be cyclical but society applies a linear model for financial profit.

Said another way, losses are socialized and profits are privatized. Society is left with the burden of cleaning, disposing of, and recycling any item that a company generates.

Mr. Anderson adjusted his company's process, a carpet company – typically considered to have some of the worst pollutants – to be a cyclical system similar to the one Ms. Leonard speaks of in the movie. Items are manipulated, sold, used, *and this is the change*, taken back to the manufacturer and recapitulated into another product or a revitalized version of the same and resold. In this scenario, minimal items are extracted, but rather the bulk of the materials are sourced from existing products.

Mr. Anderson came up with a revolutionary thought. He hypothesized that logistically, his company could easily maintain records of what products were sold and to whom. Based on this information, his designers could design the next generation of carpet based on the re-usable materials content of the most recently sold products. The company would offer to pick-up the old carpet when no longer needed and replace it. They would take the carpet back to the manufacturing plant, strip down the materials, and recreate new carpet. Every piece of the old carpet was recycled. Additionally, consumers appreciated the idea and the quality which increased purchasing.

It is this mentality that must be applied to the built environment. Buildings too are a commercial product. The private industry does not think cyclically, but rather linearly about the life of a building. The Army is progressive in that it provides standards for the lifespan of a building. The Corps building process and life cycle cost calculations are dependent on a fifty-year life cycle with a renovation occurring at thirty-five years.

The 2030 Project team recommends designing buildings with a principle for ease of renovation and deconstruction. Buildings are most cost effective when orientation, skin, glazing, and structure are designed for the climate and site. The interior partitions will change due to user requirements. For this reason, emphasis should be removed from interior requirements and focused on developing a solid and compatible building structure that is energy efficient. It is expected that if less cost were focused on the design and materials of partition walls and more emphasis placed on the structure and quality of exterior materials, the building lifespan could be drawn out to a second renovation. This prediction takes the building life span from fifty years to sixty years.

Technology has developed with strategy. The interior design industry is ripe with solutions for malleable interiors. The quality and operability of these systems-style furniture and walls are high. However, Army and installation policy is highly prohibitive of the integration of these systems into the military construction program. Typical reactions include statements of concern that there are no Real Property codes to address this type of system and thus it is not possible. These arguments must be eliminated. Industry standard construction has significantly decreased in quality in the last twenty-five years. Buildings are becoming more specific and tailored while the tenants have rapidly changing requirements. Costs are decreasing as materials become cheap and labor practices lower standards in pursuit of schedule. The Army is caught alongside industry in the battle for quality versus quantity. Why not apply the concept to their advantage? The Army could emphasize quality in the structure and enduring portions, while focusing on quantity and economy in the interior partitions that are expected to change rapidly.

This will produce a modified building life cycle of sixty years with three to four renovations at lower cost than the existing model. This also more accurately aligns with the current pace for changing requirements.

The concept can be taken further to include user behavior and space planning. Industry is wholeheartedly grasping the concept of telework, compressed work schedule, and remote working centers. Some states, such as Nevada, have initiated programs that only open the federal working centers Monday thru Thursday for employees that work nine hour days. This serves to reduce operating costs by only heating and cooling the building four days a week. Teleworking becomes effective if applied on a rotational basis. Many in private industry are steering away from private offices and reserved cubicles in favor of open work space. This type of space planning allows users to keep a rolling and lockable file cabinet with essentials at the office. As they come into the office, they roll the short file cabinet and their laptop to a work station. Through scheduling, the office can estimate that only 80-percent of workers are in the office at any given time. Thus, with the careful placement of a few conference rooms, the buildings are designed for 80-percent capacity and therefore decreasing the building footprint by 20-percent in up-front costs and simultaneously decreasing the utility bill by a minimum of 20-percent annually.

The Army has an opulence of opportunity to design for deconstruction, to invest in quality structures and malleable interiors, and to strategize about the office environment. With the adaptation of these concepts over the next fifteen years, the Army will surely lead the way to a net zero 2030.

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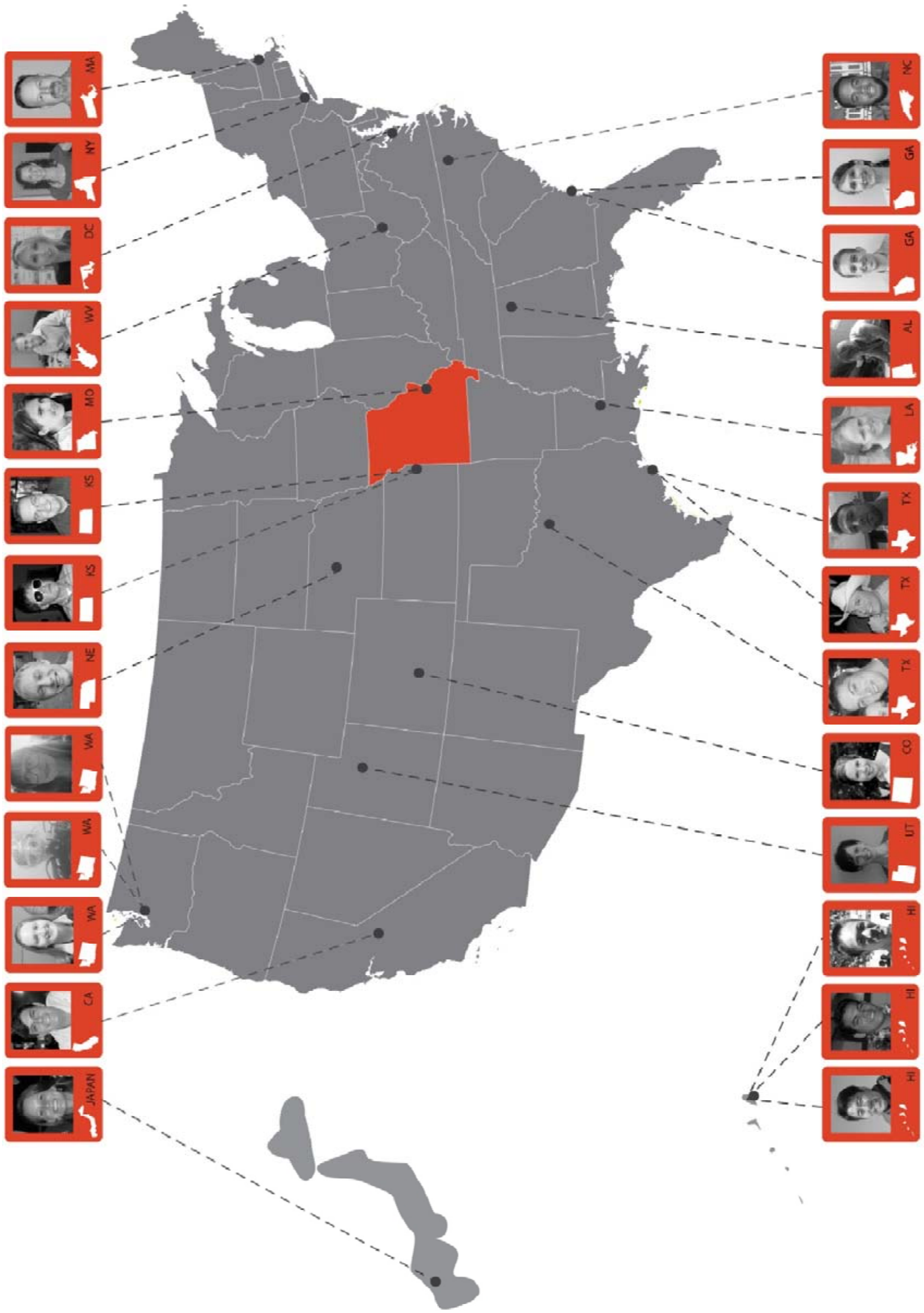
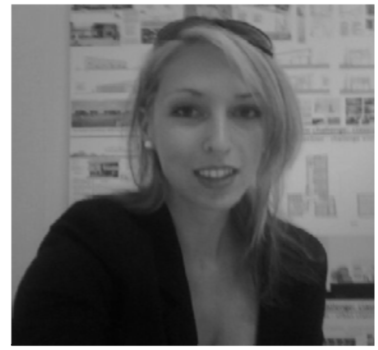
5.0 Authors: Integrated Project Team



5.1 LYNDSEY PRUITT

Team Lead
Master Planning Perspective



Lyndsey Pruitt initiated the USACE 2030 Project to expose the U.S. Army Corps of Engineers as leading technical experts in the field of sustainable design and engineering. Simultaneously, Lyndsey serves as a Sustainability & Energy Program Manager for USACE Headquarters Engineering & Construction Branch as well as the BIM liaison for the Center of Standardization. She joined the COE as a Project Engineer for the Construction Branch in USACE Savannah District, managing the Special Operations funded projects on Fort Benning. She has since worked for Far East District's design branch assisting with sustainability implementation in Host Nation projects.

During the 2005 BRAC, Lyndsey was on the board of directors for Georgia Work Ready Program Grant for Sustainable Construction which designated the Chattahoochee Valley as the Sustainable Construction Center of Georgia. With this grant she initiated the Georgia Alabama Partnership for Sustainability (GAPS) Conference, annually bringing together over 350 sustainable construction enthusiasts.

Lyndsey graduated from Georgia Institute of Technology with a B.S. in Architecture, and a Minor in International Affairs. She holds a Masters in Building Construction Management from Auburn University.

She began her career as a strategic planner at Science Applications International Corporation (SAIC) consulting for TRADOC at Fort Benning, GA. She led the facilities and engineering Line of Effort for the Maneuver Center Realignment Coordination Cell that planned the relocation of the Armor School and several other units to Fort Benning in conjunction with the 2005 Base Realignment and Closure.

Lyndsey is active in the DC Triathlon Club. She enjoys traveling and has a personal goal of visiting every country in the world, with 34 down and 160 to go!

5.2 Dan Brauch

Civil Perspective

Dan currently serves as a Civil Engineer for the U.S. Army Corps of Engineers, Kansas City District. His primary interest is the overlap between civil design and sustainable design, with a passion for low impact development. He has experience with both the civil works and military programs in designing for grading, drainage, utilities, and stormwater management. Additionally, Dan supports sustainable design and LEED project integration at his District.

Dan is the civil design lead for an unprecedented forward operating base (FOB) on Fort Leonard Wood, MO. Still in the schematic design phase, the project team intends to develop the Contingency Basing Integration Technical Evaluation Center to be net zero energy. Simultaneously, the team is focusing on limiting the supply chain so that the FOB relies less on external supplies brought in by convoy and thus decreases the opportunity for casualties in theater.

Dan earned a Bachelors of Science in Civil Engineering from the University of Kansas. While pursuing his undergraduate degree he interned at several companies including SEGA, INC, a small energy design firm in Kansas City. Dan supported civil engineers with designing substations and power plants. Since joining the U.S. Army Corps of Engineers, he has become a LEED AP in building design and construction (BD+C), graduated from the DA Intern program, and has become the LEED subject matter expert for numerous project validation teams. Dan is also an instructor for USACE Sustainability Classes, presenting webinars and classroom learning on Low Impact Development, water use, master planning, and LEED implementation.

Dan resides in Olathe, KS and enjoys spending his free time running, traveling with friends, and playing Ultimate Frisbee.

5.3 Sara Murphy

Construction Perspective

After spending a few years in private sector architectural / engineering firms, Sara began her career with the U.S. Army Corps of Engineers as a Student Research Assistant at the Engineering Research and Development Center - Construction Engineering Research Laboratory (ERDC-CERL) in Champaign, IL. Her work at ERDC-CERL consisted primarily of analysis, documentation, and preservation of historic sites on Army installations. In 2009, Sara transitioned to a position in the FORSCOM/USARC HQ Resident Office at Fort Bragg, NC, where she was responsible for coordinating architectural features of various projects including the Forces Command/US Army Reserve Command Joint Headquarters. In 2011, she transferred to the Quality Assurance (QA) Section of Savannah District Construction Division, where she serves as the architectural specialist and LEED contact on the QA Team.

Sara has participated in many design competitions, including the Plym Design Competition for a Modern Art Museum at One Omotesando Avenue in Tokyo, Japan, while she was attending the University of Illinois at Urbana-Champaign. She is also involved in the local Savannah Chapter of the USGBC's Emerging Professionals organization. She most recently participated in an Earth Day event where the group laid sod and potted plants in three parking spots on a city street to raise awareness of the importance of sustainable master planning.

Sara was born and raised in Quincy, Illinois. She graduated Cum Laude from Southern Illinois University Carbondale with a Bachelor of Science in Architectural Studies and from the University of Illinois at Urbana-Champaign with a Master of Architecture degree. In college, Sara first developed an interest in sustainable design; she quickly learned that incorporating sustainable design theory is a crucial facet of great design.

Sara lives just west of Savannah with her husband and their small dog. She enjoys playing volleyball, travelling, reading mystery novels, and doing crossword puzzles. Sara and her husband are working to retrofit their home to become off the grid and ultimately net zero.

5.4 KEANE NISHIMOTO

Mechanical Perspective

Keane began full time employment with the Corps in 2005 as a Department of the Army ACTEDS intern stationed at Fort Shafter, Hawaii. Upon completion of the internship program, he was permanently placed in the Honolulu District Design Branch.

While serving in the Design Branch, Keane has designed mechanical systems for MILCON projects located in Japan and Hawaii. He provides Building Information Modeling (BIM) and design support to the New York District, and has supported Savannah District with building energy modeling. He was interested in the 2030 USACE Integration Project because he saw it as an opportunity to increase awareness and momentum for sustainability within the Corps.

Keane Nishimoto was born in Honolulu, Hawaii and grew up in the nearby town of Mililani. He graduated from the Massachusetts Institute of Technology with degrees of Bachelor of Science and Master of Science in Mechanical Engineering. He returned home during summers in college to work for the Corps of Engineers as an Engineering Aide and to teach math at a local high school.

Keane traces his environmentalism back to growing up in Hawaii, always wanting to be outside surrounded by nature and life, and playing the role of the Air Doctor in an elementary school play where he diagnosed a cloud with acid rain. Keane currently lives within walking distance of work and enjoys golf and plate lunches. He lives fully intending to get in better shape, play more ultimate Frisbee, and learn new things every day.

5.5 KELLI POLZIN

Project Management Perspective

Kelli joined the Corps in 2009 as a Project Manager in the Military Programs Branch of Seattle District. Her time with USACE has been challenging and rewarding in a way she never expected. She's had the opportunity to manage both in-house and A-E designed Air Force projects at Mountain Home AFB, Malmstrom AFB and JBLM. While primarily a Project Manager, her branch has been supportive in allowing her to contribute her talents on in-house design work, acting as LEED reviewer for Northwestern Division projects, support for construction efforts including tracking LEED Construction credit compliance, and of course gaining the rewarding experience of this unique project that has become a catalyst for an exciting future.

In addition to the USACE 2030 project, Kelli and her team earned the Chapter Prize in the Architecture for Humanity (AFH) 2009 Open Architecture Challenge with over 400 competitors. The competition called for design entries for a 'Classroom of the Future' was developed in collaboration with "teachers and students to create smarter, safer, and more sustainable learning environments." Kelli's entry, 'Limitless Boundaries,' integrated solar panels, natural lighting, urban agriculture, demountable partitions for space reconfiguration, and sustainable interiors.

Kelli grew up in Indianapolis, IN and graduated with honors from U of I at Urbana-Champaign earning a B.S. in Architectural Studies. She was accepted into a competitive study abroad program and spent a year studying at the National School of Architecture in Versailles; it was a life changing experience which broadened and influenced her design perspective.

Kelli began her career as an intern at BSA LifeStructures. After graduation, she became a designer working on evidence-based design strategies and sustainable practices with a focus on phased growth planning for Healthcare and Higher Education clients.

Kelli looks forward to continuing her career focused on sustainable planning and design with the Corps of Engineers. In her spare time she still volunteers her skills with Architecture for Humanity and other non-profits, and enjoys exploring the beauty of the North-West, traveling, skiing, golf, and taking the occasional art or professional development course.

5.6 Parker Sherard

Electrical Perspective

Parker is from Goldsboro, North Carolina. He attended North Carolina State University (NCSU) in Raleigh, NC and graduated with a B.S. degree in Electrical Engineering.

Parker's experience working for the United States Army Corps of Engineers (USACE) began in 2007 as a result of participation in the University's Cooperative Education Program. Post-graduation he accepted an offer with the USACE as an Electrical Engineer in the Savannah District. During his time with USACE, Parker served as a field engineer providing technical support to project teams during the construction phase, as well as the Engineering Division.

Parker's interest in sustainable design was sparked when he joined NCSU's EcoCAR2 team as a part of his senior design project and assisted the team in placing 5th overall out of sixteen competitors. The EcoCAR2 Challenge was a competition hosted by the United States Department of Energy, General Motors, and Argonne National Laboratories that was composed of students from several universities working to convert a vehicle powered by a traditional combustion engine into an alternative fuel vehicle. Parker supported the team during the project's second year and specifically contributed by developing a controls scheme to use the high voltage battery to charge the low voltage battery which ran the twelve-volt accessories in the vehicle.

When the opportunity arose for the USACE 2030 Project, to participate on a team of individuals eager to incorporate the most innovative design practices in the sustainable construction process, Parker was very enthused about continuing to diversify his experiences in the field of sustainability.

Parker lives in Fayetteville, North Carolina working with the Corps on Fort Bragg. Parker enjoys traveling and spending time with family and friends. Parker is an AVID fan of the Dallas Cowboys; he has been known to cheer for the Carolina Panthers, as long as they are not facing the Cowboys. He is however a fan of North Carolina State University's Wolfpack sports. GO PACK!!

5.7 KENNY SIMMONS

Architecture Perspective

Kenny currently supports the Architectural & Interior Design Section of the Kansas City District. Kenny's tenure with USACE has been extremely challenging and rewarding. His dedication to progressive initiatives and continued partnering with stakeholders at installations has led to vast opportunities to positively impact building design and construction programs across the Army.

Kenny is currently the lead master planner on a twenty-acre technology evaluation center at Fort Leonard Wood. This enduring project will be home to soldiers training on the integration of energy efficient and net zero technologies that will be implemented not only at U.S Army installations, but also in combat theaters abroad. He looks forward to his future career with the Corps.

Kenny grew up in the Dallas, TX area and attended the University of Kansas for architectural school. He spent his final year of design studio researching sustainable community planning and co-housing developments before graduating with a Masters of Architecture.

His professional career began at JHP Architecture / Urban Design in Dallas. Kenny was an architectural designer on many mixed-use and multifamily projects focused on community redevelopment, infill strategies, transit oriented development, and sustainability. He was involved throughout the planning, design, and construction of Village View Apartments, which received the 2010 National Association of Home Builder (NAHB) Pillars of the Industry Award, for Best Garden Apartment Community. In 2009, Kenny and his colleagues at JHP entered into the Urban Re:Vision Dallas design competition where they designed a futuristic, 'living block' in the heart of downtown Dallas, Texas. This experience of conceptual design mixed with urban planning sparked an interest of Kenny's that still motivates him to challenge standards and push the limits of design.

Kenny volunteers for non-profit organizations, and is an extreme motorsports enthusiast, specifically NASCAR. Despite being very proud to live in the heart of downtown KC, Kenny avidly supports the Texas Rangers, Chicago Bears, and most importantly the Kansas Jayhawks!

5.8 Andy Temeyer

Architecture Perspective

In 2009, Andy joined the Corps – Omaha District, Architecture Section. During his time with Omaha District, he has had the opportunity to lead design efforts in a variety of projects – many with sustainability and energy efficiency as targeted concerns. Andy is actively involved in developing the District's capability as a technical lead in energy modeling, BIM integration, architectural renderings and sustainable design strategies.

Andy Temeyer was born in Council Bluffs, Iowa. He grew up on a farm outside of the small town of Treynor, Iowa. Andy attended Iowa State University in Ames and graduated Magna Cum Laude with a Bachelors of Architecture degree.

Andy began his professional career while still in school at HGM Associates Architecture & Engineering firm in Council Bluffs, Iowa. As a small firm, HGM provided opportunities to apply knowledge of the design profession. It was at HGM where Andy was first exposed to sustainable design in the built environment. His contact with developing energy efficient designs influenced his remaining college courses toward learning the application of sustainable design and technology into our communities.

In 2008, Andy relocated to Rome for six months to study classical and modern architecture. He traveled to eight countries throughout Europe with a focus on developing a vocabulary for diverse building practices. This experience profoundly shaped his outlook on design, architecture and sustainability.

During his final year of school, Andy joined the Iowa State University's Solar Decathlon Team. Andy held a leadership position and led the design, construction, and presentation of Iowa State's Interlock House on the National Mall in Washington D.C. Despite budget concerns and being a first-time competitor against predominately repeat contenders, the Intelock House placed fourth out of twenty in the Market Viability and Communications Competitions. The house now resides as a learning lab and interpretive center at Honey Creek Resort State Park near Ottumwa, Iowa – where it teaches visitors about net zero and passive-solar design.

Andy lives with his wife, Jen, and son, Will, in Council Bluffs. He enjoys running, biking, working on his house and rooting for the Cyclones.

5.9 Competition Entry Team

Jennifer Ramirez
Graphic Design Team Lead

Angela Curtis
Water Team Lead

Greg Gilkison
Energy Team Lead

Cambrey Torres
Master Planning Team Lead

Keith Molina
Energy Team

Sean Beville
Water Team

Leslie Campbell
Water Team

Tracy Dorgan
Energy Team

Laura Ruf
Water Team

Eric Li
Water Team

Lindsey Matetich
Graphic Team

Ryan Murphy
Graphic Team

Martin Regner
Master Planning Team

Elizabeth Smith
Energy Team

Paul Szemprunch
Waste Team

Cristin Szydlik
Waste Team

Matt Valentine
Graphic Team

Nathalie Westervelt
Graphic Team

6.0 Holcim Competition Submission

The excerpt below is taken from the *USACE Engineer Update*, written by Eugene Pawlik for the December 2011 issue.

U.S. ARMY CORPS OF ENGINEERS RECEIVES INTERNATIONAL AWARD FOR SUSTAINABLE DESIGN

A 26-person multidisciplinary U.S. Army Corps of Engineers team was recognized by the Holcim Foundation for their work on a net zero implementation plan for Fort Leonard Wood, Mo., during a ceremony conducted October 20 in Washington, D.C. at the National Building Museum.

The USACE team received an Acknowledgement Award in the North American category of the 3rd International Holcim Awards for Sustainable Construction, an international competition. The team's entry, "Energy water and waste efficient military installation, Fort Leonard Wood, Mo.," was one of 6,065 original international entries submitted for awards consideration for sustainable construction projects to be potentially built in 146 countries.

From the original entries, 2,251 were determined to meet the formal criteria for the competition and were then assessed by independent regional juries comprising esteemed representatives from science, business and society. Entries in the competition were judged based on five target issues:

- Innovation and transferability
- Ethical standards and social equity
- Environmental quality and resource efficiency
- Economic performance and compatibility
- Contextual and aesthetic impact

Together, the target issues "address the triple bottom line of economic, environmental, and social factors together with architectural quality and the potential to apply the innovation in other locations" per the Holcim Foundation.

The USACE entry is described as a replicable pilot project for an Army base in Missouri to change the planning of all 280 American military installations to a state of net positive energy, net zero water, and net zero waste. The project reflects the specific requirements of the military in relation to sustainability, with an additional motivation for independent systems to withstand disasters. The research led to a holistic strategy from road planning and master plan level to building design and incorporating a diversification in energy supply, water supply and waste disposal, focusing on reduction and renewable sources.

The North American awards jury recognized the project for its "adaptation of sustainable planning and construction to the military field in general and moreover in this instance for the serious and profound strategy, based on an impressive multidisciplinary research."

In addition to the implementation plan that formed the basis for the award, the team has written a book to detail the installation recommendations and the evolution in business process that is required by USACE. The USACE 2030 Project book is expected to be available as an E-book and in print in spring 2012.

"This is really quite an amazing accomplishment," said Mr. James Dalton, USACE chief of Engineering and Construction. "The Holcim Foundation awards are prestigious in the international architecture, planning, and engineering community. For our team's work to be one of only a few around the world to receive this recognition speaks to the type of outstanding people and talent we have in the USACE."

The USACE award was one of 10 North American awards presented on the night. Awards included gold, silver and bronze awards; four Acknowledgement Awards; and first, second and third prizes in the "Next Generation" category which recognizes the sustainable design work of postgraduate university students.

The North American Gold Award winner is a project for regional food-gathering nodes and logistics network in Iqluit, Nunavet, Canada. The award winner also claimed the accompanying $100,000 prize as a result of their winning entry.

Each of the four Acknowledgement prizes also included a cash award of $18,750. USACE, however, is unable to accept the cash award because it is a public organization and is unable to designate a charity to donate the award to. The Holcim Foundation announced at the ceremony that it will use the prize to fund an additional student research grant in North America.

Per the Switzerland-based Holcim Foundation, the competition seeks innovative, future-oriented and tangible sustainable construction projects and offers total prize money of $2 million per three-year competition cycle. Winning projects show how greater levels of sustainability can be reached in building and construction through people-focused designs that include simple adaptation, innovative materials, and clever architecture. The awards aim to promote sustainable responses to contemporary technological, environmental, socioeconomic and cultural issues from the building and construction industry.

It was noted at the awards ceremony that the winning projects provide a glimpse into the built environment of the future.

"It was an honor to be present at the Holcim Awards ceremony and to see the USACE team recognized for its forward-thinking work," said Ms. Chris Hinton-Lee, chief architect for USACE. "It was also very impressive and encouraging to see that the team comprises young professionals from around USACE. That holds a lot of promise for the future of our great organization."

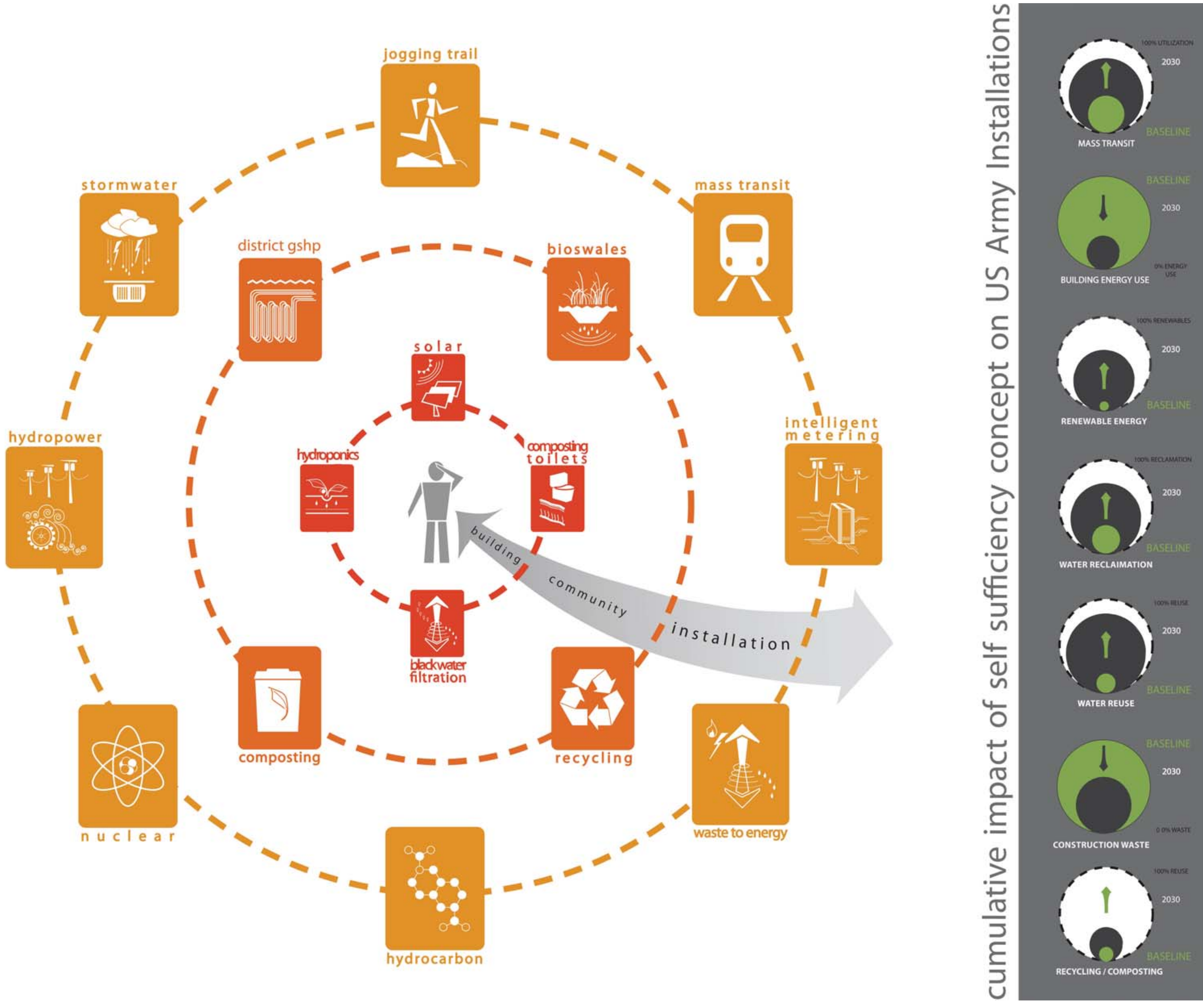
The North American region is one of five competing regions. Other regions are Europe, Latin America, Africa Middle East and Asia Pacific. The gold, silver and bronze awardees in each region automatically qualify for the 2012 Global Holcim Awards. All awardees, to include the Acknowledgement and Next Generation winners, qualify to further compete for the Global Holcim Innovation prizes to be awarded in 2012.

"This award acknowledges USACE as the technical experts in sustainable design for military construction," said Ms. Lyndsey Pruitt, a Sustainability & Energy Program Manager for Engineering & Construction in the USACE headquarters and the leader for the USACE 2030 project. "This study shows how the integration of systems from planning to buildings to people becomes a force multiplier and delivers far more net gains than designing each project independently.

"We are excited about the chance to compete for an international Holcim innovation award, but the real excitement for our team is the opportunity to bring this project to reality at For t Leonard Wood," said Pruitt. "And, when we demonstrate success there, to further expand the concepts and benefits to all the Army's installations."

Additional information about the USACE 2030 project and Acknowledgement Award can be found on the Holcim Foundation's Web site at:

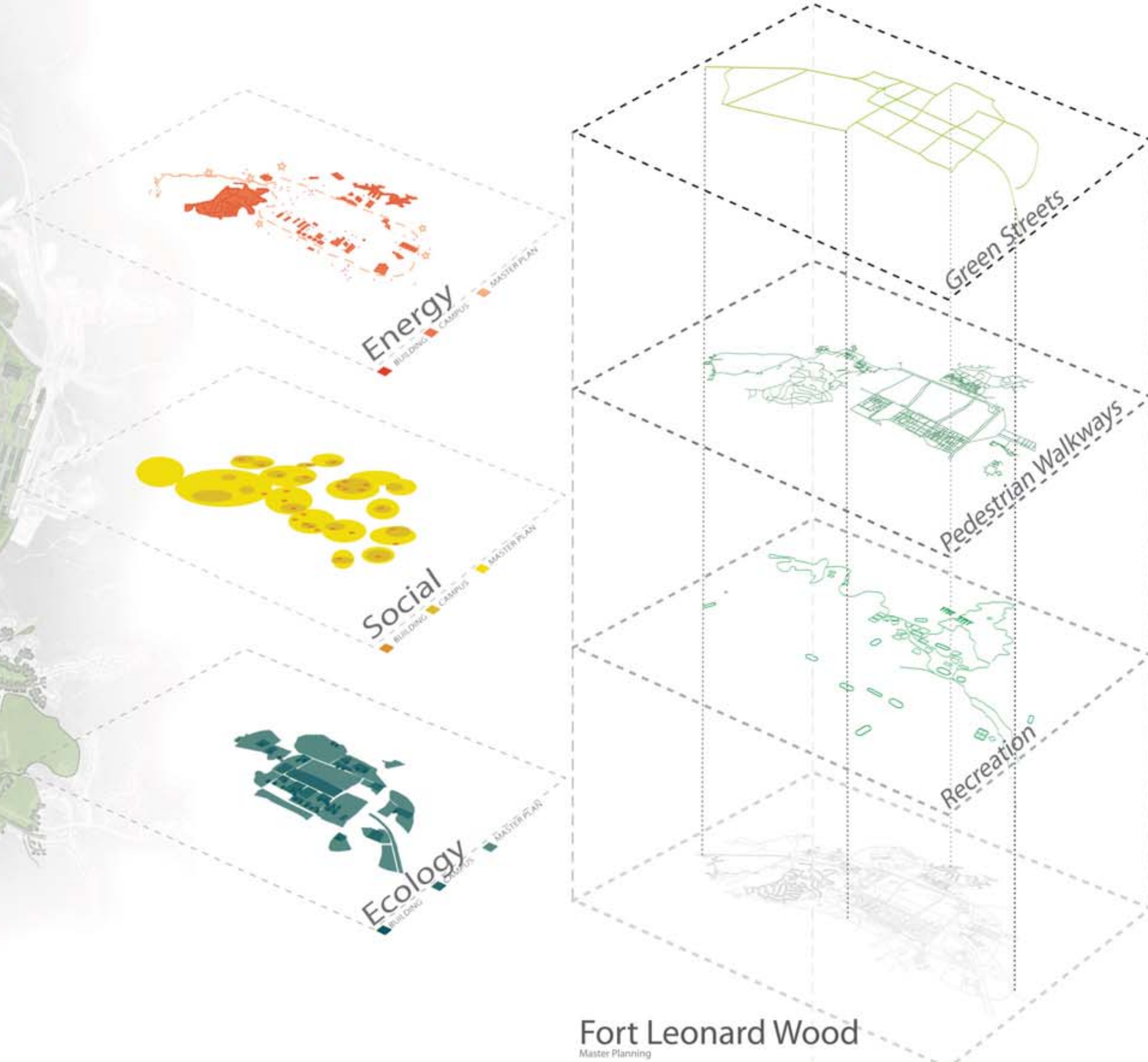
www.holcimfoundation.org/T1385/A11NAacUSms.htm#gallery


jogging trail
stormwater
mass transit
district gshp
bioswales
solar
hydropower
intelligent metering
hydroponics
composting toilets
building
community
installation
blackwater filtration
composting
recycling
nuclear
waste to energy
hydrocarbon
100% UTILIZATION
2030
BASELINE
MASS TRANSIT
BASELINE
2030
0% ENERGY USE
BUILDING ENERGY USE
100% RENEWABLES
2030
BASELINE
RENEWABLE ENERGY
100% RECLAMATION
2030
BASELINE
WATER RECLAIMATION
100% REUSE
2030
BASELINE
WATER REUSE
BASELINE
2030
0 0% WASTE
CONSTRUCTION WASTE
100% REUSE
2030
BASELINE
RECYCLING / COMPOSTING
cumulative impact of self sufficiency concept on US Army Installations

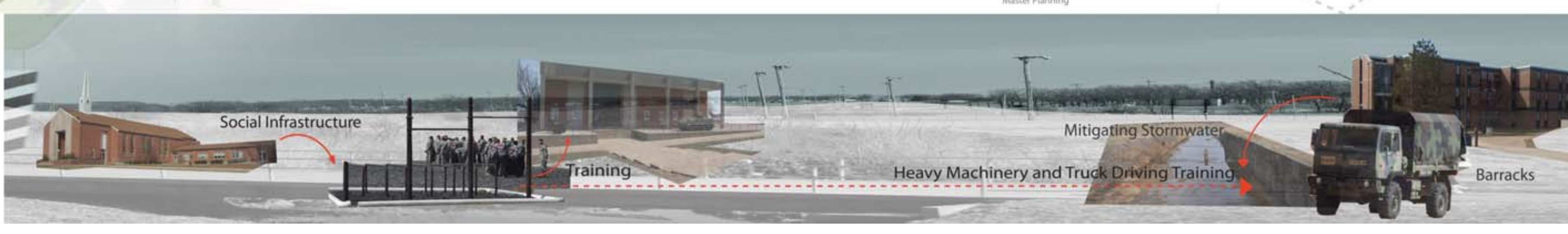
SYMCOM: Integrated Living Community

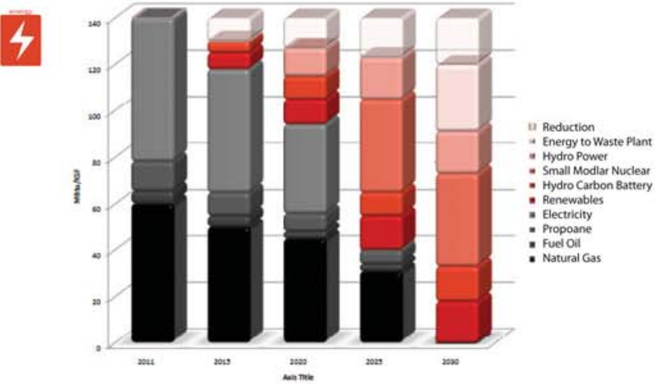
Masterplanning for Net Positive Military Installation by 2030

building. community. master plan

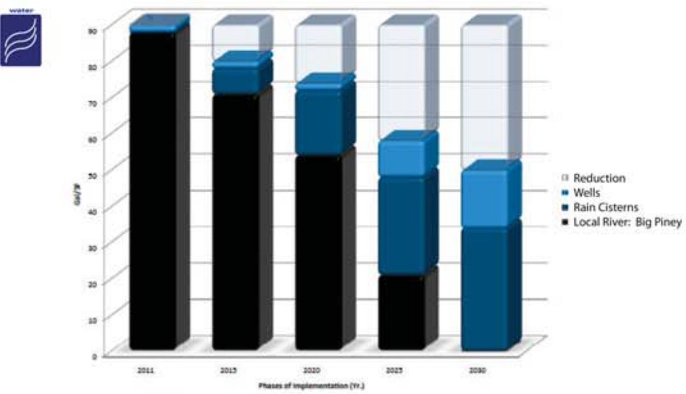


master plan scale

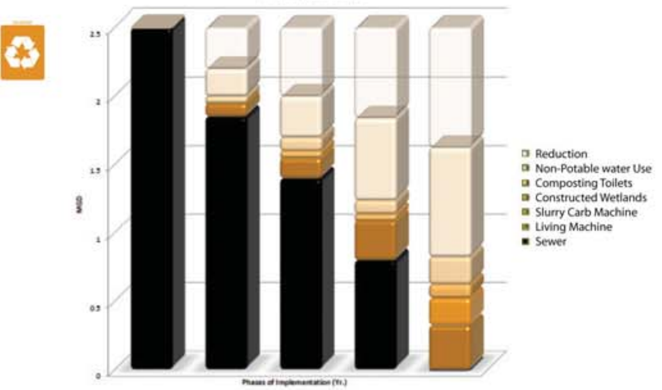




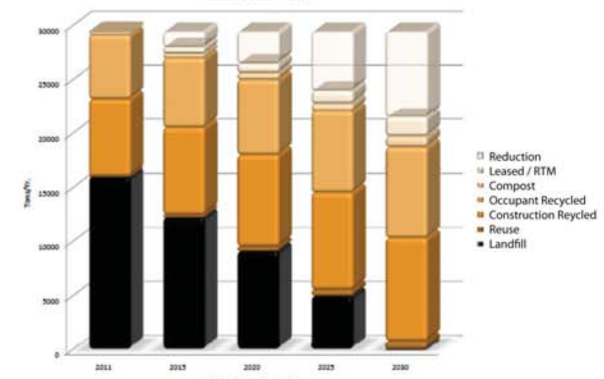
Reduction
Energy to Waste Plant
Hydro Power
Small Modlar Nuclear
Hydro Carbon Battery
Renewables
Electricity
Propane
Fuel Oil
Natural Gas
2011
2015
2020
2025
2030



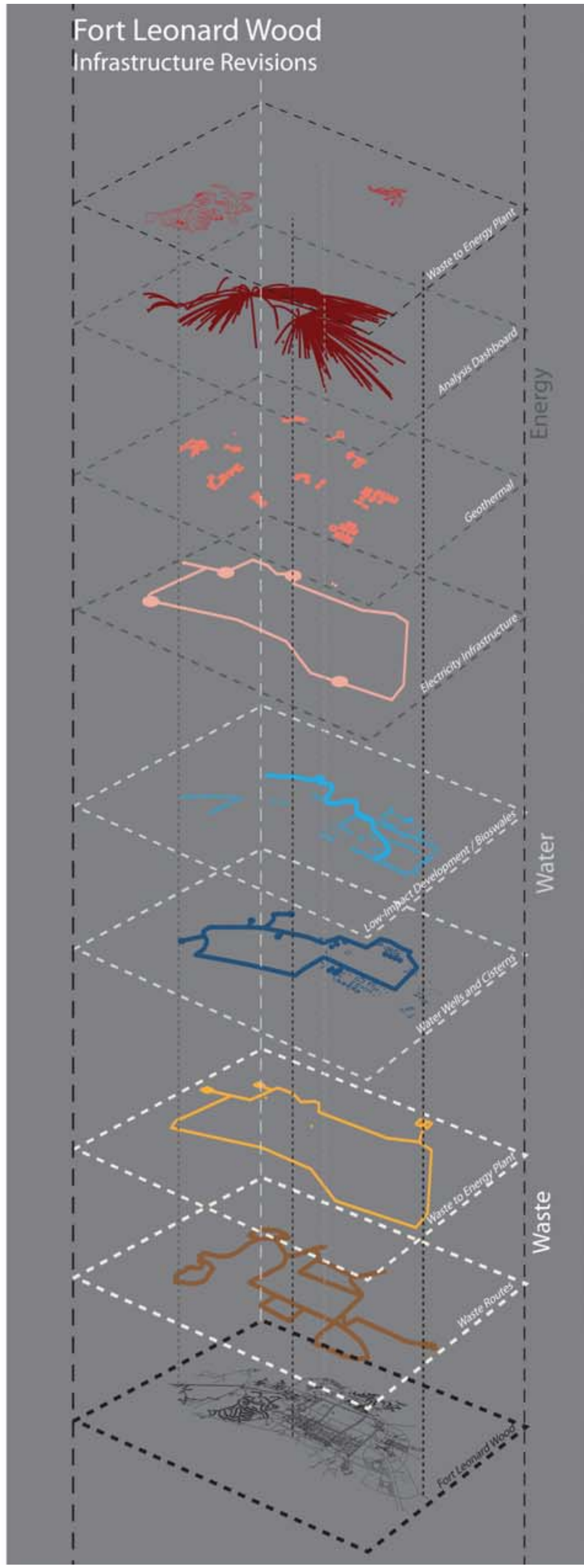
Reduction
Wells
Rain Cisterns
Local River: Big Piney
2011
2015
2020
2025
2030
Phases of Implementation (Yr.)



Reduction
Non-Potable water Use
Composting Toilets
Constructed Wetlands
Slurry Carb Machine
Living Machine
Sewer



Reduction
Leased / RTM
Compost
Occupant Recycled
Construction Recycled
Reuse
Landfill
2011
2015
2020
2025
2030



Fort Leonard Wood
Infrastructure Revisions
Waste to Energy Plant
Analysis Dashboard
Geothermal
Electricity Infrastructure
Energy
Low-Impact Development / Bioswales
Water Wells and Cisterns
Water
Waste to Energy Plant
Waste Routes
Waste
Fort Leonard Wood

Community Scale
Infrastructure Revisions
district ground source heat pump
low impact development (bioswale)
building utility dashboard
rain water cistern
Basic Training Complex (BT) Community
Advanced Individual Training Complex (AIT) &
Existing Building Community
community scale

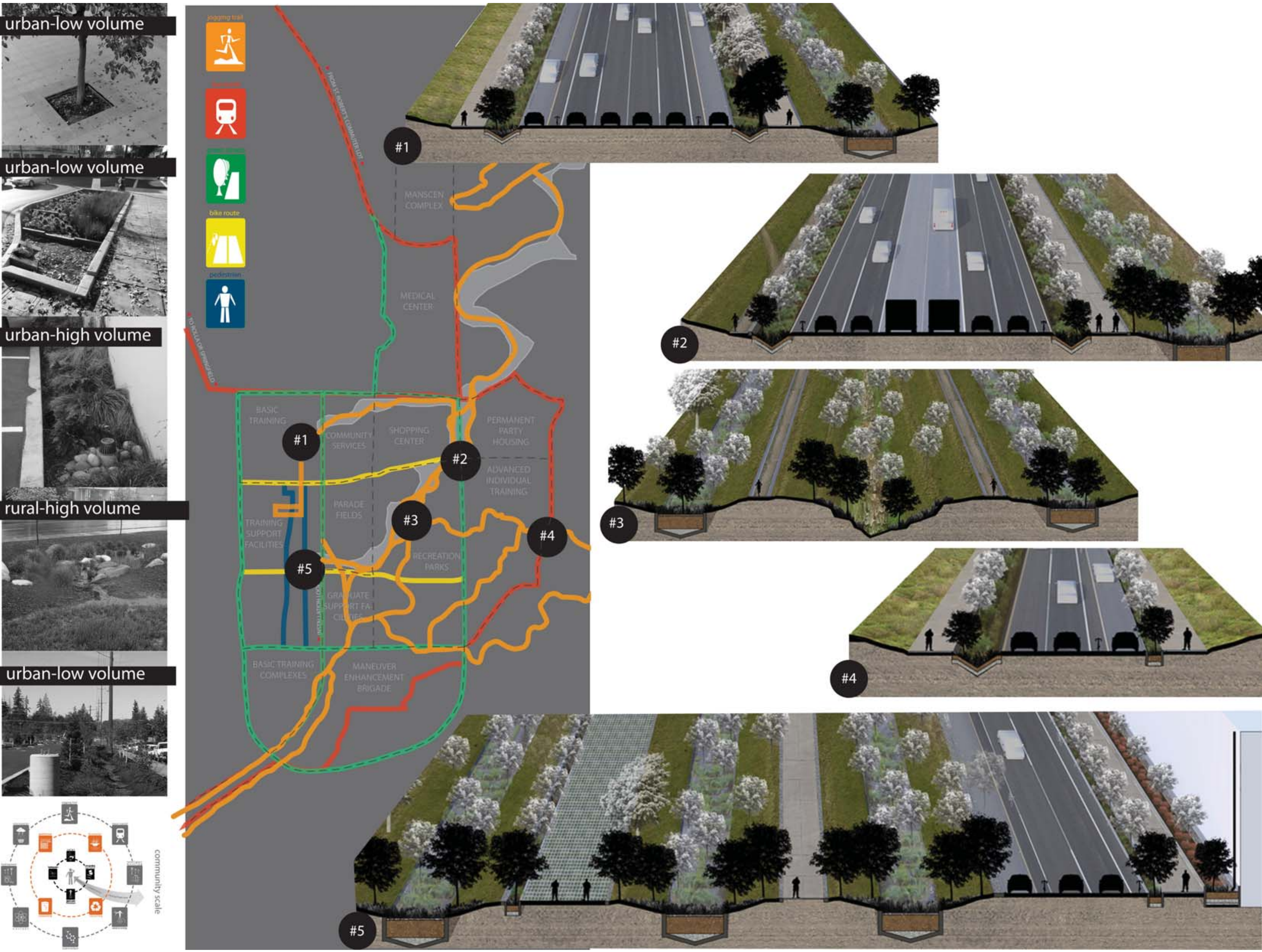
2011 | 2013 | 2015 | 2017 | 2020 | 2022 | 2025 | 2027 | 2030


building scale


community scale


master plan scale

	phase 1	phase 2	phase 3
building scale	Transit Systems: Implement priority parking for Fuel Efficient Vehicles & Carpools	Transit Systems: Develop on-street parking on building site	Transit Systems: Restore parkinglots to rehabilitated green space to support local species and promote biodiversity on the installation
	Water Infrastructure: Assess existing building water leaks Water Conservation: Low Flow and waterless systems on all new construction mandatory	Water Infrastructure: Fix all Identified water leaks LID Stormwater Management: Use constructed wetland principals on perifery of all new construction as applicable	Water conservation: Mandate all new construction harvests rainwater to cisterns
	Energy Conservation: Mr. Kilowatt Campaign Energy Management: Start metering all existing buildings and all new construction	Energy Resilience: Mandate supplemental solar on all new construction	Energy Resilence: Install verticle micro wind turbines on facilities with high wind shear
	Mandate waterless urinals & low flow fixtures	Mandate blackwater composting systems on all new construction	Adapt existing facilities to remediate waste water with living machines
community scale	Transit Systems: Coordinate ride-share program	Transit Systems: Contract private bussing service on post (2 loops w/ off-site parking at Wal-Mart)	Transit Systems: Close select streets for pedestrian access only
	Water Conservation: Mandatory elimination of potable water for lanscaping	LID Stormwater Management: Use bioswales to connect cantonement area culverts	Water Infrastructure: Add wells to north portion of installation for supply
	Energy Management: Implement load-shifting program	Install 5 hydro-carbon batteries in residential areas Ground Source Heat Pumps applied to communities Commission micro-grid on installation	Install 10 additional hydro-carbon batters in redeveloped residential areas Establish Waste to Energy Plants on select communities
	Develop community construction materials network Food Systems/Waste Management: Implement food balancing system at all DFACs	Food Systems: Shift DFAC Menus to compostable & locally grown items	Food Systems: Install community gardens
master plan scale	Transit systems: Change Streets to one-way Transit Systems: Develop continuous jogging trail within cantonement area	Transit Systems: Widen select roads in cantonement area	Transit Systems: Relocate transport school motorpool and AIT to southwest near training grounds Transit Systems: Develop safe streets through landscaping
	LID Stormwater Manageement: Rehabilitate culverts with low-flow rip rap	LID Stormwater Management: Add bioswales and bike lanes to select streets	LID Stormwater Management: Extend remediated culvert waterway to perifery of installation and terminate in constructed wetlands
	Implement energy analysis dashboard system	Disconnect transformers 1 and 2 from regional electric grid Implement demand management control system Install turbine on exsiting Pig Piney River dam	Disconnect transformer 3, 4, & 5 from regional grid Install small modular nuclear plant near existing transformer 5 Install slurry-carb facility on post
	Add recycling to existing trash route	Implement program to collect forest waste and biomass from external community	Waste Management: Policy change to allow for leasing of carpet, furniture systems and laundry machines, etc. (for recycling)



urban-low volume
urban-low volume
urban-high volume
rural-high volume
urban-low volume
jogging trail
bike route
pedestrian
MANSCEN COMPLEX
MEDICAL CENTER
BASIC TRAINING
COMMUNITY SERVICES
SHOPPING CENTER
PERMANENT PARTY HOUSING
ADVANCED INDIVIDUAL TRAINING
PARADE FIELDS
TRAINING SUPPORT FACILITIES
RECREATION PARKS
GRADUATE SUPPORT FACILITIES
BASIC TRAINING COMPLEXES
MANEUVER ENHANCEMENT BRIGADE
#1
#2
#3
#4
#5
community scale

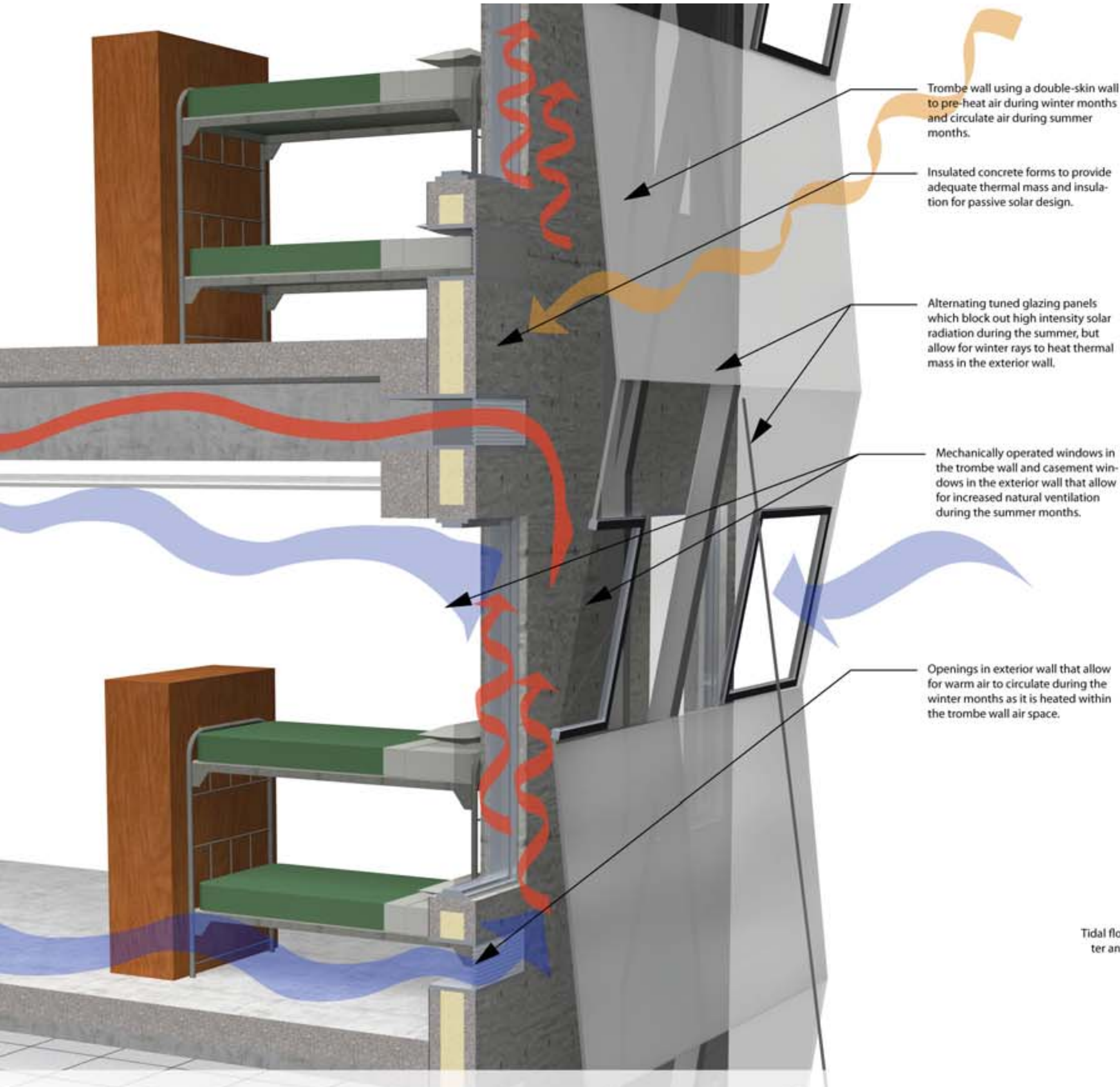
Permaculture and Ecology - The rehabilitation of the natural environment

BT Complex - Urban Agriculture Garden

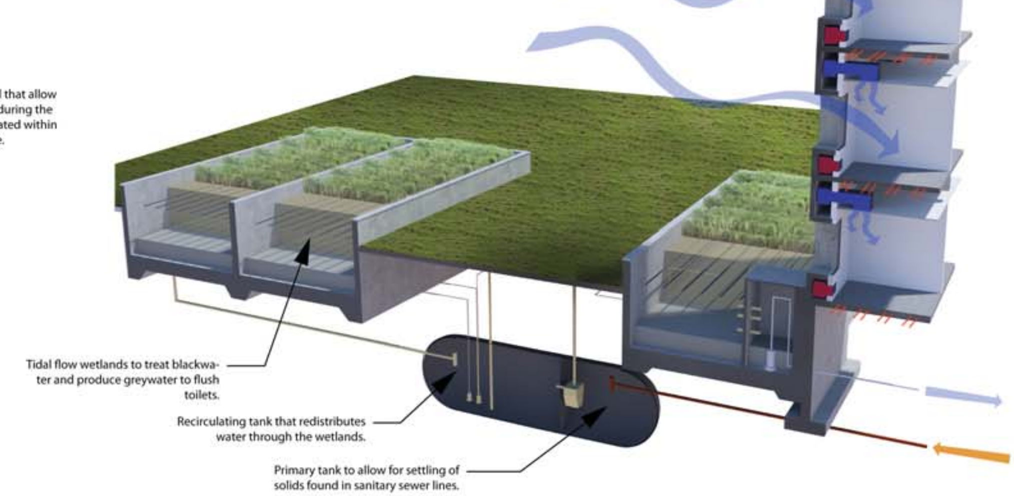
AIT Complex - Roof Jogging Trail and Urban Agriculture Garden

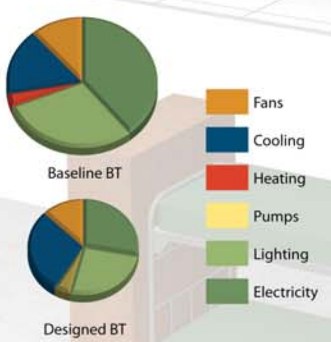

Urban Agriculture Garden
Green Roof
Solar Panels
Trombe Wall
Basic Training
Company Operations Facility (BCOF)
Solar Evacuated Tubes
Green Wall
Terra-cotta Cladding


Urban Agriculture Garden
Permeable Paving
Growth Season
PV Thin Film
FSC Certified Wood
Dormant Season
Advanced Individual Training (AIT)


Trombe wall using a double-skin wall to pre-heat air during winter months and circulate air during summer months.
Insulated concrete forms to provide adequate thermal mass and insulation for passive solar design.
Alternating tuned glazing panels which block out high intensity solar radiation during the summer, but allow for winter rays to heat thermal mass in the exterior wall.
Mechanically operated windows in the trombe wall and casement windows in the exterior wall that allow for increased natural ventilation during the summer months.
Openings in exterior wall that allow for warm air to circulate during the winter months as it is heated within the trombe wall air space.


building scale


Green roof serving as roof insulation while also providing inclined jogging trail for physical fitness training.
Occupant controlled windows to allow for natural ventilation and daylighting into individual sleeping rooms.
Tidal flow wetlands to treat blackwater and produce greywater to flush toilets.
Recirculating tank that redistributes water through the wetlands.
Primary tank to allow for settling of solids found in sanitary sewer lines.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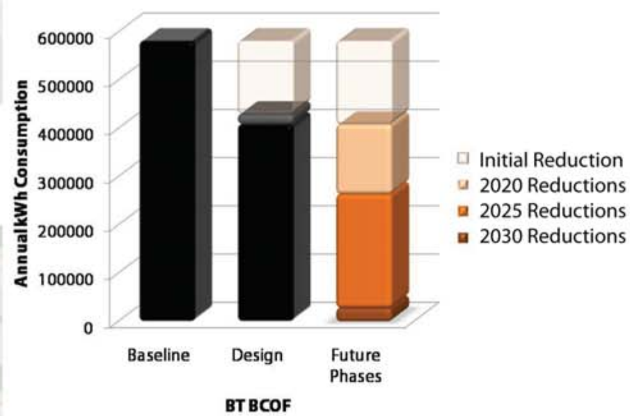
Designed BT
Fans
Cooling
Heating
Pumps
Lighting
Electricity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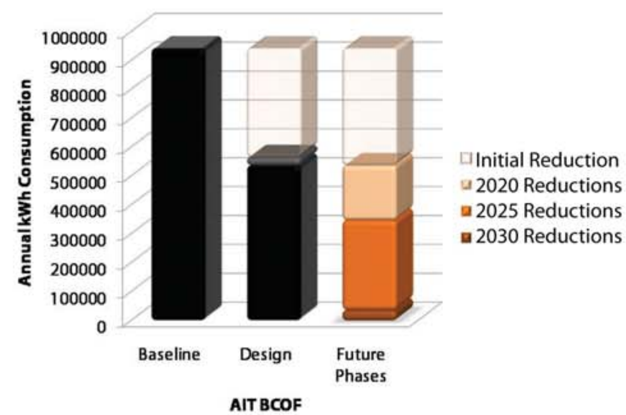
400000
300000
200000
100000
0
Baseline
Design
Future Phases
Initial Reduction
2020 Reductions
2025 Reductions
2030 Reductions
BT BCOF


Annual kWh Consumption
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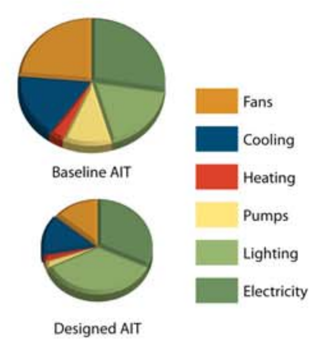
Baseline AIT
Designed AIT
Fans
Cooling
Heating
Pumps
Lighting
Electricity

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8.0 Reviewed Concepts & Technology (Tech Notes)

The technical notes included in this section provide tailored analysis of many strategies, products, and systems that are available for implementation at Fort Leonard Wood. Each tech note includes a brief description of the respective technology or strategy followed by a variety of facts and figures aimed at helping the reader determine the feasibility of each potential system. This data includes first cost, life cycle cost, maintenance information, feasibility narratives, contracting information, references, and contacts.

This study does not formally endorse any of the technologies described herein; this list is not exhaustive and independently none of these technologies is essential to the installation's success.

The potential costs, benefits, and paybacks must be evaluated in conjunction with all other technologies being considered in order to determine a fully integrated solution.

Like other portions of this document, care was taken to make analysis and calculations as accurate as possible at the time the technology was investigated. As these systems become more or less economical and functionally efficient, care should be taken to re-evaluate each system's feasibility as implementation is considered.

The appearance of external hyperlinks does not constitute endorsement by the United States Army Corps of Engineers or by the United States Department of Defense of the linked web sites, or the information, products, or services contained therein. All references are intended only to provide illustrative examples. For other than authorized activities, such as military exchanges and Morale, Welfare, and Recreation (MWR) sites, the United States Department of Defense does not exercise any editorial control over the information you may find at these locations. All links provided are consistent with the purpose of this publication.

2030 USACE Integration Project

8.1 Biomass Energy

Recommendation

Install a Biomass Wood-fuel Heating System to provide heat to the entire Advanced Individual Training (AIT) facility. Due to the size of the facility, a **Chip Boiler with Fuel Hopper** is recommended. By utilizing a Biomass System, Fort Leonard Wood will eliminate the need to burn fossil fuels at select facilities. Not only is the availability of fossil fuels in question, but fossil fuels are known to disrupt the natural ecological balance of the planet. Biomass is a regenerative (renewable) organic material that can be used to produce energy. In this instance, wood will be used as the organic material and will produce heat for the entire building. Additional information on Biomass technology can be found in Attachment A.

Location & Scale

The selected system will be installed at the **building scale**. These heating units are typically installed on the ground floor along with the other mechanical equipment and hooked into the ventilation system. Location should be easily accessible as regular maintenance is required and the wood hopper must be refilled when low. This system depends on a consistent supply of wood to burn and provide heat. Storage areas for wood pellets are also required near mechanical room entry.

Phasing

This system is projected as part of the **2015 Phase** for Fort Leonard Wood.

Initial Cost

Full installation of a biomass fuel boiler is approximately **$20,000**. This includes all set up costs and initial installation costs. Cost can vary significantly depending on the number of boilers needed as well as special installation methods required. Please see references in Attachment A for more information on sizing.

Life Cycle Cost

Life cycle costs include price of wood pellets, this can vary depending on the season and the heating demand. One ton of wood pellets costs approximately **$320**. Deliveries are typically arranged on a monthly basis depending on user needs and manufacturer's schedule. Biomass is a natural source of energy that will make giant strides in cutting down Fort Leonard Wood's environmental footprint. While minimal, wood chip/log boilers have been proven to be an inexpensive method of heating when compared with using electricity or liquefied petroleum gas (LPG).

Maintenance

Regular maintenance is required to refill the biomass heating boiler. During cold winter months, daily refilling may be required. This simply consists of loading wood pellets into the heating unit which does not require a significant amount of time. Cleaning of used wood pellets (ashes) is required weekly during peak usage periods.

Feasibility This system will offer Fort Leonard Wood an advantage towards decreasing the amount of fossil fuel disposal and thus greatly reducing their overall environmental footprint. This heating system has a low initial cost. The biggest challenge for this system is the design that must occur during the early phases of a project. Implementing this system during early design development will offer the facility and Fort Leonard Wood significant long-term advantages.

References See Attachment A

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"Biomass, an Important Source of Renewable Energy." *Biomass, Biomass Fuel, Biomass Energy*. 2010. Web. 10 March 2011. http://www.biomass.net/

Diagrams Recommend viewing the resources page provided on the Biomass Energy Resource Center website, http://www.biomasscenter.org/, for example technology diagrams and images.

Funding Plan The funding for this system should be integrated into the initial design / construction funds as awarded. This will not have a significant cost impact on the overall project but could be included in the solicitation as a Bid Option.

Contract Language Provide a complete Biomass Heating System utilizing a chip boiler with a fuel hopper fully integrated into the mechanical system. Please see Appendix for a concept diagram illustrating system components and typical layout.

As noted above, this can be included in the solicitation as a Bid Option.

Manufacturers Applicable systems may be available by these manufacturers:

Ashwell Biomass	http://www.ashwellbiomass.com/
Greenwood	http://www.greenwoodusa.com/
Multiple Suppliers	http://www.biomass-heat.com/

Baseline Relation The Biomass system will utilize approximately the same amount of space as the baseline heating unit. Changes will be taken into account during the design phase to re-size any HVAC components. Mechanical rooms already in place can house the heating units with few adjustments needed. Exterior access to mechanical rooms is needed to perform required maintenance.

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Attachment A: Reference Material

Biomass

Recent events in the world have placed an increased awareness on the need to provide alternative sources of fuel and energy. Not only is the availability of fossil fuel in question, but fossil fuels are also known to disrupt the natural ecological balance of the planet. Within the past twenty-one years there have been two catastrophic oil spills in the United States alone that are disrupting the ecology both in local areas as well as around the globe. The Exxon Valdez Oil Spill of 1989 along with the BP Oil Spill in the Gulf of Mexico in April of 2010 has severely disrupted a delicate ecological balance and may continue to do so for years to come. While these two spills are significant, they are by no means among the worst on a global level. Taking into consideration that burning fossil fuels also promotes a greenhouse effect in the ozone, it is understandable that scientists around the world are exploring biomass (which is a renewable organic energy) as a safer alternative.

A Brief Definition of Biomass

Biomass can be understood as regenerative (renewable) organic material that can be used to produce energy. These sources include aquatic or terrestrial vegetation, residues from forestry or agriculture, animal waste and municipal waste. In laymen's terms, that means biomass is manufactured from crops, wood, manure, land fill gasses and alcohol fuels. Ethanol is a prime example of biomass alcohol fuel. Producing fuel and energy from biomass is a complex procedure but the principle behind it corresponds directly to photosynthesis. This is a chemical reaction in which carbon dioxide and water are transformed into oxygen gas and glucose through the input of energy from the sun. Plants become autotrophs because they use glucose as a source of energy rather than fossil fuels.

A Self Renewing Energy

Biomass is basically self-renewing energy. The chemical equation for photosynthesis is notated as $6CO_2 + 6H_2O \dashrightarrow C_6H_{12}O_6 + 6O_2$. It shows through scientific notation that carbon dioxide plus water are converted into glucose and oxygen gas through the input of energy. With this in mind, harnessing that natural energy has become the focus of scientists in an effort to reduce the dependence on fossil fuels and find a safer and cleaner alternative source of energy.

Benefits of Biomass Fuel to the Atmosphere

One of the main benefits of biomass fuel over fossil fuel can be best understood in terms of greenhouse gasses. While both biomass fuels and fossil fuels release about the same amount of carbon dioxide into the atmosphere when burned, there is a distinct difference in the effect they each have on the atmosphere. Burning fossil fuel releases carbon dioxide that was captured during photosynthesis literally millions of years ago. As it is burned, carbon dioxide is released as a new greenhouse gas, a ‘new’ carbon dioxide. Biomass fuel, on the other hand, releases carbon dioxide that was recently captured during photosynthesis and it tends to equal itself out. Nothing ‘new’ is being sent into the atmosphere, thus greatly reducing the greenhouse gas effect on the ozone layer.

Biomass Fuel to Limit Dependence on Foreign Oil

Part of the big picture involves the Middle East and other foreign oil producing nations. With such dependence on petroleum products for fuel, there is always a tension between the need for petroleum and foreign sanctions when there is a need to sanction one or more of those countries. As biomass fuel becomes more available and as such, the dependence on outside sources of fossil fuel will become much less necessary.

Biomass Fuel Reduces Risk to the Ecology

As those two major oil spills in the United States have evidenced, there is a tremendous need to find alternative sources of fuel. Biomass is ideal because it is renewable. There is no need to drill for it and transporting it does not provide the same risk factor that is involved in transporting fossil fuel. The danger to the ecology is significantly reduced even in the event that there should be a spill. The impact would be immediate but not over a period of hundreds of years. Live video feed is being broadcasted from the Louisiana coastline to show the sludge that is washing ashore due to the most recent (2010) spill; as a result, it could be centuries before vegetation and living creatures are able to inhabit those shorelines once again. A biomass spill would not have that kind of far-reaching and long-term consequences.

B**iomass for Products Currently Dependent on Petroleum**

There is a wide array of products that are currently dependent on fossil fuels. Chemicals, plastics and an assortment of products like Vaseline are dependent on petroleum. Many of these products have become a staple of contemporary lifestyles and can easily be replaced by the same or similar products being manufactured from biomass. Some products that can be manufactured from biomass include such things as antifreeze, plastics, acids for photographic film, oil, wood adhesives, foam insulation, glues, and even toothpaste gel or artificial sweeteners. Scientific research is currently ongoing to provide cost effective methods of providing these ecologically preferable products to consumers.

Crops for Biomass Utilize Inhospitable Agricultural Land

One concern that many people have is where the land will come from that is used to produce crops for biomass. It has been a real concern that agricultural land which is needed for producing foods for human or animal consumption will be taken over. This is not the case because many crops which are otherwise inedible can be used in the production of biomass fuels. The added benefit to this is that as crops are harvested for use in biomass, they can be immediately replanted. Because of this, biomass can be harvest yearly instead of having to wait millions of years for the fossil fuels that we currently use.

Biomass provides a cleaner and renewable source of energy as well as the ability to reduce dependence on oil. More and more uses are being discovered as research continues in this amazing field with the current emphasis being placed on the fact that Biomass is not only affordable but is also a safer alternative fuel. With this in mind, new bio fuels will become more easily available in the future which in turn provides a solution to some of the current ecological and atmospheric concerns.

Biomass and Fossil Fuels

The Difference Between Biomass And Fossil Fuels

Fossil fuels, which are located all over the world have been in existence for millions of years. They are rotted down organic matter, which became entombed between rock layers. As time went on the pressure of the earth's movements, heat and other factors caused these materials to become hydrocarbons, which we have today. Biomass and Fossil Fuels are related in that they both originated from organic matter.

At the current time the Middle East region has the largest concentration of fossil fuels. They are followed by Eurasia and North America. They are the three countries of the world that have the greatest amounts of this fuel.

The fossil fuels produce great energy and are used in all types of manufacturing as well as everyday life. Things such as gasoline, electricity, natural gas and many others are derived from this source. The fact that they are rapidly becoming depleted and are non-renewable, as well as putting dangerous emissions into the air, has become a concern of governments worldwide.

Biomass is also composed of organic matter. However, it has not laid around for millions of years to become part of the earth's structure. It is natural products such as trees, plants, wood waste and other such things. Manure of certain animals is also included in this mix.

The chemistry of biomass is not difficult to understand. It receives its energy from the sun that mixes with the plants natural chemistry to form solar energy. The conversion process involves carbon, hydrogen and oxygen within the plant structure. This is stored and can be converted into commercial energy use.

With the threat of global warming and studies showing that carbon emission into the air is harmful to the human body, a great deal of interest is being concentrated on biomass as a major energy source. It is clean, only releases natural elements into the air so is not harmful to the atmosphere or humans.

Biomass can be converted into ethanol or methanol by two methods. Thermal processes produce ethanol and methanol is produced by fermentation and digestion. The thermal processes include combustion, gasification or pyrolysis, while the fermentation and digestion processes include the use of yeast and various acids.

The process of using biomass on a large scale has been held back mainly by the expense of the conversion. There are a number of plants throughout the United States that are using these methods but so far, it has been too expensive to really become a viable option.

The agricultural industry is being encouraged to plant crops, such as corn, that has an elevated concentration of the chemical combinations that produce a high yield of energy. This, however, has backfired, in a way, as the use of this crop has lowered the amount available for human and animal consumption. As a result, in the market today, one will find that meat has increased considerably in price due to the cost of feeding these animals. This is why more encouragement is being given to planting things such as switchgrass, which will not affect the food production chain.

Biomass Boilers

The New "Green" Option With Biomass Boilers

For those unfamiliar with the term biomass, it is an alternative fuel source that utilizes organic materials made into pellets that is used as a fuel source. It has been found to generate heat equivalent to other forms of fuel, yet results in lower emissions and residues. Today, one more piece of equipment has been added to an already broad array of products in the form of Biomass Boilers.

As the cost of fossil fuels continues to increase, the need for low cost alternatives is ever-increasing. Although the heating industry has been dominated for the past five decades by gas, oil, and electric models, the growing trend for "green" alternatives is boosting sales in the biomass business providing many with a new view of options available on the market today.

Although many forms of this kind of fuel are available, today's boilers generally utilize wood pellets collected from manufacturing enterprises that generate residue and cast-offs in the form of sawdust as well as wood scraps. These are preferred since they require less maintenance. Although originally manufacturers were pleased to have anyone haul off their cast-offs, today they have realized the value of this commodity and now charge for it.

Today's boilers come in various types, sizes, and compositions. Although most are made for residential use, there are a growing number of designs available for commercial use. Constructed for use both inside and outside the structure, there are advantages and disadvantages to both. Since they require a hopper to hold the pellets as well as a storage bin for supplies, most prefer outdoor models for their convenience.

The open systems available in most designs allow them to be made to accommodate a variety of needs making it safer than pressurized systems. Although they can rust, corrode, and develop mineral deposits, the lower costs and emissions can make up for any disadvantage they may have.

In order to help change the mindset of those who want to go "green, " but continue to have reservations, hybrid systems are also being manufactured that provide flexibility as well as reliability. They burn biomass fuels, just like other systems, but also fossil fuels such as oil, natural gas, and propane. In this way, if the hopper is not refilled, an order for pellets that arrives late, or an emergency situation occurs which results in the failure of traditional fuels, the system can continue to feed off the back up system ensuring that the boiler continues to function as designed.

One need not worry about refilling the hopper during severe weather as fully automated operating systems are also available. With this addition, storage bins can be connected to conveyor belts and traveling stokers in order to provide a fully-automated or semi-automated system used in conjunction with heating, water, and radiant floor boiler systems. This also provides an added convenience for those who are older as well.

Biomass boilers today have taken heating systems to a whole new level. It has many advantages over traditional systems and, for those who choose to go "green", it is considered a renewable energy source. The fuels have a tendency to be less expensive, but they do generate smoke and, therefore, should be reviewed by the local planning committee in each community before a final decision is made.

Benefits of using biomass as a sustainable fuel

Correctly managed, biomass is a sustainable fuel that can offer a wide range of benefits:

- Biomass is a "carbon lean" fuel producing a fraction of the Carbon emissions of fossil fuels.
- Biomass can be sourced locally, from within the UK, on an indefinite basis, contributing to security of supply.
- UK sourced biomass can offer local business opportunities and support the rural economy.
- The establishment of local networks of production and usage, allows financial and environmental costs of transport to be minimized. There is no region in the UK that cannot be a producer of biomass.
- The use of biomass fuel provides an economic incentive to manage woodland which improves biodiversity.
- Many biomass fuels generate lower levels of such atmospheric pollutants as sulphur dioxide, that contributes to 'acid rain'. Modern biomass combustion systems are highly sophisticated, offering combustion efficiency and emission levels comparable with the best fossil fuel boilers.
- Biomass residues, arisings, co-products and waste not used for energy, or some other application will usually rot. This will generate CO_2 in any case, and may also produce methane (CH_4), a greenhouse gas 21 times more potent that CO_2.

Recommendation

Incorporate requirements for Greywater Irrigation Systems and Blackwater Composters in all new construction projects starting in 2015.

Greywater Irrigation System: Irrigate the entire site using greywater that originates from washing machines, bathtubs, showers, dishwashers, sinks, as well as rainwater run-off from the roof. Simple plumbing features including a holding tank, flow splitter, irrigation chamber, and piping can filter greywater from the source to the surrounding site; bypassing the sewer drain. Significant site consideration will need to be taken into account to ensure piping and irrigation chambers are laid out systematically.

Blackwater Composters: Install blackwater composters in bottom floor or basement level that will collect wastewater from the source and use aerobic decomposition to slowly break down both urine and feces into stable compounds. Composting is a method of breaking down organic waste matter on-site and eliminating the demand on sewage plants. Due to the size of the facility, multiple composters would be needed, taking up a considerable amount of space. This would be recommended for remote locations on base and facilities with lower sewage demand.

Location & Scale

Greywater Irrigation System: This system is implemented at the **building scale**. Source pipes run vertically through the building to the storage tank. Piping from the storage tank brings irrigation water to the surrounding site.

Blackwater Composters: This system is implemented at the **building scale**. Multiple composters would need to be located on the lower level and would take up a considerable amount of space.

Phasing

Both the **Greywater Irrigation System** and the **Blackwater Composters** should be implemented as part of the **2015 Phase** in all new construction. These systems must be designed specifically for each facility and installed post site work and pre-laying of the foundation.

Initial Cost

Greywater Irrigation System: While the initial cost of this system will vary based on the facility, it **should not exceed $50,000** to ensure the payback period can be met. Components in the cost consideration include pumps, valves, fittings, piping, and filters. These items would vary depending on the site configuration.

Blackwater Composters: Initial cost of this system would primarily include the waste composters that must be situated at the lower level. These tank systems (include 2-4 toilet fixtures connected to each) are approximately **$7-8,000 each** with an install cost of 40 man hours per tank system. Due to the occupant size in facilities this would be added to, numerous tanks would be needed. Single tank at lower level approximate size: 6' wide x 10' long x 7.5' tall; with 4' clearance in front for maintenance.

Life Cycle Cost

Greywater Irrigation System: By eliminating the need for fresh water irrigation, this system would possibly save thousands of dollars each year. An actual life cycle cost would vary based on irrigation demand.

Blackwater Composters: This system would result in cost savings due to a decrease in off-site sewage needs as well as decrease the environmental impact of the facilities waste footprint. Actual Life Cycle Cost varies based on size of facility and actual sewage demand.

Waterless toilets add no water to the system while foam flush toilets used for upper levels would add 3-6oz. of water per use as opposed to conventional water closets using 1.6 gal per flush (34:1 water use ratio). Each tank system also requires 1 gal of water per day to keep the compost pile moist. One tank system with (4) four foam flush toilets connected would have an initial install cost of **$10,000**, use approximately 1/34 amount of water over (4) four conventional water closets, require wood chips raked into the composter monthly $15*****, major maintenance for emptying every 3-5 years $480-960*****, replacement of pumps and fan motors $175 each every 10 years, per tank system. Total operations and maintenance cost for a system in place for fifty years, would be approximately **$28,000**.

**Cost of maintenance based on $60/hour wage for Department of Public Works (DPW) staff to perform.*

Maintenance

Greywater Irrigation System: This system will not require significant maintenance at any point unless problems arise such as clogging, etc. The main holding tank will need to be emptied approximately twice a year. Exterior pipes/drains/pumps may need to be cleaned a couple times a year to make sure the system does not get backed up from debris.

Blackwater Composters: This system will require significant maintenance every 3-5 years to empty each blackwater composter. This work will more than likely need to be performed by a private contractor trained in this type of work. Monthly maintenance will be required for adding wood chips and raking into the compost pile (maintenance time estimated at 10-15 minutes per tank) which could be done by the DPW. Routine monitoring should also be done by the DPW staff for potential clogs detected by sensors in the system.

Feasibility

Greywater Irrigation System: This system contributes to the **2030 Net Zero Water and Waste** goals. If incorporated early in the design process, the greywater irrigation system can be a very inexpensive and efficient way to irrigate the entire site using both building greywater and rainwater from roof run-off. This system will eliminate the need to bring fresh water in from off-site which will lower the cost and demand of the entire facility. Considering plant irrigation does not require fresh water, re-using greywater from building uses and rainwater is a very feasible consideration for this project.

Blackwater Composters: This system contributes to the **2030 Net Zero Water and Waste** goals. While this system significantly decreases the waste exiting the site, it can be very expensive and space intensive. A large amount of space at the lower level of the facility is needed to house the multiple composter tanks. Due to this, the recommendation is to utilize The Living System (See Tech Notes) in the place of the blackwater composters since that system will not take up significant amounts of building space.

References

See Attachment A

Ludwig, Art. "Greywater Recycling." *Greywater Recycling Basics*. 2011. Web. 14 Feb. 2011. http://www.letsgogreen.com/greywater-recycling.html

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Diagrams

Recommend viewing the science and technology pages provided on the Clivus New England website, http://www.clivusne.com/, for example technology diagrams and images.

Funding Plan

Both systems would need to be funded with initial design/construction funds as awarded. Greywater irrigation will not be a significant cost; however, blackwater composting will need additional consideration since it affects a large part of the design and construction process.

Contract Language

Greywater Irrigation System: Provide *greywater irrigation system* to supply irrigation for entire site. System shall bring water from various greywater sources (i.e. shower, bath, washing machine, sink, rainwater drainage etc.) and empty water into a holding tank which, in turn, shall pump water throughout site (flower beds, grassed areas, tree beds, etc.).

Blackwater Composters: Provide *blackwater composting system* to be utilized by the entire facility. Design the system to accommodate maximum uses with minimum maintenance. As part of the system, include a fan that eliminates odors in the restroom, a liquid removal pump, an automatic moistening system (1 gal of water per tank/day) and storage for the liquid end product.

Manufacturers

Greywater Irrigation System: No specific manufacturer.

Blackwater Composters: Clivus Multrum – Designed to accommodate the range of commercial and residential needs, Clivus Multrum systems are made of Polyethylene and accommodate 18,000 to 65,000 uses per year per composter and a number of space arrangements. All systems come equipped with a fan that eliminates odors in the restroom, a liquid removal pump, an automatic moistening system and storage for the liquid end product. All Clivus Multrum composting systems are compatible with both our waterless toilet and our Foam-flush toilet.

Other applicable systems may be available by these manufacturers**:**

Envirolet	http://www.envirolet.com/
Santerra Green	http://www.santerragreen.com/

Baseline Relation

Greywater Irrigation System: This technology will decrease water demand by eliminating the cost of landscape irrigation in new facilities. Since there is no meter data available on irrigation consumption, it is difficult to estimate the cost saving from this reduction.

Blackwater Composters: This system will reduce the load on the wastewater treatment facility and eliminate the need for sanitary sewer piping from the facility.

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Attachment A: Reference Material

Greywater Recycling Basics

What Is Greywater?

Greywater is any household wastewater with the exception of wastewater from toilets, which is known as blackwater. Typically, 50-80% of household wastewater is greywater from kitchen sinks, dishwashers, bathroom sinks, tubs, and showers. Of course, if you use a composting toilet, 100% of your household wastewater is greywater.

Freshly generated greywater is not as nasty as blackwater, but if it's not handled properly it can soon become so. Greywater decomposes at a much faster rate than blackwater and if stored for as little as 24 hours, the bacteria in it use up all the oxygen and the greywater becomes anaerobic and turns septic. After this point it is more like blackwater - stinky and a health hazard. In fact, many jurisdictions have strict regulations about disposal of greywater, some even require it to be treated as blackwater.

The safest way to handle greywater is to introduce it directly to the biologically active topsoil layer, where soil bacteria can quickly break it down, rendering the nutrients available to plants. This biological water purification is much more effective than any engineered treatment, thus protecting the quality of groundwater and surface waters.

Benefits of Greywater Recycling For Irrigation

- **Reduce fresh water use** - When the weather is warm, about half of the water consumed by the average household in North America is for outdoor use. Capturing the indoor greywater for use outdoors can cut water usage in half.

- **Reduce strain on septic system or treatment plant** - Greywater makes up the majority of the household wastewater stream, so diverting it from the septic system extends the life and capacity of the system. For municipal systems, decreased input means more effective treatment coupled with cost savings.

- **Develop otherwise unsuitable real estate** - A greywater recycling system, along with the use of composting toilets, can enable the development of property that is unsuitable for a septic system.

- **Groundwater Recharge** - Greywater recycling for irrigation replenishes groundwater, helping the natural hydrologic cycle to keep functioning.

- **Plant growth** - Greywater can support plant growth in areas that might otherwise not have enough water.

- **Maintain soil fertility** - The nutrients in the greywater are broken down by bacteria in the soil and made available to plants. This helps to maintain soil fertility.

- **Enhance water quality** - The quality of groundwater and surface waters are much better preserved by the natural purification processes the greywater undergoes in the top layers of the soil than by any engineered water treatment.

- **Satisfaction** - The greywater user gets the satisfaction of direct participation in the responsible management of global nutrient and water cycles.

Elements of a Greywater Irrigation System

- **Greywater source(s) -** Washing machine, shower, bathtub and/or sinks
- **Collection plumbing -** Pipes that transport greywater from inside the house to just outside the house
- **Surge Tank, filter and pump -** Optional elements that add complexity and cost but make the distribution plumbing's job easier
- **Distribution plumbing -** Pipes that transport greywater from just outside the house to locations throughout the receiving landscape
- **Receiving landscape -** Soil, roots, plants, and mulch basins that contain, cover, purify, and use the greywater
- **People -** Those who design, make and maintain the system, generate the greywater, tend the garden and eat the food it produces. People are a critical but often overlooked component of the system

Blackwater Composting

How it works

The Clivus composting toilet uses aerobic decomposition to slowly break down both urine and feces into stable compounds within the polyethylene composting unit. The sloped design (“Clivus Multrum” means inclined chamber) separates urine from feces.

As urine moves by gravity to the lowest point of the composting unit, bacterial action causes a chemical transformation that converts the chemically unstable components of urine (urea and ammonia), into a liquid end-product containing nitrite and nitrate. This liquid end-product is biologically and chemically stable and contains nutrients which are valuable for fertilizer. The liquid end-product is generated at a rate of about one gallon for every 20 uses and, in most cases, is automatically pumped from the compost chamber into a separate storage tank.

The separation of urine from feces ensures that feces remain in an aerobic environment which includes bacteria, fungi, insects and compost worms. The organisms slowly break down feces into a compost material that has chemical, biological and aesthetic characteristics similar to topsoil and reduces its volume by over 90%.

Since the mass of organic matter in the composting unit available to the decomposer organisms is relatively small, temperatures inside the composting unit never exceed 100°F. Carbon dioxide (CO_2) and water vapor are the primary vent gases. A continuously operating fan pulls air down the toilet fixture and out through a vent stack creating a completely odorless bathroom at all times.

Potential human pathogens are either killed by predatory organisms or by the long retention time in the system, as demonstrated by National Sanitation Foundation field testing. No compost is removed before a year of use and it is often several years before any is taken out of the compost tank.

All Clivus compost toilet systems are certified under the National Sanitation Foundation's Standard 41, as required by many state and local governments. Health or environmental codes regulate the use of the liquid or solid compost products from the Clivus system. We encourage the use of these compost products as a fertilizer/soil conditioner wherever codes allow.

Composting Science

Composting is the bio-chemical decomposition of organic matter by aerobic organisms, i.e., organisms which get oxygen from the atmosphere and give off carbon dioxide. Composting takes place in all soils which support plant and animal life. The compost toilet employs the same process in the controlled environment of the compost chamber.

This process is distinct from anaerobic decomposition, which takes place naturally in water-saturated environments such as swamps, and is typical of septic tanks. Anaerobic, or liquid-saturated, conditions produce methane and the offensive odors associated with septic systems.

Organisms found in the composter include bacteria, actinomycetes, fungi, arthropods, and earthworms and are added manually once the system is operating. Energy, carbon dioxide and water vapor are released by the organic matter in feces through the activity of the composting organisms. A less chemically complex, more chemically stable substance, rich in organic matter, is produced. Feces volume, which is mostly water, is reduced by over 90%.

Temperatures in the compost toilet remain in the middle, or mesophilic, range (65-113°F) and don't exceed 100°. Potential pathogens in feces are, therefore, not destroyed by heat. Those pathogens that require an aqueous environment die quickly in the non-saturated condition of the compost chamber. Others die because of the intense competition for nutrients; still others are consumed by predators which populate the system. The biological content of the dry end-product is similar to that found in topsoil. As a measure of its stability, the dry end-product from the Clivus Multrum contains less than 200 MPN (Most Probable Number) of fecal coliform per 100 grams. This meets the level required under National Sanitation Foundation Standard 41 for Non-saturated Systems. The dry end-product contains a wide array of plant nutrients and is intended to be used as a fertilizer/soil conditioner. Its use may or may not be regulated by local authorities.

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8.3 Building Occupant Training

building occupant training

TECHNOTE

Recommendation

In order for facilities at Fort Leonard Wood to meet design goals for building performance, occupants need to receive training on how to operate these buildings effectively and efficiently. Case studies on learning suggest a basic level of knowledge must be acquired and established, in this case sustainability principles, to provide a foundation of context for all students to build upon. This will help Recruits understand results of their behaviors and will increase level of understanding when presented with additional training content specific to individual building operation requirements.

Training for building occupants needs to be an Army wide initiative. As Basic Combat Training (BT) is very regimented, the training for resource conservation initiatives and building operation must be just as regimented. The basic knowledge of sustainability goals should start before the recruits arrive at Fort Leonard Wood. Training should start at the Drill Sergeant School. The Drill Sergeants must understand the Commander's intent and the importance of resiliency at installations. Just like soldiers must obtain marksman with their rifles, complete a road march in three hours, or pass a physical training test; units should have standards to adhere to for energy use, waste disposal, and water use.

To reinforce training received, metering feedback through building dashboards (see Dashboard Tech Note) should be installed in facilities as a useful tool for occupants to see results of their behavior on resource usage and operating cost. This tool should be introduced and explained in training as it will play a strong role in reinforcing and sustaining learned behavior as it is applied.

Location & Scale

This training must be addressed at the U.S. Army Training and Doctrine Command (TRADOC) level to instill change to building occupancy habits throughout the Army.

Phasing

Training plan should be implemented in the **2015 Phase**.

Initial Cost

Low initial cost for set up and implementation of training as a part of Basic Combat Training.

Life Cycle Cost

Life cycle cost savings through optimized building operation and conservation strictly observed by building occupants. Success of high-performance buildings depends highly on how it is managed and operated; this is where training initiatives pay off by helping to drive down life cycle costs of operating buildings.

Maintenance

As new technologies are introduced through future construction projects at Fort Leonard Wood working towards net zero goals the building occupant training plans will need to be re-evaluated and updated. Training plans should be updated and tailored to accommodate changes in basic level of knowledge in conservation behavior and sustainability principles as well as the evolution of buildings and technology at the installation.

Feasibility

Training will contribute to the **2030 Net Zero Water, Energy, and Waste** goals by actively teaching and applying behaviors that will help building occupants conserve resources and operate the buildings they occupy for heightened performance.

Many of the technologies found in high performing buildings are controlled by occupants such as window shades, individual thermostat controls, and waste reduction which are all affected by user behaviors. Development of a decision matrix approach (see article, "Developing a Focus for Green Building Occupant Training Materials") to help limit information provided in training to the most relevant and necessary content may be useful as high performance buildings require user's to have a wide breadth of knowledge to change behaviors to meet the operation goals of the building.

References

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Sustainable Cities Institute. "Building Occupant Education and Training." Web. 23 July 2011.
http://www.sustainablecitiesinstitute.org/view/page.basic/class/feature.class/Lesson_Occupant_Traing_Education

Funding Plan

Training plan development and updates would need to be funded with operations and maintenance (O&M) funds.

Contract Language

Require O&M manuals to have sections specifically geared toward building occupant participation in controlling their environment within the building as a "user's guide". This document should include information on how the high performance building differs from a typical building. Additionally, information on appropriate times to open windows, manually control blinds or louvers when certain conditions permit should all be described herein for reference in putting together training plans for individual facility use.

Add design requirement to include extensive educational signage plan to teach building users about the building and reinforce points covered in training for operation of the individual facility. This can also gain a LEED Innovation in Design credit for educational signage.

Baseline Relation

By implementing training for all new recruits and continuing education for building occupants to demonstrate the influence of their behavior on buildings and the installation operability it improves overall operation which cuts resource waste and costs.

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8.4 Building Orientation

Recommendation

Building orientation is one element of integrated building design that must be coordinated with envelope, fenestration, and shading to achieve maximum energy efficiency. Building orientation affects the energy usage within the building by changing the timing and magnitude of envelope loads (conduction and solar radiation) and affecting the required amount of electric lighting. Building envelope, fenestrations, and shading features must be applied based on the building orientation to maximize daylighting potential, minimize summer solar heat gains, maximize winter solar heat gains, and perhaps take advantage of natural ventilation when appropriate.

Location & Scale

This system is implemented at the **area scale**. Individual building orientation and site layout should be established early in the design process with surrounding land features, climate, adjacencies, and landscaping considered. These features contribute to the effectiveness of design features to be incorporated in each building.

Phasing

Building orientation should be a consideration for every project and should be implemented in the pre **2015 Phase** for all future master planning actions.

First Cost

Changing a building's orientation on the site can affect first cost by affecting the run and length of utility connections, the type of building features and systems, and the magnitude of landscaping and grading required.

Life Cycle Cost

If building orientation is accounted for as a part of an integrated design, it can contribute to an overall lower life cycle cost of the building due to reduced first cost and energy use. As mentioned above, architectural, mechanical, and electrical energy saving features and strategies must be selected based on the building orientation in order to end up with a high performing building.

Maintenance

Building orientation should not directly contribute to operating and maintenance costs of the building. However, individual building features such as shade structures and lighting controls that require varying amounts of maintenance could be added, modified, or removed depending on building orientation.

Feasibility

Discussion integrating building orientation with other building design features can take place during the pre-design charrette process along with discussion of other energy efficiency / sustainability issues. Ideally, projects will be provided with sites that offer sufficient flexibility for the design team to experiment with various building orientations.

Funding Plan Implementation of optimal building orientation will not require any additional funding. Any cost to the project will be part of the project funding and design.

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8.5 Composting

Recommendation

Install an **In-Vessel Composting System** to process large amounts of waste using aerobic microorganisms. In-Vessel Composting systems can accommodate virtually any type of organic waste (e.g. meat, animal manure, biosolids, food scraps). This type of composting occurs within a contained vessel, allowing more control over the process compared to other composting systems. Composting systems create numerous positive physical, chemical, economical, and biological impacts, including reducing erosion and runoff, drought resistance, providing soil nutrients and biota, reducing environmental contaminants like heavy metals, and reducing the need for pesticides. Composting also reduces environmental pollution and landfill mass.

Location and Scale

This system is implemented on the **installation scale**. An in-vessel system of this size requires at least a five acre site. An optimum location for an in-vessel composting system is a large tract of land in an industrial area or a site near a municipal solid waste landfill and wastewater treatment facility.

Phasing

The composting system should be implemented as part of the **2015 Phase**. This type of compositing system can be operational in ninety days.

Initial Cost

Depending on the capacity of the In-Vessel Composting System prices range from **$9,000 to $25,000 per container** including process control systems. Minimum systems, which can processes twenty tons per day (TPD), consist of five to forty cubic yard containers to one biofilter. Components in the cost consideration include a front-end loader and roll-off truck.

Life Cycle Cost

General annual operation and maintenance costs for an In-Vessel Composting System range from **$100-$280 per dry ton** of biosolids processed.

Maintenance

In-Vessel Composting Systems require some maintenance, but compared to other composting systems, In-Vessel Composting Systems reduce the amount of manual labor and monitoring needed for operation. Typical labor requirements for this type of system include heavy equipment operators, maintenance personnel, and instrumentation/computer operators. A clear understanding of biological systems is necessary. Additional staff or consultants may be needed to manage end use and market compost.

Feasibility

This system contributes to the **2030 Net Zero Waste** goals. If implemented early in the initial construction phase, compost product can be used to significantly diminish runoff and contaminants introduced into the environment during construction from the site, reducing water pollution, and can minimize soil erosion commonly associated with construction sites.

In-Vessel Systems are more suitable in more densely populated areas because the system allows for containment and treatment of air to remove odors before release and can be operated on much less land.

There are several benefits related to composting. In-vessel systems help meet new air quality, ozone, smog and green house gas rules, by reducing the production of methane and other greenhouse gases. Compost also enhances soil structure by increasing nutrients, stabilizing pH levels, binding to contaminants, increasing infiltration, reducing runoff, suppressing plant pathogens, and supplying significant quantities of organic matter. In addition, this enhanced soil structure may provide greater drought resistance and more efficient water utilization.

A disadvantage for In-Vessel Composting Systems is increased cost compared to other systems. Because it is more mechanized, more equipment maintenance is necessary. A significant risk of composting is the potential for fires. The large amount of carbonaceous material stored and used at composting facilities creates the potential for fires in storage areas as well as in the active composting mass. Sufficient aeration and moisture are necessary to avoid fires.

The most important feature of a composting system is the ability to control uniform aerobic conditions during the process.

References

See Attachment A

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Office of Water. "EPA Biosolids Technology Fact Sheet In-Vessel Composting of Biosolids." *EPA.gov*. EPA, 09/2008. Web. 21 Jul 2011.
http://www.epa.gov/owm/mtb/invessel.pdf

Contract Language

Every composting system is unique based on each location, capacity, and intended use, and some manufacturers provide service and support when designing a composting system. They offer: feasibility assessments, material sourcing, site selection, design and development, permitting assistance, operational support and troubleshooting, leasing and financing, and operator training. Consideration should be given to involving a manufacturer in a feasibility study for composting systems.

Manufacturers

NaturTech: The system was recently certified by the U.S. Navy to illustrate the advantages of in-vessel composting and to serve as a demonstration project for the entire U.S. military. This is a modular system which provides easy monitoring, accessible maintenance layouts, feasible transportation options, and detailed commissioning plans. NaturTech systems are certified for carbon credits under the Kyoto greenhouse gas protocols.

Other applicable systems may be available by these manufacturers**:**

Green Mountain Tech	http://www.compostingtechnology.com/
Ecodrum	http://www.ecodrumcomposter.com/

Baseline Relation

Composting can be sold for profit. Sale prices range from five to sixty dollars per ton. Compost sales will not cover production costs but should offset market development costs. There are three different marketing approaches when selling compost. The first is sale to the public sector (parks, ball fields, landfill cover, urban reclamation projects, etc.). Second is direct sale to users, which maximizes revenue and improves the public image of the producer. The third is to use a compost broker, which reduces revenue, but also removes the administrative burden of compost marketing.

Compost can be used on-site to eliminate or reduce the cost of fertilizers, pesticides, and herbicides. The use of compost also reduces irrigation water from increased water holding capacity of three to ten percent, which can save up to 14,000-100,000 gallons/acre/year.

Compost systems reduce the costs and impacts of landfill operations and wastewater management operations.

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Attachment A:

Science/Technology

Understanding the Composting Process

One of the most important steps for evaluating composting options is to become familiar with how the composting process works. Before you begin composting or start a composting program, you should understand the five primary variables that must be “controlled” during composting. These include the following:

- **Feedstock and nutrient balance.** Controlled decomposition requires a proper balance of “green” organic materials (e.g., grass clippings, food scraps, manure), which contain large amounts of nitrogen, and “brown” organic materials (e.g., dry leaves, wood chips, branches), which contain large amounts of carbon but little nitrogen. Obtaining the right nutrient mix requires experimentation and patience and is part of the art and science of composting.

- **Particle size.** Grinding, chipping, and shredding materials increases the surface area on which the microorganism can feed. Smaller particles also produce a more homogeneous compost mixture and improve pile insulation to help maintain optimum temperatures (see below). If the particles are too small, however, they might prevent air from flowing freely through the pile.

- **Moisture content.** Microorganisms living in a compost pile need an adequate amount of moisture to survive. Water is the key element that helps transports substances within the compost pile and makes the nutrients in organic material accessible to the microbes. Organic material contains some moisture in varying amounts, but moisture also might come in the form of rainfall or intentional watering.

- **Oxygen flow.** Turning the pile, placing the pile on a series of pipes, or including bulking agents such as wood chips and shredded newspaper all help aerate the pile. Aerating the pile allows decomposition to occur at a faster rate than anaerobic conditions. Care must be taken, however, not to provide too much oxygen, which can dry out the pile and impede the composting process.

- **Temperature.** Microorganisms require a certain temperature range for optimal activity. Certain temperatures promote rapid composting and destroy pathogens and weed seeds. Microbial activity can raise the temperature of the pile’s core to at least 140° F. If the temperature does not increase, anaerobic conditions (i.e., rotting) occur. Controlling the previous four factors can bring about the proper temperature.

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8.6 Dashboards

TECHNOTE

dashboard

Recommendation

Use a dashboard system for building performance reporting at facilities installation wide to advance building operation by making energy and water use visible to users in real-time through user-friendly graphic displays. Dashboard Kiosks at individual buildings will improve conservation behavior in occupants by providing active feedback on utilities used (can be programmed by occupant, room, floor, building, etc.) which can lead to proven cost savings results in building operation through conscious conservation of resources. A building dashboard network system can also be set up to report on all facilities to aid Fort Leonard Wood's Directorate of Public Works (DPW) in determining maintenance requirements.

Historic data can be collected through this system and should be compiled for research to inform design teams of post-occupancy status of buildings at the post when working on future projects. This data is crucial for understanding the built environment at the installation and will help to validate systems that are working and identify those that are not. Data from this system will lead to improved design decisions for projects at Fort Leonard Wood going forward.

The Federal Energy Management Program (FEMP) has guidelines listed on their website located at the following link:
http://www1.eere.energy.gov/femp/program/om_cmms.html

Location & Scale

This would be installed at the **building scale** and recommended for all buildings to be linked to a dashboard network for universal connectivity with existing UMCS systems, meters, and submeters for monitoring at the **installation scale**.

Phasing

Building Dashboards should be included in construction projects to enhance building operations at the **2015 Phase**. Retrofitting existing facilities with dashboard monitoring by the **2020 Phase** through operations and maintenance (O&M) projects to ensure all buildings with metering are connected to the system by 2030.

Initial Cost

Call the preferred manufacturer for a quote with answers to questions below:

Cost dependent on the following:

- Data hosting can be done by manufacturers or locally at Fort Leonard Wood.
  - o If hosting is by Fort Leonard Wood, server space needs to be established, determine procurement process to include installation and training by the dashboard manufacturer for running and maintaining as they would do for clients using their services.

- How many buildings and resources will be monitored (extent of sub-metering within the building)?
- Type of Building Automation System (BAS) in place, what type and protocol does it speak?
- Does solar or wind feed the building? If so, can you produce enough power to feed the grid?
- What Apps and Widgets are you interested in seeing in the Dashboard? For some examples of what is possible, please see the Lucid Design Group Information on Apps and Widgets found here: http://www.luciddesigngroup.com/network/apps.php
- How many touch screens would you like to include and size required? More information: http://www.luciddesigngroup.com/downloads/Building_Dashboard_Touchscreen_Packages.pdf

Life Cycle Cost

Life cycle cost savings will be experienced installation wide through optimized building operation and conservation strictly observed by building occupants with access to training and monitoring resource usage. Building Dashboard Network has the flexibility to be set up to monitor one to thousands of buildings and will assist the DPW in identifying operations and maintenance issues at buildings for timely response leading to further cost savings related to energy and water consumption at Fort Leonard Wood.

Maintenance

This management program will not require significant maintenance but may have periodic, scheduled updates to keep the software secure and current. A timeline will be developed and followed to effectively transition facilities. Training must be provided to all applicable personnel in conjunction with the turnover of each building / project.

Also, as various buildings and building systems throughout the installation are maintained, repaired, and/or replaced, the systems information must be added to & monitored by this O&M program. Personnel must be trained as necessary to become familiar with each new or updated building system(s) as well as the new component in the O&M program.

Feasibility

Dashboard reporting will contribute to **2030 Net Zero Energy and Water** goals by providing instantaneous energy and water use information on user-friendly, publicly accessible, touch-enabled displays. This system is capable of monitoring and displaying all resources consumed and produced within a facility including: electricity, water, natural gas, heating, cooling, solar electricity, wind electricity, solar thermal energy, geothermal energy, rainwater collection and recycling, wastewater recycling and more. Individual locations can be monitored and broken down to show individual end uses of HVAC, lighting, plug loads, and servers as well as report on other variables such as temperature.

For support of facility maintenance, the DPW can set up a base map which includes all buildings hooked into the dashboard network and click on any building they want to monitor at a particular instant. The DPW will be able to track any information the building dashboard is set up to monitor. The DPW can also compare numerous buildings on one screen.

The building itself or manager can control the real-time water and energy usage on easy display panels and can customize which charts and features work best for their display. The application can report on the building by room, floor, or individual. Competition applications can be used to promote conservation between facilities linked into the same network on the local, regional, or national scale.

References See Attachment A

Diagrams Please see the manufacturer listing below for links to their respective websites.

Funding Plan Require Dashboards installed on all new projects and integrated through design/construction funding when awarded. DPW will need to assess operations and maintenance (O&M) projects required for retrofitting existing buildings currently on metering systems for connection to the dashboard network.

Contract Language Make this a requirement for all new buildings.

Manufacturers Applicable systems may be available by these manufacturers:

Green Building Services, Building Insights O+M Track
http://www.greenbuildingservices.com/Services/software.asp
Lucid Design Group, Building Dashboard Network
http://www.luciddesigngroup.com/network/features.php
Pulse Energy, Pulse Engagement Dashboard
http://www.pulseenergy.com/pulse-platform/pulse-engagement-dashboard/
Cimetrics Energy Dashboards
http://www.cimetrics.com/index.php/dashboard.html

Baseline Relation Without dashboard reporting building users go about their day without feedback on their energy and water usage. Users and residents see energy and water bills only as frequently as once a month for the kind of feedback dashboards can provided daily. It is difficult to improve and sustain good occupant behavior without instantaneous, direct feedback to confirm modified activities are making a difference on operations. The dashboard as a learning tool can save resources and be used to promote competition in energy and water conservation among units at Fort Leonard Wood and between Fort Leonard Wood and other installations in a race to achieve net zero goals.

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Attachment A: Building Dashboard Specifications – Lucid Design Group as a basis of design

Technical specifications

Building Dashboard® has been designed to be the most technically capable and visually spectacular data monitoring and display system available for commercial and institutional facilities. Lucid's award-winning display interface and comprehensive data acquisition system meet the requirements of hundreds of unique building scenarios. Read more about the technical specifications of **Building Dashboard Kiosk** below:

Universal connectivity:

Building Dashboard connects to virtually all building automation systems and energy management systems, including Alerton, Automated Logic, Cisco, Honeywell, Johnson Controls, Siemens, Square D/Schneider Electric, Trane, Tridium and more. Building Dashboard connects to all utility meters and submeters with either pulse or Modbus registers. Lucid also offers a network-enabled data logger, which can be used in buildings without sophisticated control systems or in standalone technology applications such as photovoltaic systems.

Automated data collection and real-time display over the web:

Building Dashboard enables easy, reliable and fully automated data collection, processing, storage and real-time display over the web. A powerful data warehouse makes real-time data crunching possible across thousands of buildings simultaneously. Lucid's hosted, off-site solution eliminates the need for on-site server hardware, lowering overall cost and allowing Building Dashboard to be broadcast to any personal computer, touchscreen display or web-enabled device anywhere in the world.

Comprehensive resource use monitoring:

Building Dashboard is capable of monitoring and displaying all resources consumed and produced within a facility, including: electricity, water, natural gas, heating, cooling, solar electricity, wind electricity, solar thermal energy, geothermal energy, rainwater collection and recycling, wastewater recycling and more. Individual locations such as wings, floors and area loads; breakdowns of individual end uses such as HVAC, lighting, plugs and servers; and other variables such as temperature can also be monitored and displayed separately.

Rapid scalability:

Building Dashboard is designed to rapidly scale from one building to hundreds or thousands of buildings for an organization. Scaling of monitored resources and buildings can take place incrementally, with additional resources and buildings added over time. Scaling of display methods, via either the addition of Building Dashboard Network or Building Dashboard Kiosk, is also possible incrementally and over time for any number of resources or buildings.

Local, regional and national comparisons and competitions:

Building Dashboard Kiosk allows users to make resource use comparisons and launch resource use reduction competitions at the most localized level (individual end uses, apartment units, floors or areas within buildings, or between neighboring buildings) up to the broadest level possible (between different buildings at your organization). Local comparisons and competitions utilize building- and organization-specific cost and emissions data.

Historical data access and carbon accounting:

Lucid's **Data Downloader** tool allows building operators, facilities managers, sustainability officers, researchers and students to quickly and easily download archived data into an Excel® spreadsheet for carbon accounting, monitoring and verification, troubleshooting or further manipulation. Password protection provides access that is limited to specified variables within the database.

Configuration and branding:

Building Dashboard Kiosk can be configured uniquely for your organization or buildings. Color palettes and background photos allow you to brand any dashboard to accommodate different physical, regional or audience-specific contexts, and brand, labeling and client or reseller identity requirements. Every Building Dashboard is one-of-a-kind.

Touchscreen accessibility:

Building Dashboard Kiosk enables display on widescreen monitors and interactive touchscreen kiosks. Touchscreens are offered in 22", 32" and 42" models to suit your specific display requirements. All touchscreen units are housed in rugged enclosures and are easily mountable.

LEED credits

Building Dashboard facilitates your ability to earn Measurement and Verification and Innovation in Design credits toward the U.S. Green Building Council's LEED certification for both LEED for New Construction and LEED for Existing Buildings.

US Army Corps of Engineers

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8.7 Daylight Collection

Recommendation

Install daylight collection/distribution devices. Daylight collection devices could produce a noticeable impact on lighting and cooling energy use. Harnessing natural daylight and distributing it throughout the interior building space saves electricity by reducing the number of electric lighting fixtures that are on during the day via daylight sensors and dimmable light ballasts. In addition, the use of these daylight collection devices saves on cooling energy by reducing the need to remove the resultant heat from electric lighting fixtures. The actual savings will depend partially on the local climate condition.

There are two different types of daylight collection: Active and Passive.

Active Collection – Solar Tracking Skylights: Sunlight tracking is an active daylighting system, which collects sunlight using a mechanical device to increase the efficiency of light collection. Mirrors in 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.

Passive Collection – Solar 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 tube light uses a highly reflective material or plastic optical fiber to lead light rays through a building.

Location & Scale

This system is implemented at the **building scale**. Each new structure shall have a rooftop daylight collection device(s) installed in the appropriate location. Typically, these locations would be defined by the United States Green Building Council (USGBC) as “critical visual task areas.” Examples of critical visual task areas are: classrooms, conference rooms, computer labs and private/open office spaces. Other areas to consider would be lobby areas, waiting rooms and corridors. Installation on new structures will have the devices incorporated into the building at the time of design. Existing structures will need a feasibility analysis conducted prior to installation.

Phasing

This system is projected as part of the **Pre-2015 and 2015 Phases**. These daylighting systems can be easily incorporated into the building architecture if proper consideration is taken into account during the design phase. The daylight collection devices should be installed in conjunction with each new building. Existing structures should be evaluated prior to retro-fit of the daylight collection systems to determine whether installation is cost effective.

Initial Cost

The Solar tracking skylights cost approximately **$5,900** per system. Light tube systems cost varies from **$300-$5,000** depending on manufacturer, tube & pipe size. The systems include a complete control package with occupancy, vacancy, and photometric sensors, as well as damper control motors.

Life Cycle Cost

The first cost will range from **$300 - $6,000**. While the initial costs associated with both examples of the daylight harnessing technology is considered to be significant, the energy savings have been reported to be significant as well. With the rising cost of electricity on Fort Leonard Wood, implementation of these systems would be ideal. A complete life-cycle cost analysis has not been conducted for either system.

Maintenance

Several daylighting systems require on-site or remote programming, control, and monitoring of proprietary hardware and software. This will likely increase the maintenance costs of the system after the expiration of the 10-year warranty. The programming of the Sunlight Tracking systems is more "user-friendly" and non-proprietary, therefore the same maintenance costs after the warranty period (to be determined) will not be incurred.

Feasibility

With the cost of electricity at Fort Leonard Wood on the rise, daylight collection/distribution devices would be ideal for installation on new construction, as well as for retro-fitting existing structures. In a typical energy use profile for a building, more than 60% of the energy consumption is lighting and HVAC equipment. Installation of lighting tubes and/or sunlight tracking devices can significantly reduce lighting power consumption by utilizing natural sunlight during the day, thusly reducing the use of artificial electric lights and the electricity they consume. These daylighting technologies have incorporated measures to combat inefficiencies of traditional skylights. The biggest shortcoming of any traditional skylight is heat loss and gain. Even with an optimal design, up to forty-five percent of the electrical lighting savings produced from skylights is lost in additional HVAC expense. Often, times the effect the building lighting has on the HVAC system is overlooked. Electric lighting fixtures produce heat that the HVAC system must remove to maintain a comfortable environment. With a reduction in the number of fixtures used, the need to remove the heat generated is eliminated and the energy costs are saved. Implementation of these systems will help buildings conform to the ASHRAE 90.1 – 2007 30% energy reduction standards, contribute to LEED certifications, and ultimately to the Army **2030 Net Zero Energy** goals.

References

Applicable systems may be available by these manufacturers:

Monodraught SunPipe (UK) http://www.monodraught.com/sunpipe/index.php
Sun Pipe Co., Inc SunPipe® http://www.sunpipe.com/
Solatube® Daylighting Systems http://www.solatube.com/
Sunflower Corporation, Sundolier™ http://www.sunflowerdaylightings.com/
Natural Lighting Co., Inc. Active Daylighting™ System
http://www.daylighting.com/index.asp

Diagrams

Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.

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8.8 Daylight Photosensors

Recommendation

Install daylight photosensors as an integral part to an automated daylight control system. Each building, new or existing, containing spaces with adequate daylight should be considered for automated daylight switching.

Technology

Daylight photosensors are used in automated daylight control schemes to detect the light level in a space. Dimming ballasts in artificial light fixtures then automatically adjust to maintain the desired levels of illumination.

Location & Scale

This system is implemented at the **building scale**. Each new structure shall have daylight sensors installed where most practicable. Open cubicles near windows and meeting rooms with daylight collection devices such as light tubes and sunlight tracking skylights are good candidates for daylight dimming control. Daylight switching can be used in the lobbies, hallways, and small offices with adequate daylight.

Phasing

This system is projected as part of the **Pre-2015 and 2015 Phases**.

Initial Cost

System components consist of a photo sensor, handheld calibrator, and dimming ballast. The photo sensor and calibrator cost **$150-$200** per sensor and the dimming ballast **$50-$200** per ballast. The first cost is dependent on the size of the room and the number of control zones you choose to set. An increase in zones, directly affects the number of sensors and ballasts. Choosing to use switching controls in lieu of dimming controls will result in a twenty percent cost savings, however, transition from light level to light level becomes more noticeable. Therefore, use of switching ballasts is more suitable for spaces that have adequate daylight for the duration of the day and for non- critical visual task areas.

Life Cycle Cost

The life cycle cost of this technology is dependent on the size of the building space utilizing an automated daylight control scheme. However, independent of the building size, there are elements of the system that will affect the lifecycle costs. Dimmable fixtures could potentially create cost savings of twenty to fifty percent when used in lieu of constant electronic ballasts. There will be a decrease seen in the electricity consumption for the lighting and HVAC system. Rooms that are equipped with daylight control systems require less cooling. The savings in cooling energy are derived from the reduced need to remove heat produced by the electric lighting and the reduced cooling necessary to condition ventilation air.

Maintenance

Maintenance includes:

- Calibration of sensors is essential to the efficiency of system function.
- Poorly calibrated daylight sensors could virtually eliminate all potential energy savings.
- Replacement sensors and ballasts may be needed on occasion.
- Sensors come with a 5-Year Warranty

Feasibility

Implementation of an automated daylight control system in buildings spaces on Fort Leonard Wood could prove to be vital in efforts to conserve and reduce overall energy consumption. Not only do the daylight sensors provide a feasible option to reduce electricity expended on artificial lighting and HVAC systems, but they offer a level of versatility in regards to their installation. These daylight photosensors can be utilized in applications that only offer traditional glazing schemes and also in designs that take more innovative approaches with daylight collection and distribution devices such as light tubes. As a result, photosensors as a part of an automated daylight control system are prime candidates for incorporation in new designs and well as retro-fits. This is an important point to make in strides to become a **Net Zero Energy** military installation by 2030. Solely incorporating technology that has one dimensional installation capabilities limits the ability to maximize conservation efforts.

References

WattStopper LightSaver® LS-301 Dimming Photosensor
http://www.wattstopper.com/products/productline_list.html?category=6&type

Peerless Automatic Daylight Dimming Option
http://www.peerless-lighting.com/info/?pg=controls

Lutron EcoSystem daylight sensor
http://www.lutronbrasil.com/cms400/page.aspx?mn=737&id=5421

Diagrams

Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.

Funding Plan

Annual Military Construction (MILCON) funding

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8.9 Drain Water Heat Recovery

drain water heat recovery

TECHNOTE

Recommendation

Install gravity-film heat exchanger for heat recovery in shower drains for BCT complex. The design is a vertical counter flow heat exchanger that extracts heat from the drain and preheats the water entering the building. It consists of a copper carrying the warm waste water and a smaller line wrapped around the central pipe carrying the cold supply water. This technology could recover 25%-90% of the waste heat from a shower drain depending if the flow is designed to preheat only the cold water to the shower, water to the water heater or both. Also, different sources of information gave different efficiencies.

Location & Scale

This system is implemented at the **building scale**.

Phasing

This system is projected as part of the **2015 Phase**. The system could be implemented in new construction or as a retrofit.

Initial Cost

The cost of this heat recovery unit was approximately **$500-$600 per unit**. Typically this system would be implemented with **FY15 Military Construction Army (MCA) project funds**.

Life Cycle Cost

This system would reduce the heat load by 7,000 kWh/yr per barrack, assuming 25% heat recovery, 0.8 kWh used per shower, and 100 soldiers living in a barrack for 50 weeks per year. At the $0.08/kWh rate, this would save $5,600 per year. The payback period would be a couple of **years**. The payback period for this system in a residential home ranged from two to seven years.

Maintenance

The heat exchanger is installed as part of the domestic water and sanitary sewer piping systems within the building and requires no additional maintenance once the system is in place.

Feasibility

The unique hot water usage profile found in training barracks, with all of the soldiers showering within a short period of time, allows for more efficient use of drain water heat recovery since the heat exchangers work best when the need for hot water coincides with the production of warm wastewater. Several shower drains can be combined to run through a single heat exchanger to reduce the initial cost and payback period.

References

Heat Recovery from Wastewater Using Gravity-Film Heat Exchanger. Accessed July 2011. http://gfxtechnology.com/Femp.pdf

Energy Savers. *Drain Water Heat Recovery.* Accessed July 2011. http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13040

US Department of Energy. *Energy Saver Drain Water Heat Recovery.* Accessed July 2011. http://energy.gov/energysaver/articles/drain-water-heat-recovery

Diagrams See Attachment A

Funding Plan Drain water heat recovery heat exchangers would be installed as part of the construction contract for new barracks and would be paid for with project funds.

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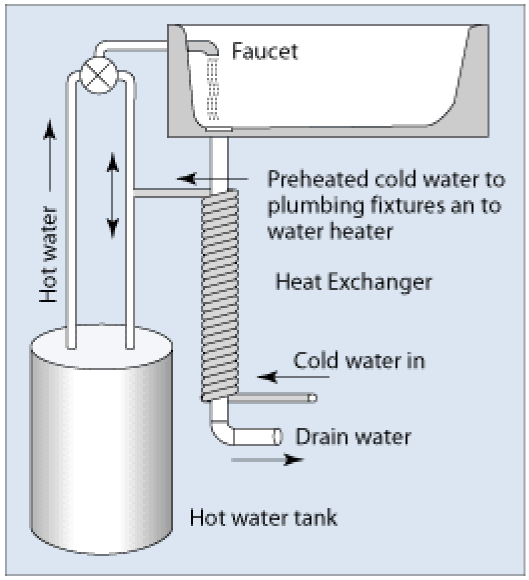
Attachment A:



Typical Drain Water Heat Recovery Diagram – Image courtesy of the US Department of Energy

2030 USACE Integration Project

8.10 Dual Flush Toilets

Recommendation

Install high efficiency toilets which have manual dual flush valves in all new buildings and evaluate retrofitting existing facilities which have toilets installed. Fixtures should be Environmental Protection Agency (EPA) WaterSense® certified and meet its waste removal performance requirements. WaterSense® certified fixtures use no more than an average equivalent flush volume of 1.28 gallons per flush (gpf) of water, while providing the users the choice to use less water for liquid waste (approximately 0.8 gpf) or slightly more water for solid waste (1.6 gpf). Implementing these types of fixtures will maximize water conservation with minimal impact to fixture & system costs.

Signage or labels should be included with each fixture as dual flush toilets are interactive and require user comprehension & participation in order to be effective.

Location & Scale

This would occur at the **building scale** and is recommended for **all buildings.**

Phasing

This system is projected as part of the **2015 Phase** in all new construction. As various other buildings on the installation are renovated, old fixtures could be easily retrofit or replaced with these new fixtures.

Initial Cost

Including purchase price and installation (average cost in Missouri), each toilet's initial cost would be between **$400 - $600**. This figure depends on the specific fixture selected and each installer's labor wage. Initial cost for a retrofit fixture installed would be between **$110 - $190**, also dependent on fixture & installer. Retrofit fixtures would also require removal & disposal of old components, with the estimated price based on an installation with no unforeseen issues.

Components which are different than or in addition to standard plumbing pipes system for toilets in the cost consideration may include toilet bowls, flushometers, seats, and signage / directions for use.

Life Cycle Cost

Life Cycle Cost of this type of toilet fixture would include maintenance & water use costs in addition to the initial costs for each fixture. This type of fixture's typical life span is thirty years. The total estimated Life Cycle Cost of one standard toilet about $2,000. However, the total estimated Life Cycle Cost of one dual-flush fixture which could potentially use approximately 4,380 fewer gallons per year of water than a standard toilet is estimated at **$2,655***.

Operations and maintenance costs would be very minimal as water is inexpensive and required repairs are very minimal. Maintenance could be performed by Fort Leonard Wood building maintenance staff, coming to about

$55/year. Each toilet is assumed to provide for three people, and be used for (5) liquid waste flushes & two solid waste flushes per person per day, or 7.2 gal/person/day of water use (7,884 gal/yr). Fort Leonard Wood water cost is currently estimated at $2.30/1000 gallons. The estimated annual water costs for one fixture is approximately $18.13. Total annual O&M costs, including water use, would be approximately **$80***.

An average dual-flush toilet costs $410, installed for $50. Total installation/initial cost would be approximately **$460** per fixture.

Maintenance

**At current dollar values (no inflation included), and if all estimates and assumptions of fixture use & water costs are accurate.*

This system will not require significant maintenance unless problems arise such as clogging, physically abused fixtures, etc. Minor repairs should be within the ability of Fort Leonard Wood building maintenance staff, but large issues with this system are no different than problems and maintenance of standard toilets.

Feasibility

This system contributes to the **2030 Net Zero Water** goals. This type of fixture has the same plumbing design as standard toilets, with the differences being in the flushometer & toilet bowl/tank itself. Maintenance is very similar to standard fixtures and, if used correctly, dual-flush toilets use 20% less water than a standard toilet. If incorporated into the design process and confirmed in specifications, the dual-flush toilet units can be an inexpensive and efficient way to conserve water while maintaining functionality.

In order to be effective at reducing water demand & consumption, dual-flush toilets must be operated correctly by the user if manual function is selected. If liquid waste is not flushed with the appropriate amount of water, a dual-flush toilet would probably perform not unlike a new standard toilet.

Automatic or sensor operated dual-flush flushometers are available. Users will not have to consciously activate the manual dual-flush mechanism unless the energy source powering the sensor is disconnected or lost. However, sensor flushometers will add anywhere from $340 - $480 in cost per unit. These fixtures also require additional energy to operate (electricity, batteries, etc.), which not only increases energy costs but also increases maintenance potential for the fixtures (i.e. changing batteries regularly).

References

See Attachment A

Environmental Protection Agency (EPA). "WaterSense® Specification for Tank-Type Toilets." Version 1.1. 20 May 2011. Web. 18 July 2011. www.epa.gov/watersense/docs/revised_het_specification_v1.1_050611_final508.pdf

"Dual Flush Toilets." *High Performance Technology Strategy Templates.* Revision 0. 31 October 2010. Web. 18 July 2011. http://mrsi.usace.army.mil/cos/TechNotes/05%20Fixtures%20Dual%20Flush%20Toilets%2010-31-10.pdf

“Examples of Life Cycle Cost Analysis.” *Urban Edge Building Community.* Web. 18 July 2011. www.urbanedge.org/green-housing.php?subcode=ExamplesLCA

“The ABCs of Toilets.” *Flushmate*. Web. 18 July 2011. www.toiletabcs.com/toilet-water-conservation.html

Sloan. “The first of its kind, the first in its class.” *Sloan, Manual Flushometers.* 2011. Web. 18 July 2011. http://www.sloanvalve.com/Our_Products/Manual_Flushometers.aspx

Sloan. “Advanced technology for the convenience of touchless flushing.” *Sloan, Sensor Activated Flushometers.* http://www.sloanvalve.com/Our_Products/Sensor_Operated_Flushometers.aspx

Diagrams

Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.

Funding Plan

This system would need to be funded with initial design/construction funds as awarded. Specifying dual-flush toilets in place of standard toilets will not be a significant cost to the overall project, but will be an expense above standard units.

Contract Language

Provide *dual-flush toilets* for all water closet fixtures in new buildings. Units shall be manual function flushometer with average equivalent flush volume of 1.28 gallons (i.e. 0.8 gpf for liquid waste & 1.6 gpf for solid waste). All units must be certified under the Environmental Protection Agency’s (EPA) WaterSense program.

Manufacturers

See Attachment A for generic specification

Baseline Relation

Older toilets may use up to 5 gallons per flush (gpf) for every flush, while newer standard units use 1.6 – 3.5 gpf. A dual-flush toilet uses 0.8 gal per liquid waste flush & 1.6 gal per solid waste flush. If used correctly, this technology will decrease water consumption of toilets by roughly 20% (if baseline is for typical new toilet). Water demand of toilets would decrease by nearly 78% based on older toilets.

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Attachment A: Dual-Flush Toilet Specifications**

**As adapted from the Whole Building Design Guide *Federal Green Construction Guide for Specifiers*

SECTION 22 40 00 (SECTION 15400) – PLUMBING FIXTURES

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water closets
   2. Accessories

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
   3. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
      a. Plumbing fixtures

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

1.3 QUALITY ASSURANCE

A. Water flow and consumption rates for plumbing fixtures:
   1. Comply with requirements in Public Law 102-486, Energy Policy Act.
   2. Provide WaterSense labeled products for:
      a. High-Efficiency Toilets - Dual Flush

PART 2 – PRODUCTS

2.1 MATERIALS

A. Fixtures:
   1. Water management: Provide low flow fixtures. *(If automatic, sensor operated flush valves are used, they must comply with ASSE 1037 and UL1951).*
      a. Water closets: WaterSense labeled high-efficiency toilet with maximum effective flush volume of 1.28 gallons. For dual flush toilets, the effective flush volume is the composite, average flush volume of two reduced flushes and one full flush per ASME A112.19.2 and ASME 112.19.14. [Gravity tank type water closets not allowed.]
   2. Toxicity/IEQ:
      a. Low corrosion flux for copper pipe: Comply with ASTM B813.

2.2 ACCESSORIES *(Include #2-4 if automatic sensors are selected.)*

A. Labels: Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:
   1. The identification of the manual flush mechanism and its operation with written, graphic, and Braille description.
   2. The identification of the sensor and its operation with graphic, written, and Braille description.
   3. Range of sensor.
   4. For batter operated units, the batter replacement schedule.

PART 3 – EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

1. Water Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.
    a. *(If automatic sensors are selected, include: Adjust automatic sensor operated valves in accordance with manufacturer's instructions. Comply with ASHRAE 90.1 for energy efficiency.)*

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8.11 Energy Demand Mgmt. Control System

demand control

TECHNOTE

Recommendation

Install an Energy Demand Management and Control System to reduce the load variation, automate control of both on peak and off peak demand to a user selectable set point, and reduce two of the three cost components of the garrison's power bill. An example may involve an Energy Management System employed for utility scale control of typical grid components including renewable generation, energy storage components, substation monitoring, and distributed typical loads.

Location & Scale

This demand control system is implemented at the **area scale**. The supervisory control and data acquisition (SCADA) computer can be located in the directorate of public works (DPW) administration building for monitoring by trained facilities personnel. Distributed sub-meters, utility provider billing meters, and all load control devices are installed at equipment sub-station locations and linked to the control computer via industrial Ethernet on a fiber optic local area network.

Phasing

This system could be installed and operational in less than nine months, with the flexibility to expand and grow with load increases and/or power supply upgrades in the future. Therefore, the expectation is that it will be implemented in the **2015** period.

Initial Cost

The initial cost of this system is estimated at **$305,000**. This figure will include all necessary equipment installation and training to monitor the total power usage and control of up to fifteen independent loads for shedding and demand control, historic trending, and database storage capability.

Life Cycle Cost

The system would have a computed simple payback period of **less than one year**. Estimates for potential first year savings are $511,000. In light of the exceptional savings to investment ratio, a conventional life cycle cost analysis (LCCA) was not performed. According to an Environmental Leader Magazine article in 2009 by Gus Ezcurra, *"Extraordinarily feature-rich, modern energy management and control systems are now far more cost effective to deploy, with low starting price points, nominal monthly fees and rapid return-on-investment in just six to twelve months."*

Maintenance

The responsibilities for the operations and maintenance (O&M) staff will include training, installing spare parts, and upgrades as additional meters are installed. Training will be required above the level of journeyman maintenance employee (e.g. Electrician, Mechanic) to include programmable logic controllers, communications equipment installation and replacement, basic energy collection devices including watt meter, and instrumentation placement and data retrieval. Anticipate that two full-time persons could perform this duty. However, as the development of energy conservation measures and practices are employed, additions to the O&M energy staff will be required to perform audits, leak checks, and other functions as necessary. In addition, at least one full-time employee trained as a system integrator and will be required to:

- Monitor system / equipment performance
- Maintain the information database flow from all field installed devices such as water, gas, and electric meters
- Analyze data, produce and interpret periodic energy use reports, and report deviations to the energy manager
- Calculate and produce bill allocation by departments (mock billing)
- Perform utility bill proofing

Feasibility

The system would consist of:

- A series of strategically located smart meters that would provide real time duplex power information at the garrison level.
- Electrical control elements to accomplish sequential, prioritized, load shedding.
- A centrally located control PC running open architecture software with user interface and reporting capability.
- A trained technician to monitor the system and report alarm conditions to O&M personnel.

References

Measurlogic, Inc. http://www.measurlogic.com/contactus.html

Building Automation Systems (BAS) page of the EKO portal. https://eko.usace.army.mil/public/fa/bas/

HPAC Engineering. *Reducing Utility Costs Through Peak Shaving.* October, 2001. http://hpac.com/motors-drives/reducing_utility_costs/#

JouleX Energy Manager: *Data Center Energy Reduction Strategies.* http://www.joulex.net/about/

The Department of Energy: Federal Energy Management Program. http://www1.eere.energy.gov/femp/

The Department of Energy: *Energy Efficiency & Renewable Energy, Power Purchase Agreement.* 20 April, 2010

Comprehensive Energy and Water Master Plan: USACE Contract No: W912DY-06-D-0006-0014. 15 October, 2010

PNNL -18378: *Renewable Energy Opportunities at Fort Leonard Wood, Missouri.* May 2009

ERDC/CERL TR-03-23: *Process Optimization Assessment Fort Leonard Wood, MO and Fort Carson, CO.* November 2003

EmacxSystems, Inc. – Green Energy Technology.
http://www.emacx.com/alc_expert.html

Diagrams See Attachment A for generic Army Installation load profiles

Funding Plan According to the DOE website, Energy Savings Performance Contracts (ESPCs) allow Federal agencies to accomplish energy savings projects without up-front capital costs and without special Congressional appropriations. They allow installations to improve infrastructure and implement projects and pay for the work with anticipated cost savings over time (usually 10-25 year payback). Other opportunities may be available through the local utility through programs including customizable service riders and interruptible service agreements. Tariff based programs can include time-of-use and "critical peak" rate options. On the state level, the Missouri Department of Natural Resources website (http://www.dnr.mo.gov/energy/financial/index.html) lists a variety of commercial and industrial incentives including:

- *Energize Missouri Appliance Rebates* – State energy efficient appliance rebate program
- *Energize Missouri Agriculture* – State energy program, cost-share grants for energy saving projects
- *Energize Missouri Communities* – Energy efficient and conservation block grant program
- *Energize Missouri Industries* – State energy program
- *Energize Missouri Renewable Energy* – State energy program for study subgrants and biogas grant

Contract Language The goal is the installation of a system consisting of a utility monitoring and control systems center (UMCS) master controller and local control systems that function as a single integrated system. The system must be usable by the O&M personnel, the energy manager, and others. In addition, it must have the flexibility to expand and grow with the needs of the DPW using the technology available in coming years. The following, in part, are design criteria and functions presented in the June 2007 report by the Engineer Research and Development Center (ERDC) and the Construction Engineering Research Laboratory (CERL) titled, "IMCOM LONWORKS BUILDING Automation Systems Implementation Strategy":

- Remote monitoring of buildings. Provide O&M staff and other the capability to easily:
    - Display real-time system/equipment performance.
    - Set up and collect trend data (e.g. historical temperature data).
    - Set up alarm points including routing of alarms to appropriate personnel while avoiding the creation and generation of nuisance alarms.
- Improve work order process especially for HVAC.
    - Analyze the problem remotely and send the correct technician.
- Identify problems initially when they are small and cost less to fix instead of complete replacement due to system failure.
- Support energy savings.

- Temperature setback during nights and weekends including scheduled start-stop of air handling units.
- Monitoring of energy usage and cycling of mechanical and electrical equipment during energy peaks to reduce electrical power demand.
- Improved maintenance and thus performance of equipment.
- Automate other processes such as parking lot and baseball field lighting.

Product Specifications The Whole Building Design Guide (WBDG) website (http://www.wbdg.org/) contains the Unified Facilities Guide Specification (UFGS) for use in specifying the construction guidelines for the military and the USACE. Design specifications applicable to the installation of the proposed Energy Demand Management and Control System include ANSI standard 709.1 communications protocol and:

- Specification section 23 09 23, Direct Digital Control for HVAC and Other Building Systems
- Specification section 25 10 10, Utility Monitoring and Control System (UMCS)

Additional information on the selection and requirements are available at Building Automation and Design, Engineering Knowledge Online at https://eko.usace.army.mil/public/fa/bas/.

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Attachment A: Example Diagrams

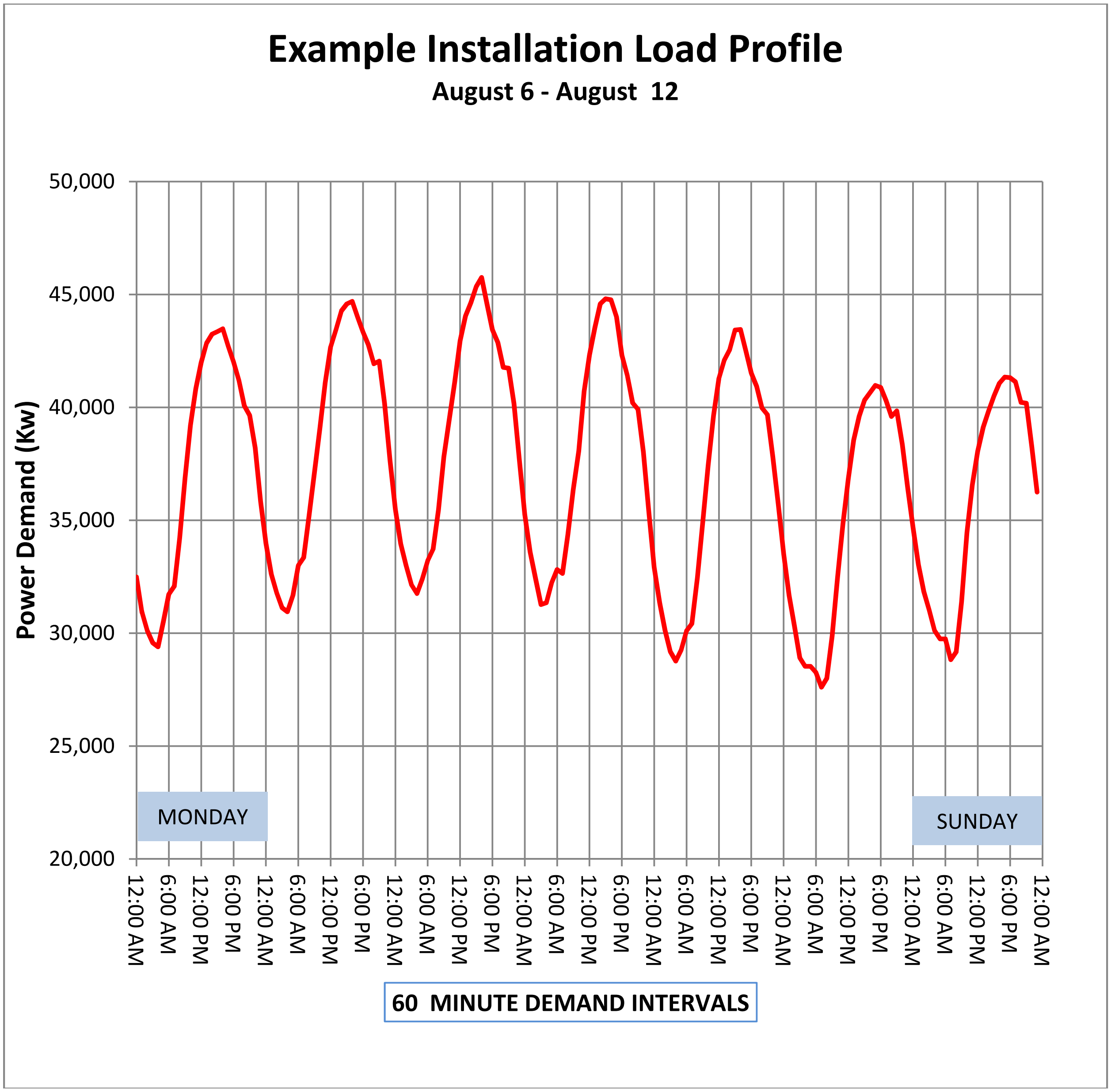

Figure 1. Example Installation Load Profile, Summer – Image courtesy of USACE

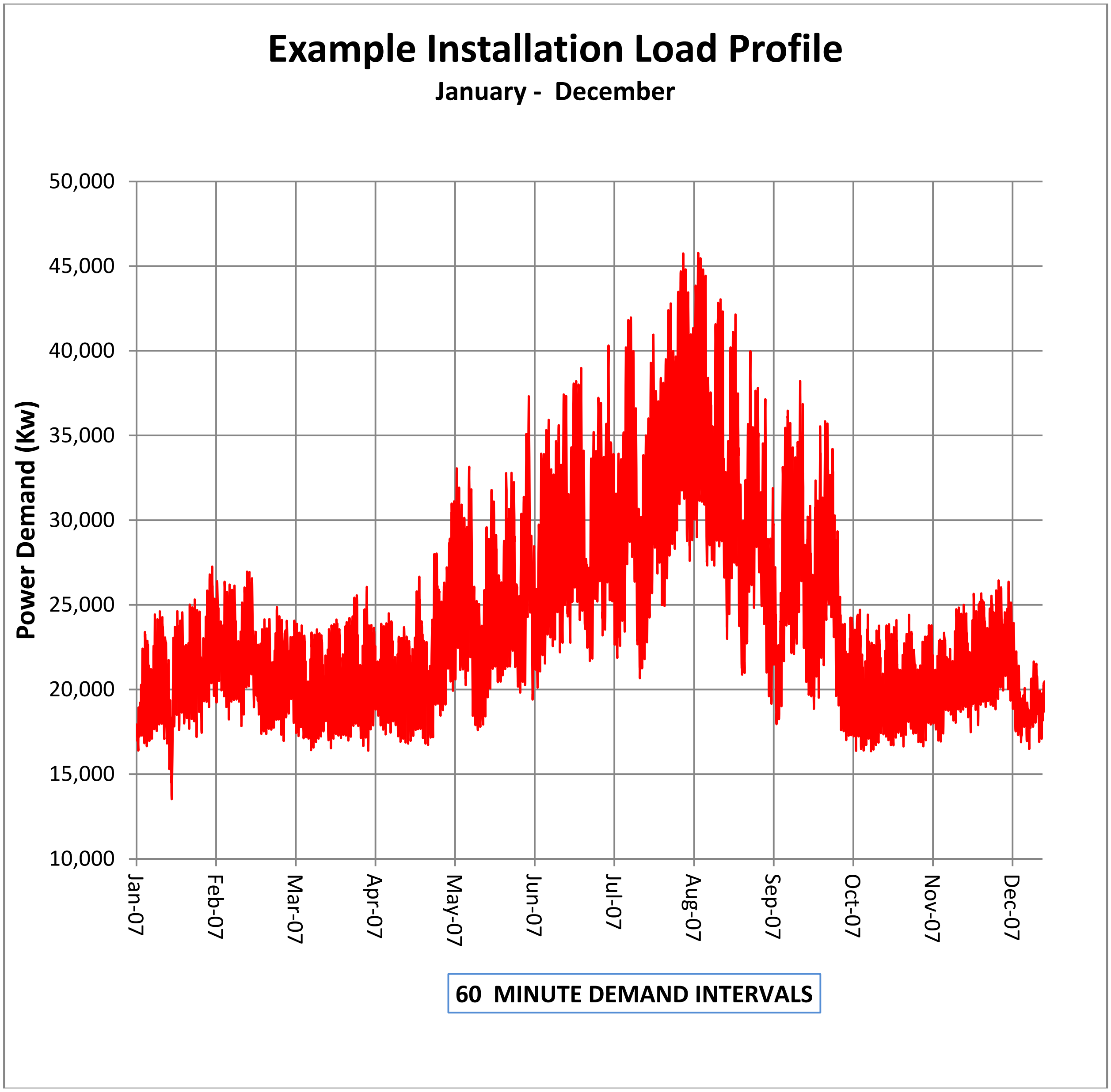

Figure 2. Example Installation Load Profile – Image courtesy of USACE

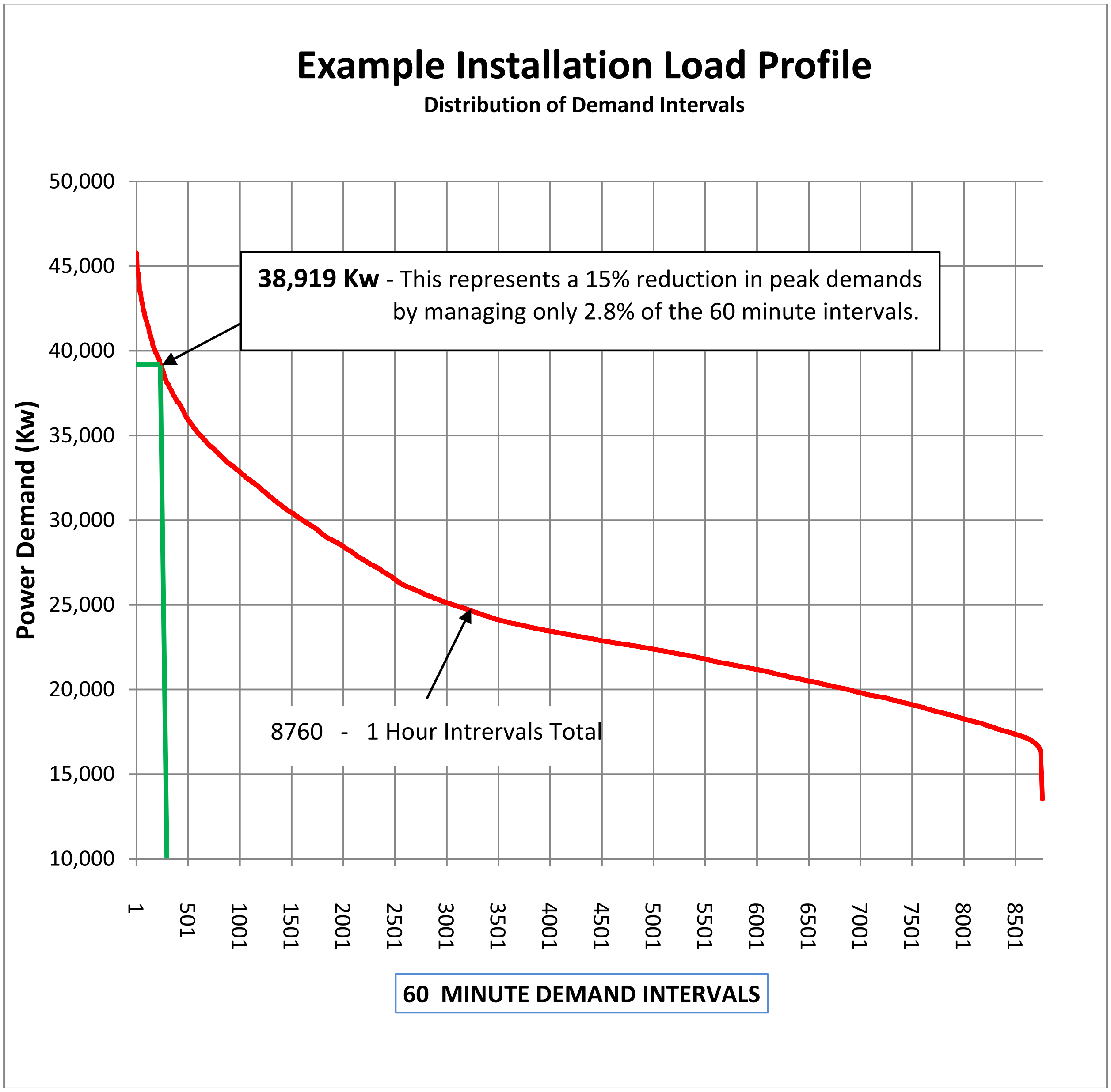

Figure 3. Example Installation Load Profile, distribution of demand intervals – Image courtesy of USACE

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8.12 Enhanced Commissioning

enhanced commissioning

TECHNOTE

Recommendation

Enhanced Commissioning includes a number of tasks that go beyond normal building commissioning to provide a higher level of assurance that building systems and components will function properly. Commissioning tasks begin prior to the start of design and continue through construction and building occupancy to ensure that the owner’s requirements are being met.

Location & Scale

This system is implemented at the **building scale**. Each new building will be designed and built following the requirements of the Energy and Atmosphere Credit 3 (EAc3) - Enhanced Commissioning from the USGBC LEED rating system.

Phasing

This system is projected as part of the **2015 Phase**. It should be pursued in conjunction with each new building.

Initial Cost

Based on industry and research data, enhanced commissioning could cost between 0.4% and 1.25% of the total construction cost. In 2004, the General Services Administration (GSA) estimated that enhanced commissioning would cost $0.10-$0.15 more than standard commissioning per gross square foot. A recent Lawrence Berkley National Laboratory (LBNL) study reported median commissioning costs at $1.16/ft^2 for new construction.

Life Cycle Cost

Enhanced commissioning costs are basically limited to building design and construction periods. The commissioning authority must review the operation of the building during the first year of occupancy, but the cost for this visit could be covered in the original commissioning contract.

Maintenance

After the original commissioning process is completed, retro-commissioning of the building can be performed as desired by the building owners. Retro-commissioning tasks would be similar to original enhanced commissioning tasks, ensuring that the building systems are operating as originally intended and identifying opportunities for additional energy savings and increased efficiency. An LBNL study reported the median cost for retro-commissioning at $0.30/ft^2.

Feasibility

US Army Corps of Engineers (USACE) Engineering and Construction Bulletin (ECB) No. 2010-14 requires that all Military construction projects achieve EAc3 Enhanced Commissioning for design build projects with requests for proposals in the 4th quarter of FY2010 and beyond and design-bid-build projects at 35% or less as of July 2010.

The main hurdle to implementing enhanced commissioning is working within the government’s contracting rules. The commissioning authority must be brought on board prior to the start of the design process and must report directly to the building owner. The commissioning authority contract would also have to continue through the construction phase of the project and only be completed several months after building occupancy. These challenges can be met as requirements in a design build project contract, but are more difficult to realize in design-bid-build contracts where funds are separated for design and construction phases.

References

USGBC LEED Reference Guide for Green Building Design and Construction, 2009 Edition

GSA LEED Cost Study: Final Report. October 2004. Prepared by Steven Winter Associates, Inc.

Building Commissioning: A Golden Opportunity for Reducing Costs & GHGs. July 2009. Prepared by Evan Mills of LBNL.
http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf

Funding Plan

Enhanced commissioning can be included as a project requirement on design build projects. The commissioning authority may not be an employee of the design or construction firm and must report directly to the government. On design-bid-build projects, getting a commissioning authority on board is more difficult since the same commissioning authority must serve throughout the life of the project, starting before design begins and continuing through the first year of building occupancy.

Contract Language

Guide specifications for commissioning can be found on the Whole Building Design Guide website (http://www.wbdg.org/deisgn/greenspec.php) in word or pdf formats under file name is fgs_019100.pdf. The specifications can be tailored to meet contract requirements and the LEED Enhanced Commissioning credit.

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2030 USACE Integration Project

8.13 Form Based Code

Recommendation

Hold a **Visioning Workshop** to update and refresh Fort Leonard Wood's visioning statement. Following the workshop, the Garrison should group communities and transportation routes into area developments on Fort Leonard Wood's cantonment area. Each area development shall be developed into a plan using techniques commonly established as the Congress for New Urbanism. The best practice to design an Area Development Plan (ADP) entails gathering stakeholders from the community and installation to collaboratively generate an illustrative plan and regulating plan. Collectively these tools help establish a Form Based Code.

Location & Scale

This would occur at the **installation scale** and is recommended for **area developments.**

Phasing

This regulating system is projected as part of the **2015 Phase** for the Visioning Workshop, Basic Combat Training (BT) Area Development Plan (ADP), and Advanced Individual Training (AIT) ADP. In the **2020 Phase**, the Garrison shall initiate the Community Core ADP charette, the Fields ADP charette, and the Graduation ADP charette. In the **2025 Phase**, the Garrison shall initiate the MANSEN ADP charette, the Bowling ADP charette, and the Education ADP charette. In the **2030 Phase**, the Garrison shall initiate the Support ADP charette and address any additional ADP's developed in the visioning workshop that were not designated in Attachment A.

Initial Cost

If facilitated by the US Army Corps of Engineers (USACE), a Visioning Workshop that consists of five business days of visioning activities with community and military representatives and a final report with a formal out brief, typically ranges in price from **$150,000.00 to $200,000.00** for travel and labor. Similar pricing is applied to each area development planning charette. Private consultants range in price from **$250,000.00 to $350,000.00**.

Maintenance

Area Development Plans and the Form Based Code that they represent are only beneficial if socialized with the key stakeholders at regular intervals; recommend updating the ADPs at five-year intervals.

Feasibility

This system contributes to the **2030 Net Zero Energy, Water, and Waste** goals. Only through advanced planning can high performance systems be applied and net zero benefits realized. The development and utilization of form based codes on the installation is similar to an insurance policy for the intention of the community and stakeholders. As stakeholders participate in the workshops, they become invested in the results. As more participants invest, they ensure the intention moves forward even when the leadership changes. Only through this democratic system of planning can a true net zero installation be realized.

References

See Attachment A for the Installation breakout of Area Development Plans

See Attachment B for the BT Illustrative Plan and BT Regulating Plan Example

See Attachment C for the AIT Illustrative Plan and AIT Regulating Plan Example

See Attachment D

Parolek, Daniel G. *Form Based Codes: A Guide to Planners, Urban Designers, Municipalities, and Developers.* John Wiley & Sons, 2008.

Ed. Michigan Chapter of the Congress of the New Urbanism. *Form-Based Code in Seven Steps: The Michigan Guidebook to Livability.* CNU Michigan, 2010.

Gowder, W. Andrew, Daniel Slone, and Dois Goldstein. *A Legal Guide to Urban and Sustainable Development for Planners, Developers and Architects.* John Wiley & Sons, 2008.

Crawford, Paul, Bill Dennis, and Geoffrey Ferrell. *Form-Based Zoning.* American Institute of Certified Planners.

Katz, Peter. *The New Urbanism: Toward an Architecture of Community.* McGraw-Hill, 2004.

Jacobs, Allan B. *Great Streets.* MIT Press, 1995.

Form Based Codes. Web. 10 September 2011. www.formbasedcodes.org

Funding Plan

This system would need to be funded with Installation Funds. Additional support should be sought through partnerships with the community. For example, in developing partnerships with leased property, some of the leasing fund could be applied to the area development that the land resides in.

Contract Language

See Attachment D: FBC Fergusen Downtown FBC

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Attachment A: Area Development Plans

Figure 1. ADP Delineations

Attachment B: BT Area Development

Figure 2. Illustrative Plan

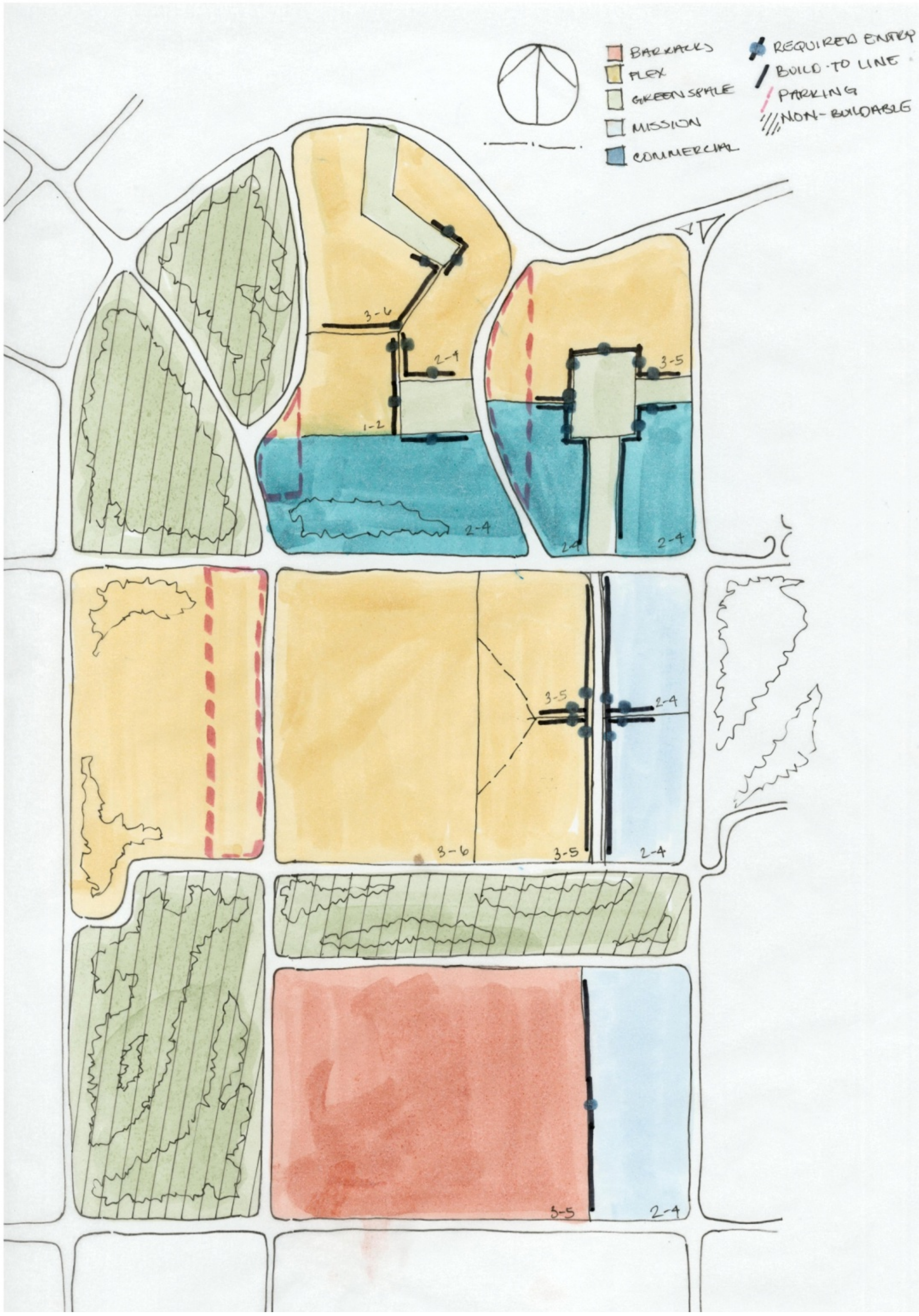

Figure 3. Regulating Plan

Attachment C: AIT Area Development

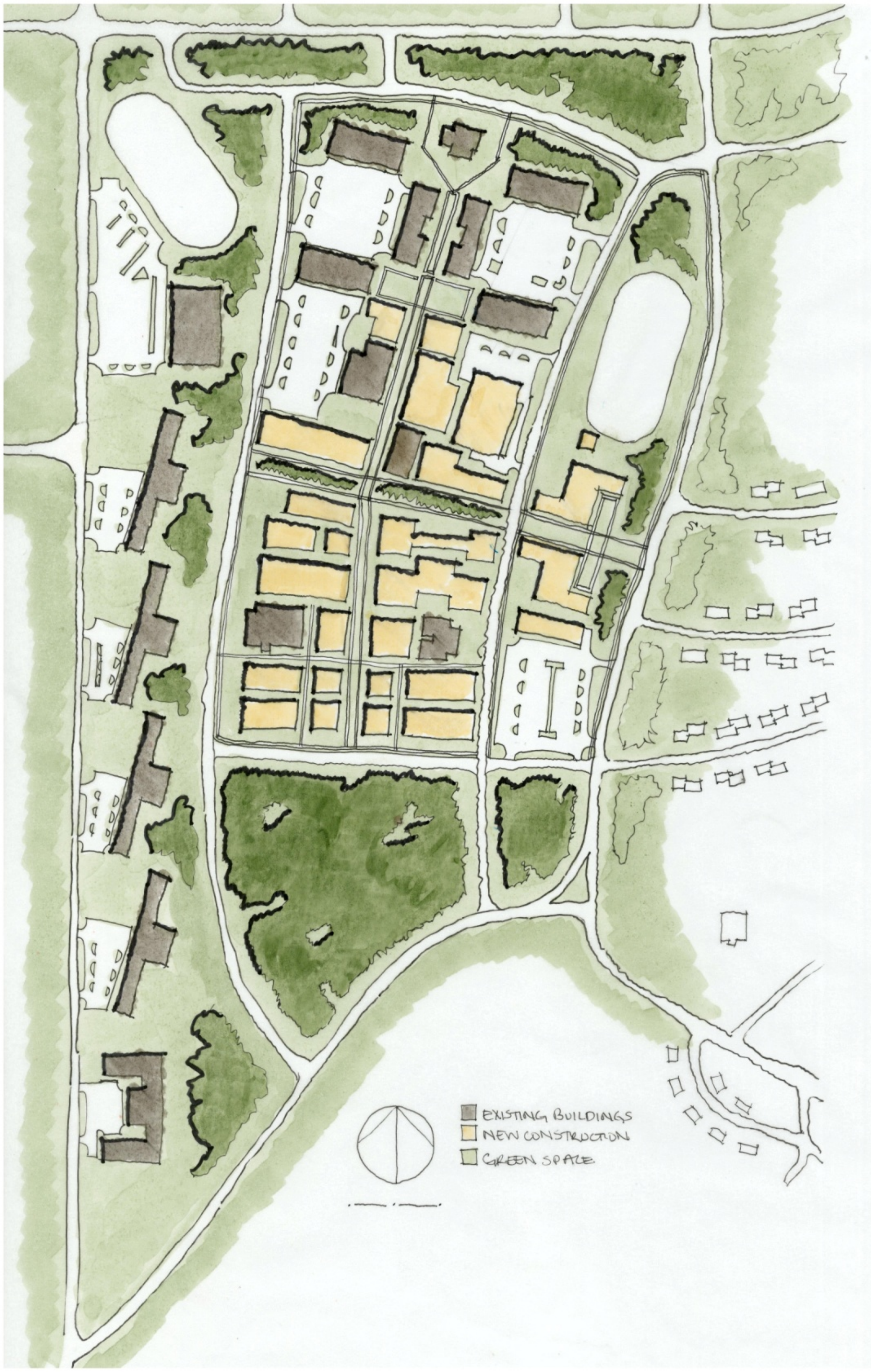

Figure 4. Illustrative Plan

Figure 5. Regulating Plan

Attachment D:

Request for Proposals (RFP)

For Consultants to Prepare a Form-Based Code

For Downtown Ferguson, Missouri

The City of Ferguson will receive proposals at the office of the Department of Planning and Development located at Ferguson City Hall, 110 Church Street, Ferguson, Missouri 63135. Proposals should be addressed to Rosalind Williams, Director of Planning and Development. Proposals will be accepted until 5:00 p.m. on Friday, September 16, 2011.

BACKGROUND:

In January 2009, the city of Ferguson approved the *Downtown Strategic Development Plan*, which expanded on the original *Ferguson Downtown Vision, 1999* and developed additional strategies for the revitalization of the downtown central business district. The *Plan* establishes a new vision for downtown and sets a five year course of action for capturing the potential of downtown as a regional entertainment and shopping destination that is attractive, inviting, walk-able, and supports a mix of uses, including retail, office and housing, while maintaining downtown as a civic and social focus of the community. The final recommendation, which resulted from extensive meetings with the Steering Committee, case study comparisons, focus groups, and community workshops, included developing and adopting an urban design plan and revising zoning and other regulations to match the vision for downtown.

CHARACTER OF THE AREA:

Ferguson, Missouri is an older suburb about 10 miles northwest from the city of St. Louis and located in St. Louis County. The City's population in 2010 was approximately 21,000. The City's "Main Street" is located along Florissant Road, which has served as the primary artery since the City was founded as a commuter railroad suburb in the 1870's. The downtown core began as a traditional small downtown centered on the commuter rail station. During the City's major growth period more auto-oriented development extended from the core along Florissant Road at both ends. Today downtown Ferguson and the immediate residential area encompass about 285 acres and are about 1.5 miles long.

SUGGESTED SCOPE OF SERVICES:

The City of Ferguson will receive funding for this project from the Missouri Foundation for Health. The budget is limited to $35,000. Respondents to the RFP should keep in mind the budget constraint when drafting their proposals. Proposals will be evaluated based upon overall qualifications and the extent to which the following Suggested Scope of Services can be performed by the consultant within the budget. The City has indicated which tasks City staff anticipates undertaking partially or completely.

PRIMARY WORK PRODUCT:

This contract will result in a proposed form-based code, meant to supersede (either entirely or in part) the present zoning ordinance and other local land development regulations that apply to downtown Ferguson. This code is to be consistent with the definitions and evaluation criteria established by the Form-Based Codes Institute (FBCI); see *www.formbasedcodes.org* for more details.

1. **INITIAL REVIEW AND ANALYSIS**
   a. ***Interviews***. The Consultant will interview appropriate stakeholders involved with the project. These interviews will include groups and individuals including elected officials, nonprofit organization leaders, property owners, neighborhood representatives, developers, business organizations, and municipal staff.
   b. ***Site Analysis.*** The Consultant will become familiar with the physical details of downtown Ferguson and the historic patterns of urbanism and architecture in the surrounding region.
   c. ***Media coverage***. The Consultant/ Ferguson will participate in a press conference with local officials and draft a press release to inform the local citizenry about the planning efforts to be undertaken.
   d. ***Website***. The Consultant will provide information for Ferguson's website. As officials deem appropriate, the Consultant will provide materials including text, photographs, maps, renderings, and other images for the web site. These material will describe the Consultant's credentials and help explain the project's process.

2. **PUBLIC DESIGN PROCESS**
   a. ***Generate necessary background maps***. Ferguson will provide all necessary base map information as needed by the Consultant. These documents will be used to produce the maps that will be used during the preparation of the form-based code.
   b. ***Public Workshop and/or Design Charrette.*** The Consultant will organize and lead design workshops or a full planning charrette to engage the community, gather ideas and goals, and formulate implementation strategies. The Consultant will tailor the workshop or charrette to obtain maximum community input so as to produce the best possible master plan on which to base the new code. The charrette format will also take into consideration the findings of the initial site analysis, input from staff, and information obtained at previous meetings, workshops, and interviews. At the conclusion of the workshop(s), the Consultant will present the work generated to-date. Plans, renderings, and initial coding ideas that reflect ideas articulated in the workshops will be publicly presented and further feedback solicited from the community. It is essential that local government officials attend this presentation along with citizens, stakeholders, and technicians.

3. **DRAFTING THE FORM-BASED CODE**
   a. ***Design Parameters for the Form-Based Code***. The new code will regulate development to ensure high-quality public spaces defined by a variety of building types and uses including housing, retail, and office space. The new code will incorporate a regulating plan, building form standards, street standards (plan and section), use regulations as needed, descriptive building or lot types (optional), and other elements needed to implement the principles of functional and vital urbanism, and practical management of growth. Sections of this document would typically include the following:
      - Overview, including definitions, principles, and intent; and explanation of the regulations and process in clear user-friendly language.
      - Regulating Plan (a schematic representation of the master plan) illustrating the location of streets, blocks, public spaces (such as greens, squares, and parks), and other special features. Regulating plans may also include aspects of Building Form

Standards such as “build-to-lines” or “required building lines” and building type or form designations.

- Building Form Standards governing basic building form, placement, and fundamental urban elements to ensure that all buildings complement neighboring structures and the street. These standards should be based upon study of building types appropriate for the region, climate, and neighborhood vitality.
- Public Space/Street Standards defining design attributes and geometries that balance the needs of motorists, pedestrians, bicyclists, and transit riders while promoting a vital public realm. These standards should include design specifications for sidewalks, travel lane widths, parking, curb geometry, trees, and lighting.

b. ***Integration of the Form-Based Code.*** With the assistance of the Consultant, Ferguson staff will undertake the integration of the form-based code into Ferguson’s existing regulatory framework (zoning and land development regulations) in a manner that insures procedural consistency, meshes with state and local legal requirements, provides clarity as to applicability of existing regulations, and maximizes the effectiveness of the code.

4. **REFINING THE FORM-BASED CODE**
   a. ***Presentation of First Draft.*** Ferguson staff with the assistance of the Consultant will present the first draft of the form-based code, which will include graphics, for the purpose of gathering comments. Copies of the first draft will need to be in hardcopy and digital form to be posted on the website. The presentation may be made to a special audience of neighborhood residents or stakeholders, or may be presented before a joint gathering of municipal boards and committees.
   b. ***Presentation of the Second Draft*.** After making revisions in response to comments on the first draft, Ferguson staff will with review by the Consultant prepare the second draft of the form based code and present at another meeting convened by Ferguson.
   c. ***Meetings with Stakeholders*.** The Consultant will attend and participate in up to two additional meetings with key stakeholders to explain the details of the new code and obtain further input and comments.

5. **APPROVAL PROCESS**
   a. ***Public Hearing Presentations.*** Ferguson staff with the Consultant in attendance will make formal presentations to the Plan Commission and the City Council.
   b. ***Additional Revisions*.** Ferguson staff will be responsible for two rounds of revisions that may become necessary between presentations and will be responsible for collecting comments, questions, and suggestions for these refinements from various sources and consolidating them into a series of action items for revision or responses. Consultant will participate in the review of revisions.

SUBMITTAL SUMMARY:

Submittals should be provided in <u>three</u> identical copies and include the following items, along with other material to demonstrate the Consultant’s expertise and capability:

1. A brief written description of the Consultant’s approach to the project.
2. The expertise of the team assembled by the Consultant to carry out the work.
3. A list of comparable projects undertaken by the Consultant and/or team members.
4. A copy of at least one municipal form-based code, overlay code or hybrid code previously created by the Consultant and adopted into law.

5. A detailed proposal outlining the scope of services the Consultant proposes to perform within the budget constraints explained in the RFP.

RECOMMENDED FORMAT FOR SUBMITTALS:

1. **DESCRIPTION OF THE METHODOLOGY:** A detailed description of the Consultant's proposed approach to this project, including the nature of the public process and intended extent of public involvement and the anticipated involvement of Ferguson staff.
2. **WORK PROGRAM DETAILING:** Provide a proposed work program describing:
   a. Tasks to be performed.
   b. When each will be completed (timeline).
   c. Tentative allocation of person days by task.
   d. Schedule of work products

3. **PROJECT MANAGEMENT:** Methods the Consultant proposes to use to manage the project and communicate with Ferguson and the public as to project progress, reviews, and conduct of public meetings.

4. **PERSONNEL:** Identification of key personnel to be assigned to the project and their roles, with resumes of all key personnel.

5. **RATES:** Hourly rates (inclusive of overhead and profit) for personnel or personnel categories.

6. **CITY'S RESPONSIBILITIES**: Data expected to be provided by Ferguson**.**

7. **HOURS:** Estimated number of hours included in the proposed work program.

8. **TEAM EXPERTISE**: Brief description of general qualifications, the multi-disciplinary nature of the team assembled for this project, specific evidence of relevant experience creating form-based codes, and a listing of key personnel that would be available to work on this project.

9. **COMPARABLE PROJECTS:** Summary of form-based code projects in progress or completed, with the following information for each code:

   a. Reference name, with current contact information
   b. Current status of code (drafting in progress; drafting completed; adopted?)
   c. Nature of public involvement in formulation of code
   d. Client type (clarifying role of private sector client, if any)
   e. Was the vision plan created as part of this process or done separately?
   f. Size and scale of geographic area
   g. Type of development (greenfield? infill/redevelopment? city-wide code?)
   h. Type of code
      - Mandatory (integrated into existing code, or freestanding?)
      - Optional "parallel" code?
      - Floating-zone code?

10. **SAMPLE CODE DOCUMENT:** Please include one or more sample code documents selected from the list of comparable projects. If this document is the code as originally proposed by Consultant, please also include the code as formally adopted by the municipality and a brief explanation of differences between the two. Photos of designed or built results of the code are encouraged but must be accompanied by a description of their specific relationship to the form-based coding process.

EVALUATION OF SUBMITTALS:

The city of Ferguson will evaluate all submittals to determine which Consultants have the experience and qualifications that are most suited for this project. The City will hold interviews with the highest-ranked Consultants.

Consultants responding to this RFP must demonstrate the following:

- Experience in preparing municipal form-based codes that regulate development and redevelopment in other communities.
- Experience in building community consensus to support innovative regulatory structures.
- Strong graphic skills.
- Strong skills in written and oral communication.
- Experience in identifying, evaluating, codifying, and explaining the essential qualities of community design and character.
- Experience in writing or implementing municipal land development regulations.

CONDITIONS OF PROPOSAL ACCEPTANCE:

This RFP does not commit the city of Ferguson to award a contract, to pay any costs incurred in the preparation of a proposal for this RFP, or to procure or contract for any services. The city of Ferguson reserves the right to accept or reject any or all proposals received as a result of this request; negotiate with any qualified source or to cancel the RFP in part or whole. All proposals and materials submitted will become the property of the city of Ferguson and will not be deemed confidential or proprietary.

EXISTING AVAILABLE DOCUMENTS:

1. Vision 2015 Plan Update, 1998 – comprehensive plan
2. Ferguson Downtown Vision, 1999 – a plan for the public improvements along Florissant Road.
3. Downtown Strategic Development Plan, 2009
   http://www.fergusoncity.com/DocumentView.aspx?DID=387 - plan
   http://www.fergusoncity.com/DocumentView.aspx?DID=388 - concept map
4. Ferguson Zoning Ordinance
   http://library3.municode.com/default-test/home.htm?infobase=13298&doc_action=whatsnew

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8.14 Future Infill Strategies

future infill strategies

TECHNOTE

Recommendation

Fort Leonard Wood (FLW) has located the Cadre and their families to the North and East. Soldiers in training are to the West and to the South with the exception of the Advanced Individual Training (AIT) complexes to the east of the core community facilities. Re-site the Transportation School Motorpool and AIT Facilities downrange adjacent to similar training facilities in order to minimize mass movements of soldiers and military vehicles through the main cantonment area. This would allow for infill of future U.S. Army Forces Command (FORSCOM) and permanent party facilities within the main cantonment area that would benefit from adjacency to housing and community facilities.

Due to demolition of aging housing and tornado damaged areas there are abundant opportunities to increase housing density and provide mixed use developments incorporating retail and concessions into RCI Housing in the existing residential footprints.

General Planning Guidelines:

- As the master plan is developed, site facilities within the interstitial space already delineated by current developments instead of developing greenfields.
- The constituents that the building is meant to serve should determine the area where the development should occur. Access to community resources and housing development should be taken in to consideration to reduce traffic congestion.
- The establishment of a mass transit system could further inform where future infill should happen. Specifically, higher density development can occur along the two major transit routes established along State Highway, 4th Street, and Missouri; and Oklahoma, 4th, Iowa, Arkansas , Artillery, Battery, W19th, Nebraska, and South Dakota. The overall benefits of mass transit systems are listed in more detail in that respective tech note, but the implementation of this type of system – combined with the creation of more walk-able mixed-use infill strategies – has the potential to profoundly reduce street maintenance costs.

Location & Scale

This would occur at the **installation scale**.

Maintenance

Increasing development density should increase the efficiency of maintenance efforts due to a reduction in transit time to outlying facilities.

Reference

See the master planning and Residential Area Development Tech Notes for more information.

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2030 USACE Integration Project

8.15 Geothermal Ground Source Heat Pump

Recommendation

In the Renewable Energy Opportunities at Fort Leonard Wood (FLW), MO Report prepared by the U.S. Department of Energy (DOE), May 2009, DOE looked at the feasibility of installing geothermal ground source heat pumps (GSHPs) at various types of buildings at the installation. Geothermal GSHP heating and air conditioning systems use the stable temperatures of the earth and groundwater to improve the coefficient of performance of heating and cooling applications for buildings and can be combined with desuperheaters to supplement or pre-heat potable water supplies. Ground source heat pump systems commonly achieve 30-40% reductions in total energy usage for buildings. Building heating and cooling costs can often represent up to 70% of a facility energy demand so significant reductions here can have large overall impacts. GSHP systems utilize existing Site conditions, are renewable, and can provide more secure energy options compared to other HVAC alternatives such as natural gas reliant on pipeline capacity. If the electrical power used to operate the GSHP system is from a renewable source, then significant progress towards net zero goals for 2030 can be made. A focused program of GSHP HVAC system retrofits combined with energy efficiency upgrades to existing buildings combined with GSHP HVAC systems in new construction should be used as a significant approach to achieving Net Zero objectives.

Location & Scale

This system is implemented at the **building, complex, and installation scale.** The ground field components can be located beneath new building construction prior to foundation construction, beneath open space such as physical training (PT) pits, recreational fields, parking areas, and green space. An example existing BT Complex at Fort Leonard Wood is indicated in the diagram. This example shows sufficient space beneath the running track/PT Pits for a vertical closed loop GSHP ground field of more than 400 vertical closed loop wells with an estimated capacity of 894 tons (1 ton is equal to 12,000 btu/h) in the central location to the majority of the Complex buildings. GSHP mechanical HVAC systems typically require less interior space than conventional HVAC equipment making retrofits appealing in the sense of making additional interior space available for other use. If proper conditions exist (good water quality, reasonable depths to groundwater, and high available well yields) for more efficient open type GSHP systems, then significantly reduced area and number of wells for extraction and re-injection of groundwater would be required. Typical groundwater pumping rates of 2.5 to 3 gallons/ton are required to satisfy a commercial scale open GSHP system. This type of information is determined as a component to detailed building design. As a point of comparison, the BT Complex 6 recently constructed at the Installation was designed for peak cooling loads of 1,055 tons of air conditioning for each of the five BCOF buildings, the Battalion Headquarters (BNHQ) building, and the adjacent DFAC building. These peak loads are very likely in excess of more representative block load requirements for sizing a common-linked GSHP system, but the example shown in the diagram indicates there is ample space between the buildings and in surrounding parking lots or green space for a system of this size.

Phasing

This system is projected as part of the **2015 Phase**. The ground loop borings, in the instance of a vertical closed loop system are installed, pressure tested, and all insulated lateral heat-fused tubing connections made post site work for new construction and pre-laying of the foundation and utilities. HVAC systems are installed and combined systems balancing and inspections made prior to and during initial building use. Current schedules suggest 2015 for systems construction for new buildings. Building retrofit schedules can be phased to target worst energy consumers first in 2015, and proceed over time as buildings with aging systems require replacement through 2030.

Initial Cost

Based on the Renewable Energy Opportunities at Fort Leonard Wood, MO report prepared by the U.S. Department of Energy, May 2009 Appendix D: High Efficiency Open loop GSHP average installed costs were **$156 per kBtu/hr** with High Efficiency Vertical Closed Loop systems costing between **$332-$449 per kBtu/hr** depending on the funding type (ECIP vs. ESPC). Typically this system would be implemented with **FY15 MCA project funds**, although other options such as Energy Savings Performance contracts (ESPC) are available for retrofit situations and can have significant impacts on the payback period.

Life Cycle Cost

Based on the 2007 Report to Congress on Ground Source Heat Pumps at DoD Facilities, for Department of Defense (DoD) facilities within Climate Zone 4A, such as Ft. Leonard Wood, average cost effectiveness as Annual Savings was 9,682.90 kWh/ton installed and had an Average Project Payback Period of 12 years. This same Report noted that “138 out of the 264 existing GSHP projects currently operating at DoD facilities have positive annual energy savings, operations and maintenance savings, and overall reduced energy consumption. For the remaining GSHP projects, data related to savings was not reported.” GSHP systems will reduce both total load as well as peak demand due to the more constant nature of the operation. Simple payback periods ranged from as low as 4.9 years to 12.7 years based on the DOE building modelling conducted as part of the 2009 Renewable Energy Opportunities at Fort Leonard Wood, MO Report which was based on Sho-Me Power’s projected rates. For this FEDS analysis it was assumed to be a flat rate of **6.441¢/kWh** (the average energy rate, which is the charge for the current year), plus **$4.20/kW** demand (the demand charge for the peak load, which is a seasonal amount based on the previous year’s consumption and is fixed for 1 year at a time). Natural gas costs used were **$12.97/MMBtu**, based on historical and future trends according to the National Institute of Standards and Technology.

Maintenance

Closed loop GSHP systems typically require significantly less maintenance then other open type GSHP systems, and these systems have low operational costs compared to other conventional HVAC systems. The systems will require weekly monitoring by qualified person resulting in an additional workload of 2 hrs/wk or 104 man hours per year. Recommend adding the weekly inspection to a current maintenance contract or DPW staff, but rolling the annual service into a maintenance contract with the installer for five years with the option to renew. Annual servicing and balancing must take place as well as the replacement of a filter in the HVAC system. Projected annual maintenance costs are **$2,500-5,000.00/year** and include supplies.

Feasibility

Ground source heat pump technology has been in use in the United States since the 1970s for building heating and cooling and the DoD has been installing GSHP systems on installations since the late 1980s. As reported to Congress in Jan. 2007, more than 52,000 tons of GSHP systems are operating on DoD installations. This number has increased significantly since then and the trend continues, especially in light of the Federal government and DoD specific criteria for energy efficiency improvements, increased renewable resources, and energy security from both natural and man-made hazards. GSHP's meet all of these objectives and if the electricity required to operate the GSHP systems is generated by renewable resources makes a significant impact on achieving net zero goals.

Many of the future building projects such as the BT Complex's or Advanced Individual Training (AIT) complex planned for construction at the Installation lend themselves to a multi-building linked GSHP system to provide heating, air conditioning, and supplemental domestic water supply heating. In a vertical closed loop system, environmentally safe water and anti-freeze solution is recirculated via pumps, contained within mechanical spaces inside buildings, through a loop of tubing permanently installed in a network of borings typically spaced 20-25 feet apart and extending 100-500 feet deep. This heat transfer fluid is used as by a network of heat pumps within each building. Heat is either extracted or added by the primary refrigerant loop, and the water is returned to the ground loop network or to another heat pump within the same or another building at the BT Complex in order to balance the system. Domestic water supply heating can be achieved through combined use of desuperheaters/heat pumps and reuse of rejected heat primarily from the DFAC as well as other cooling dominated facilities such as computer server rooms. Other existing building retrofits should be evaluated for open and closed-loop GSHP systems including buildings or facilities that are near surface bodies of water or already expend energy to move water such as at the water treatment plant or the Officers Club and recreational facilities at the golf course where water is used and pumped for irrigation purposes and may provide a lower initial cost and highly efficient alternative to GSHP retrofits.

This system attributes to the **2030 Net Zero Energy** goals by utilizing existing site conditions to harness geothermal energy to support the building load. The risks for the system revolve around correctly designing, installing and maintaining it. Specifically, Site specific data including soil and bedrock types, thicknesses, solution cavities, thermal properties a well as ensuring separation of surface water and ground water during installation should be monitored. Thermal testing for thermal conductivities and diffusivities are also critical design criteria.

Proper drilling depths, and construction and grouting of the U-tube followed by pressure testing are additional concerns.

References See Attachment A

http://www.acq.osd.mil/ie/energy/library/GSHP-Report_JAN242007.pdf

http://www1.eere.energy.gov/femp/pdfs/ghptf.pdf

http://www.acq.osd.mil/ie/energy/ecip/ecip.shtml

Missouri Department of Natural Resources. "Missouri Well Construction Rules: Private Water Wells, Heat Pump Systems, Pump Installations, and Monitoring Wells." Division of Environmental Quality. Rolla, Missouri. May 2007. http://dnr.mo.gov/pubs/pub2175.pdf

Diagrams See Attachment B

Funding Plan Energy Conservation & Investment Program (ECIP) projects focus on energy and water savings, implementing renewable energy, and converting systems to cleaner energy sources. Geothermal HVAC upgrades are just one example of viable EPIC funded projects.

According to State Law 43-5, a thirty percent tax credit is available for geothermal water heating systems installed prior to 2020. The owner will receive a tax credit resulting in a lowered net cost. This cost can be captured by the contractor which will result in a lower cost proposal to the government.

Since 2007 one segment of the utility industry, the rural electric cooperatives (RECs), have been able to obtain long-term loans with terms of up to 35 years at the cost of government funds from the U.S. Department of Agriculture Rural Utilities Service (USDA/RUS) to provide the outside-the-building portion of GHP systems to customers in exchange for a tariff on the utility bill, which would be more than offset by the GHP system's energy cost savings.

Contract Language See Attachment C

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Attachment A: Reference Material

Geothermal Heating and Cooling Key Terms

Key Terms:

BTU (or British Thermal Unit): The amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. BUT is used to signify the heating and cooling capacity of a system and the heat losses and gains of buildings and homes.

BTUH: The number of BTUs produced in one hour.

Closed-loop heat-pump system: A heat-pump system that uses a loop of buried plastic pipe as a heat exchanger. Loops can be horizontal or vertical.

Compressor: The central part of a heat pump system. The compressor increases the pressure and temperature of the refrigerant and the simultaneously reduces its volume while causing the refrigerant to move through the system.

Condenser: A heat exchanger in which hot, pressurized (gaseous) refrigerant is condensed by transferring heat to cooler surrounding air, water or earth.

Cycling losses: The actual efficiency of a heating or cooling system is reduced because of start-up and shut-down losses. Over sizing a heating or cooling system increases cycling losses.

Desuperheater: A device for recovering superheat from the compressor discharge gas of a heat pump or central air conditioner for use in heating or preheating water.

Fossil Fuel: Any of several types of combustible fuels formed from the decomposition of organic matter. Examples are natural gas, propane, fuel oil, oil and coal.

Geothermal Heat Pump: A heat pump that uses the earth as a heat source and a heat sink.

Heat Exchanger: A device designed to transfer heat between two physically separated fluids or mediums of different temperatures.

Heat Pump: A mechanical device used for heating and cooling, which operates by pumping heat from a cooler to a warmer location. Heat pumps can extract heat from air, water or the earth. They are classified as either air-source or geothermal units.

Heat Sink: The medium – air, water or earth – which receives heat rejected from a heat pump.

Heat Source: The medium – air, water or earth – from which heat is extracted by a heat pump.

Open-Loop Heat-Pump System: A heat-pump system that uses groundwater from a well or surface water from a lake, pond or river as a heat source. The water is returned to the environment.

Payback: A method of calculating how long it will take to recover the difference in cost between two different heating and cooling systems by using the energy and maintenance-cost savings from the more efficient system.

Ton: One ton of cooling is equal to 12,000 BTU/h and represents the amount of energy required to melt one ton of 32 degree F. ice within 24 hours.

Supplemental Heating: A heating system used during extremely cold weather, when additional heat is needed to moderate indoor temperatures. It may be in the form of fossil fuel or electric resistance.

General Geothermal Energy Questions

What is a geothermal heat pump?

A geothermal heat pump is an electrically-powered device that uses the earth's natural heat storage ability to heat and cool your home or business at significantly less energy costs.

How efficient is a geothermal heat pump?

The geothermal heat pump is one of the most efficient residential heating and cooling systems available today, with heating efficiencies 50 to 70% higher than other heating systems and cooling efficiencies 20 to 40% higher than available air conditioners. That directly translates into savings for you on your utility bills.

Can one geothermal system provide both space heating and cooling for my home? And what about heating hot water?

Yes, a geothermal heat pump can be a combination heating, cooling and hot water heating system. You can change from one mode to another with a simple flick on your indoor thermostat. Using a desuperheater, some geothermal heat pumps can save you up to 50% on your water-heating bill by preheating tank water.

How does a geothermal heat pump system heat water for my home?

Using what is called a desuperheater, a geothermal heat pump turns waste heat to the task of heating hot water. During the summer, when the system is in cooling mode, your hot water is produced free as a by-product of the thermal process. In winter, with the heating mode, the desuperheater heats a portion of your hot water. Desuperheaters are standard on some units, optional on others. Stand-alone systems that will heat water all year can be purchased.

How much space does a geothermal unit require?

Most of the geothermal system installations are underground. Inside the house, the heat pump units are about the same size as a traditional heating and cooling unit.

How long will my geothermal system last?

Geothermal units are durable and highly reliable. The geothermal heat pumps contain fewer mechanical components, and all components are either buried in the ground or located inside the home, which protects them from outside conditions and vandalism. The underground pipe carries up to a 50-year warranty although anticipated life spans are expected to be between 50 and 100 years.

How noisy is the geothermal heat pump unit?

Geothermal units are very quiet, providing a pleasant environment inside and outside of the home. Geothermal units have no noisy fan units to disturb outdoor activities, on or near the patio.

How safe are geothermal heat pumps?

Geothermal systems are safe and protected. With no exposed equipment outdoors, children or pets cannot injure themselves or damage exterior units. Geothermal heat pumps have no open flame, flammable fuel or potentially dangerous fuel storage tanks.

What about comfort?

A geothermal system moves warm air or water (90-105(F)) throughout your home or business via standard ductwork or piping. An even comfort level is created because the warm air is moved in slightly higher volumes and saturates the building with warmth more evenly. This helps even out hot or cold spots and eliminates the cold air blasts common with fossil fuel furnaces.

How effective is this underground system?

The buried pipe, or ground loop, is the most recent technical advancement in heat pump technology. Recently, new heat pump designs and improved buried pipe materials have been combined to make geothermal systems the most efficient heating and cooling systems available.

Are geothermal systems guaranteed?

Nearly all geothermal heat pump system manufacturers offer a warranty for major components that is equivalent to the warranties for conventional heating and cooling systems. Manufacturers of plastic pipe used for ground loops warrant their products for 50 years.

Can these systems be used for commercial, industrial, or apartment requirements?

Yes. Many geothermal systems are being installed using a multitude of systems hooked up to an array of buried vertical or horizontal loops. This simplifies zone control and internal load balancing.

What are the advantages to an HVAC dealer?

Geothermal systems create a huge retrofit market not subject to wild fluctuations in housing construction. There is also ample opportunity for stable growth benefiting the dealer and his employees. In addition, these systems are relatively maintenance-free, requiring only regular filter changes. This means fewer maintenance and support calls. There is no outside equipment, so wear and tear is less.

Geothermal Heat Pump Installation Questions

How much space does a geothermal system require?

The geothermal heat pump unit inside the home is about the same size as a traditional heating and cooling unit. Most of the rest of the installation is buried underground so it depends on which system is used.

Can geothermal systems be used for commercial buildings or apartment complexes?

Yes, multiple systems can be installed by hooking them up to an array of buried vertical or horizontal loops, thus simplifying zone control and internal load balancing.

Are Geothermal heat pump systems difficult to install?

Most units are easy to install, especially when they are replacing another forced-air system. This is known as a retrofit. Geothermal heat pumps can be installed in areas unsuitable for fossil fuel furnaces because there is no combustion and thus no need to vent exhaust fumes. Ductwork must be installed in homes without an existing air distribution system. Your dealer or installer can assess the cost of installing ductwork.

Can I install a geothermal heat pump system myself?

It's not recommended. Thermal fusion of the pipe, drilling and trenching are procedures best handled by licensed professionals. Non professional installations may result in less than optimum performance, which could cancel out anticipation savings.

How far apart are trenches and vertical boreholes spaced?

Trenches are spaced four to five feet apart while vertical boreholes are typically spaced twenty feet apart.

How long does it take to install a horizontal geothermal system?

This depends on soil conditions, length and depth of pipe, and equipment required. A typical installation can be completed in one or two days.

How long does it take to install a vertical geothermal system?

With the vertical installation, time varies with conditions on the site such as type and depth of the overburden, type and hardness of the bedrock, and the presence and quantity of groundwater encountered. Typical drilling times are one or two days; total installation can usually be accomplished in two days.

What are the advantages and disadvantages of the horizontal and vertical installations, respectively?

Horizontal installations are simpler, requiring lower cost equipment. However, they require longer lengths of pipe due to seasonal variations in soil temperature and moisture content. Since a horizontal heat exchanger is laid out in trenches, a larger area is usually required than for a vertical geothermal system. Where land is limited, vertical installations or horizontal installation can be ideal. If regional soil conditions include extensive hard rock, a vertical installation may be the only available choice. Vertical installations tend to be more expensive due to the increased cost of drilling versus trenching, but since the heat exchanger is buried deeper than with a horizontal system, vertical systems are usually more efficient and can get by with less total pipe. Your geothermal contractor at will be able to help you decide which configuration best meets your specific needs.

How much does a geothermal system cost?

The initial investment for geothermal systems is greater than that of a conventional system. However, when you consider the operating costs of a geothermal heating, cooling and water heating system, energy savings quickly offset the initial difference in purchase price.

How long will the geothermal pipe loop last?

Geothermal systems use the industry standard high density polyethylene pipe. This pipe is often times guaranteed by the manufacturer to be free from leaks for 55 years and is expected to last beyond 100 years.

What other costs are there besides the geothermal system?

You can expect an installation charge for any electrical work, ductwork, water hook-up, and other provisions or adaptations to your home that are required. Your installer can estimate these costs in advance.

How would increased use of geothermal systems affect electricity costs and availability?

The reduced peak load requirements would allow utilities to serve more customers and to lower fixed costs per customer, thus offsetting some increased variable costs. This would result in less cost per kilowatt, since fixed investment for new capacity is high.

How do GSHPs protect the environment?

GSHP systems conserve natural resources by providing climate control very efficiently-thus also lowering emissions. GSHPs also minimize ozone layer destruction by using factory-sealed refrigeration systems, which will seldom or never have to be recharged.

What are the environmental benefits of GSHP systems?

Currently installed systems are making a huge difference in our environment! The systems are eliminating more than three million tons of carbon dioxide and are equivalent of taking 650,000 automobiles off the road. GSHP systems conserve energy and, because they move heat that already exists rather than burning something to create heat, they reduce the amount of toxic emissions in the atmosphere. They use renewable energy from the sun, and because the system doesn't rely on outside air, it keeps the air inside of buildings cleaner and free from pollens, outdoor pollutants, mold spores, and other allergens.

Do soil freezing conditions create any problems?

Not if a system is properly designed and installed. The three to four foot depths allow the sun to melt the frozen soil during the summer. Adequate length per ton capacity prevents objectionable soil movement.

Does this mean that in extremely cold climates additional heat sources are necessary?

Geothermal Heat pumps can provide all the heat necessary even in the coldest weather. An economic analysis by your contractor should dictate if and what portion of the heat should be provided by the heat pump and what portion by auxiliary means if desired.

Tax Credits for Commercial Geothermal Heating and Cooling Installations

On October 3rd 2008, geothermal heat pumps were added to the definition of energy property under section 48(a) of the Internal Revenue Code, which provides a 10% tax credit for spending on property placed in service through the end of 2016.

Energy property is classified as 5-year depreciable property in section 168(e)(3)(B)(vi)(I) of the Internal Revenue Code, meaning the cost of the property can be deducted on an accelerated MACRS basis. For depreciation purposes, the basis must be reduced by one half of the tax credit. For a corporation in a 35% tax bracket, the MACRS depreciation provides additional tax savings equal to 33.25% of the energy property spending within the first years, and this is largely front-loaded. By comparison, conventional heating and cooling systems are usually depreciated on a 39-year straight line basis, and would provide 4.5% in tax savings over the first 5 years.

Highlights of the Federal Tax Credits for Commercial Geothermal Installations

- 10% of total system cost
- No limit to total credit amount
- Can be used to offset Alternative Minimum Tax
- Can be used in more than one year
- 10% grant available in lieu of tax credit
- Can be combined with solar and wind tax credits
- Can be combined with energy-efficient building deduction

Accelerated Depreciation for Geothermal Systems

- 5 year MACR depreciation on entire system
- Eligible for 50% first-year bonus depreciation for 2008-2009

Eligibility for Geothermal Energy Tax Credits

- Building located in U.S.
- Original use begins with taxpayer
- Installed between 10/3/2008 and 12/31/2016

Eligible Geothermal Heat Pump Energy Property

The tax credit may be claimed for spending on equipment which uses the ground or ground water as a thermal energy source to heat a structure or as a thermal energy sink to cool a structure. The structure must be located in the United States. Spending includes costs of installation.

Additional Tax Incentives Available to Geothermal Heat Pump Purchasers

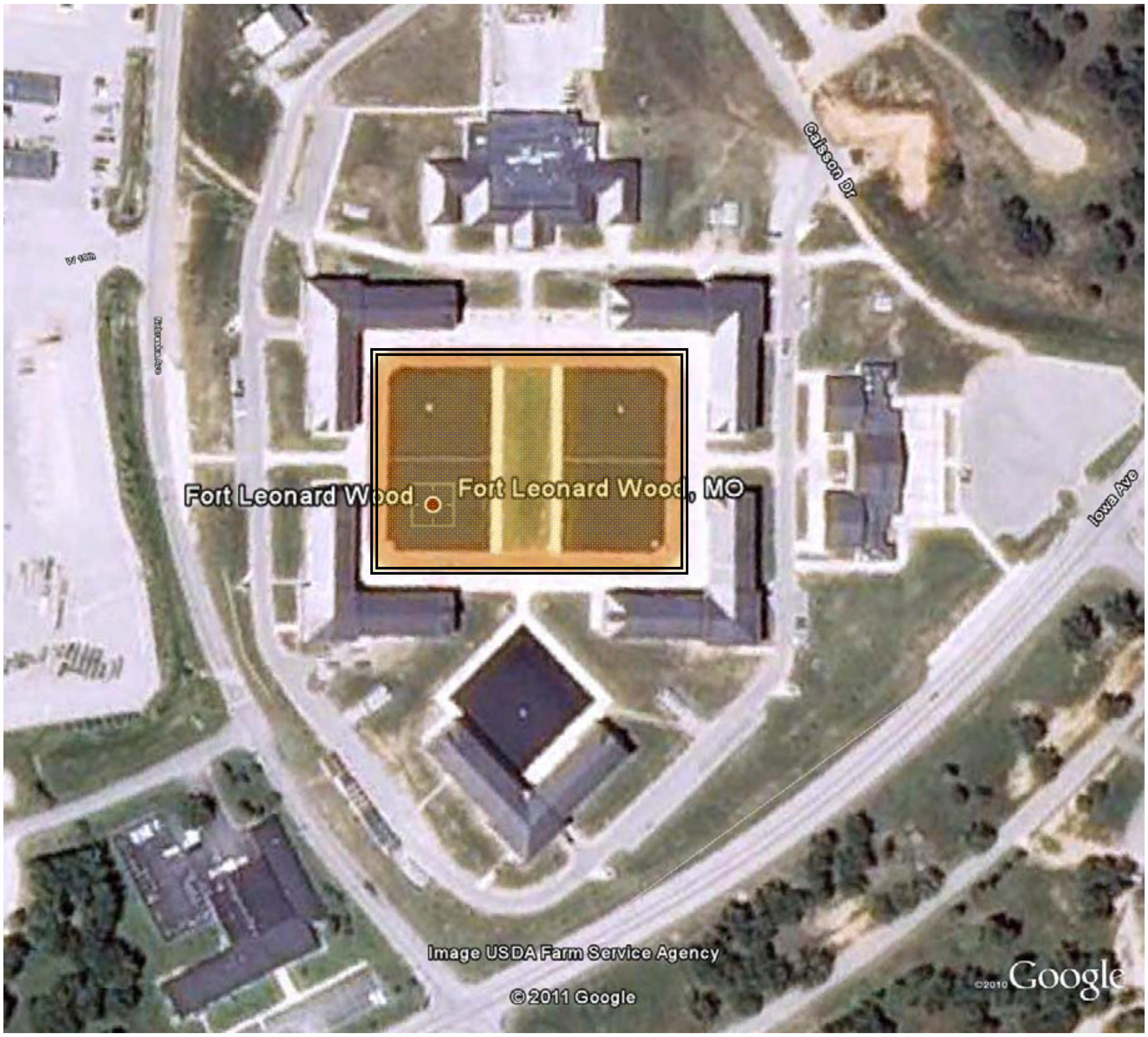
Grants for Energy Property in Lieu of Tax Credits

Section 1602 of H.R. 1, the American Recovery and Reinvestment Act, provides for a 10% grant in lieu of the energy credit for eligible geothermal heat pump energy property placed in service during 2009 and 2010, or beyond 2010 for those projects that began during that time period. The grants are available upon request and will be paid within 60 days of the date of receipt of the application, or within 60 days of the date the energy property is placed in service, whichever comes later. The grant eligibility requirements are the same as those for the energy credit.

Energy-Efficient Buildings Deduction

Section 179D of the Internal Revenue Code provides a tax deduction of up to $1.80 per square foot to owners, or if government owned, designers, of new or existing commercial buildings that achieve a 50% annual energy cost savings compared to a reference building that meets the minimum requirements of ASHRAE Standard 90.1-2001. The savings are determined from the combined heating, cooling, hot water, and lighting use. If the full savings is not achieved, a partial deduction of up to $.60 per square foot can be taken for a heating, cooling, and hot water system that provides at least 1/3 of the required 50% annual savings. See IRS Notices 2006-56 and 2008-40 for details.

Attachment B: Diagrams



Example BT Complex at Fort Leonard Wood – Image courtesy of Google Maps (© 2011 GOOGLE)

There is sufficient space beneath the running track and PT Pits inside the four central Barracks buildings to allow installation of an approximately 890 ton vertical closed-loop well field assuming 2 tons/well. There is ample additional space in parking lots and green space to allow expansion if needed, or modification of the ground well field layout based on utilities and other setback requirements.

Attachment C: Contracting Language

Geothermal/GeoExchange Heat Pump Purchasing & Procurement

Sample Procurement Language
The following is an example of language you may wish to require in your upcoming contract:

The Vendor Must:
Provide single or multi-speed geothermal (GeoExchange) heat pumps that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy efficiency as outlined below. The vendor is encouraged to visit energystar.gov for complete product specifications and an updated list of qualifying products.

Product Type	**Current Criteria**	
	EER	COP
Closed Loop System With integrated water heater	14.1 14.1	3.3 3.3
Open Loop System With integrated water heater	16.2 16.2	3.6 3.6
DX System With integrated water heater	15 15	3.5 3.5

NOTE: These specifications apply to single-speed models. Multi-speed models may be qualified based on EER = (high speed EER+low speed EER)/2; and COP = (high speed COP+low speed COP)/2.

Additional considerations for the procurement official:
Request that the vendor ensure:
The heat pump is properly sized for the conditioned space to ensure optimal operational cycles and comfort using industry accepted sizing protocols such as ACCA's Manual J or N as appropriate. Contractors are properly trained on the following issues:

- equipment installation and hookup,
- domestic water heater connection for desuperheater or integrated water heating, and
- code compliance.

Light Commercial Air Conditioners and Heat Pumps Purchasing & Procurement

Sample Procurement Language
The following is an example of language you may wish to require in your upcoming contract:

The Vendor Must:
Provide light commercial air-source air conditioners, air-source heat pumps, and gas/electric package units that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy efficiency as outlined below. The vendor is encouraged to visit energystar.gov for complete product specifications and an updated list of qualifying products.

Table 1. Criteria for ENERGY STAR Qualified Light Commercial Air Conditioners

Equipment Type	**Size Category**	**Heating Section Type**	**Minimum Energy Efficiency Criteria**	**Test Procedure***
Air-Source Central Air Conditioner (3 phase – Single Package)	< 65,000 Btu/h	ALL	**Tier 1 (May 1, 2010):** 14 SEER; 11 EER **Tier 2 (July 1, 2011):** TBD	AHRI 210/240-2008 or AHRI 1230-2009
Air-Source Central Air Conditioner (3 phase – Split System)	< 65,000 Btu/h	ALL	**Tier 1 (May 1, 2010):** 14 SEER; 12 EER **Tier 2 (July 1, 2011):** TBD	AHRI 210/240-2008 or AHRI 1230-2009
Air-Source Central Air Conditioner	>= 65,000 Btu/h – < 135,000 Btu/h	Electric Resistance (or None)	**Tier 1 (May 1, 2010):** 11.7 EER; 11.8 IEER **Tier 2 (July 1, 2011):** TBD	AHRI 340/360-2007 or AHRI 1230-2009
		All other	**Tier 1 (May 1, 2010):** 11.5 EER; 11.6 IEER **Tier 2 (July 1, 2011):** TBD	
Air-Source Central Air Conditioner	>= 135,000 Btu/h – < 240,000 Btu/h	Electric Resistance (or None)	**Tier 1 (May 1, 2010):** 11.7 EER; 11.8 IEER **Tier 2 (July 1, 2011):** TBD	AHRI 340/360-2007 or AHRI 1230-2009
		All other	**Tier 1 (May 1, 2010):** 11.5 EER; 11.6	

			IEER **Tier 2 (July 1, 2011):** TBD	

Table 2. Criteria for ENERGY STAR Qualified Light Commercial Heat Pumps

Equipment Type	Size Category	Heating Section Type	Minimum Energy Efficiency Criteria	Test Procedure*
Air-Source Heat Pump (3 phase – Single Package)	< 65,000 Btu/h	ALL	**Tier 1 (May 1, 2010):** 14 SEER; 11 EER; 8.0 HSPF **Tier 2 (July 1, 2011):** TBD	AHRI 210/240-2008 or AHRI 1230-2009
Air-Source Heat Pump (3 phase – Split System)	< 65,000 Btu/h	ALL	**Tier 1 (May 1, 2010):** 14 SEER; 11 EER; 8.2 HSPF **Tier 2 (July 1, 2011):** TBD	AHRI 210/240-2008 or AHRI 1230-2009
Air-Source Heat Pump	>= 65,000 Btu/h – < 135,000 Btu/h	Electric Resistance (or None)	**Tier 1 (May 1, 2010):** 11.3 EER; 11.4 IEER; 3.35 COP **Tier 2 (July 1, 2011):** TBD	AHRI 340/360-2007 or AHRI 1230-2009 COP rated at 47° F
Air-Source Heat Pump	>= 135,000 Btu/h – <= 240,000 Btu/h	Electric Resistance (or None)	**Tier 1 (May 1, 2010):** 10.9 EER; 11 IEER; 3.25 COP **Tier 2 (July 1, 2011):** TBD	AHRI 340/360-2007 or AHRI 1230-2009 COP rated at 47° F

***Note:** Beginning January 1, 2010, test procedures ARI 210/240 and ARI 340/360 will be referenced as AHRI 210/240-2008 and AHRI 340/360-2007, respectively. Test procedure AHRI 1230-2009 is applicable to VRF equipment only.

Additional considerations for the procurement official:

Request that the vendor ensure:

- The unit is properly sized and installed to ensure maximum comfort and efficiency using industry accepted sizing protocols such as ACCA's Manual J.
- Contractors are well trained in the proper installation of equipment.

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8.16 Glazing

TECHNOTE glazing

Recommendation

Glazing is included in buildings in vertical fenestrations such as windows and storefront doors, and horizontal fenestrations such as skylights. The transfer of heat through the glazed portion of the building envelope takes two forms, transmission of solar radiation and conduction based on the temperature different across the glazing. Glazing plays an integral part in the building energy usage and must be designed and specified carefully to function as part of the overall building system to maximize building energy efficiency. It is recommended that future projects include the ASHRAE 189.1-2009 fenestration assembly ratings at a minimum. Energy Star maintains a higher standard than ASHRAE 189.1-2009 and can also be used as the baseline.

Location & Scale

This system is implemented at the **building scale**. Fenestration and glazing size, location, type, and shading must be designed as part of an integrated building design process. Optimal fenestration design will be dependent on each building's orientation, floor plan, location, and use and should be evaluated accordingly on a building by building basis.

Phasing

This system is projected as part of the **2015 Phase**. It can be pursued for new buildings and funded under the Military Construction (MILCON) construction funds. Replacing fenestration systems for existing buildings is more difficult because window replacement projects trigger Anti-Terrorism / Force Protection (ATFP) requirements.

Initial Cost

First cost of high performance glazing will be at a premium when compared to ordinary glazing. However, with the army requirement for all new construction in FY13 and beyond to meet ASHRAE 189.1-2009 standards, high performance glazing will be the new baseline.

Life Cycle Cost

Maintenance of glazing is minimal, requiring periodic cleaning and maintenance due to normal wear. The cost of maintenance would not be appreciably higher than for conventional windows.

Maintenance

Cleaning of glazing is suggested every six months to maintain light transmission performance if daylighting or passive solar heating strategies are implemented.

Feasibility

Glazed fenestrations are usually the only part of a building envelope that allows light to pass through. This feature makes them an important factor in designing high performance, energy efficient buildings because they factor into lighting power reductions due to daylighting, cooling load reductions due to lighting power reductions, heating load reductions due to passive solar heating, and greater productivity of building occupants due to natural light and views.

The placement and specifications of glazed fenestrations must be designed as an integral part of the building sustainability strategy. Designing in the glazed area without consideration of how they will affect other building systems could result in increased energy usage and decreased quality of work environment.

High performance fenestration assemblies are widely available and can be configured to meet a range of uses by varying insulation and reflective properties of the frame and glazing. Increasing attention to sustainability issues and the widening adoption of energy standards such as ASHRAE 189.1 and EnergyStar will likely increase the availability of high performance glazing and reduce its cost.

References

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Department of Energy Criteria Letter to Energy Star Windows Stakeholders. May 28, 2003. Accessed July 2011.
http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/windows_doors/final_windows_criteria_letter.pdf?5991-c9fe

Diagrams

See Attachment A

Funding Plan

Glazing and fenestrations must be designed as an integral part of the building envelope, lighting, and cooling systems. They will be funded through MILCON project funds for new buildings and Operations and Maintenance, Army (OMA) or through Facilities Sustainment, Restoration and Modernization (SRM) funds for retrofits.

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Attachment A:

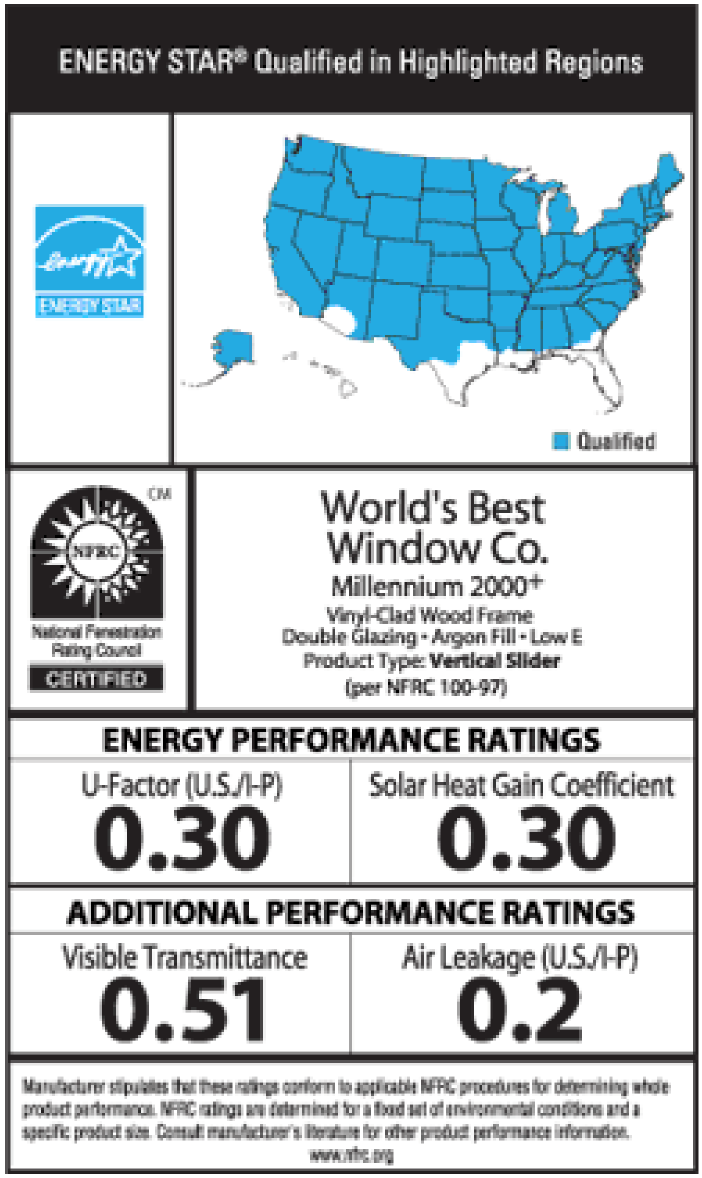

Figure 1. Sample Energy Star window label – Image courtesy of the US Environmental Protection Agency, Energy Star

ENERGY STAR Qualification Criteria for Windows and Doors			
Zone	Approximate HDD/CDD Coverage	U-factor	SHGC
Northern	≥ 5,400 HDD	≤ 0.35	Any
North/Central	3,600 - 5,400 HDD	≤ 0.40	≤ 0.55
South/Central	6,300 - 4,500 CDD	≤ 0.40	≤ 0.40
Southern	≥ 6,300 CDD	≤ 0.65	≤ 0.40

ENERGY STAR Qualification Criteria for Skylights			
Zone	Approximate HDD/CDD Coverage	U-factor	SHGC
Northern	≥ 5,400 HDD	≤ 0.60	Any
North/Central	3,600 - 5,400 HDD	≤ 0.60	≤ 0.40
South/Central	6,300 - 4,500 CDD	≤ 0.60	≤ 0.40
Southern	≥ 6,300 CDD	≤ 0.75	≤ 0.40

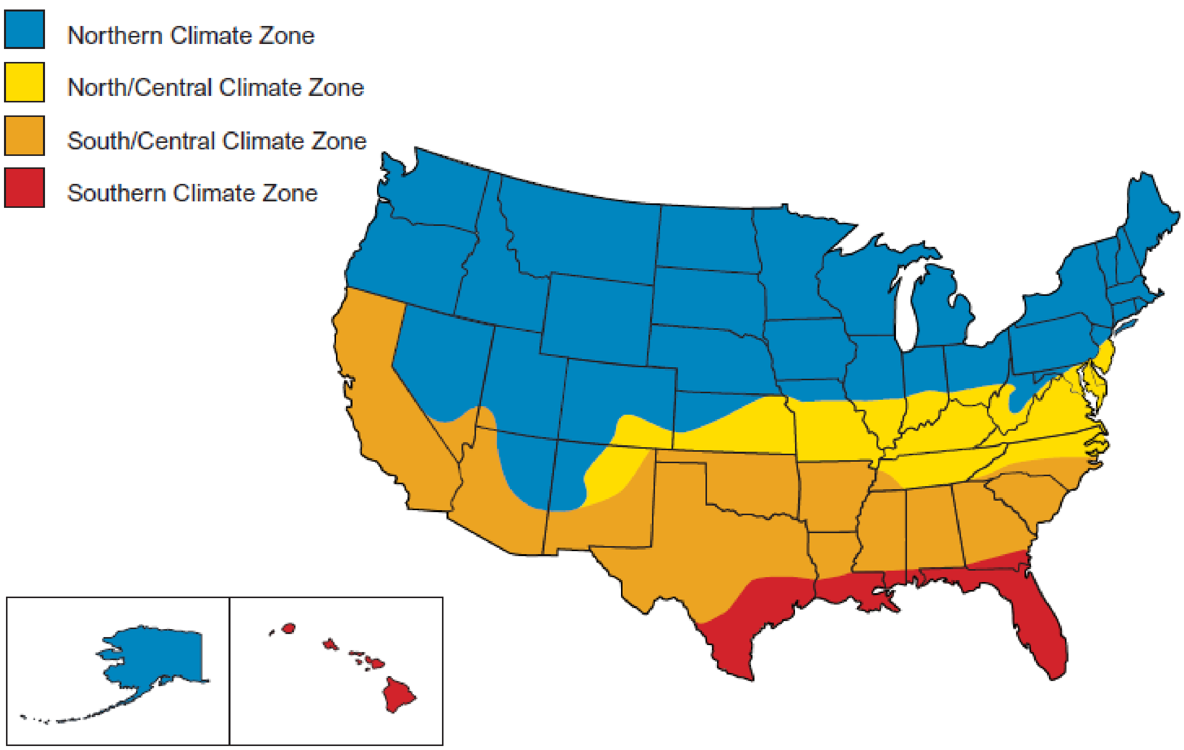

Figure 2. Energy Star Qualification Criteria for Windows, Doors, and Skylights (August 2003) – Image courtesy of the US Environmental Protection Agency, Energy Star

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8.17 Green Roof (Heat Island)

TECHNOTE green roof

Recommendation

As new facilities are designed or as existing facilities need roof replacements, implement green roof strategies to the greatest extent possible. Two types of these green roofs are: Cool and Vegetate Roofs.

Cool Roof Technologies – Cool roofs are roofing systems that exhibit the ability to reflect and emit the sun's heat back into the sky instead of that energy being absorbed by the building system. The "coolness" of a roof is measured by two properties, solar reflectance and thermal emittance. Both properties are measured from zero to one and the higher the value, the "cooler" the roof.

There are a large number of benefits that can be yielded from these systems. Cool roofs have been proven to minimize air-conditioning loads by up to ten percent just by creating a more reflective roof surface. Vegetated roofs have been known to save equivalent if not slightly more energy because of their higher insulation value. The planting systems placed on the roof plane not only prevent that thermal energy from the sun from entering the building envelope, but they hold internal loads in. Vegetated roofs can also reduce water runoff, present rainwater filtering and capturing opportunities, and preserve the waterproofing membrane.

Vegetated Roof Technologies – Vegetated roofs are generally composed of a waterproofing membrane, insulation, and any components necessary to hold and maintain native or adapted plant-life with minimal care or irrigation. Vegetated roof systems come in a variety of types, sizes, and applications ranging from flexible, modular systems, to seamless, monolithic ones that are much more energy efficient. Each system lends itself to different design strategies and applications.

Green roofs are categorized as intensive, semi-intensive, or extensive. This all depends on the depth of the planting that they require. Intensive roofs refer to roofs that have a full lawn or trees that have public access and require large amounts of soil and maintenance. Extensive roofs refer to roofs that require very little maintenance and are more self sustaining. Semi-intensive roofs split the difference between the two, where they might have more grass and small shrubs, but only would not be accessible by building tenants.

Location & Scale

These technologies can be implanted at the **building scale** throughout the entire installation. While it is difficult to measure and analyze, this strategy will have the largest impact in the most densely built areas of the installation. Green roofs will have the largest impact in reducing the heat-island effect in densely built and heavily paved areas.

Phasing Cool and vegetated roofs can be integrated into new construction projects **immediately**. These systems should be considered when existing roofs are due for replacement. On facilities that roof loads are of concern, cool roof systems are more favourable given their lighter weight on average.

Initial Cost Cool roofs can be composed of standard roofing systems (with special attention paid to color, reflectivity and emissivity). There are no large cost impacts for the design and construction of a cool roof over a standard roof system. Vegetated roofs can have significantly more first cost depending on the specific system.

Life Cycle Cost Life Cycle costs for cool roofs is **similar to standard roof systems** (TPO, EPDM, standing seam metal roof, etc) because those exact systems can be designed to function as cool roofs. Vegetated roofs will have slightly higher maintenance costs, but will often pay that back with energy savings. Significant savings can be identified in vegetated roofs given that the waterproofing membrane's life expectancy can be doubled in instances due to decreased UV exposure. Some membrane manufacturers are starting to acknowledge this in their warranties. All of these systems promise lower lifecycle costs when integrated with other conservation strategies such as rainwater collection, filtration, etc.

Maintenance Cool roofs will have maintenance requirements similar to corresponding standard roofing systems. Vegetated roofs may take more effort to get established – including irrigation to get vegetation started. Once established, however, these systems have proven to be very low maintenance. There are a lot of misconceptions about vegetated roof maintenance and each system should be evaluated on its merits.

Feasibility Cool roofs are extremely feasible. The installation design guide may need to be evaluated to consider more lightly colored roof surfaces, and a broader range of roof types. Favor should be given to roofs that reflect more light. While dark roofs may meet LEED Criteria, the same roof in a lighter color will most likely function even better in terms of reflectivity and emissivity.

References Cool Roof Rating Council www.coolroofs.org
Vegetated Roofs http://www.greenroofs.com/Greenroofs101/index.html

Funding Plan There are examples of both of these roof types being designed into new construction projects.

Baseline Relation These systems can be expected to improve energy performance in relation to baseline roof systems.

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8.18 Green Streets

green streets

TECHNOTE

Recommendation

Visually demonstrate Fort Leonard Wood's (FLW) commitment to sustainability by transforming centrally located streets into green streets with pedestrian-friendly features. Develop the green streets to include Low Impact Development (LID) areas, sidewalks, trees, and bike lanes.

Location & Scale

Green streets with pedestrian friendly features should be implemented initially at the **installation scale** by the year 2020.

Phasing

Implementation of green streets, bike lanes, sidewalks, and other pedestrian-friendly features should continue at Fort Leonard Wood in the following phases:

Phase I, by 2020: Implement green streets in 'The Loop' originating at the corner of Iowa Avenue and 4th Street, continuing East along 4th (Replacement Avenue) to Nebraska, continuing South on Nebraska to South Dakota, and continuing North on Iowa back to 4th Street. The Loop is contingent upon Iowa Avenue being changed into a one-way, southbound street.

Phase II, by 2025: Expand the green streets from Phase I, 'The Loop', by continuing North on Nebraska to the proposed wildlife area (see Stormwater Tech Note) and South on Nebraska along the curve to Artillery Circle. Extend the green streets North on Iowa to North Dakota, looping back to Nebraska. Add green streets with tree-lined sidewalks and bike lanes on Evans Street, between Frizell and Turner Street, alongside the schools.

Phase III, by 2030: Continue installation of green streets into residential areas and shopping areas. Specific streets should be selected at a later date to coordinate with any changes in the streets and stormwater mitigation needs.

Initial Cost

Phase I, 'The Loop': **$1.36 million.** Rough order of magnitude (ROM) cost estimate to install green streets along 'The Loop' described above in Phase I by 2020 on an existing street of approximately 17,550 LF. Upgrade existing streets to green streets by adding ten-foot wide sidewalk along one side of road loop ($6/SF), add trees at every 200 feet along sidewalk ($500/3"), add forty-foot long by four-foot wide bioretention cells every 500 feet along one side of road($ 6400/each), and add bicycle lane striping along one side of road ($1.50/LF).

Installation of storm pipes ($30/LF) and replacing a six-foot wide bitumous road over the pipes ($45/LF) along the same Phase 1 'The Loop' would cost $1.32 million. Thus, by this ROM costs analysis, the cost for a traditional stormwater pipe placement with bituminous road cover is comparable to that of installing green streets with trees, sidewalks, and bike lanes. Green streets, however, provide tremendous benefits over traditional stormwater pipe systems.

Phase II: $695,000. Estimate is based on the green street upgrades (described above in Phase 1) and the street extensions a total of 8,917 LF described below:

- Curve of Nebraska Avenue, South: 3,811 LF.
- Extension of Iowa Avenue, North: 1,011 LF.
- Extension of Nebraska Avenue, North: 1,562 LF.
- Evans Street near schools, between Frizell and Turner: 2,533 LF

Phase III: **$936,000**. Based on assumption 12,000 LF of streets would be selected in the future for upgrade to green streets. ROM cost for same green street elements as described above for Phase I and Phase II, at $78/LF.

Life Cycle Cost

The calculation of a life cycle cost analysis for the green streets with bioretention cells and pedestrian features would be plausible *only* if an estimate for the benefits these green streets provide could be conducted. Specifically, it would be difficult, if not impossible, to quantify the improved safety for military and civilian personnel, improved water quality and aquifer recharge, reduction of river bank erosion, and prevention of toxic first flush stormwater reaching the Big Piney River. All of these benefits are possible with the installation of green streets. Therefore, although ROM cost estimates for the green streets were provided and compared to traditional storm pipe installation costs, life cycle cost analyses are considered 'not feasible' for this Tech Note.

Maintenance

Green Streets: Following installation of a bioretention cells along green streets, the native plants typically need additional watering for two years to establish root systems. After that, costs for bioretention structures should be limited to maintenance tasks. Based on an estimated $40/hr fully burdened rate for one maintenance employee to maintain bioretention structures and the maintenance requirements listed below in Table 1, each bioretention cell would cost $720 to maintain annually. For an estimated thirty-five bioretention cells for the Phase I loop, this would equate to $25,270 in maintenance labor costs. This would not include costs for replacement of plants or irrigation water.

Table 1. Expected Maintenance for Green Street

Task	Frequency
Sediment removal	twice per year (2 hours)
Trash removal	spring/summer (2 hours)
Hand-weeding	spring/summer (4 hours)
Leaf removal	winter/fall (2 hours)
Plant replacement	as necessary (4 hours)
Watering	first two years (4 hours)

Sidewalk and bike lane maintenance would be very minimal. Trees planted along sidewalks would require additional watering until their root systems were established. After the establishment period, trees would require very little care.

The maintenance estimate for sidewalks, bike lanes, and trees is 25% of that of bioretention cells, or $6,317 annually.

Feasibility

A Green Street is a sustainable storm water strategy that meets regulatory compliance and resource protection goals by using a natural systems approach to manage storm water, reduce flows, improve water quality and enhance watershed health. Green streets are designed to mimic local hydrology prior to development. This supports Fort Leonard Wood's efforts to meet Energy Independence and Security Act of 2007 (EISA) Section 438 mandates.

Green streets use vegetated facilities to manage stormwater runoff at its source, cleaning and replenishing groundwater. Green streets can be combined with pedestrian zones: areas in which walking and cycling are encouraged and where vehicular traffic is calmed. Together, green streets and pedestrian zones can be combined with sidewalk connectivity features to support safe, walk-able access for the community, soldiers in training, and the Cadre throughout the installation.

For Fort Leonard Wood, green streets will use bioretention cells to capture stormwater runoff from streets and nearby developed areas. The bioretention cells will be filled with native plants that require little maintenance and help clean stormwater runoff, supporting recharge of the subsurface groundwater. The bioretention cells will also help prevent large volumes of stormwater from being channelled to the Big Piney River, where heavy stormwater currently washes toxins into the river and erodes the river banks. Bioretention cells could incorporate a slotted drain and pipe connection to proposed stormwater systems (see Stormwater Management Tech Note) in the event 50- to 100-year storms overwhelmed bioretention cells on the green streets.

The proposed green streets for Fort Leonard Wood also include the installation of wide, tree-lined sidewalks along the streets and between frequently visited areas on post. These create safe, walk-able connections for visitors and military / civilian personnel at Fort Leonard Wood. Use of permeable pavers, attractive brickwork, or other permeable materials in lieu of concrete for sidewalks would enhance infiltration of rainwater into the soils and recharge of the aquifer.

Bike lanes are also proposed along the green streets to encourage the use of bicycles, reduce vehicular traffic and pollution, and improve health and safety for military and civilian personnel.

Green streets and bioretention systems contribute to the **2030 Net Zero Water** goals by supporting the recharge of groundwater resources and cleaning stormwater that may eventually be released to Fort Leonard Wood's current primary source of potable water, the Big Piney River. Should Fort Leonard Wood pursue construction of potable water wells in the future as either a primary or supplemental source of potable water, green street bioretention systems throughout the base will help ensure stormwater is collected, cleaned, and released for reuse.

Green street bioretention systems use native plants which are well adapted to the local climate and require minimum maintenance. The bioretention systems will be sized to accommodate the calculated volume of water consistent with twenty-five year storm events and ensure filtration of captured stormwater. This will eliminate any concerns over ponding water and subsequent breeding of mosquitoes. The early life stages of mosquitoes require water lasting 7-10 days, but the water will only remain in bioretention structure for 24-48 hours.

Bioretention structures improve water quality because they control the "first flush" of runoff, which refers to the first half-inch of rainfall and contains the highest pollutant loadings. Bioretention structures retain water so infiltration can occur, reduce runoff velocity, filter particulate matter, and remove pollutants from stormwater.

Should Fort Leonard Wood become subject to national pollution discharge elimination system (NPDES) regulations for stormwater, bioretention cells can support the installation's efforts to clean stormwater before it is released to nearby water sources. Low Impact Development studies document that bioretention structures remove heavy metals and over 90 percent of suspended solids. Removal of nutrients like phosphorus and nitrates varied from 0 to 80 percent. Vegetated swales have documented removal rates of 35 to 90 percent for metals, 44 to 80 percent for nutrients, and 60 to 98 percent for suspended solids. (See LID & Bioswales and Stormwater Management Tech Notes for additional information.)

References

See Attachments A & C

Examples of green streets:
http://www.lakesuperiorstreams.org/stormwater/toolkit/bioretention.html

Benefits of green streets:
http://www.epa.gov/owow_keep/podcasts/transcript_greenstreets.html

Installation of green streets in a town:
http://www.mepp.umd.edu/documents/Christine-Gallagher-Practicum-report-June-6-2009.pdf

http://mdc.mo.gov/sites/default/files/resources/2010/05/4904_2854.pdf

LID: http://www.lid-stormwater.net/bio_costs.htm

Plants that remove lead: http://www.wpxi.com/health/9957275/detail.html

Cost references:
http://www.otsegocounty.com/depts/pln/documents/CostSummaryandPreliminaryOpinionofCostREV04-13-10_000.pdf

Diagrams/Photos

See Attachment B

Funding Plan

The Utilities Modernization Program may be a resource to provide funding for green streets with pedestrian friendly features upgrades.

Product Specifications The concrete curbs, drainage pipes, soil amendments, and non-native plants suitable for bioretention systems are non-proprietary and should be readily available from local resources. Helpful information related to design, native plants, and pipe drainage is included in Attachments.

Baseline Relation Green streets contribute to Fort Leonard Wood's water resources by collecting and treating stormwater where it falls, recharging the groundwater, slowing stormwater velocities, and delivering cleaner water to receiving streams.

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Attachment A:

The design of the green street treatment could include following design criteria:

- Landscaped area (sq ft) must equal at least 7% of drainage area
- Curb-cuts must allow water to enter treatment areas (number of inlets determined by street slope and length of treatment)
- Fore-bay design controls entering flow (must be present at inlets)
- Curb-cuts must allow overflow to exit treatment area
- Check dams must hold water throughout treatment train (number of check-dams determined by street slope and length of treatment)
- Curb extension cannot interfere with existing utilities

The recommended planting mix one third pearlite, compost, and topsoil, respectively. This soil mix has been used successfully in other bioretention projects. The vegetation recommendations include native, non-invasive plants that could be expected to flourish in both wet and dry conditions in Missouri. A summary of the planting selection is included below.

Table 2. Planting Selection

Quantity	Size	Plant
Depends on size of bioretention structure	1 gal.	Tussock sedge *carex stricta*
Depends on size of bioretention structure	1 gal.	Little bluestem *schizachyrium scoparium*
Depends on size of bioretention structure	1 gal.	Prairie dropseed *sporobolus heterolepis*
Depends on size of bioretention structure	plugs	Buffalo grass

Some plants are capable of removing lead and other toxins from the first flush stormwater. Mustard greens can be used for this purpose.

Additional information for bioretention cell costs: The cost for a bioretention cell can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains, and under drains. In any bioretention cell design, the cost of plants varies substantially and can account for a significant portion of the final cost. The cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention cells quite attractive financially. A 4' x 20' bioretention structure could cost $3200, using the $40 per square foot rate.

Attachment B: Diagrams / Photos

Photo 1. Curb Cuts into landscaped bioretention cell – Photo courtesy of USACE, Kansas City District

Attachment C:

Reference Material

By design and function, urban areas are filled with impervious surfaces: roofs, roads, sidewalks, and parking lots. Although all contribute to stormwater runoff, the effects and necessary mitigation of the various types of surfaces can vary significantly. Of these, roads and travel surfaces present perhaps the largest flow regime altering and urban pollution sources. However, roads also present one of the greatest opportunities for green infrastructure use. One principle of green infrastructure involves reducing and treating stormwater close to its source. Urban transportation right-of-ways integrated with green techniques are often called "green streets". Green streets achieve multiple benefits, such as improved water quality and more livable communities, through the integration of stormwater treatment techniques which use natural processes and landscaping. Green streets can incorporate a wide variety of design elements. Although the design and appearance of green streets will vary, the functional goals are the same: provide source control of stormwater, limit its transport and pollutant conveyance to the collection system, and provide environmentally enhanced roads.

Green Streets are designed to:

- Mimic local hydrology prior to development
- Improved pedestrian experience along the street right of way
- Reduce polluted stormwater entering rivers and streams
- Improve pedestrian and bicycle safety
- Divert stormwater from the sewer system and reduce basement flooding, sewer backups and combined sewer overflows (CSOs) to the nearby rivers and streams
- Reduce impervious surface so stormwater can infiltrate to recharge ground and surface water
- Increase urban green space
- Improve air quality and reduce air temperatures
- Reduce demand on the city's sewer collection system and the cost of constructing expensive pipe systems
- Address requirements of federal and state regulations to protect public health and restore and protect watershed health; and
- Increase opportunities for industry professionals
- Provide multiple benefits along the street right of way including:
    - Integrated system of stormwater management within the right of way
    - Volume reductions in stormwater which reduce the volume of water discharged via pipe into receiving streams, rivers and larger bodies of water
    - Key linking component in community efforts to develop local green infrastructure networks
    - Aesthetic enhancement of the transit right of way
    - Improves local air quality by providing interception of airborne particulates and shade for cooling
    - Enhanced economic development along the transit corridor

    - **Alternative Street Designs (Narrower Street Widths):** A green street design begins before any BMPs are considered. If building a new street or streets, the layout and street network must be planned to respect the existing hydrologic functions of the land (preserve wetlands, buffers, high-permeability soils, etc.) and minimizing the impervious area. If retrofitting or redeveloping a street, opportunities to eliminate unnecessary impervious area should be explored.

- **Swales:** Swales are vegetated open channels designed to accept sheet flow runoff and convey it in broad shallow flow. The intent of swales is to reduce stormwater volume through infiltration, improve water quality through vegetative and soil filtration, and reduce flow velocity by increasing channel roughness. In the simple roadside grassed form, they have been a common historical component of road design. Additional benefit can be attained through more complex forms of swales, such as those with amended soils, bioretention soils, gravel storage areas, under drains, weirs, and thick diverse vegetation.
- **Bioretention Curb Extensions and Sidewalk Planters:** Bioretention is a versatile green street strategy. Bioretention features can be tree boxes taking runoff from the street, indistinguishable from conventional tree boxes. Bioretention features can also be attractive attention grabbing planter boxes or curb extensions. Many natural processes occur within bioretention cells: infiltration and storage reduces runoff volumes and attenuates peak flows; biological and chemical reactions occur in the mulch, soil matrix, and root zone; and stormwater is filtered through vegetation and soil.
- **Permeable Pavement:** Permeable pavement comes in four forms: permeable concrete, permeable asphalt, permeable interlocking concrete pavers, and grid pavers. Permeable concrete and asphalt are similar to their impervious counterparts but are open graded or have reduced fines and typically have a special binder added. Methods for pouring, setting, and curing these permeable pavements also differ from the impervious versions. The concrete and grid pavers are modular systems. Concrete pavers are installed with gaps between them that allow water to pass through to the base. Grid pavers are typically a durable plastic matrix that can be filled with gravel or vegetation. All of the permeable pavement systems have an aggregate base in common which provides structural support, runoff storage, and pollutant removal through filtering and adsorption.
- **Sidewalk Trees and Tree Boxes:** From reducing the urban heat island effect and reducing stormwater runoff to improving the urban aesthetic and improving air quality, much is expected of street trees. However, most often street trees are given very little space to grow in often inhospitable environments. The soil around street trees often becomes compacted during the construction of paved surfaces and minimized as underground utilities encroach on root space. By providing adequate soil volume and a good soil mixture, the benefits obtained from a street tree multiply. To obtain a healthy soil volume, trees can simply be provided larger tree boxes, or structural soils, root paths, or “silva cells” can be used under sidewalks or other paved areas to expand root zones. These allow tree roots the space they need to grow to full size.

Green Streets / Low Impact Development (LID):

Common LID measures include bioretention systems, grass swales, rain gardens, and permeable pavements. A bioretention cell typically incorporates green buffer strips, sand beds, ponding areas, organic layers, planting soil, and vegetation. Grass swales are typically constructed along highways or residential streets.

LID practices improve water quality because they control the “first flush” of runoff, which refers to the first half inch of rainfall and contains the highest pollutant loadings. LID designs, like green streets, bioretention cells, and grass swales, control “first flush” by reducing runoff velocity, retaining water so infiltration can occur, and increasing the time of concentration (the amount of time it takes for water to travel from the most distance point to the watershed outlet). A bioretention cell reduces runoff velocity, filters particulate matter, and removes pollutants from stormwater. Grass swales also reduce runoff velocity and aid in pollutant removal through sedimentation, filtration, and infiltration.

Green street creates attractive streetscapes that enhance neighborhood livability by enhancing the pedestrian environment and introducing park-like elements into neighborhoods. It serves as an urban greenway segment that connects neighborhoods, parks, recreation facilities, schools, main streets, and wildlife habitats. Finally, it meets broader community goals by providing pedestrian and where appropriate bicycle access.

There are also benefits and costs not captured in the installation and O&M costs of LID controls. For example, the erosion of stream banks and the deposit of pollutants due to stormwater create ecosystem and public health risks. Benefits of the LID strategies include mitigating flooding, improving water-quality, and providing amenity value for properties next to controls like green streets. Finding a way to better capture these costs and benefits will better reflect the cost of LID projects compared to conventional stormwater management controls.

Green streets have benefits to ecosystems and public health that are not often captured when comparing installation of LID projects to conventional stormwater management structures. Efforts to measure these benefits are growing in academia, in government agencies, and among global communities as well. Ultimately, it will become clear that the great benefits far outweigh the near term expenses in constructing LID measures and green streets. The federal government must use the Chesapeake Bay restoration effort as a case study in managing the rest of the nation’s water resources. Postponing investment will only increase the costs in both construction and loss of ecosystem benefits.

Costs Considerations

ECONorthwest, a consulting firm in Eugene, OR completed an extensive literature review regarding the economics of LID, such as bioretention cells, to mitigate stormwater. Examining academic literature, government reports, non-profit organizations’ reports, and other articles, the review drew a number of conclusions. First, the costs and benefits of LID controls can vary depending on the specific site, the LID technology implemented, and the local biophysical conditions including precipitation and soil type. A number of economic studies concluded LID strategies in new development are cost-effective. On the other hand, a few studies concluded LID controls are more expensive than conventional stormwater controls; however, these studies did not account for operation and maintenance (O&M) costs of conventional controls or for additional benefits of LID controls.

Additionally, urban stormwater retrofits are very expensive often costing tens of thousands of dollars. To analyze the economic costs of green streets or other LID controls, the installation costs of two alternatives should be compared, and the costs should be compared with the benefits. When comparing installation costs of LID to conventional stormwater management structures, it is important to include operation and maintenance (O&M) costs of conventional structures. Weeding and sediment removal from green streets is simple and not costly; cleaning underground structures, on the other hand, can cost over $1,000 each time even a small structure is maintained.

Table 3. Cost Components for Bioretention Practices			
Implementation Stage	Primary Cost Components	Basic Cost Estimate	Other Considerations
Site Preparation	Tree & plant protection	Protection Cost ($/area) x Affected Area	Removal of existing structures, topsoil removal and stockpiling
	Clearing & grubbing	Clearing Cost ($/area) x Affected Area	
	Topsoil salvage	Clearing cost ($/area) x Affected Area	
Site Formation	Excavation / grading	4-ft Depth Excavation Cost ($/acre) x Area (acre)	Soil & rock fill material, tunneling
	Hauling material offsite	Excavation Cost x (% of Material to be hauled away)	
Structural Components	Under-drains	Under-drain cost ($/lineal foot) x length of device	Pipes, catch-basins, manholes, valves
	Inlet structure	($/structure) or ($/curb cut)	
	Outlet structure	($/structure)	
	Liner	Liner cost ($/square yard) x area of device	
Site Restoration	Filter strip	Sod cost ($/square foot) x filter strip area	Tree protection, soil amendments, seed bed preparation, trails
	Soil preparation	Topsoil or amendment cost ($/acre) x Area (acre)	
	Seeding	Seeding Cost ($/acre) x Seeded Area (acre)	
	Planting / transplanting	Planting Cost ($/acre) x Planted Area (acre)	

Annual Operation, Maintenance, and Inspection	Debris removal	Removal Cost ($/acre) x Area (acre) x Frequency	Vegetation maintenance, cleaning of structures
	Sediment removal	Removal Cost ($/acre) x Area (acre) x Frequency	
	Weed control	Labor cost ($/hour) x Hours per visit x Frequency	
	Inspection	Inspection Cost ($) x Inspection Frequency	
	Mowing	Mowing Cost ($) x Mowing Frequency	
Source: *Minnesota Stormwater Manual 2005*, Chapter 12-BIO, Table 6 [http://www.pca.stat.mn.us/publications/wq-strm8-14af.pdf, 1.8 MB] (Pg 18 of 26)			

US Army Corps of Engineers

2030 USACE Integration Project

8.19 High Efficiency Toilets

high efficiency toilets

TECHNOTE

Recommendation

Install high efficiency toilets (HETs) which have manual flush valves in all new buildings and evaluate retrofitting existing facilities which have toilets installed. Fixtures should be EPA WaterSense® certified and meet its waste removal performance requirements. WaterSense® certified fixtures use no more than an average flush volume of 1.28 gallons per flush (gpf) of water. It is critical that the HET unit selected have a larger trap size to eliminate choke points & ensure clog free operation. Implementing these types of fixtures will maximize water conservation with minimal impact to fixture & system costs.

Location & Scale

This would occur at the **building scale** and is recommended for **all buildings.**

Phasing

This system is projected as part of the **2015 Phase** in all new construction. As various other buildings on the installation are renovated, old fixtures could be easily retrofit or replaced with new units of this type.

Initial Cost

Including purchase price and installation (average cost in Missouri) of a modest HET system, each unit's initial cost would likely be between **$500 - $700**. This figure depends on the specific fixture & components selected and the installer's labor wage. Initial cost for a retrofit fixture installed would be between **$150 - $250**, also dependent on unit and installer. Retrofit fixtures would also require removal & disposal of old components, with the estimated price based on an installation with no unforeseen issues.

Components which are different than or in addition to standard plumbing pipes system for toilets in the cost consideration may include toilet bowls, flushometers, and seats.

Life Cycle Cost

Life Cycle Cost of this type of toilet fixture would include maintenance & water use costs in addition to the initial costs for each fixture. This type of fixture's typical life span is thirty years. The total estimated Life Cycle Cost of one standard toilet about $2,000. However, the total estimated Life Cycle Cost of one high efficiency unit which uses approximately 2,450 fewer gallons per year of water than a standard toilet is estimated at **$2,930***.

Operations and maintenance (O&M) costs would be very minimal as water is inexpensive and required repairs are very minimal. Maintenance could be performed by Fort Leonard Wood building maintenance staff, coming to about $55/year. Each toilet is assumed to provide for (3) three people, and be used for (7) seven flushes per person per day, or about 9 gal/person/day of water use (9,811 gal/unit/yr). Fort Leonard Wood water cost is currently estimated at $2.30/1000 gallons. The estimated annual water costs for one fixture is approximately $22.57. Total annual O&M costs, including water use, would be approximately **$80***.

An average HET costs $550, with installation cost of about $50. Total installation & initial cost would be approximately **$600** per fixture.

**At current dollar values (no inflation included), and if all estimates and assumptions of fixture use & water costs are accurate.*

Maintenance

This system will not require significant maintenance unless problems arise such as clogging, physically abused fixtures, etc. Minor repairs should be within the ability of Fort Leonard Wood building maintenance staff, but large issues with this system are no different than problems and maintenance of standard toilets.

Feasibility

This system contributes to the **2030 Net Zero Water** goals. This type of fixture has virtually the same plumbing design as standard toilets, with the differences being in the flushometer & toilet bowl / tank itself. Maintenance is very similar to standard fixtures and HETs use at least 20% less water than a standard toilet. If incorporated into the design process and confirmed in specifications, these types of units can be an inexpensive and efficient way to conserve water while maintaining functionality.

Automatic or sensor operated flushometers are also available. However, sensor flushometers will add anywhere from $300 - $550 in cost per unit. These fixtures also require additional energy to operate (electricity, batteries, etc.), which not only increases energy costs but also increases maintenance potential for the fixtures (i.e. changing batteries regularly). There are benefits to these fixtures as well, but manually operated toilets are more practical for this use.

References

See Attachment A

Environmental Protection Agency (EPA). "WaterSense® Specification for Tank-Type Toilets." Version 1.1. 20 May 2011. Web. 18 July 2011. www.epa.gov/WaterSense/docs/revised_het_specification_v1.1_050611_final508.pdf

"High-Efficiency Toilets (HETs)." *High Performance Technology Strategy Templates.* Revision 0. 31 October 2010. Web. 18 July 2011. http://mrsi.usace.army.mil/cos/TechNotes/06%20Fixtures%20High%20Efficiency%20Toilets%2010-31-10.pdf

"No Plunge." *American Standard, Features & Innovations.* 2011. Web. 18 July 2011. www.americanstandard-us.com/learn/american-standard-advantage/innovations/?f=2

Whole Building Design Guide. "Federal Green Construction Guide for Specifiers, Section 22 40 00 (15400) Plumbing Fixtures." 4 January 2010. Web. 18 July 2011. www.wbdg.org/ccb/FEDGREEN/fgs_224000.pdf

Diagrams

Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.

Funding Plan This system would need to be funded with initial design/construction funds as awarded. Specifying high efficiency, WaterSense toilets in place of standard toilets will not be a significant cost to the overall project, but will be a considerable expense above standard units.

Contract Language Provide *high efficiency toilets* for all water closet fixtures in new buildings. Units shall have manual function flushometer with average equivalent flush volume of 1.28 gallons. All units must be certified under the Environmental Protection Agency's (EPA) WaterSense program.

Manufacturers See Attachment A for generic specification.

Baseline Relation Older toilets may use up to five gallons per flush (gpf) of water for every flush, while newer standard units use 1.6 – 3.5 gpf. An HET uses anywhere from 1.0 gpf to 1.28 gpf. This technology will decrease water consumption of toilets by 20% - 60% (if baseline is for a new toilet). Water demand of toilets would decrease by nearly 75% based on older toilets.

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Attachment A: High Efficiency Toilet (HET) Specifications**

**As adapted from the Whole Building Design Guide *Federal Green Construction Guide for Specifiers*

SECTION 22 40 00 (SECTION 15400) – PLUMBING FIXTURES

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water closets
   2. Accessories

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
   3. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
      a. Plumbing fixtures

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

1.3 QUALITY ASSURANCE

A. Water flow and consumption rates for plumbing fixtures:
   1. Comply with requirements in Public Law 102-486, Energy Policy Act.
   2. Provide WaterSense labeled products for:
      a. High-Efficiency Toilets - Single Flush

PART 2 – PRODUCTS

2.1 MATERIALS

A. Fixtures:
   1. Water management: Provide low flow fixtures. *(If automatic, sensor operated flush valves are used, they must comply with ASSE 1037 and UL1951).*
      a. Water closets: WaterSense labeled high-efficiency toilet with maximum effective flush volume of 1.28 gallons. For single flush toilets, the effective flush volume is the average flush volume per ASME A112.19.2. [Gravity tank type water closets not allowed.]
   2. Toxicity/IEQ:
      a. Low corrosion flux for copper pipe: Comply with ASTM B813.

2.2 ACCESSORIES (Include this section if automatic sensors are selected.)

A. Labels: Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:
   1. The identification of the sensor and its operation with graphic, written, and Braille description.
   2. Range of sensor.
   3. For batter operated units, the batter replacement schedule.

PART 3 – EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

1. Water Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

    a. *(If automatic sensors are selected, include: Adjust automatic sensor operated valves in accordance with manufacturer's instructions. Comply with ASHRAE 90.1 for energy efficiency.)*

2030 USACE Integration Project

8.20 Hybrid Solar

hybrid solar

TECHNOTE

Recommendation

Thermal and photovoltaic (PV) solar systems have traditionally been treated as separate technologies, either one or the other being chosen for a particular application. This underutilizes the potential for solar energy by failing to capitalize on the thermal potential when using PV systems, or the electrical generation potential when using thermal systems. Hybrid thermal / PV systems eliminate competition for space, using roughly 38% less roof space than two independent systems. Tests have shown that hybrid PV / thermal systems can generate four times the energy from the same surface for a 25% increase in cost. These systems are integral with the roofing, compromising the roofing's integrity by attachments and penetrations is avoided.

Location & Scale

This system is implemented at the **building scale**. Each new structure shall have hybrid solar systems located on the roof. The roof components of this system will experience no adverse affects from being incorporated into solar / PV systems. Appearance, structural performance, weather tightness, and durability remain as they would be without the solar / PV components. (ESTCP Proposal 11 E-S15-021)

Phasing

This system is projected as part of the **2015 Phase**. It should be installed in conjunction with each new building. Existing structures should be evaluated prior to retro-fit of solar water heating systems to determine whether installation is cost effective, etc.

Initial Cost

The hybrid thermal / PV system is installed at a unit cost of within $145 per square foot, on average.

Solar energy systems have been available for several decades in both photovoltaic (PV) and thermal versions. Historically, neither method of converting insolation to useable energy has been cost effective or dependable in performance or longevity. However, a Lawrence Berkley Laboratory study determined the cost of PV installations has declined 30% from 1998 to 2007. Federal tax incentives reduce cost to the customer even further, reducing the 2007 cost to a U.S. average of $3.10/watt.

The target annual energy savings from the hybrid solar thermal / PV roofing system will be 270 MBtu at Fort Leonard Wood. (ESTCP Proposal 11 E-S15-021)

Life Cycle Cost

Life Cycle Cost Analyses were performed using the National Institute of Standards and Technology (NIST) Building Life Cycle Cost (BLCC) Program. Two scenarios are represented: installation of photovoltaic and solar thermal systems independently of each other. It was felt this was the best way to represent the integrated nature of the proposed technology, to illustrate the difference in performance between an integrated system and two systems competing for space on a building's roof.

In summary, the Savings-to-Investment Ratio at Fort Leonard Wood is calculated to be as follows.

Separate PV & solar thermal systems, ten year period: 0.12
Integrated PV & solar thermal system, ten year period: 0.39

Separate PV & solar thermal systems, twenty year period: 0.10
Integrated PV & solar thermal system, twenty year period: 0.37

Assumptions and values are as follows:

Installation prices are conservative, and are based on participants' first-hand experience. Installation prices include all contract costs, commissioning, and maintenance warranty and represent the in-place condition. Meters are also included.

Design and operations and maintenance (O&M) costs are conservative.

Both the PV and solar thermal components are serviceable long after the 10 and 20 year periods used in these analyses. Therefore, a relatively high residual value was assigned; ninety percent after ten years, and eighty percent after twenty years.

Energy costs represent the current rates for electricity and natural gas at the demonstration sites.

A conservative electrical production of 4.3 Watts per square foot was used for calculating PV output. Depending on the type of PV film chosen for the demonstration, output could be five watts per square feet or more.

There is no single accepted industry standard for unglazed solar thermal collector efficiency. A consensus among the industry is that 20% efficiency is a reasonable figure.

(Source: ESTCP Proposal 11 E-S15-021)

The PNNL report also looked at PV systems and economics. The projected output of a South-facing PV system at Fort Leonard Wood at latitude tilt (37.7 deg) is 1,367 kWh per year for every 1 kW of installed capacity.

The cost of installing a PV system is five dollars per watt for systems below 100 kW in size, and as low as three dollars per watt for systems of one Mega Watt and above. Even though the cost of electricity at Fort Leonard Wood has greatly increased, this has changed the economics.

While the Pacific Northwest National Laboratory (PNNL) analysis put the payback period at almost eighty years, two things have changed significantly since that report. The cost of installing a PV system has decreased dramatically and the cost of electricity at Fort Leonard Wood has risen.

Maintenance

The thermal PV system will leave no greater a maintenance tail than conventional mechanical systems. Actual inspection and operation tasks do not exceed those published in the systems' inspection, operation, and maintenance schedules.

It is generally accepted (U.S. DOE Energy Efficiency and Renewable Energy Laboratory, European Union Energy Institute, others) that PV cells should provide a service life of 30 years and longer, although this characterization is somewhat misleading. Efficiency of PV cells diminishes over time; cells do not simply fail after 30 years. How long they will continue to generate electricity is yet undetermined. One PV installation at Fort Huachuca was installed in 1982, 28 years ago, and has experienced only a 15 percent efficiency reduction during that time.

Feasibility

"The Directorate of Public Works (DPW) at Fort Leonard Wood (FLW) supports the hybrid solar roofing proposal for the FY 11-13 Environmental Security Technology Certification Program (ESTCP) with installations at...Fort Leonard Wood, Missouri with technical support from the Network Enterprise Technology Command (NETCOM) Engineer... We realize that the goal of the certification proposal is to demonstrate a more cost effective way to meet the renewable electric goals of 7.5% by 2013 with PV along with a hybrid solar thermal domestic hot water system to meet the 30% minimum solar domestic hot water requirements for buildings within the Department of Defense (DoD)." (Letter from Dwight Robertson (Fort Leonard Wood DPW) to Bill Stein (ERDC-CERL), 30 July 2010. ESTCP Proposal 11 E-S15-021)

Both PV and thermal solar systems have been used on military installations, but on a very limited basis to date. In 2007, only 2.1 percent of the Army's electrical energy was generated from renewable sources. Recent developments in PV technologies, however, indicate PV arrays are becoming less expensive, providing greater performance, and are more versatile in their applications.

References

See Attachment A

Diagrams

See Attachment B

Funding Plan

Fort Leonard Wood has many funding opportunities. To illustrate how here are some examples of hybrid solar funded on the installation:

- A PV array is installed on a flat roof elastomeric membrane at Fort Dix NJ. This research is part of the FY09 Energy Conservation Investment Program (ECIP).
- A Building Integrated Photovoltaic (BIPV) system was installed at Fort Huachuca AZ under the Army's FY 09 Installation Technology Transition Program (ITTP).
- A project is currently underway to demonstrate the application of PV film to flexible membrane roofs. This research is funded under the FY08 SERDP Program, project SI-0813.

Contract Language

The Energy Independence and Security Act of 2007 (EISA 2007) requires that 30% of the hot water demand of new federal buildings (and major renovations) be met with solar water heating equipment, as long as the solar system remains cost effective over its life cycle (www.eere.energy.gov/femp/regulations/eisa.html; accessed July 20, 2010).

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Attachment A: References

- http://www1.eere.energy.gov/femp/pdfs/26013.pdf
- http://www.ehow.com/how_5848802_size-water-heaters-commercial-use.html
- http://www.nrel.gov/docs/legosti/fy96/17459.pdf
- http://www1.eere.energy.gov/buildings/ush2o/pdfs/life_cycle_costs_info_sheet.pdf
- http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf
- http://www.eng-tips.com/viewthread.cfm?qid=226520&page=2
- http://www.firstsolar.com/en/about.php

Attachment B:

Many types of these systems are available on the commercial market today. Below are links to diagrams of some select systems. These references are for schematic understanding only and do not constitute an endorsement (by the government) of the system, product, or manufacturer in any way:

- Schematic of a hot air solar roof (Roof Hugger, Inc.)
  http://www.roofhugger.com/docs/SolarHeatRecovery.pdf

- Fluid-filled solar collector / PV design (Dawn Solar Systems, Inc.)
  http://www.dawnsolar.com/gallery.html

US Army Corps of Engineers

2030 USACE Integration Project

8.21 LEED EBOM

Recommendation

Implement LEED EBOM in three Phases: The Army has achieved great success using LEED (Leadership in Energy and Environmental Design) for New Construction as a tool to teach the US Army Corps of Engineers (USACE) and the Department of Defense (DoD) about designing and building high performing facilities. When the project is complete and the building is in operation, LEED for New Construction has performed its intended task. The intent of LEED for Existing Buildings: Operations & Maintenance is to certify the operations and maintenance of the building and create a plan for ensuring high performance over time. The rating system captures both a building's physical systems (equipment, design, land use, etc.) and the way the building is occupied and operated (waste management, temperature monitoring, commuting programs, etc.). The goal of this recommendation is to institutionalize a process of reporting, inspection and review over the lifespan of the building.

This certification system identifies and rewards current best practices and provides an outline for buildings to use less energy, water and natural resources; improve the indoor environment; and uncover operating inefficiencies. LEED helps building owners identify and solve problems, improve building performance, and maintain and improve this performance over time. LEED should reduce cost streams associated with building operations, environmental impacts, create healthier and more productive workspaces, and provide public recognition for leadership in sustainability.

Phase I (Certify Master Site and Maneuver Support Center (MANSCEN) Facility): LEED EBOM should be implemented at the installation scale and building scale in Phase I between 2015 and 2020.

- Retain the services of a LEED Consultant for the implementation of Phase I activities.
- Hire 1 full-time staff member with a LEED AP (with EBOM specialty) and relevant experience in LEED EBOM at the GS-11 to GS-12 level to serve as the Installation's Sustainability Coordinator.
- Register the Mater Site for Fort Leonard Wood in LEED Online encompassing the main cantonment area of the installation (excluding family housing).
- Installation and supporting agencies create, implement, and enforce installation level policies and programs to support prerequisites and program requirements for LEED EBOM IAW Attachment A: Installation Responsibility Matrix.
- Incorporate all Required Items and as many Recommended Items as possible outlined in the attached Attachment B: Facility Recommendations

Matrix. Recommendations apply to all regularly occupied facilities within the Master Site Boundary. Total quantity of facilities is estimated at 647 with a total square footage of 10,248,673.
- Submit shared credits for the Master Site to the GBCI for review to reduce documentation for individual facilities. Credits must apply to all facilities pursuing LEED EBOM.
- Register, document, and certify the Maneuver Support Center (MANSCEN) facility to the CERTIFIED level IAW Attachment C: LEED EBOM Checklist for Facilities Not Previously LEED Certified.

Phase II (BT and AIT Area Developments): Should be implemented at the Area Development Scale at the Basic Combat Training (BT) and Advanced Individual Training (AIT) Area Developments between 2020-2025.

- Installation and supporting agencies re-evaluate, revise, implement, and enforce installation level policies and programs to support prerequisites and program requirements for LEED EBOM.
- Continue to incorporate all Required Items and as many Recommended Items as possible outlined in the attached Attachment B.
- Certify all facilities in the BT and AIT Area Developments to the CERTIFIED, SILVER, or GOLD level IAW the applicable project checklist in Attachment C or Attachment D: LEED EBOM Checklist for Facilities Previously LEED Certified under LEED-NC or BD&C.
- Recertify the MANSCEN Facility within 5 years of initial certification.

Phase III (Installation): Implement LEED EBOM at the installation scale from 2025 and beyond.

- Installation and supporting agencies re-evaluate, revise, implement, and enforce installation level policies and programs to support prerequisites and program requirements for LEED EBOM every five years.
- Continue to incorporate all Required Items and as many Recommended Items as possible outlined in the attached Attachment B.
- Certify all facilities within the Master Site boundary that meet the Minimum Program Requirements as identified by the USGBC to the CERTIFIED, SILVER, or GOLD level IAW the applicable project checklist in Attachment C or Attachment D.
- Recertify previously certified LEED EBOM facilities within 5 years of initial certification.

Location & Scale

Implementation should be phased as stated above with the Master Site and MANSCEN facility in 2015-2020, AIT and BT Area Developments in 2020-2025, and remaining facilities in 2025 and beyond.

Phasing

This system is projected to start in **2015** with Phase I. Phase II should start in **2020** with Phase III occurring starting in **2025**.

Initial Cost

Phase I (Master Site and MANSCEN): Total Cost $4,154,754 + variable costs.

- Cost to hire a LEED Consultant to facilitate certification of the master site and MANSCEN faculties can vary widely from $25-50K based on qualifications and experience.
- The installation should hire a Sustainability Coordinator at approximately $70-80K per year for a total cost of $375K.
- Cost of registration for the Master Site and each facility is $900. Certification of the Fort Leonard Wood master site is $1,500. Certification for the MANSCEN facility is $12,000. Total cost is $14,400.
- Cost to establish a central UMCS and establish connectivity with Building Monitoring Systems in each existing facility can vary greatly but should be considered a minimum requirement for success in achieving net zero.
- The cost to conduct an ASHRAE Level II Audit indicated in the recommendations table can range from $0.07-.15/SF. An estimate of $0.11 /SF was used resulting in a total cost of $1,127,354 to complete an audit all 647 new and existing facilities.
- The cost to install water and energy meters is approximately $2,000 per meter. Assuming each of the 647 facilities will require 2 meters the total cost of basic metering is $2,588,000.
- Costs to implement the remaining recommendations listed in Attachment B and recommendations from the ASHRAE Level II Audits will vary greatly based on facility and issues identified and cannot be accurately estimated here. The installation should attempt to implement all low or no cost recommendations and incorporate all life cycle cost effective recommendations into budget projections for follow on fiscal years.

Phase II (BT and AIT Area Developments): Total Cost $522,954 + variable costs

- Cost to retain the Installation Sustainability Coordinator over this 5 years period is $375K.
- Cost of registration for each facility is $900. Certification costs for each facility varies from $1,200 – 12,000 based on square footage. Total Cost is approximately $147,954.
- Costs to implement the remaining recommendations listed in Attachment B and recommendations from the ASHRAE Level II Audits will vary greatly based on facility and issues identified and cannot be accurately estimated here. The installation should continue to incorporate all life cycle cost effective recommendations as funding is available.

Phase III (Installation): Total Cost $1,614,998 + variable costs

- Cost to retain the Installation Sustainability Coordinator over this 5 years period is $375K.
- Cost of registration for each facility is $900. Certification costs for each facility varies from $1,200 – 12,000 based on square footage. Total Cost is approximately $731K. Recertification is required every five years to maintain LEED certification. Recertification costs for each facility varies from $600 – 6,000 based on square footage. Total cost is approximately $1,239,998.

- Costs to implement the remaining recommendations listed in Attachment B and recommendations from the ASHRAE Level II Audits will vary greatly based on facility and issues identified and cannot be accurately estimated here. The installation should continue to incorporate all life cycle cost effective recommendations as funding is available.

Life Cycle Cost

Total cost to sustain the LEED EBOM program is $784,158. Once Best Practices are ingrained in the installation culture and planning process, pursuing formal re-certification should no longer be required.

- Cost to maintain the Sustainability Coordinator permanently will continue to be approximately $375K every five years.
- Recertification is required every five years to maintain LEED certification. Recertification costs for each facility varies from $600 – 6,000 based on square footage. Total cost of re-certification is approximately $409,158 over five years.

Feasibility

Implementation of LEED EBOM as a means to achieve **2030 Net Zero Energy, Water, and Waste** goals will be successful only if there is full support from the Command and active participation by all supporting Installation Agencies and Tenant Users Responsibilities for significant contributors identified below are listed in Attachment A:

- Installation CG and Staff (CG)
- Garrison Command Group (GC)
- Directorate of Public Works (DPW)
- US Army Corps of Engineers (USACE)
- Mission Installation Contracting Command (MICC)
- Directorate of Plans Training and Mobilization (DPTM)
- Directorate of Logistics (DOL)
- Army and Air Force Exchange Service (AAFES) / Defence Commissary Agent (DECA)
- Mission and Installation Contracting Command (MICC)
- Tenant Commands (DENTAC/MEDDAC/USAES/ARNG/etc.) who are Facility Occupants

With successful implementation across the installation, performance of existing facilities can be expected to improve substantially resulting in a net reduction of potable water consumption of thirty to forty percent, energy consumption of twenty percent, and waste diversion of fifty to ninety-five percent.

References

LEED for Existing Buildings: Operations & Maintenance

For more information visit USGBC.org

Funding Plan

Funding for LEED EBOM Implementation may fall into several categories:

- Military Construction, Army (MCA) and Operations and Maintenance, Army (OMA) Funds should be used as a last resort to fund implementation of LEED EBOM.

- The Army Installation Technology Transition Program (ITTP): Consider submission of Phase I (Master Site and MANSCEN) recommendations as a project under the ITTP program to validate if use of LEED EBOM is desirable or cost effective for IMCOM to implement Army Wide.

- Resource Efficiency Manager (REM): Consider utilizing the REM program in lieu of hiring a full time GS Employee to serve as the Installation's Sustainability Coordinator (LEED AP with EBOM specialty).

- Energy Awareness and Conservation Assessments (EACA): This may be a feasible method having the government provide an ASHRAE Level II style Energy Audit for select facilities. Recommend a Credit Interpretation Ruling (CIR) be submittal to the Green Building Certification Institute (GBCI) for review and approval before considering this course of action.

- Energy Conservation & Investment Program (ECIP) or Energy Savings Performance Contracts (ESPC). ECIPs preferred due to the payback cycle of ESPCs.
    - ASHRAE Level II Audits
    - Installation Utility Monitoring and Control System (UMCS)
    - Building Automation Systems / HVAC Controls
    - Install energy meters; sub metering
    - Upgrade HVAC systems
    - Improve weatherization
    - Upgrade Lighting Systems & Controls
    - Install Energy Recovery Systems
    - Install Renewable Energy Systems

- Energy Incentive Programs (EIP):
    - Missouri's Proposition C requires all utility providers to offer a rebate for new solar photovoltaic systems of 100 kW or less. The current rebate is $2.00 per W (DC), up to a maximum of $50,000.
    - Several Rebate programs are available if current power provider Sho-Me is replaced with AmerenUE or Kansas City Power and Light (KCPL).

- Utilities Modernization Program (UMP):
    - Installation UMCS
    - Building Automation Systems / HVAC Controls
    - Install energy and water meters; sub metering
    - Install Renewable Energy Systems

As noted above, first costs are heavily weighted by establishing a baseline for building performance, installing meters and building automation systems, and starting a centralized UMCS. Implementation of remaining recommendations is based on Life Cycle Cost Analysis feedback provided by the ASHRAE Level II Auditor and should result in a net savings over the facility's life.

A significant effort was given to transferring some of the remaining responsibility of implementing LEED EBOM to partner agencies and occupants as indicated in Attachment A. This achieves the dual intent of transferring program cost and enforcing buy in from all stakeholders.

There are several examples of public and private sector projects that have demonstrated success in planning and implementing LEED EBOM projects with Life Cycle Payback Periods from six months to twenty years using one of various Paid from Savings Strategies discussed in the Paid-From-Savings-Guide to Green Existing Buildings published by the USGBC. It may be useful to refer to this guide for more information and insight into the potential payoffs of this program.

Contract Language

See Attachment A

Baseline Relation

Energy Baseline – A net reduction of energy intensity of 20% results in a savings of 27 kBTU/SF/Year from the 2009 baseline of 138.8 kBTU/SF/year. This equates to approximately $0.518/SF/Year.

Water Baseline – A net reduction of water use intensity of 30% results in a savings of 30 gal/SF from the 2009 baseline of 90.4 gal/SF/year. This equates to a savings of approximately $0.000705/SF/year.

Waste Baseline – No estimate at this time.

Phase I Savings at current utility rates
- Energy – $327,637/year
- Water – $456/year
- Waste – No estimate at this time

Phase II Savings at current utility rates
- Energy – $1,347,907/year
- Water – $1,836/year
- Waste – No estimate at this time

Phase III Savings at current utility rates
- Energy – $3,263,669/year
- Water –$ 4,945/year
- Waste – No estimate at this time

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Attachment A: Installation Responsibilities Matrix

AGENCY	SUPPORTING THE RECOMMENDATION	ACTION REQUIRED	REFERENCES
Garrison / CPAC / DPW	Hire 1 full time staff member with a LEED AP (with EBOM specialty) and relevant experience in LEED EBOM at the GS-11 to GS-12 level to serve as the Installation's Sustainability Coordinator.	Prepare a detailed duty description, roles, and responsibilities for this position. Determine appropriate agency where the Installation's Sustainability Coordinator should serve (most likely DPW). Hire and provide oversight and direction for the individual hired.	
DPW /MICC	Implement LEED EBOM	Incorporate the requirement to prepare LEED EBOM documentation and meet performance requirements of recommended LEED credits into the Base Maintenance Contract.	LEED EBOM Implementation Guide www.leedonline.com
DPW	Retain the services of a LEED Consultant for the implementation of Phase I activities.	Prepare a scope of work and contract the services of the LEED Consultant to assist with preparation of Master Site credit documentation and certification of the MANSCEN Facility.	
DPW	Register Fort Leonardwood Master Site for LEED EBOM	Register Fort Leonardwood Master Site for LEED EBOM	LEED EBOM Implementation Guide www.leedonline.com
DPW	FOR EXISTING FACILITIES: Register existing facilities for LEED EBOM	Register existing facilities for LEED EBOM	LEED EBOM Implementation Guide www.leedonline.com
USACE	FOR NEW CONSTRUCTION: Register LEED Certified facilities for LEED EBOM at project turnover	Incorporate the requirement to register all MILCON LEED Certified facilities for LEED EBOM into construction contract requirements to facilitate transfer of new facilities	LEED EBOM Implementation Guide www.leedonline.com
USACE / DPW	ASHRAE Level II Audit of all qualifying facilities	Develop a scope of work and establish a 5 year Indefinite Delivery Indefinite Quantity (IDIQ) type contact with Firm Fixed Price (FFP) task orders for ASHRAE Level II Energy Audit services at Fort Leonardwood	ASHRAE 1989
USACE	FOR NEW CONSTRUCTION: 1. Install energy meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements. 2) Sub meter systems that comprise 40-80% of energy demand based on results of ASHRAE Level II Audit 3) Install water meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements 4) Sub meter at least one major water system which may include irrigation, plumbing fixtures, domestic hot water, or other process water	Install facility meters to meet LEED EBOM EA Credit 3.2 and WE Credit 1 requirements in all new facilities and major renovations. Sub-meter 80% of energy demand and at least one major water system.	LEED EBOM EA Credit 3.2 and WE Credit 1
USACE / DPW	FOR EXISTING FACILITIES: 1. Install energy meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements. 2) Sub meter systems that comprise 40-80% of energy demand based on results of ASHRAE Level II Audit 3) Install water meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements 4) Sub meter at least one major water system which may include irrigation, plumbing fixtures, domestic hot water, or other process water	Develop a scope of work and establish a 5 year Indefinite Delivery Indefinite Quantity (IDIQ) type contact with Firm Fixed Price (FFP) task orders for installation of energy and water meters at Fort Leonardwood	LEED EBOM EA Credit 3.2 and WE Credit 1
DPW	Implement all low and no-cost recommendations provided in the ASHRAE Level II Audit	Implement all Life Cycle Cost Effective recommendations provided in the ASHRAE Level II Audit	
USACE	FOR NEW CONSTRUCTION: Load facility data into Energy Star Portfolio Manager (Energy Start Rating of >69 is minimum criteria for participation in LEED EBOM; strive for a rating of 80 or greater)	Integrate this requirement into the construction contract and complete as part of facility turnover and contract closeout	LEED EBOM EA Prerequisite 1 www.energystar.gov
DPW	FOR EXISTING FACILITIES: Load facility data into Energy Star Portfolio Manager (Energy Start Rating of >69 is minimum criteria for participation in LEED EBOM; strive for a rating of 80 or greater)	Load facility data into Energy Star Portfolio Manager (Energy Start Rating of >69 is minimum criteria for participation in LEED EBOM; strive for a rating of 80 or greater)	LEED EBOM EA Prerequisite 1 www.energystar.gov
USACE	FOR NEW CONSTRUCTION: DOR for new facilities should prepare the Ongoing Facility Commissioning Plan	Integrate this requirement into the construction contract and complete as part of facility turnover and contract closeout	LEED EBOM EA Credit 2.3
DPW	FOR EXISTING FACILITIES: Prepare the Ongoing Facility Commissioning Plan for each facility	DPW shall prepare the Ongoing Facility Commissioning Plan for each facility	LEED EBOM EA Credit 2.3
DPW	Re-commission existing facilities as part of LEED EBOM Certification	Develop a scope of work and establish a 5 year Indefinite Delivery Indefinite Quantity (IDIQ) type contact with Firm Fixed Price (FFP) task orders for building Cx Services at Fort Leonardwood	
USACE	FOR NEW CONSTRUCTION: Conduct a survey of occupant thermal comfort and make corrections as needed	Develop a standard questionnaire and survey to use at the 10 month warranty walk. Require contractor to make adjustments as needed and provide documentation of the survey and results to the DPW and part of the facility turnover process.	
DPW	FOR EXISTING FACILITIES: Conduct a survey of occupant thermal comfort and make corrections as needed	Develop a standard questionnaire and survey occupants, make corrections as needed	
USACE	FOR NEW CONSTRUCTION: Prepare an Indoor Environmental Management Plan	DOR shall prepare these documents and provide to the DPW at facility turnover	LEED EBOM IAQ Credit 1.1
DPW	Prepare an Indoor Environmental Management Plan	Prepare for each facility	LEED EBOM IAQ Credit 1.1
USACE	FOR NEW CONSTRUCTION: Prepare the Building Operations Plan, System Narrative, and Narrative Preventative Maintenance Plan	DOR shall prepare these documents and provide to the DPW at facility turnover	LEED EBOM EA Prerequisite 1
DPW	FOR EXISTING FACILITIES: Prepare the Building Operations Plan, System Narrative, and Narrative Preventative Maintenance Plan	Prepare for each facility	LEED EBOM EA Prerequisite 1
DPW / Garrison	Prepare an Integrated Pest Management Policy for the Facility and Site IAW the LEED EBOM Policy Model	Prepare and implement installation policy letter and facility specific addenda	LEED EBOM SS Credit 3 and IAQ Credit 3.6
DPW / Garrison	Prepare an Building Exterior and Hardscape Management Policy IAW the LEED EBOM Policy Model	Prepare and implement installation policy letter and facility specific addenda	LEED EBOM SS Credit 2
DPW Environmental	Prepare and implement a facility stormwater management plan	Prepare and implement facility specific plan	
DPW	Prepare an Erosion Control and Landscape maintenance Plan for the facility	Prepare and implement facility specific plan	LEED EBOM SS Credit 3
DPTM / DPW	FOR EXISTING FACILITIES: Prepare a web based training program for facility occupants to educate users on facility policies, use of the facility, sustainable features, and best practices	Create a public and CAC protected Sustainability website linked to the Fort Leonardwood website. Public access site should provide "one stop shopping" for recycling, transportation, water use reduction, and energy use reduction guidelines, installation policies and resources, and general education on sustainable best practices. CAC restricted site should have facility specific data - real time data on facility resource consumption, occupant training guides, user maintenance information, green cleaning data, etc.	
USACE	FOR NEW CONSTRUCTION: Prepare a web based training program for facility occupants to educate users on facility policies, use of the facility, sustainable features, and best practices	Incorporate the requirement to provide occupant training into all new construction contracts. DOR shall create and turn over all content to support the CAC restricted site facility content. This data shall be turned over at facility turnover.	

Table 1. Installation Responsibilities 1 of 2

Garrison / DPW / MICC	Prepare an Green Cleaning Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address procurement, use and safe handling and storage of cleaning products and cleaning equipment, hand hygiene, cleaning procedures, training, and feedback to maintain effectiveness	Prepare and implement installation policy letter and facility specific addenda	LEED EBOM IEQ Prerequisite 3 and IEQ Credits 3.3 and 3.4
DPW	Incorporate all LCCA recommendations from the ASHRAE Level II Audit into capital funding plan	Incorporate all LCCA recommendations from the ASHRAE Level II Audit into capital funding plan	
DPW	Test and maintain the operations of all building exhaust systems	Ensure this requirement is incorporated into the base maintenance contract.	
DPW	Install and replace MERV 13 filters. Monitor ventilation intakes and install CO2 monitors	Ensure this requirement is incorporated into the base maintenance contract.	
DPW	Replace outdated fixtures with low-flow or water reduction devices	Ensure this requirement is incorporated into the base maintenance contract.	
Garrison / DPW / MICC	Prepare an Environmentally Preferable Purchasing Policy IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, Facility Alterations and Additions, and Reduced Mercury Lamps	Prepare and implement installation policy letter and facility specific addenda	LEED EBOM MR Prerequisite 1 and MR Credits 1-4
Garrison / DPW	Prepare an Solid Waste Management Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, and Facility Alterations and Additions	Prepare and implement installation policy letter and facility specific addenda	LEED EBOM MR Prerequisite 2 and MR Credits 7-9
DPW	Replace all refrigerants if Life Cycle Cost Effective (<10 years)	Ensure this requirement is incorporated into the base maintenance contract.	
DPW	Retrofit or replace aging roofs with cool or vegetated roofs to reduce energy loss from the facility	Ensure this requirement is incorporated into the base maintenance contract.	
DPW	Reduce irrigation 50-100% by replacing irrigated landscaping with native species and permeable hardscape or using non-potable water for irrigation	Ensure this requirement is incorporated into the base maintenance contract.	
Environmental Compliance Office / Occupants	Conduct a facility level waste stream audit	ECO should facility this occupant performed audit and document the process in LEED Online	
Occupants / Garrison / CG	Recycle 50-100% of on site waste	Establish collection services, a mechanism for reporting, and means for enforcement in the installation Solid Waste Management Policy. Consider incorporating reporting into monthly Brigade Update Briefs to the CG. Develop a means of documenting diverted waste in LEED Online.	
Occupants / DRMO / Garrison / CG	Recycle 50-95% of durable goods used in the facility (furniture and electronics)	Establish collection services, a mechanism for reporting, and means for enforcement in the installation Solid Waste Management Policy. Consider incorporating reporting into monthly Brigade Update Briefs to the CG. Develop a means of documenting diverted items in LEED Online.	
MICC / DPW	Replace aging appliances with one of the top three rated Energy Star appliances for the item to be replaced	Ensure this requirement is incorporated in the Environmentally Preferable Purchasing Policy and is enforced by contracting and part of the procurement criteria for facility appliance replacements.	
Occupants / Commands / DPW	Prevent smoking in all facilities; install no-smoking signs on a facility entrances. Designate smoking areas on site at least 50' from building	DPW should install signage at facility entrances and at designated smoking areas. Enforcement is key, commanders should ensure smoking is limited to designated areas only.	
DOL / AAFES / DeCA	Implement LEED EBOM	Incorporated requirement for Sustainable Food Purchases into food procurement contracts for all DFACs and Food Service providers	LEED EBOM MR Credit 5
USACE & DPW	FOR NEW CONSTRUCTION: Support transition to LEED EBOM by requiring contractors to meet or exceed requirements listed FOR EXISTING FACILITIES: Ensure requirements for LEED EBOM are incorporated into maintenance contracts; requirement to provide substantiation and document in LEED Online must also be included in standard contracting language	Construction contracts shall divert 95% construction waste; contactors shall prepare and implement an Indoor Environmental Air Quality Management Plan during construction activities; contractors shall install low mercury lamps; procurement of construction materials to meet requirements of MR Credit 3; install and maintain MERV 13 filters; procure furniture IAW MR Credit 2	IEQ Credit 1.4 and 1.5; MR Credit 2-4
Installation GSA Store	Implement LEED EBOM	Store shall comply with the Installation Environmentally Preferable Purchasing Policy. Products stocked shall ALL meet Federal Mandates and the LEED EBOM criteria for ongoing consumables, durable goods, cleaning materials, cleaning equipment, and Energy Star appliances.	MR Credit 1-2; IEQ Credit 3.3 and 3.4
MICC	Implement LEED EBOM	All procurement contracts shall comply with the Installation Environmentally Preferable Purchasing Policy. Goods supplied shall meet all Federal Mandates and the LEED EBOM criteria for ongoing consumables, durable goods, cleaning materials, cleaning equipment, and Energy Star appliances.	MR Credit 1-2; IEQ Credit 3.3 and 3.4
MICC	All custodial service contracts shall comply with the Installation Green Cleaning Policy and all LEED EBOM green cleaning criteria for cleaning materials and cleaning equipment. Facilities with custodial services should comply with the High Performance Custodial Program. Conduct an audit IAW the APPA Leadership in Educational Facilities "Custodial Staffing Guidelines" as part of the Custodial contractor's performance assessment.	Incorporate the requirement to prepare LEED documentation and meet performance requirements of the High Performance Custodial Program into all custodial contracts on the installation. COR shall conduct audit IAW the APPA Leadership in Educational Facilities "Custodial Staffing Guidelines" as part of the Custodial contractor's performance assessment. A score of 3 or better is required for a Successful performance rating.	LEED EBOM IEQ Prerequisite 3; IEQ Credits 3.1, 3.2, 3.3, and 3.4

Table 1 (cont.) Installation Responsibilities 2 of 2

Attachment B: Facility Recommendations Matrix

REQUIRED	RECOMMENDED	REFERENCES
ASHRAE Level II Audit of all qualifying facilities		ASHRAE 1989
Facilities with custodial services should comply with the High Performance Custodial Program	Conduct an audit IAW the APPA Leadership in Educational Facilities "Custodial Staffing Guidelines" as part of the Custodial contractor's performance assessment.	LEED EBOM IEQ Credit 3.1 and 3.2
Install energy meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements	Sub meter systems that comprise 40-80% of energy demand based on results of ASHRAE Level II Audit	
Install water meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements	Sub meter at least one major water system which may include irrigation, plumbing fixtures, domestic hot water, or other process water	
Implement all low and no-cost recommendations provided in the ASHRAE Level II Audit	Implement all Life Cycle Cost Effective recommendations provided in the ASHRAE Level II Audit	
Recommission existing facilities as part of LEED EBOM Certification		
Each facility has a building monitoring system (BMS) tied into the central Utility Monitoring and Control System (UMCS)		UMCS Center of Expertise, USACE Engineering & Support Center, Huntsville; UFGS 25 10 10;
Load facility data into Energy Star Portfolio Manager (Energy Start Rating of >69 is minimum criteria for participation in LEED EBOM; strive for a rating of 80 or greater)		www.energystar.gov
Obtain an Energy Star Rating of >69	Obtain an Energy Star Rating of >80	
Meet requirements of ASHRAE 62.1 2007		
Install lighting controls; can be stand alone or linked to UMCS		
Implement and maintain an HVAC System Maintenance program		
Conduct a survey of occupant thermal comfort and make corrections as needed		
Prepare a facility ongoing Cx Plan		LEED EBOM EA Credit 2.3
Prepare an Indoor Environmental Management Plan		LEED EBOM IAQ Credit 1.1
Prepare the Building Operations Plan, System Narrative, and Narrative Preventative Maintenance Plan		LEED EBOM EA Prerequisite 1
Prepare an Integrated Pest Management Policy for the Facility and Site IAW the LEED EBOM Policy Model		LEED EBOM SS Credit 3 and IAQ Credit 3.6
Prepare an Building Exterior and Hardscape Management Policy IAW the LEED EBOM Policy Model		LEED EBOM SS Credit 2
Prepare and implement a facility stormwater management plan		
Prepare an Erosion Control and Landscape maintenance Plan for the facility		LEED EBOM SS Credit 3
Prepare a web based training program for facility occupants to educate users on facility policies, use of the facility, sustainable features, and best practices		
Prepare and implement a facility stormwater management plan		
Prepare an Green Cleaning Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address procurement, use and safe handling and storage of cleaning products and cleaning equipment, hand hygiene, cleaning procedures, training, and feedback to maintain effectiveness		LEED EBOM IEQ Prerequisite 3 and IEQ Credits 3.3 and 3.4
Incorporate all LCCA recommendations from the ASHRAE Level II Audit into capital funding plan		
Test and maintain the operations of all building exhaust systems		
Install and replace MERV 13 filters	Monitor ventilation intakes and install CO2 monitors	
Replace outdated fixtures with low-flow or water reduction devices		
Prepare an Environmentally Preferable Purchasing Policy IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, Facility Alterations and Additions, and Reduced Mercury Lamps		LEED EBOM MR Prerequisite 1 and MR Credits 1-4
Prepare an Solid Waste Management Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, and Facility Alterations and Additions		LEED EBOM MR Prerequisite 2 and MR Credits 7-9
Replace all refrigerants if Life Cycle Cost Effective (<10 years)		
Retrofit or replace aging roofs with cool or vegetated roofs to reduce energy loss from the facility		
Reduce irrigation 50% by replacing irrigated landscaping with native species and permeable hardscape or using non-potable water for irrigation	Reduce irrigation 100% by replacing irrigated landscaping with native species and permeable hardscape or using non-potable water for irrigation	
Conduct a facility level waste stream audit		
Recycle 50% of on site waste	Recycle 95% of on site waste	
Recycle 50% of durable goods used in the facility (furniture and electronics)	Recycle 95% of durable goods used in the facility (furniture and electronics)	
Replace aging appliances with one of the top three rated Energy Star appliances for the item to be replaced		
Prevent smoking in all facilities; install no-smoking signs on a facility entrances	Designate smoking areas on site at least 50' from building	
	Install renewable energy sources to offset facility consumption when Life Cycle Cost Effective	

Table 2. Facility Recommendations

Attachment C: LEED EBOM Checklist for Facilities No Previously LEED Certified

Phase 1 (2015-2020)

	Less than 50,000 SF	# of Facilities	50,000-500,000 SF	Square footage	More Than 500,000 SF	# of Facilities	Total
Registration (Master Site Registration is $1500)	$ 900	0	$ 900		$ 900	1	$ 2,400
Initial Certification Review	$ 1,200	0	$ 0.024	0	$ 12,000	1	$ 12,000
Recertification Review	$ 600	0	$ 0.012	0	$ 6,000	0	$ -
Total Certification Cost							$ 14,400

Phase 2 (2020-2025)

	Less than 50,000 SF	# of Facilities	50,000-500,000 SF	Square footage	More Than 500,000 SF	# of Facilities	Total
Registration	$ 900	40	$ 900	20	$ 900	0	$ 54,000
Initial Certification Review	$ 1,200	40	$ 0.024	1,664,750	$ 12,000	0	$ 87,954
Recertification Review	$ 600	0	$ 0.012	0	$ 6,000	1	$ 6,000
Total Certification Cost							$ 147,954

Phase 3 (2025-2030)

	Less than 50,000 SF	# of Facilities	50,000-500,000 SF	Square footage	More Than 500,000 SF	# of Facilities	Total
Registration	$ 900	573	$ 900	11	$ 900	0	$ 525,600
Initial Certification Review	$ 1,200	573	$ 0.024	1,281,754	$ 12,000	0	$ 718,362
Recertification Review	$ 600	40	$ 0.012	1,664,750	$ 6,000	1	$ 49,977
Total Certification Cost							$ 1,293,939

Phase 3 (2030 and beyond)

	Less than 50,000 SF	# of Facilities	50,000-500,000 SF	Square footage	More Than 500,000 SF	# of Facilities	Total
Registration	$ 900	0	$ 900	0	$ 900	0	$ -
Initial Certification Review	$ 1,200	0	$ 0.024	0	$ 12,000	0	$ -
Recertification Review	$ 600	613	$ 0.012	2,946,504	$ 6,000	1	$ 409,158
Total Certification Cost							$ 409,158

Table 3. LEED EBOM Certification Costs

Attachment D: LEED EBOM Checklist for Facilities Previously LEED Certified under LEED-NC or BD&C

REQUIRED	NOTES	QTY	UNIT	UNIT COST	TOTAL
Implement all low and no-cost recommendations provided in the ASHRAE Level II Audit				$ -	$ -
Prepare and implement a facility stormwater management plan				$ -	$ -
Load facility data into Energy Star Portfolio Manager (Energy Start Rating of >69 is minimum criteria for participation in LEED EBOM; strive for a rating of 80 or greater)				$ -	$ -
Meet requirements of ASHRAE 62.1 2007				$ -	$ -
Conduct a facility level waste stream audit	Done by building occupants with assistance from DPW Environmental Compliance Office			$ -	$ -
Recycle 50% of on site waste				$ -	$ -
Prepare an Environmentally Preferable Purchasing Policy IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, Facility Alterations and Additions, and Reduced Mercury Lamps				$ -	$ -
Prepare an Solid Waste Management Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address Ongoing Consumables, Durable Goods, and Facility Alterations and Additions				$ -	$ -
Implement and maintain an HVAC System Maintenance program	Should be part of existing facility maintenance plan			$ -	$ -
Test and maintain the operations of all building exhaust systems	Should be part of existing facility maintenance plan			$ -	$ -
Prepare an Green Cleaning Policy for the Facility and Site IAW the LEED EBOM Policy Model. Policy should address procurement, use and safe handling and storage of cleaning products and cleaning equipment, hand hygiene, cleaning procedures, training, and feedback to maintain effectiveness				$ -	$ -
Install and replace MERV 13 filters	Should be part of existing facility maintenance plan			$ -	$ -
Conduct a survey of occupant thermal comfort and make corrections as needed				$ -	$ -
Facilities with custodial services should comply with the High Performance Custodial Program				$ -	$ -
Replace outdated fixtures with low-flow or water reduction devices	Variable - should not exceed normal replacement costs. Per fixture costs: 1) Low flow showerhead $50-$200 2) High Efficiency Toilet $200 – $800 3)Flush Valve (manual) $150 – $250 4) Flush Valve (automatic) $450 – $550 5)Bathroom Ultra Low-Flow Faucet $100 – $200 6) Kitchen Ultra Low-Flow Faucet $300 – $700 7) Ultra Low Flow Faucet with automatic sensor $400-$700 8)Aerator Attachment $5 – $20			$ -	$ -
Replace aging appliances with one of the top three rated Energy Star appliances for the item to be replaced	Variable - should not exceed normal replacement costs			$ -	$ -
Retrofit or replace aging roofs with cool or vegetated roofs to reduce energy loss from the facility	Variable - cost for low albeido TPO or SSMR should not exceed normal replacement costs. Vegetated roofing systems can rage from $7-$11/SF			$ -	$ -
Recycle 50% of durable goods used in the facility (furniture and electronics)				$ -	$ -
Prepare an Indoor Environmental Management Plan				$ -	$ -
Prepare the Building Operations Plan, System Narrative, and Narrative Preventative Maintenance Plan				$ -	$ -
Prepare an Integrated Pest Management Policy for the Facility and Site IAW the LEED EBOM Policy Model				$ -	$ -
Prepare an Building Exterior and Hardscape Management Policy IAW the LEED EBOM Policy Model				$ -	$ -
Prepare and implement a facility stormwater management plan	Should be part of existing facility maintenance plan			$ -	$ -
Prepare an Erosion Control and Landscape maintenance Plan for the facility	Should be part of existing facility maintenance plan			$ -	$ -
Prepare a facility ongoing Cx Plan				$ -	$ -
Prevent smoking in all facilities; install no-smoking signs on a facility entrances	Part of federally mandated facility requirements; existing facilities may not meet signage requirements. Assumes that each facility will require 5 signs each.	3235		$ 20.00	$ 64,700.00
ASHRAE Level II Audit of all qualifying facilities	Range of pricing is $0.07-0.15 / SF	10248673	SF	$ 0.11	$ 1,127,354.03
Install energy meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements		647	EA	$ 2,000.00	$ 1,294,000.00

Table 4. Implementation Costs

Install water meters which can be monitored and read at the UMCS; calibrate meters IAW manufacturers requirements		647	EA	$ 2,000.00	$ 1,294,000.00
Facility recommissioning	Pricing estimate is $.30/SF for existing facility recommissioning	10248673	SF	$ 0.30	$ 3,074,601.90
Each facility has a building monitoring system (BMS) tied into the central Utility Monitoring and Control System (UMCS)	Variable- TBD based on facility				Variable
Incorporate all LCCA recommendations from the ASHRAE Level II Audit into capital funding plan	Variable - TBD during ASHRAE Level II Audit				Variable
Replace all refrigerants if Life Cycle Cost Effective (<10 years)	Variable - TBD during LCCA				Variable
Prepare a web based training program for facility occupants to educate users on facility policies, use of the facility, sustainable features, and best practices	Variable - TBD based on approach				Variable
Install lighting controls; can be stand alone or linked to UMCS	Variable - TBD based on approach Per fixture costs: 1) Photo sensor and calibrator $150 - $200 per sensor 2) Dimming ballast $50 - $200 per ballast				Variable
Reduce irrigation 50% by replacing irrigated landscaping with native species and permeable hardscape or using non-potable water for irrigation	Variable - TBD based on approach See tech notes on LID, permeable paving, and graywater harvesting				Variable
				Variable Costs +	$ 6,854,655.93
RECOMMENDED	**NOTES**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL**
Conduct an audit IAW the APPA Leadership in Educational Facilities "Custodial Staffing Guidelines" as part of the Custodial contractor's performance assessment.				$ -	$ -
Obtain an Energy Star Rating of >80				$ -	$ -
Recycle 95% of durable goods used in the facility (furniture and electronics)				$ -	$ -
Recycle 95% of on site waste				$ -	$ -
Designate smoking areas on site at least 50' from building	Install Sign and Post to designate smoking area	647	EA	$ 100.00	$ 64,700.00

Sub meter at least one major water system which may include irrigation, plumbing fixtures, domestic hot water, or other process water		647	EA	$ 2,000.00	$ 1,294,000.00
Sub meter systems that comprise 40-80% of energy demand based on results of ASHRAE Level II Audit	Assume facilities will need an average of 2-3 additional meters	1618	EA	$ 2,000.00	$ 3,235,000.00
Implement all Life Cycle Cost Effective recommendations provided in the ASHRAE Level II Audit	Variable - TBD based on approach				Variable
Install renewable energy sources to offset facility consumption when Life Cycle Cost Effective	Variable - TBD based on approach				Variable
Monitor ventilation intakes and install CO2 monitors	Variable - TBD based on approach				Variable
Reduce irrigation 100% by replacing irrigated landscaping with native species and permeable hardscape or using non-potable water for irrigation	Variable - TBD based on approach				Variable
				Variable Costs +	$ 4,593,700.00

Table 4 (cont). Implementation Costs

US Army Corps of Engineers

2030 USACE Integration Project

8.22 Light Shelf

light shelf

TECHNOTE

Recommendation

Install light shelves in conjunction with window glazing where practicable in building spaces utilizing daylight.

Location & Scale

This system is implemented at the **building scale**. Fort Leonard Wood's climate makes it a great candidate for installation of light shelves. Light shelves function well in mild climates due to the potential solar heat gain that would result in tropical or desert climates. The shelves can be installed on the interior or exterior of the building and are usually installed on the South face of the building where maximum sunlight is usually found.

Phasing

This system is projected as part of the **Pre-2015 and 2015 Phases**.

Initial Cost

The light shelf unit alone comes at a cost of approximately **$100** per window, but is subject to variation. A fully functioning system will include the following components: the light shelf, window, ceiling, and a shading device.

Life Cycle Cost

The life cycle cost of the light shelf technology includes the first cost of **$100,** maintenance costs, and any savings as a result of reduced electricity consumption. The width of the daylighting zone along the exterior wall extends into the space ten to twenty feet, which translates to electricity savings of ten to forty watts along the wall. The heat added to the space would be much more than what is added by an equivalent amount of electric lighting. Light shelves can also yield a reduction in monthly demand charges due to reduced lighting energy during peak hrs.

Maintenance

Light shelves are a low maintenance technology. Dust and other debris can settle on top of the light shelf and will begin to degrade illumination; therefore shelves need to be cleaned on a regular basis.

Feasibility

The light shelf is an affordable, low maintenance energy conservation measure that will be aid in reducing electricity consumption of lights. The light shelf technology takes a simplistic approach to increasing daylight dispersion in interior spaces. Installation requires no complex procedures and can be easily integrated into design and typical construction practices.

References

InLighten™ Light Shelf (Material: Aluminum)
http://www.alcoa.com/global/en/products/product.asp?prod_id=1852

Nysan Light Shelf (Material: Metal and others)
http://www.hunterdouglascontract.com/solarcontrol/lightshelves/

	HIGH PERFORMANCE TECHNOLOGY STRATEGY TEMPLATES (Version 0, 10-31-2010)
Contract Language	See Attachment A
Author	Produced as part of the 2030 USACE Integration Project

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Attachment A:

Consider the following when preparing specifications:

- Light shelves are to be used for south facing windows to maximize daylight potential.
- Light shelves should be mounted at a height above the floor that does not interfere with passers-by.
- Maximum light shelf projection is 30inches from back of glazed wall system.
- It is suggested that a white finish be used for upper surface of a light shelf to maximize the reflection of daylight in the space.
- Consult with local building and fire codes for applications with light shelves and fire sprinkler systems.
- Some light shelves can be integrated with a certain type of curtain wall and sun control systems. Check the compatibility before installation.

2030 USACE Integration Project

8.23 Living Machine

Recommendation

Install a fully functional Living Machine system that will serve as a natural, on-site method of circulating/cleaning blackwater and greywater. The system consists of piping, underground tanks (settling tank and recirculation/control tank), and wetlands placed around the site. Sewage piping transports the blackwater from the facility to the primary and recirculation tanks and then to the wetlands where it is filtered through natural processes and, finally, re-circulated throughout the building to be used for toilets, irrigation, and cooling towers. Requirements for this system are underground locations for the various tanks as well as designated plots on the site for the wetlands. The wetlands incorporate some 200 species of plants that soak up the nutrients of the sewage while bacteria and microbes on the plant's roots break down the pollutants. Attachment B includes a generic diagram of how the system works.

Location & Scale

A Living Machine system is implemented at the **building scale**. This technology is integrated within the site and needs to be taken into consideration at the initial phase of design to ensure all mechanical, civil, and architectural disciplines are coordinated. While wetlands can play a large role in the site / landscaping aesthetics, they still must be placed systematically. Often, wetlands are enclosed with attractive infrastructure to enhance the appearance. Odor is not an issue if installed correctly so isolation of wetlands is not necessary.

Phasing

This system is projected as part of the **2015 Phase**. It should be installed during site construction and before foundations are placed.

Initial Cost

The cost to install a Living Machine system is approximately **$300,000** for an Advanced Individual Training (AIT) Barrack (300 person Dormitory) using an estimated 12,000 gallons per day. This cost will vary significantly with different site conditions, wetland locations, and piping requirements. Initial cost savings specifically come from avoiding sewer hook-up fees and avoiding the cost of constructing sewer lines. Additional savings can be realized by economy of scale. If this system serves an entire AIT Complex (four Barracks and a Dining Facility), initial installed system cost would be in the range of $700,000. A Marine Corps Recruiting Depot in San Diego saved approximately $4.5 million in infrastructure by utilizing a full Living Machine.

Life Cycle Cost

Life cycle cost savings would depend on the current usage in comparable facilities at Fort Leonard Wood. This system will greatly reduce the building's carbon footprint as it takes away the need for offsite sewage transport and can provide building needs for toilet water, cooling tower demands, and irrigation around the site. For a Living Machine Tidal Flow Wetland system, recycling

30,000gal/day would require 15 kWh and a 4,500 square feet (SF) footprint. Depending on the size of the facility, projected annual water usage requirements may be based on applying these numbers to develop an estimate of energy costs associated with the system operation.

A Marine Corps Recruiting Depot in San Diego re-uses about 5 million gallons of water annually. Long term cost savings can be found specifically by:

- Reducing cost of water and sewer services
- Reducing energy cost
- Reducing O&M labor and cost

Maintenance

A Living Machine system typically requires regular operations and maintenance work as follows:

- Daily (30-60 minutes):
    - Review controls system for any alerts
    - Wetland cells – check general appearance
    - Disinfection system (if included) – adjust operation if needed
    - Collect samples to monitor effluent quality (if required)
- Weekly (1-3 hours):
    - Verify horn/beacon operation and evaluate system operation
    - Wetlands cells – check high and low water levels are acceptable
    - Disinfection system (if included) – adjust system as required
    - Collect samples for monitoring effluent quality (if required)
- Monthly (2-8 hours):
    - Perform maintenance activities listed on the O&M manual
    - Prepare monthly operation and maintenance report
    - Wetland cells – perform vegetation maintenance
    - Collect samples for monitoring influent and effluent quality (if required)

Once a year, perform clean out of the holding tank, if necessary, and clear drains or piping if clogging occurs. This work will require someone who is trained in the system to ensure no part is compromised during maintenance.

Feasibility

This system attributes to the **2030 Net Zero Water and Waste** goals by decreasing / eliminating the water waste diversion from the facility and re-using water for facility non-potable water uses like toilets or irrigation. Additional benefits include the potential for improving air quality and increasing biodiversity through integrating wetlands inside the facility or as part of the landscaping.

The main risks for this system revolve around correctly installing and maintaining it. Proper installation of holding tanks, pumps, and piping is crucial as any slight malfunction can result in a contaminated site.

References

See Attachment A

"The Living Machine." *Living Machine*. Worrell Water, 2011. Web. 14 Feb. 2011 http://www.livingmachines.com/

Berg, Nate. "Deja Poo: The Living Machine Sewage System." *Wired.com*. 22 May 2009. Web. 14 Feb. 2011 http://www.wired.com/science/planetearth/magazine/17-06/st_sewagegrid

Diagrams See Attachment B

Funding Plan The funding for this system would need to be integrated into the initial design/construction funds as awarded. Due to the significant cost impact, this could possibly be included in the solicitation as a Bid Option.

Contract Language Provide a complete *Living Machine system* fully integrated into the site. Please see Appendix for concept diagrams for system components and typical layout.

As noted above, this can be included in the solicitation as a Bid Option.

Manufacturer Worrell Water Technologies' Living Machine® system uses living plants and beneficial microorganisms to turn wastewater into clean water. The patented technologies produce water that is cleaner and greener than conventional water treatment methods – and with huge savings in energy and infrastructure costs.

Other applicable systems may be available by these manufacturers**:**

Ecological Engineering Group	http://www.ecological-engineering.com/
Aqua Treatment Technologies	http://www.aqua-tt.com/index.html
Modular Wetlands	http://www.modularwetlands.com/

Baseline Relation A Living Machine technology is a fully integrated system that would require the baseline model to be altered so that black/greywater drainage is taken to the appropriate underground tank and further distributed to the wetlands which are systematically placed in the outdoor areas surrounding the facility. While this system can be configured in numerous ways, the baseline will be affected greatly due to the large amounts of site re-configurations needed to house the large underground tanks. Additional changes are also needed to divert the waste lines from the facility to the holding tanks versus the Installation's central sewage lines. Although a significant initial impact, this technology will offer huge advantages for numerous years as it will eliminate the need to transport waste off-site as well as decrease the water demand for the facility and site. By decreasing the supply and waste demand of the entire facility, this system provides a big step forward in reaching a net zero building.

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Attachment A: Reference Material

The Living Machine Fact Sheet

The Living Machine® Wastewater Reuse Technology Worrell Water Technologies

What: The Living Machine® is an ecological wastewater treatment system that treats wastewater for re-use – allowing communities or institutions to locally manage wastewater, create high quality reuse water, avoid sewer hook-up fees while dramatically reducing water and energy consumption and their associated costs. The Living Machine is a "turbo-charged" wetland system, which speeds up natural processes for a smaller footprint and a faster return on investment.

We're proud that we have developed the most energy efficient wetland system with a compact footprint. We've incorporated this technology into a variety of cutting-edge water reuse systems. The Living Machine® is in operation in more than two dozen locations worldwide, saving over 100 million gallons per year.

Why: Water is scarce and as a result, the cost of water is increasing. Rather than expend the energy and dollars to transport clean water many miles to your location, only to pump it out and send water again many miles away for sewage treatment, the Living Machine® allows for on-site, local water recycling, producing fresh water for irrigation, toilet flushing, industrial processes, washing equipment or animal areas, filling landscape water features (i.e. fish ponds) and other uses. This cost-effective water reuse solution can be part of a green design and water saving strategy for institutions and communities.

Where: From Ghana to Las Vegas and from animal shelters to hotels, the Living Machine® is the wastewater treatment of choice for organizations, educational institutions and municipalities that want a wastewater treatment system that is environmentally friendly, energy efficient, and beautiful. Many institutions, especially in water-scarce states such as California, have integrated the Living Machine into their infrastructure improvements or new construction resulting in water and energy savings, as well as LEED credits.

When: The Living Machine® system has significantly evolved over the last two decades, improving upon an original design by Dr. John Todd in the 1980s. For more than 10 years, Worrell Water Technologies has invested in extensive research and development to create a viable product that performs reliably and economically. The New Generation of Living Machines® is now a commercial reality. This patented and trademarked technology is offered only by Worrell Water Technologies. The Living Machine® already has more than two dozen satisfied customers.

How: Our Tidal Wetland Living Machine® system incorporates a series of wetland cells, or basins, that are filled with special gravel. As water moves through the system, the cells are alternately flooded and drained to create multiple tidal cycles each day, much like we find in nature, resulting in high quality wastewater treatment. This patented tidal process naturally brings oxygen to the wastewater, improving treatment performance by producing cleaner water using less energy. Then, wetland vegetation and microorganisms, especially in the root zone, promote a complex and stable ecosystem, generating clean water performance under a variety of conditions.

Living Machine® systems not only speed up the natural process of a tidal wetland, but have aesthetic and biological advantages over other onsite treatment systems while providing the performance, control and monitoring benefits of state-of-the-art engineered systems.

The Living Machine® system offers distinct benefits when compared to both conventional constructed wetlands and traditional onsite technologies such as membrane bioreactors or activated sludge package plants.

Benefits over other treatments systems include:

- Lower operating costs
- Advanced quality fresh water suitable for reuse
- Small footprint and readily scalable for high volume
- Low energy consumption and low GHG emissions
- Aesthetic quality, integrating the beauty and complexity of nature into the structure of buildings – providing residents and visitors with an educational experience and direct tangible connection to natural systems

Attachment B: Diagrams

Examples of generic Living Machine type features that may be used at Fort Leonard Wood.

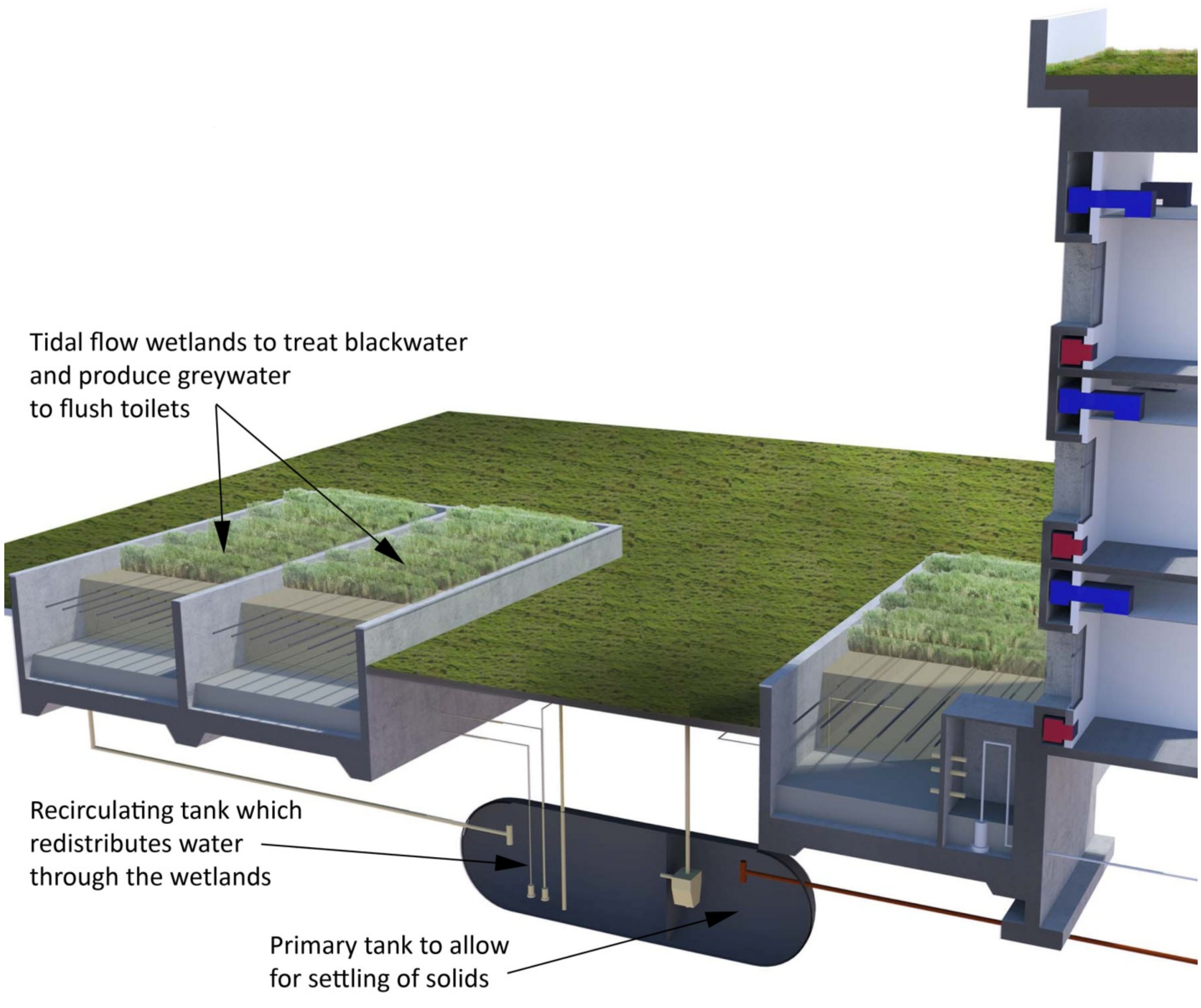

Figure 1. Wetlands with underground tanks – Diagram courtesy of HQ USACE

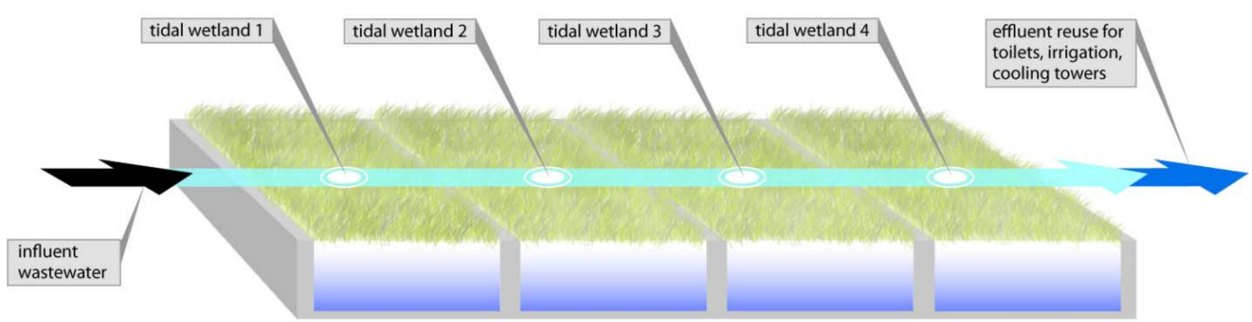

Figure 2. Basic process of wastewater flow through wetlands – Diagram courtesy of USACE, Seattle District

US Army Corps of Engineers

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8.24 Local & Regional Materials

local & regional materials

TECHNOTE

Recommendation

Use and require the use of local and regional materials to the greatest extent possible on all newly constructed facilities and renovations. Primary benefits of this strategy include, but are not limited to:

- Local materials tend to blend aesthetically with existing and historic architecture because those raw materials were the most readily available at the time of the other facility's construction.
- Often, regional materials from local suppliers are more easily replaced or maintained.
- Regional materials tend to withstand local climactic conditions better on general terms than materials from other climates.
- A main attribute of this strategy is to reduce embodied energy associated with the transportation of goods and also to stimulate local economies.

Local and regional materials are often defined as materials that were processed from raw material to finished product within a day's drive (approx. 500 miles) from a site. LEED bases its local and regional material credits off of this 500 mile radius. This term can also be used on relative terms (i.e. if deemed necessary, granite from the Rocky Mountains would be far better than using marble imported from Italy). Regardless, designers can take care to consider the source of the products that they design with and specify around. When combined with the prudence of the contractor to hire local (knowledgeable of local resource streams) subs, facilities and infrastructure can be constructed very efficiently.

Location & Scale

This strategy can be implemented on **all scales** from infrastructure and master planning projects to building scale projects throughout the entire installation.

Phasing

Requirements to use local and regional materials should be enforced on all new construction and renovation projects **immediately**. These requirements can be increased as local economies develop and maintain those resource streams.

Initial Cost

Naturally, general contractors select materials that are most easily accessible for the least cost. Sometimes these are local materials, but in our global economy, items are often shipped from across the globe at lower cost than similar local products produced at a smaller scale. While cheap, it is not sustainable. Generally first cost for local products is comparable, but care must be given during design to specify and design with products that are accessible locally.

Life Cycle Cost

Life cycle costs should be minimally impacted when comparing directly related products. Difficulty may arise in locally sourcing those comparable products.

Maintenance Maintenance needs can obviously vary depending upon the product, but it is much more likely that a local maintenance contractor is going to be familiar with locally sourced materials and products than something that was sourced a larger distance from the site.

References LEED Reference Guide for Green Building Design and Construction, 2009 Edition

Diagrams The image below indicates an approximate 500 mile radius centered around Fort Leonard Wood (FLW), MO.

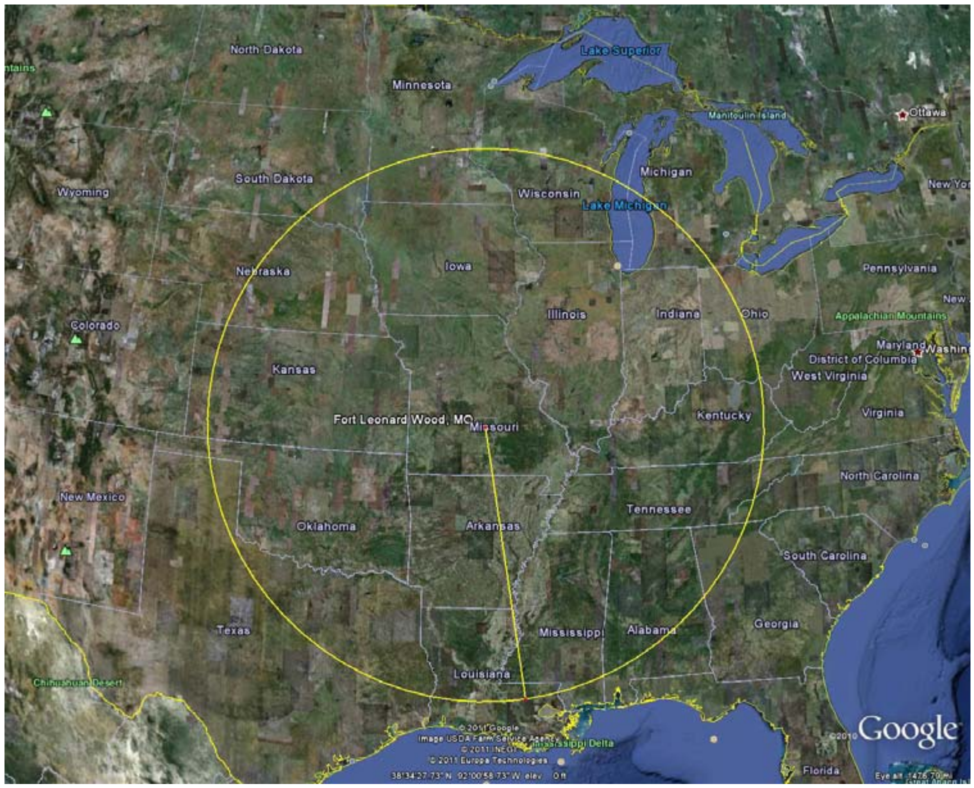

Image 1. Fort Leonard Wood 500 Mile Radius – Image Courtesy of Google Earth (© 2011 Google)

Funding Plan Suggest favoring contractors (in contract evaluation documents) that propose using local labor resources as well as local material resources in design and construction projects.

Contract Language Existing contracting language and specifications often require use of local and regional materials as part of LEED Certification. Contracting documents can be written to assign favor to designs that use local materials during the project advertisement and award phases.

Product Specifications Provide front-end requirements that mandate a certain percentage of a project's materials be sourced locally or regionally. All technical specifications that may have products that can be sourced locally should reference the requirements established in the front-end. Adhering to requirements set in the LEED Rating System for Local and Regional requirements may be helpful, but are not mandatory.

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8.25 Low Flow Showerheads

Recommendation

Install single function, non-aerated low flow showerheads which are single function in all new buildings and retrofit existing facilities as applicable. Fixtures should be Environmental Protection Agency (EPA) WaterSense® certified and meet its water performance requirements. WaterSense® certified fixtures use a maximum of 1.5 gallons per minute (gpm) of water. It may be beneficial in some cases to utilize smaller hot water pipe diameters and locate the water heating system near the end use (showerheads) to minimize the length of time it takes for hot water to reach the fixtures. Implementing these types of fixtures will maximize water conservation with minimal impact to fixture & system costs.

Location & Scale

This would occur at the **building scale** and is recommended for all applicable buildings.

Phasing

This system is projected as part of the **2015 Phase** in all new construction. As various other buildings with shower facilities on the installation are renovated, old fixtures could be easily retrofit with new units of this type.

Initial Cost

Including purchase price and installation (average cost in Missouri) of a moderate non-aerated low flow showerhead, each unit's initial cost would likely be between **$50 - $100**. This figure depends on the specific fixture selected and the installer's labor wage. Initial cost for a retrofit fixture installed would be about the same, but would require removal & disposal of old components.

Components which are different than or in addition to the standard plumbing system for showers in the cost consideration may only include showerheads, arms, valves, and escutcheons.

Life Cycle Cost

Life Cycle Cost of this type of showerhead would include maintenance and water use costs in addition to the initial costs for each fixture. A low flow showerhead's typical life span is the life of the building, assumed to be about 50 years. The total estimated Life Cycle Cost of (1) one standard showerhead is about $5,915. The total estimated Life Cycle Cost of (1) one low flow showerhead, which uses approximately 11,680 fewer gallons per year of water than a standard showerhead, is estimated at **$7,100***.

Operations costs would be minimal as the cost of water is inexpensive. Maintenance costs would be greater than that of standard showerheads due to their need of more frequent cleaning. Maintenance, cleaning and most repairs, could be performed by Fort Leonard Wood building maintenance staff, coming to about $100/year. Each showerhead is assumed to provide (4) four, 8 minute showers per day, or about 32 min/day of water use (17,520 gal/fixture/yr). Fort

Leonard Wood water cost is currently estimated at $2.30/1000 gallons. The estimated annual water costs for one low flow showerhead is approximately $40. Total annual O&M costs, including water use, would be approximately **$140***.

An average low flow showerhead costs $60, with installation cost of about $25. Total installation & initial cost would be approximately **$85** per fixture.

**At current dollar values (no inflation included), and if all estimates and assumptions of fixture use & water costs are accurate.*

Maintenance This system will not require significant maintenance unless plumbing problems arise. Minor repairs and regular cleaning should be within the ability of the Fort Leonard Wood building maintenance staff, but large issues with the system are no different than problems and maintenance of standard showers.

Feasibility This system contributes to the **2030 Net Zero Energy and Water** goals. Low flow showerheads have the same plumbing design as standard showers, with the differences being in the showerhead itself. Maintenance is very similar to standard fixtures and WaterSense low flow heads should use twenty to forty percent less water than a standard shower fixture. If incorporated into the design process and confirmed in specifications, these types of units can be relatively inexpensive but a very efficient way to conserve water while maintaining functionality.

Installing low flow showerheads should yield a reduction in energy to deliver and treat the water used for showers. Less hot water is required, resulting in a need for less water to be heated. Utilizing these fixtures may reduce the energy use by 30%.

References See Attachment A

Environmental Protection Agency (EPA). "WaterSense® Specification for Showerheads." Version 1.0. 4 March 2010. Web. 18 July 2011. www.epa.gov/WaterSense/docs/showerheads_finalspec508.pdf

"Low Flow Showerheads." *High Performance Technology Strategy Templates.* Revision 0. 31 October 2010. Web. 18 July 2011. http://mrsi.usace.army.mil/cos/TechNotes/07%20Fixtures%20Low-Flow%20Showerheads%2010-31-10.pdf

Whole Building Design Guide. "Federal Green Construction Guide for Specifiers, Section 22 40 00 (15400) Plumbing Fixtures." 4 January 2010. Web. 18 July 2011. www.wbdg.org/ccb/FEDGREEN/fgs_224000.pdf

Delta Faucet Company. "Delta Touch-Clean® Showerhead." 2011. Web. 18 July 2011. www.deltafaucet.com/bath/details/rp41589.html

American Standard Brands. "Showers: Invigorating and relaxing choices to match your dream." *American Standard, Showers.* 2011. Web. 18 July 2011. www.americanstandard-us.com/bathroom-products/shower-faucets/

Diagrams	Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.
Funding Plan	This system would need to be funded with initial design/construction funds as awarded. Specifying low flow, WaterSense showerheads in place of standard showerheads will not be a significant cost to the overall project, but may be a considerably higher first cost than standard units.
Contract Language	Provide non-aerated *low flow showerheads* for all shower facilities in new buildings. Units shall be vandal-resistant and single function with a maximum flow rate not to exceed 1.5 gpm when measured at a flowing water pressure of 80 psi. All units must be certified under the Environmental Protection Agency's (EPA) WaterSense program.
Product Specifications	See Attachment A for generic specification.
Baseline Relation	Standard showerheads use approximately two and a half gallons per minute (gpm) of water. A low flow showerhead uses anywhere from one to one and a half gpm. This technology will decrease water consumption of showers by **twenty to forty percent.**
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Attachment A: Low Flow Showerhead Specifications**

**As adapted from the Whole Building Design Guide *Federal Green Construction Guide for Specifiers*

SECTION 22 40 00 (SECTION 15400) – PLUMBING FIXTURES

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Showerheads
2. Accessories

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

3. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:

a. Plumbing fixtures

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

1.3 QUALITY ASSURANCE

A. Water flow and consumption rates for plumbing fixtures:

1. Comply with requirements in Public Law 102-486, Energy Policy Act.
2. Provide WaterSense labeled products for Showerheads.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Fixtures:

1. Water management: Provide low flow fixtures.

a. Showerheads: Maximum flow rate shall not exceed 1.5 gal/min (7.6 L/min) when measured at a flowing water pressure of 80 pounds per square inch.

2. Toxicity/IEQ:

a. Water filter system: Provide filters for chlorine at showerheads.

b. Low corrosion flux for copper pipe: Comply with ASTM B813.

PART 3 – EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

1. Water Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

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8.26 Low Impact Development (LID) & Bioswales

Recommendation

Implement Low Impact Development (LID), such as bioswales, to control stormwater flow at Fort Leonard Wood (FLW). Bioswales are engineered vegetated depressions designed to collect and clean stormwater runoff from impervious surfaces and reduce unwanted ponding in streets and near buildings. They consist of a swaled drainage course with gently sloped sides (less than 6%) and are filled with vegetation, compost and/or riprap. Bioswales improve water quality by filtering stormwater to remove pollutants, metals and other toxins that could otherwise be conveyed to local streams and rivers. Bioswales at Fort Leonard Wood would support stormwater mitigation and minimize or eliminate pollutant discharge to the nearby Big Piney River. This would support Fort Leonard Wood's objectives of meeting Energy Independence and Security Act's (EISA) Section 438 Stormwater requirements and **2030 Net Zero Water** efforts.

Location & Scale

Bioswales should initially be implemented at the **building scale**. Two bioswales should be constructed to collect surface flow at the new Advanced Individual Training (AIT) sites. Locate one bioswale parallel along Minnesota Avenue and curve it along the new track construction at Minnesota Avenue and Nebraska Avenue, as annotated in Diagram 2. The bioswale, shown meandering through the dry detention area in Diagram 2, was designed to increase flow time within the bioswale. This design increases detention time and encourages infiltration of stormwater through the bioswale. The second bioswale should be constructed parallel to Nebraska Avenue, also along the new track construction.

Basic Combat Training (BT) site: Bioswales will be constructed along Colorado Street and Minnesota Avenue on the East and South sides of the site. All stormwater from the BT site will be directed to these bioswales.

Phasing

This system is projected as part of the **2015 Phase** and is recommended for the BT and AIT sites.

Initial Cost

The cost of a typical bioswale has been estimated to be approximately **$11,000** for a 900 square foot swale. Actual cost for this system will be determined based upon final design measurements. While proposals may vary due to contractors and bioswale designs, installation costs of typical bioswales can be estimated using **Table 1** below:

Item	Unit	Estimated unit cost (2005 Dollars)
Excavation	C.Y.	$8 - $10
Grading	S.Y.	$0.10 - $0.15
Bioretention media	C.Y.	$40 - $60
Filter fabric	S.F.	$0.70 - $1.00
Gravel (for underdrain trench)	C.Y.	$30 - $35
8” dia. perforated underdrain pipe	L.F.	$15 - $20
Seed	S.F.	$1 - $2

Life Cycle Cost

Traditionally, life cycle costs compare the first cost of a new technology with the operation and maintenance cost savings realized after installation of the new technology. The value of a bioswale does not easily fit the life cycle cost analysis format. Bioswales can help reduce costs for some storm systems, but a bioswale is best evaluated by considering what can happen if adequate drainage is *not* provided for a specific site. Typically, a drainage problem creates significant damage long before it is discovered, resulting in expensive repairs. Implementation of a bioswale supports proper drainage. A properly designed and maintained bioswale cleans stormwater, helps prevent erosion and supports recharge of groundwater.

Maintenance

Bioswale general maintenance consists of mowing, landscaping, and cleaning out debris. It is substantially important that bioswales are inspected on schedule and cleared of dead plants, debris, and sediment build-up. If a bioswale is left and not maintained it could potentially choke with trash and sediment. This trash and sediment can kill plants and contribute to erosion in the swale which can lead to more problems than just routine maintenance. In the event they choke and are not functional, additional repair work can be involved. This work includes replanting or bringing in more soil needed to ensure that the bioswale is working properly.

The selection and planting of vegetation should be in accordance with the pollutants to be removed and the flow and velocity design requirements of the bioswale. Landscaping and mowing are determined by the type of grass and vegetation that is in the bioswale. Grass should be kept between four and six inches in height and can typically be mowed at intervals already set by the maintenance and landscaping crews. Other landscaping may include trimming bushes. These can also typically be set with normal landscaping.

Because the intent of bioswales is to clean the stormwater, they will inherently become obstructed with the sediment and trash that they extract out of the stormwater. This will increase maintenance costs, but this sediment and trash in the past has just become an additional problem downstream when the runoff should be responsibility of the installation to ensure the best quality of water will go to downstream neighbors. A conservative estimate of this additional cost is eight hours a month per thirty feet of bioswale.

Feasibility

Bioswales are relatively inexpensive to construct and maintain. Bioswales would turn all of the stormwater conveyance on Fort Leonard Wood into a designed conveyance system instead of just grassed channels. It has been proven that bioswales will do a better job of cleaning stormwater runoff, improving water quality and recharging groundwater than the grassed channels and concrete channels currently in place. Bioswales should be designed to retain water and will help alleviate some flooding problems because they slow down stormwater.

To further minimize risks, bioswales should be properly designed and constructed to accommodate local geologic conditions. In areas with karst that are susceptible to sink holes, bioswales should not be designed to retain water. Construction should be monitored by an engineer who is familiar with bioswale design. Bioswales are some of the last items to be constructed for a project as the soil under bioswales should not be compacted to a high degree. If this soil is compacted during construction, it should be broken up and replanted to help the bioswale infiltrate water and better establish plant growth.

Maintenance of bioswales must be considered. If bioswales are not properly maintained they run the risk of choking and becoming clogged with sediment and trash. If a bioswales becomes clogged it will not infiltrate, evapotransiparte, or slow down stormwater as designed.

Using available data, it appears that bioswales are not only feasible at Fort Leonard Wood, but would also greatly benefit the installation to help meet new stormwater requirements and provide better designed stormwater conveyance methods throughout the installation.

References

See Attachment A

Biofilters: Bioswales, Vegetative Buffers, and Constructed Wetlands for Storm Water Discharge Pollution Removal
http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf

Contract Language Example:
http://www.co.thurston.wa.us/stormwater/woodland/PDFs/Grant%20Agmt%20with%20PA%20and%20WWM%20signature.pdf

Landscape Maintenance Specifications for a Resource Efficient Landscape
http://www.greengardener.org/pdf/LandscapeSpecs.pdf

Pollutant removal efficiencies of bioswales
http://www.illinoisfloods.org/documents/2009_IAFSM_Conference/3C%20Bioswale%20presentation%20IASFM%20Mar%2009.pdf

Diagrams/Photos

See Attachment B

Funding Plan

There are no known tax credits or incentives at Fort Leonard Wood at the time of this report. If the bioswale is constructed as part of a larger building project-as the drainage for the site, then the bioswale can be paid for using **Military Construction (MILCON) funding.**

Contract Language Contracting language should be determined after the final design is submitted and should mirror similar construction contracting language. An example of contracting language for the design and construction of a bioswale is provided in the Reference section of this document.

Product Specifications There are no product specifications outside the final design.

Baseline Relation Bioswales, like green streets and other drainage systems, do not directly affect the water baseline. Bioswales do support cleaning of stormwater runoff which then helps ensure cleaner water reaches nearby waster bodies. Bioswales provide a natural way to reduce pollution and enhance infiltration, reduce stormwater velocities and help reduce river bank erosion.

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Attachment A: Reference Material

Key Terms:

2-yr storm: This is a storm that has a 50% chance of occurring each year. The design of the bioswale should be able to handle this type of storm.

Check Dam: This is a low, fixed structure, constructed of timber, loose rock, masonry, or concrete, to control water flow in an erodible channel or irrigation canal. Typical check dams in bioswales are composed of rip-rap.

Drainage: Drainage is where the water naturally flows.

Drainage Basin: This consists of all the land area sloping toward a particular discharge point.

Erosion: This is the process by which something can be worn away. In this case, we are concerned with the erosion of soil and rock caused by water flow.

Filtration: Filtration is the process by which a liquid, in this case water, is passed through a substance such as soil, which then collects suspended impurities.

Flow Rate: This is the rate or speed for which water moves either above ground or through the ground horizontally.

Gaining Stream: Gaining streams are streams which at least a portion of its flow comes from the water table. These streams are typically distinguished by the fact they have water throughout the year.

Infiltration: Infiltration is the process of water to move vertically through the ground.

Infiltration Factor: This is the speed at which a certain volume of water can infiltrate through a certain type and depth of soil.

Karst System: This is a geological term to describe underlying bedrock which is soluble and is characterized by fissures, caves, underground streams, and sinkholes. Karst systems are typically formed from limestone and sometimes dolomite.

Rip-rap: Broken stones deposited loosely for an engineering purpose such as stabilization or in this case, to slow water flow.

Slope: This is the rate at which a hill moves horizontally verses the movement vertically. This can be described at a ratio, e.g. 3:1 (horizontal movement: vertical movement) or as a percent, e.g. 5% rise.

Slope Stability: Slope stability is the resistance of a slope from changing through slides, creep, or other failure. A more horizontal slope is considered to be more stable.

Swale: A depression in the ground. These can be formed naturally or engineered in order to produce certain results.

General Bioswale Questions:

What are all the benefits to having a bioswale as opposed to a grass swale?

Bioswales are designed with the intent of retaining and infiltrating the water back into the water table. This decreases the amount of sheet flow more than grass swales and helps filtrate out various pollutants in the water. By adjusting the vegetation within the bioswale, it is possible to control specific pollutants from getting into streams and the water table.

How are bioswales affected by karst systems?

The filtration rate of the soil used would control the retention of water and the rate of infiltration into the karst system. It should be determined what rate is needed in order to keep the excess infiltration from degrading the karst system. Other methods of helping to control the rate of infiltration include placing trees or medium to large bushes within the bioswale system, using filter fabric, or placing a subdrain beneath the bioswale to collect the excess water.

When should a slotted drain be used?

If there is an issue with two much water flowing into a bioswale so that it does not drain within 48 hours after a 2-year flood or if there is concern for the amount of flow running through the bedrock, a slotted drain can be used. The slotted drain should be designed to mimic a French drain along the center line of the bioswale. It will then collect the additional water and because it is at a low angle, send the drainage further along the line. It should be noted that a slotted drain will need to have an output location.

What vegetation should be used for the bioswale?

The vegetation best suited for a bioswale are native plants which can withstand both wet and dry periods. Native is often used for the simple reason of they are typically low maintenance.

When should the planting begin after the construction of a bioswale?

Construction should be planned so that the planting portion of the construction of the bioswale occurs in early to late autumn. This allows for some growth to occur prior to the first rain season. Summer should not be used due to the lack of rain and hot weather.

What is involved with a final bioswale design?

There are several components that are going to need to be looked at prior to a final design. Water components include the current drainage and the location of the water table in relation to the location and elevation of the proposed bioswale. They also include the rate of flow and volume to be expected out of the drainage coming into the bioswale. Rock components include the location and condition of the bedrock, particularly in karst system areas. Structure considerations include the design of the bioswale in order to keep the flow within the bioswale low, but not standing. This includes locations of any necessary check dams. Vegetation includes what plants to place in the bioswale for low-maintenance and high-performance. Other information would include the construction documents for this area as it appears the area is not yet completed.

Attachment B: Diagrams & Photos

Photo 1. View of Nebraska Ave facing west from the Minnesota Avenue, Fort Leonard Wood. The track area is located on the mound to the left. - Photo courtesy of USACE, Kansas City District

Photo 2. View facing parking on Michigan; The track area is located to the right. - Photo courtesy of USACE, Kansas City District

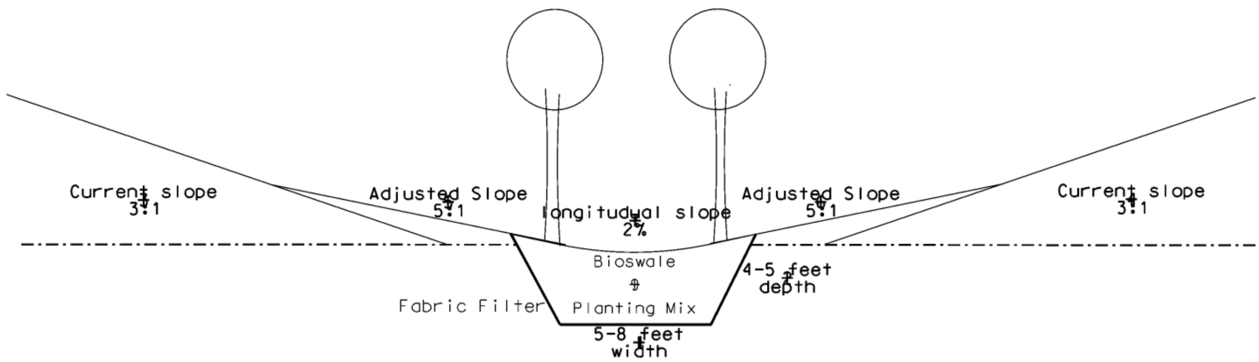

Diagram 1. Section Cut through proposed generic Bioswale - Image courtesy of USACE, Kansas City District

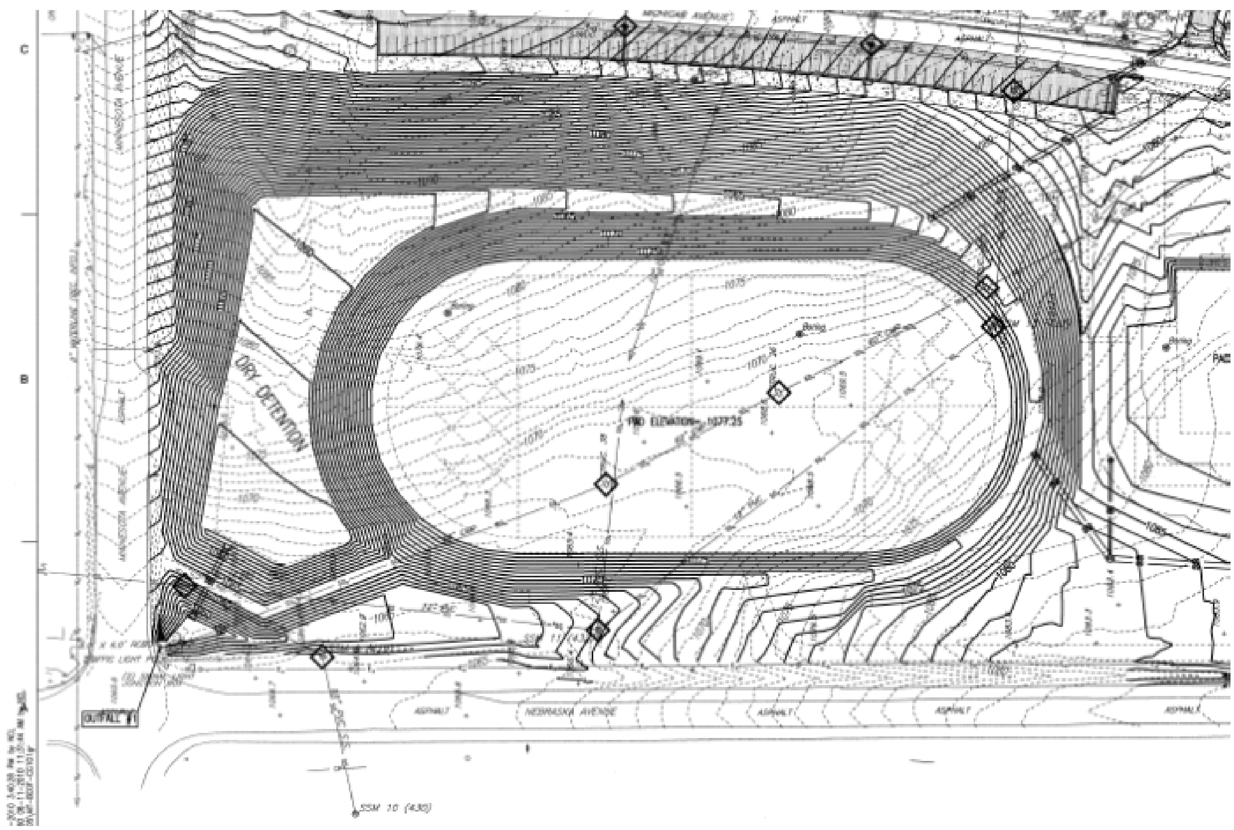

Diagram 2. Proposed LID area at Nebraska Avenue and Minnesota Avenue – Image courtesy of USACE, Kansas City District

US Army Corps of Engineers

2030 USACE Integration Project

8.27 Mass Transit

Recommendation

Fort Leonard Wood (FLW) shall implement a bus system in the near future for the main cantonment area and consider the addition of a light rail as long as the population of trainees maintains or increases over the next ten to twelve years.

The current buses or "cattle cars," that move trainees around should be replaced with hybrid electric or natural gas buses. In time, all high occupancy traffic should be conducted through the use of sustainable transit systems while diesel fueled buses are phased out.

"Park & Ride" locations should be provided off post, but near the Main and West gates that serve a high volume of daily traffic. Alternatives to locations just off post include potential lots at Interstate-44, Exit 156 and 161. The Wal-Mart parking lot off of St. Robert Boulevard should also be considered as an aspect of regional partnering. From a conceptual standpoint, Park & Ride locations need to be placed before bottlenecks occur, such as the daily backup along Missouri Avenue. If placed just outside of the gate, traffic congestion will not be alleviated. Once implemented, bus routes shall be added in phases, with the first two serving the highest density of people at Fort Leonard Wood (FLW): The Maneuver Support Center (MANSCEN) Route and the United States Army Forces Command (FORSCOM) route. On call shuttles will run to housing areas and additional areas not on the main bus lines and take patrons to the nearest transit stop.

Light rail implementation will only be viable after a highly detailed cost to benefit analysis is completed comparing the addition of light rail to an expansion of the bus system. Light rail will be more successful once established and highly used bus lines are being used.

This tech note does not specifically choose what type of bus to use since accurate numbers on use have not been obtained. However, many comparisons and real world examples show compressed natural gas (CNG) buses as a more effective option than hybrid-electric buses.

Location & Scale

This system is implemented at the **installation scale** for the installation. Heavy traffic congestion exists along major thoroughfares and will be eased with a bus system that moves heavy volumes of people to and from similar locations. For example, much of the population enters the installation at the north gate and goes to the processing center, or the FORSCOM area.

Phasing

This system is projected to begin as part of the **2015 Phase**, but must continue to be revamped and expanded every few years. Initial bus lines should be implemented for the highest density areas and additional lines should be created and implemented as the population adjusts to the mass transit network. Bus line implementation should be the focus of **2015 and 2020** with light rail possibilities being introduced at **2025 Phasing**.

Initial Cost

The costs of these systems are as follows:

(1) Hybrid electric bus:	**$500,000**
(1) Natural Gas bus (29 ft):	**$130,000**
(1) Natural Gas bus (40 ft):	**$465,000**
Bus Depot Retrofit:	**$500,000**

Park & Ride Lot Construction (West Gate, 1,000 spaces):

If current crushed aggregate base is appropriate for concrete paving on top, approximate cost would be **$2,100,000**

Park & Ride Lot Acquisition / Construction (Main Gate 1,800 spaces):

Varies on acquisition costs, but existing infrastructure leftover from previous site usage should offset some initial costs. If base course is appropriate for concrete paving on top, approximate cost would be **$3,780,000**

Precast concrete parking structure: **$10,000** per space (2008)

Note that the cost of a precast parking structure is more expensive than laying a concrete parking lot on a previously built on site, and therefore should only be considered if cost analysis proves effective. Additionally, any placement of impervious surfaces should be bound by bioswales for effective rainwater management.

Typically capital in this system would be implemented with **FY15 Operations and Maintenance, Army (OMA) project funds**, and the operations and maintenance costs would be covered by **FY15 and beyond OMA funds.** However, if regional partnerships are made Fort Leonard Wood may avoid high early investment costs by using existing infrastructure (i.e. Wal-Mart's parking lot).

Life Cycle Cost

Varies in accordance with ridership and fluctuating diesel fuel and natural gas prices. High first cost will lengthen payback time, but will be helped with the implementation at a large scale. Reference section has links to articles on private industry, for-profit transit systems that are replacing entire fleets of diesel buses.

Maintenance

Early research indicates that compressed natural gas vehicles have lower maintenance costs than other fuel-powered vehicles and positive comparison is helped by the use of internal combustion engines in CNG buses. Engine oils last longer since they are not contaminated by typical ignition of gasoline or diesel. Operational costs therefore are similar to a fleet of diesel buses and small margins of cost savings are further multiplied by the implementation of a fleet-wide system. The implementation of mass transit systems reduces the volume of traffic and impact on existing road infrastructure, which will reduce maintenance costs.

Feasibility	Fort Leonard Wood operates as a U.S. Army Training and Doctrine Command (TRADOC) installation and therefore must rely on a form of mass transit to move trainees to and from multiple locations. Current bus systems operate on a daily basis to move numerous soldiers across the installation for relatively short distances. Additionally, the current "on call" bus system could be expanded to serve as a model for future wide scale implementation of compressed natural gas buses. The current transit system is committed to burning fossil fuels through the use of low efficiency diesel buses. The implementation of natural gas buses is a fine tuning of an existing, proven, and accepted transit system. The risk associated with this system is relatively high initial costs for new buses and external parking lots with success based on human factors. Therefore, the implementation of these new systems must make it easier for people to get on and off post, and to conduct daily activities that require movement across the installation.
References	See Attachment A http://www1.eere.energy.gov/cleancities/natural_gas_forum_meeting_aug05.html http://www.kaapeli.fi/~tep/projektit/liikenteen_biopolttoaineet/CNGbuses_MythvsFact.pdf http://www.oudaily.com/news/2011/feb/21/cart-adds-green-buses/ http://www.pegasusnews.com/news/2011/jan/26/dart-buses-switch-compressed-natural-gas-2013/
Diagrams	See Attachment B
Funding Plan	The Army Installation Technology Transition Program (ITTP) may fund projects to evaluate effectiveness for possible implementation at other installations. The Enhanced Use Leasing (EUL) Program may offer opportunities for private developers to take advantage of under-utilized real estate on an Army installation, which in this case would be areas for park & ride lots.
Contract Language	This should be similar to existing contracts for bus line capital and maintenance, with an option to lock in a specific price for phased replacement of current buses.
Product Specifications	Various bus companies are providing different models of CNG buses.
Baseline Relation	The implementation of a mass transit network influences many of the goals of the master plan for Fort Leonard Wood. Initially, soldiers and civilians are introduced to "green thinking" through the example that the installation sets by providing greener modes of transportation. Fort Leonard Wood's support of net zero goals makes it easier for patrons on post to modify lifestyles that

collectively make larger impacts. As the transit system immediately reduces the carbon footprint of the installation, Fort Leonard Wood is making its surrounding environment more liveable. As traffic congestion reduces on the installation, the sub-communities become more walk-able which allows the reduction in carbon emissions to grow exponentially. Due to reduced maintenance on the roadways, funding once previously used for repair may be channelled to other roadway improvement as nearby “green streets” and other low impact development strategies are accepted.

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Attachment A: Reference Material

Key Terms:

Compressed natural gas (CNG) is a fossil fuel substitute for gasoline (petrol), diesel, or propane/LPG. Although its combustion does produce greenhouse gases, it is a more environmentally clean alternative to those fuels, and it is much safer than other fuels in the event of a spill (natural gas is lighter than air, and disperses quickly when released). CNG may also be mixed with biogas, produced from landfills or wastewater, which doesn't increase the concentration of carbon in the atmosphere.

CNG is made by compressing natural gas (which is mainly composed of methane [CH_4]), to less than 1% of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 200–248 bar (2900–3600 psi), usually in cylindrical or spherical shapes.

CNG is used in traditional gasoline internal combustion engine cars that have been converted into bi-fuel vehicles (gasoline/CNG). Natural gas vehicles are increasingly used in the Asia-Pacific region, Latin America, Europe, and America due to rising gasoline prices. In response to high fuel prices and environmental concerns, CNG is starting to be used also in tuk-tuks and pickup trucks, transit and school buses, and trains.

Attachment B: 2015 Phase Diagrams

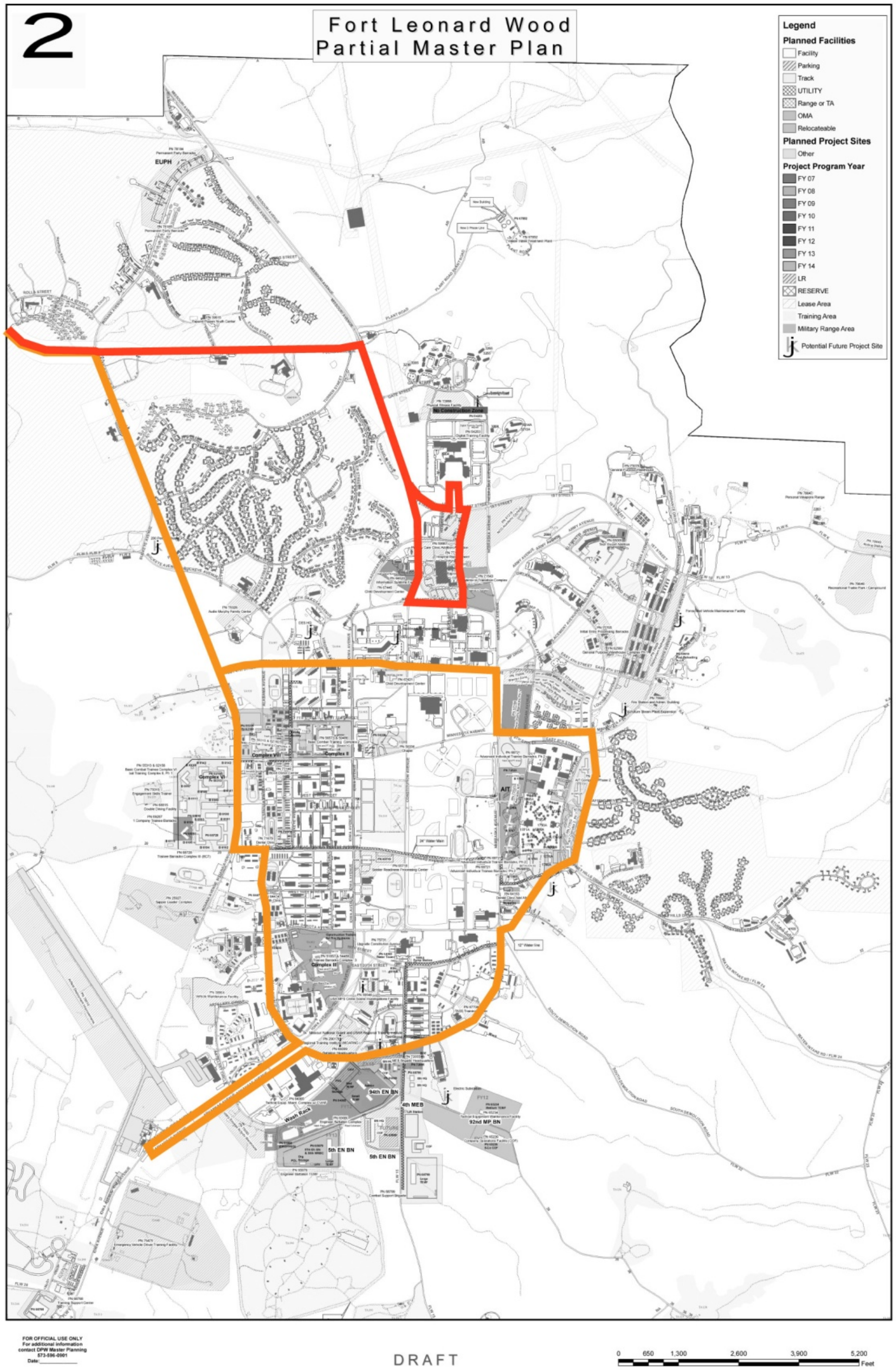

Diagram 1. West Gate to FORSCOM Route - Orange
West Gate to MANSCEN Building Route - Red

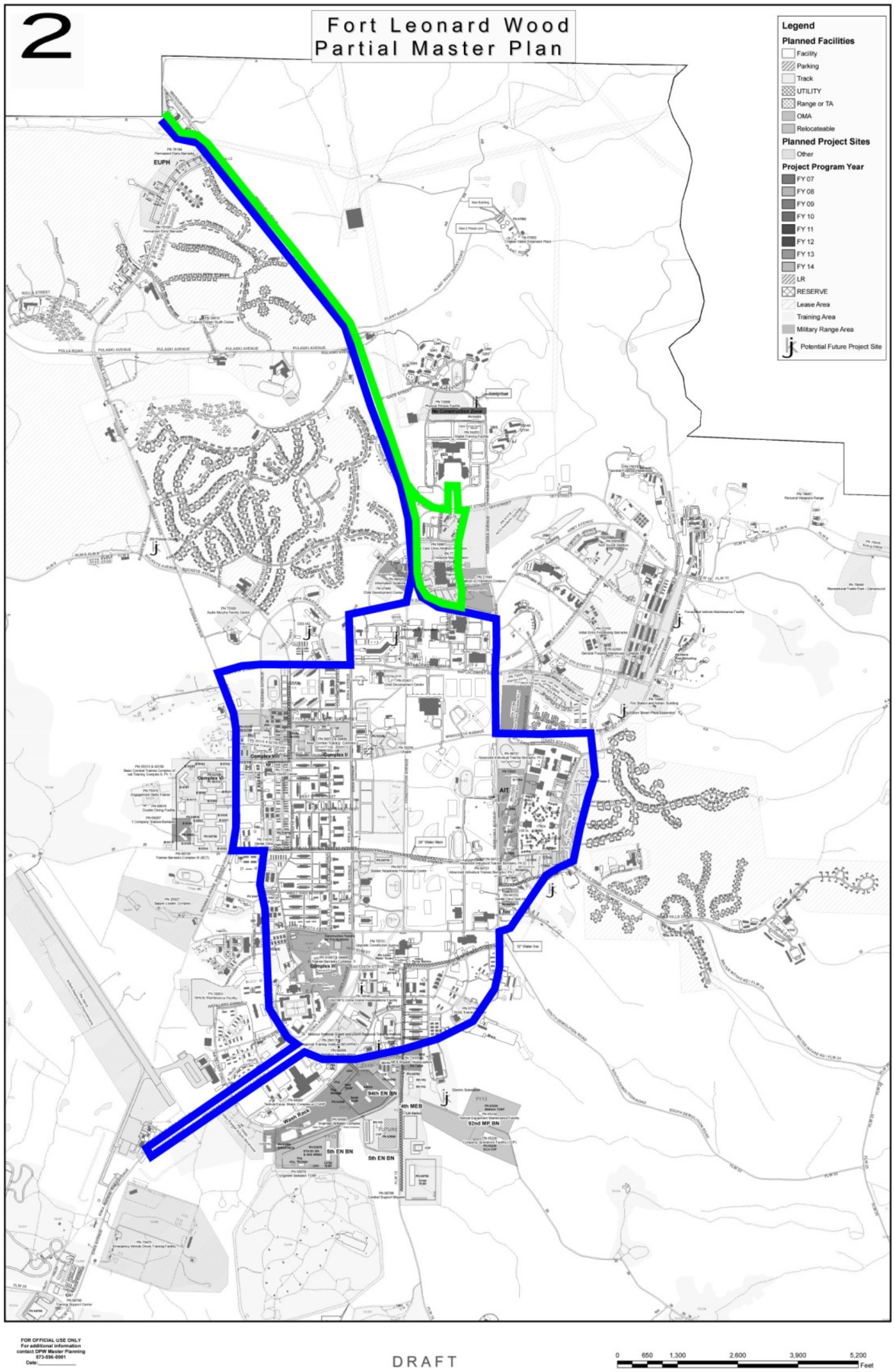

Diagram 2. North Gate to FORSCOM Route – Blue
North Gate to MANSCEN Building Route - Green

Image 1. Possible West Gate Park and Ride Location – Image courtesy of Google Earth (© 2011 Google)

Image 2. Possible West Gate Park and Ride Location at Exit 156 on Interstate 44 – Image courtesy of Google Earth (© 2011 Google)

Image 3. North Gate Park and Ride Location, just outside of main gate – Image courtesy of Google Earth (© 2011 Google)

Image 4. Regional Partnership Opportunities near Exit 161 on Interstate 44 – Image courtesy of Google Earth (© 2011 Google)

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8.28 Nuclear Energy Reactor

nuclear RX

TECHNOTE

Recommendation

Install a modular nuclear reactor to serve the energy needs for all of Fort Leonard Wood (FLW). A single light water reactor system would provide the entire energy capacity to take the installation completely off the commercial power grid.

Location & Scale

This system is implemented at the **installation scale**. The power plant would provide energy for the entire base, with the existing commercial grid in place for plant downtime and maintenance. Fort Leonard Wood, MO would require a plant to produce 71 MWe. (Source: Feasibility of Nuclear Power on U.S. Military Installations, 2010, Table 7)

Phasing

This system is projected as part of the **2020 Phase**. The system could be installed within three to four years, with many models ready to be shipped and assembled. Typical plants are assembled in forty-eight to fifty-four months.

Initial Cost

The cost of a micro-nuclear reactor system ranges in the multi-millions of dollars into the billions, with starting plant cost average around $2,500 per kW and generating cost about $0.08 per kWh. With Fort Leonard Wood's need to produce 71MWe, that would equate to a cost of $177M.

Life Cycle Cost

The reactor life-cycle cost would include: **First Cost ($177 M),** the operating cost which includes a charge of 0.2 cents per kWh to fund the eventual disposal of waste from the reactor and for decommissioning the reactor. The US industry average cost for decommissioning a power plant is **USD $300 million** and the price of Uranium ore contributes approximately 0.05 cents per kWh. Since 1987 the cost of producing electricity from has decreased from 3.63 cents per kWh to 1.68 cents per kWh in 2004. The typical design lifespan of a reactor is 30-40 years, but with proper maintenance can extend well beyond this period. The total life-cycle cost would be equivalent to approximately **$477 M plus the per kWh costs**. The funds for this activity are accumulated in the operating cost of the plant. (Source: http://nuclearinfo.net/Nuclearpower)

Maintenance

Operations and Maintenance expenses are the sum of several components:

- Fixed O&M expenses calculated by multiplying the size of the plant (in kWe) by the fixed O&M factor
- Fuel expenses calculated by multiplying the number of MWh of electricity produced by the fuel cost

- Payments to the nuclear waste fund, which are $1.00 per MWh of electricity produced
- Variable O&M expenses calculated by multiplying the number of MWh of electricity produced by the variable O&M factor.

(Source: Feasibility of Nuclear Power on U.S. Military Installations, 2010)

Feasibility

"Small nuclear power reactors are a feasible alternative for producing energy for military installations. This can be done at competitive rates and with negligible greenhouse gas emission. In addition, there will be improved energy security and reliability... Determining whether it is economically feasible to build a nuclear power plant on a DoD installation depends on the unit cost of the power it will produce. If a nuclear power plant can produce power at the same cost as alternative sources of power, while reducing greenhouse gas emissions and contributing to electric energy assurance, then it's a viable option." (Source: Feasibility of Nuclear Power on U.S. Military Installations, 2010)

References

See Attachments A & C

Diagrams

See Attachment B

Funding Plan

An Energy Bill passed by the US Congress provides production credits of 1.8 cents per kWh for the first 3 years of operation. This subsidy is equivalent to what is paid to Wind Power companies and is designed to encourage new nuclear reactor construction in the USA.

Manufacturers

See Attachment C

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Attachment A:

Feasibility of Nuclear Power on U.S. Military Installations; King, Huntzinger, Nguyen, 2010.

Recognizing nuclear power as a potential benefit to Department of Defense (DoD) facilities, Congress directed the DoD, in section 2845 of the National Defense Authorization Act (NDAA) of 2010, to "conduct a study to assess the feasibility of developing nuclear power plants on military installations" (Source: National Defense Authorization Act for Fiscal Year 2010. U.S. Public Law No. 111-84, section 2845. 111th Cong., 1st Sess., 28 Oct 2009)

Background Information (From: http://nuclearinfo.net/Nuclearpower/WebHomeHowNuclearReactorsWork)

How Nuclear Reactors Work

When an atom undergoes fission it splits into smaller atoms, other particles and releases energy. Read about the physics of fission. It turns out that it is possible to harness the energy of this process on a large enough scale for it to be a viable way of producing energy. Read about how power plants work.

The fundamental point about nuclear energy is that the energy content of 1 gram of Uranium is equivalent to approximately 3 tonnes of coal. This means that we need to consume about **3 million times less** material with Nuclear Power compared to using Coal or any other Fossil Fuel. This substantially reduces the volumes of fuel and waste of nuclear power compared to Fossil Fuels.

The Different Types of Nuclear Reactors

There are a number of different types of Nuclear Reactors currently in operation throughout the world. Some of the most common types are described here.

Pressurized Water Reactors

Pressurized Water Reactors (PWR's) are by far the most common type of Nuclear Reactor deployed to date. Ordinary water is used as both neutron moderators and coolant. In a PWR the water used as moderator and primary coolant is separate to the water used to generate steam and to drive a turbine. In order to efficiently convert the heat produced by the Nuclear Reaction into electricity, the water that moderates the neutron and cools the fuel elements is contained at pressures 150 times greater than atmospheric pressure.

Boiling Water Reactors

In a Boiling Water Reactor (BWR), ordinary light water is used as both a moderator and coolant, like the PWR. However unlike the PWR, in a Boiling Water Reactor there is no separate secondary steam cycle.

The water from the reactor is converted into steam and used to directly drive the generator turbine. These are the second most commonly used types of reactors.

High Temperature Gas Cooled Reactors.

High Temperature gas cooled reactors operate at significantly higher temperatures than PWRs and use a gas as the primary coolant. The nuclear reaction is mostly moderated by carbon. These reactors can achieve significantly higher efficiencies than PWRs but the power output per reactor is limited by the less efficient cooling power of the gas.

Heavy Water Reactors

Heavy Water reactors are similar to PWRs but use water enriched with the deuterium isotope of Hydrogen as the moderator and coolant. This type of water is called "heavy water" and makes up about 0.022 parts per million of water found on Earth. The advantage of using Heavy water as the moderator is that natural, unenriched Uranium can be used to drive the nuclear reactor.

Frequently Asked Questions (From: http://www.whatisnuclear.com/faq)

Q: What can we do with nuclear waste?

A: We can bury all of it, burn most of it as fuel and bury the rest, or send it into space. Option two is our personal favorite. Long-lived high-level nuclear waste is solid ceramic or metal, not green ooze. With proper care, it can be safely buried where it will stay out of our ecosystems.

Q: What's the difference between a nuclear reactor and a bomb?

A: Atoms capable of splitting are never close enough together in a nuclear reactor to release energy as quickly as in a nuclear bomb. Reactors use reactor-grade uranium, whereas bombs use weapons-grade uranium (info on this distinction). Additionally, bombs have chemical explosives designed to compress the weapons-grade uranium into itself. Under no known circumstances in our wildest dreams could a nuclear reactor explode like a nuclear weapon. Note: this doesn't mean a reactor can't physically have an out-of-control power increase resulting in major damage to the reactor building and releases of radiation, as happened in the Chernobyl accident.

But this kind of excursion is honestly very nearly impossible in modern reactors. That's another story.

Q: Is nuclear power renewable?

A: No, but, A renewable resource is one that naturally replenishes itself such as a tree. Cut it down, it will grow back. Use wind up, it will still blow. Uranium is not being produced on Earth so it is technically not renewable. BUT (and this is a big but), the term renewable is often used to convey a resource as sustainable. If we operated nuclear power plants with breeding, or using uranium extracted from the ocean (nearly unlimited, but very expensive), or using Thorium, then nuclear power can easily be considered sustainable.

Q: What's a meltdown?

A: A melt-down occurs when a reactor heats up out so much that the fuel melts. This would happen in accident conditions, when the coolant has stopped flowing. The Three Mile Island accident was a partial melt-down, resulting in an economic loss to the utility company. When fuel melts, the core will shut itself down and will not melt through the earth to China.

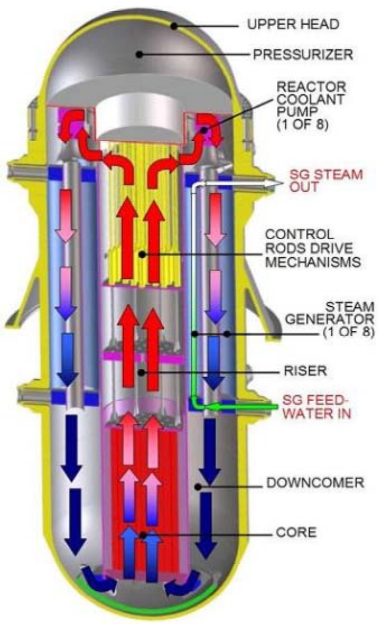
Q: Do radioactive things glow?

A: In general, no. The green ooze stereotype is a fabrication of comics. Most radiation is impossible to detect without special equipment. However, when extremely radioactive material is placed underwater (such as in a nuclear reactor), it makes a blue glow. This is called Cherenkov radiation. It is an optical shockwave, like a sonic-boom, that occurs when charged particles (alpha particles, beta particles, fission products) are emitted faster than the speed of light in a medium. Since light travels through water slower than it does in a vacuum, this does not violate relativity.

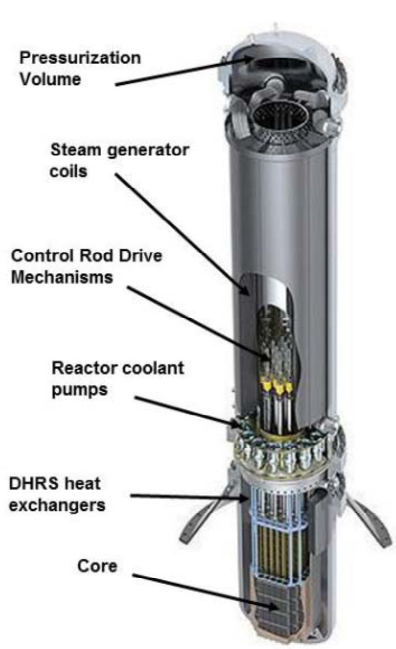
Q: How long does nuclear fuel stay in a reactor?

A: A typical reactor cycle is 12-24 months, after which typically a third of the fuel is replaced with new fuel. Thus, the nuclear fuel stays in the reactor for between 3 and 5 years before it is discharged.

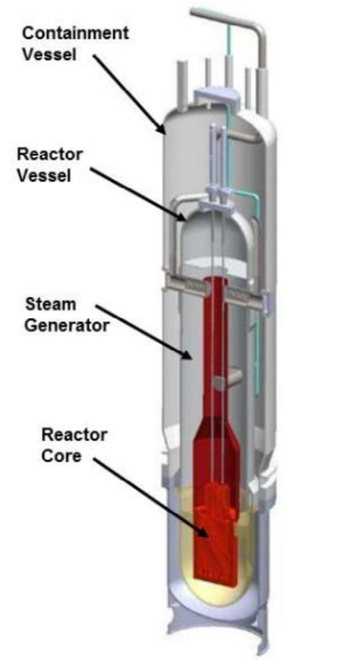
Attachment B: Diagrams



IRIS (Westinghouse)
335 MWe



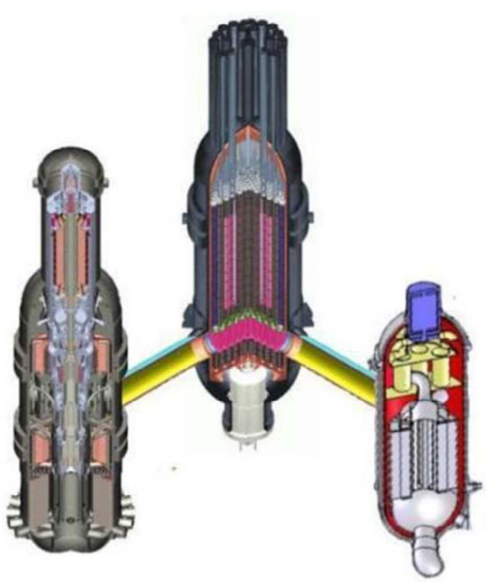
mPower (Babcock & Wilcox)
125 MWe



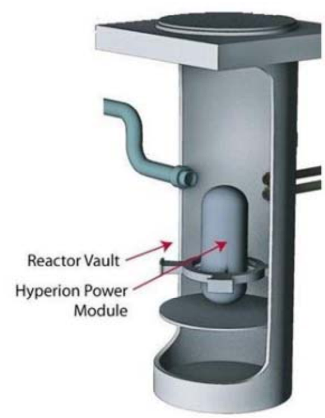
NuScale (NuScale)
45 MWe

Diagram 1. Images adapted from the Feasibility of Nuclear Power on U.S. Military Installations, 2010

PRISM (General Electric)
311 MWe



MHR (General Atomics)
280 MWe



HPM (Hyperion)
25 MWe

Diagram 2. Images adapted from the Feasibility of Nuclear Power on U.S. Military Installations, 2010

Attachment C: Potential Manufacturers

B&W mPower™ Modular Nuclear Reactor	http://www.babcock.com/products/modular_nuclear/
Tagline	a scalable, modular, passively safe, advanced light water reactor system
Specifications	
Electrical Power Capacity	125 MWe TO 750 MWe
Fabrication Location	
Thermal Capacity	
Capacity Factor	
Dimensions	
Weight	
Transportation	
Manufacturing	
Fuel	Pressurized Water Reactor (PWR)
Re-fuel Cycle	4.5 OPERATING CYCLE
Cost	
Technology	
Test Facility	
Licensing	
Initial Operations	2020

NuScale Power	http://www.nuscalepower.com/nr-FAQ-Scalable-Nuclear-Technology.php
Tagline	Safe, modular, scalable nuclear power generation
Specifications	
Electrical Power Capacity	45 MWe
Fabrication Location	USA
Thermal Capacity	160MWt
Capacity Factor	90%
Dimensions	60' x 14' cylindrical vessel
Weight	~300 Tons shipped
Transportation	Barge, truck, train
Manufacturing	Forged and fabricated at mid-size facility
Fuel	LWR fuel in 17x17 configuration, 6' long
Re-fuel Cycle	24-month cycle with fuel enriched at 4.95%
Cost	
Technology	Proven light water (LWR) technology
Test Facility	1/3 scale working model at Oregon State University
Licensing	Requires federal U.S. Nuclear Regulatory Commission to approve Design Certification for reactor and Construction & Operating License prior to construction. Initial pre-application review meeting was held with the NRC in July 2008. NuScale anticipates filing Design Certification application in early 2012.
Initial Operations	NuScale forecasts the first plant can be online producing electricity as early as 2018.

Toshiba Micro Nuclear Reactor	http://www.nextenergynews.com/news1/next-energy-news-toshiba-micro-nuclear-12.17b.html
Tagline	designed to power individual apartment buildings or city blocks
Specifications	
Electrical Power Capacity	200 kW
Fabrication Location	
Thermal Capacity	
Capacity Factor	
Dimensions	20’ x 6’
Weight	
Transportation	
Manufacturing	
Fuel	
Re-fuel Cycle	Up to 40 years
Cost	$0.05 per kW Hr
Technology	
Test Facility	
Licensing	
Initial Operations	Expected to install in Japan 2008

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8.29 Overhead Radiant Heating

Recommendation

Conventional heating systems warm spaces through convection heating, warming and circulating the air within the space. Overhead radiant heaters, also known as infrared (IR) heaters directly heat occupants or objects. In spaces with large volumes or high infiltration loads such as warehouses and vehicle maintenance facilities, radiant heaters are particularly efficient when compared to conventional heating systems. Radiant heaters can be fuelled by natural gas, propane, or electricity.

Location & Scale

This system is implemented at the **building scale**. Gas fired radiant heaters should be installed in buildings with sufficient exhaust air to remove combustion products. Radiant heaters provide inline heat and must be located and positioned so that they are pointing at the occupant/work area that they are heating.

Phasing

This system is projected as part of the **2015 Phase**. It can be pursued for new buildings where the technology provides a benefit over conventional heating systems. Typically, these locations would be buildings with high ceilings or those that open and close exterior doors often such as vehicle maintenance facilities, guard houses, and hangars.

Initial Cost

Radiant heaters are available in different configurations such as ceramic heaters, tube heaters, and patio heaters. Units typically run from **$400-$1,500** depending on the type and capacity of the unit.

Life Cycle Cost

Overhead radiant heaters can reduce heating energy consumption dramatically. Since occupants typically feel warmer at lower ambient air temperatures when heated by radiant heating systems, space thermostats can be lowered and ventilation air can be brought in a lower temperatures. Since radiant heaters do not heat the air, less energy is lost when loading dock or roll-up doors are opened. Radiant heaters reduce fan energy consumption by eliminating the need to circulate air, although ventilation air is still required.

Radiant heaters were installed in three large facilities including a hangar at Little Rock AFB, replacing the conventional heating systems. Following the retrofit, average natural gas consumption during the winter dropped forty-four percent in these buildings. This installation has a projected payback of six years.

Maintenance

Each radiant heating unit would need to be maintained as directed by the manufacturer. Typically, units would be serviced annually to ensure continued operation.

Feasibility Overhead radiant heating units would typically be included as a design feature in new buildings, or installed as a retrofit in existing buildings to replace conventional air heating systems. The greatest benefit would be realized by installing radiant heating units in buildings or spaces that have high ceilings or a high infiltration heating load such as vehicle maintenance facilities, loading docks, and access control points. The technology is proven and has been in use for several decades.

References *Air Force Civil Engineer.* Vol. 16 No. 3. Accessed July 12 2011. http://www.afcesa.af.mil/shared/media/document/AFD-081024-034.pdf

High Performance Technology Strategy Templates (Rev. 0, 10-31-2010)

Funding Plan Enhanced commissioning can be included as a project requirement on design build projects. The commissioning authority may not be an employee of the design or construction firm and must report directly to the government. On design-bid-build projects, getting a commissioning authority on board is more difficult since the same commissioning authority must serve throughout the life of the project, starting before design begins and continuing through the first year of building occupancy.

Contract Language Guide specifications for radiant heaters can be found in the Unified Facilities Guide Specification (UFGS) sections 23 82 00.00 20 Terminal Heating and Cooling Units, and 23 54 16.00 10 Heating System, Gas-Fired Heaters.

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US Army Corps of Engineers

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8.30 Pedestrian Zones

TECHNOTE pedestrian zone

Recommendation

Design a network of sidewalks that create efficient, walk-able pathways. Reclaim streets to minimize traffic and allow pedestrian access. These areas should have a sense of shade and enclosure. This can be done by simply roping off an existing street which stops traffic, but allows for emergency vehicle access and planting trees for shade, stormwater mitigation, and environmental cooling.

Pedestrian zones will be developed in three major areas of renovation or new construction:

- Each new residential development will be designed around a pedestrian zone that links to a larger network of pedestrian paths which then lead to community amenities such as dining halls and barber shops for the soldiers-in-training, or the community gardens, schools, and the Post Exchange (PX) for enlisted soldiers and their families.
- A pedestrian zone will be incorporated into the design of the urban park along the stormwater overflow stream that runs from the southwest to the northeast of the central tracks and playing fields.
- Michigan Avenue and Cooley Avenue will be closed and turned into pedestrian zones as part of the development of the current AIT site. West 6th, West 7th, West 11th, West 12th, West 16th will be converted into pedestrian zones as part of the BT Complex development. Minnesota Avenue will be made into a pedestrian zone as part of the Urban Park Development. Any time an existing vehicular corridor is converted to a pedestrian only zone, some permeable pavement will exist for appropriate maintenance and emergency access.

Location & Scale

This technology is implemented at the **installation scale**.

Phasing

Pedestrian zones should be considered as part of every construction project. Pedestrian zones related to the Basic Combat Training (BT) and Advanced Individual Training (AIT) should be constructed as part of the **2015 Phase**. The pedestrian zone of Minnesota Avenue should be part of the development of the Urban Park (Phase 2). By Phase 2, the installation should have a plan of proposed new site for future expansion that includes a cohesive network of pedestrian zones and supporting pathways.

Initial Cost

Initial cost of **$30,000 per mile** should be included as part of the overall project site plan.

Life Cycle Cost	Similar in cost to existing streets. These may last longer as pedestrian traffic causes less wear and tear on hardstand than vehicles.
Maintenance	Similar in cost to street maintenance. Native plants used to absorb stormwater may require some additional maintenance. Trash collection may be required.
References	"Bicycle and Pedestrian Ways". *St. Charles, Illinois Department of Traffic and Transportation.* http://www.ci.st-charles.il.us/departments/publicworks/TrafficAndTransportation/bicycleetc.html
Funding Plan	This should be funded by and incorporated into each building project as site development.
Contract Language	A pedestrian zone shall provide a link between major amenities for each relevant residential group. Soldiers-in-training should have access to a pedestrian zone that links them to a dining facility, a barber shop, a fitness facility, and running track. Permanent party soldiers and their families should have access to a pedestrian zone that links them to a playground, a sandwich and coffee shop, a convenience grocery, a commissary, or a PX.
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US Army Corps of Engineers

2030 USACE Integration Project

8.31 Performance Management System

performance management

TECHNOTE

Recommendation

Minimizing an installation's load is an essential first step toward net zero energy status. Load minimization can be accomplished through personnel actions to conserve energy or reduce energy waste, or by identifying approaches to conserve energy without impacting the installation's mission. This also includes the implementation of standard facility energy efficiency technologies to the extent that is economically feasible. These may include heating, ventilating, and air conditioning (HVAC) and lighting upgrades (efficient chillers and boilers, solar ventilation preheat, fluorescent or light-emitting diode [LED] lighting); environmental control systems; plug load reductions; systems generating both electricity and heat (cogeneration systems) where both forms of energy are needed; and building envelope upgrades or design features such as insulation, high-performance windows, and daylighting.

At Fort Leonard Wood (FLW), a performance management system with a proven track record should be deployed installation-wide, minimizing load *before* planning capital-intensive infrastructure design, alternative energy source development, and transmission improvements. Environmental Protection Agency (EPA) / Department of Energy (DOE) Energy Star Portfolio Manager (ESPM), an interactive energy management tool, allows tracking and assessment of energy and water consumption across an entire portfolio of buildings in a secure online environment. ESPM helps set investment priorities, identify under-performing buildings, and verify efficiency improvements, ultimately helping the installation receive recognition for superior / net zero performance. Coordination and data interchange is necessary with the Directorate of Public Works (DPW) and the Base Utility Monitoring and Control System (UMCS).

An ESPM program should be supplemented by an operations and maintenance (O&M)-specific Computerized Maintenance Management System (CMMS), of which many are available. The Dashboard tech note covers possible programs that may have benefits at the installation by offering desired LEED EBOM and maintenance capabilities, but will require licensing for internal use by Army installations. In today's business atmosphere of downsizing and reducing capital expenditures, BIO&M enables feasible opportunities for energy-efficient building operation, with task / role based management of LEED Online certification, as-built document management, and ongoing web-based building O&M.

Location & Scale

These systems are implemented at the **building scale**, but are intended for aggregation of buildings into a portfolio(s) for iterative / group management at the organizational level.

Phasing

Scope for this recommendation (Figure 1, Attachment A) includes 'Optimal Energy Strategy via behavioural change and energy efficiency', and most components of 'Project Implementation'. This system is projected as part of the **2015 Phase,** though a functional portfolio will likely take until **2020** to reach full effectiveness. More nuanced phasing, by objective, should be executed per categorical objectives and steps identified in Attachment B - ENERGY STAR® Energy Management Assessment.

Initial Cost

While ESPM is basically free, enhanced contract requirements for installation of best-available Energy Star appliances & smart metering equipment will be significant. Assume a **45-55%** increase in equipment procurement costs in addition to a 15% increase in equipment installation costs, for inclusion of Building Point of Connection (BPOC) and configuration of Direct Digital Controllers (DDC). Refer to Energy Star's Purchasing & Procurement for detailed pricing and sourcing information, vs. requirements, for relevant equipment types. Until this level of equipment becomes standard in acquisition contracts, however, funding must be worked out on a project by project basis. Ideally, general Garrison funds will be set aside to subsidize the transition process.

For BIO&M, the vendor currently offers the suite under a 'software-as-a-service' model, providing computing infrastructure / data hosting *for* the customer, at a price of $3500/building, $250/month. With an internal-licensing agreement, the cost of this system is dependent on the total number of buildings it will be used to manage. Initial estimates put BIO&M cost at **$4 million**, or **$10,000 per building**, for 400+ new or renovated buildings at Fort Leonard Wood. Once an internal use license agreement is arranged, the cost per building will decrease significantly, as buildings beyond the initial (400) threshold are incorporated into and leverage the system.

Life Cycle Cost

Per Life Cycle Costs Analysis in Attachment A, a Dedicated Performance Team (DPT) will cost **$550,000/yr**, or **$8.3 million** (ex. inflation), over a fifteen-year period. For information technology (IT) troubleshooting and maintenance specific to the DPT, case-by-case contracted IT support is the preferred support option, due to limited front-end ESPM-BIO&M-UMCS Monitoring & Control (M&C) complexity, and limited projected support hours. Life cycle cost for contracted IT support range from **$105,000-$420,000** over a fifteen-year period.

Data acquisition by construction project managers and hand-off to + entry into ESPM and BIO&M systems by engineering technicians will cost $17,600 per building, $470,000/yr, or **$7 million** total for currently planned development.

Training and equipment modernization for systems and maintenance teams (SMTs) will scale up to **$1.1 million** total over the first five years (2015-2020). Including recurring training and equipment replacement, additional Systems & Maintenance Team (SMT) life cycle costs amount to **$2.3 million**.

Costs for coordination between the DPT, Building Data Acquisition & Management Teams (BDAMs), and SMTs total **$51,000/yr** (.05 x ($550,000/yr+$470,000/yr)), or **$765,000** total over a fifteen year period.

Total costs over the fifteen year project period are **$18.7 million** (ex inflation).

Maintenance

Ongoing costs are concurrent with Garrison information systems infrastructure overhead, specifically DPW's UMCS system and network support. Participation in these systems typically requires a three to five percent IS overhead charge for owners / operators not already participating. Ongoing human capital costs are outlined in Figure 1 (Attachment A) to include qualified smart metering systems and equipment-certified technicians. On-site maintenance will likely require increased intervals for the first three to five years until system flaws, best practices, and optimal automation have all been addressed by the DPT, in coordination with the SMTs.

Feasibility

With fifteen-year costs totaling $18.5 million, ESPM and BIO&M-specific savings through reduced personal property consumption, installed building equipment consumption, and O&M process / action improvements must necessarily meet or exceed this threshold over the entire projected program period.

Reduced Personal Property Consumption:

Using Energy Star's Life Cycle Cost Estimate Calculator, assuming 4 appliances (washer, dryer, dishwasher, refrigerator) and 1 water heater, per 4 semi-permanent/permanent personnel (1 appliance/personnel *90,000*0.85 semi-perm anent personnel*0.85 compliance rate = 65,000 ES-rated appliances), gives an estimated $4.2 million annual savings and $20 million life cycle savings every 11-year replacement cycle (**1.36 cycles in the 15-year program**). To account for a phased 2015-2020 deployment, savings for the first 11-year cycle have been reduced by 20% (0.8*$20 million/cycle=$16 million). Total adjusted personal property demand reduction savings amount to **$23.2 million** ($16 million+$20 million*0.36), or **$1.5 million/year**.

Reduced Installed Building Equipment Consumption:

Energy Star cites common energy, emissions, and waste reduction goals of 25% for typical ESPM programs. Given Fort Leonard Wood's monthly electricity costs averaging $2 million, 85% of loads from buildings, 75% of building loads from installed building equipment (HVAC, lighting, etc.), and a 25% load reduction, permanent systems savings total **$3.8 million/yr**, or **$58 million** over a fifteen year period.

O&M Process/Action Improvements:

With BIO&M, senior managers and building owners can focus on maximizing return on investment in asset management and O&M staffing. Optimizing O&M strategies for keeping expensive building equipment and systems operating efficiently reduces the risk of early equipment failure, unscheduled down time, high utility costs, and tenant losses. Itemized savings include:

- Paperwork Reduction (35% savings on ongoing O&M admin supplies & communication costs)
- Enhanced Information Management (10% reduction in required DPT & BDAM work hrs)
- Improved Coordination (10% reduction in ongoing DPT-BDAM-SMTs costs)

- Proactive vs. Reactive O&M Practices (25% reduction in headline O&M operating costs)
- Catastrophic Damage Reduction
  - 15% potential for severe operator-error or cumulative neglect systems / equipment damage in a 15-year period (1%/operating yr)
  - Non-managed damage potential = approximately $13 million/yr (0.01/yr*$200 million in hard systems-equipment investment + critical operations value/15 yrs)
  - DPT efforts & SMT training / equipment reduce risk by 50%
  - Managed damage potential = $6.5 million/yr (0.5*$13 million/yr)
  - **Damage Risk reduction savings = $6.5 million/yr**

This focus increases opportunities for energy managers, facility managers, and property managers to demonstrate the relevance of energy-efficient building operation. Clearly defining O&M goals and objectives and communicating to senior management how O&M fits into the "big picture" increases management's awareness and support for the O&M department's efforts.

Combined Life Cycle Returns:

While idealized and generalized to a large degree in these cost models, savings through reduced loads, risks, and process improvements have the potential for **$13.5 million/yr** in reduced or avoided costs. Given that these savings will decline over the fifteen year project frame, as the baseline improves, a total values calculation should discount yearly savings by five percent per year, after subtracting recommended annual upkeep expenses from expected annual benefits. Resulting total values from recommendations herein amount to **$132 million** over fifteen years (($13.5 million/yr-$1.2 million/yr), 15 years, 5%/yr decay), or **$8.8 million/yr**. A repayment period of **2.12 years** is projected ($18.7 million all capital investments + operations / $8.8 million/yr benefits), *assuming the project is fully executed with consistent strategy, funding, and operations*.

References

See Attachment A

National Energy Renewable Laboratory (NREL) Net Zero Site Energy measurement approach: Energy used by the installation is accounted for at the site, for example, as indicated by building electricity and gas meters. This approach is generally straightforward, but omits transmission losses to bring energy to the site.

National Energy Renewable Laboratory (NREL). *Net Zero Energy Military Installations: A Guide to Assessment and Planning*. pp 6-7.

NREL Net Zero Source Energy measurement approach: Source energy refers to the primary energy used to generate and deliver the energy to the site, for example, by a local utility generation site and transmission system. For transportation fuel, source energy would include a multiplier to account for the energy required to transport the fuel to the fueling station.

See http://www.cmmsglobal.com/cmms-success.htm for a list of CMMS products and case studies.

- National Renewable Energy Laboratory (NREL) *Net Zero Energy Military Installations: A Guide to Assessment and Planning* http://www.nrel.gov/docs/fy10osti/48876.pdf

- ERDC/CERL TR-03-23: *Process Optimization Assessment Fort Leonard Wood, MO and Fort Carson, CO*, November, 2003

- Energy Star Portfolio Manager Tour https://www.energystar.gov/istar/pmpam/help/Portfolio%20Manager%20Tour/Portfolio_Manager_Tour.htm

- Energy Star Tools & Resources http://www.energystar.gov/index.cfm?c=tools_resources.bus_energy_management_tools_resources

- Energy Star web-based Training Resources (free) http://www.energystar.gov/index.cfm?c=business.bus_internet_presentations

- Fort Leonard Wood Installation Design Guide, S.6 (Energy), S.7 (Mechanical), S11.10 (1.1-1.3) (DDC & UMCS Specifications)

- Green Building Services Building Insights O+M Track Overview http://www.greenbuildingservices.com/Services/software.asp

- EPA & DOE "*15 O&M Best Practices*" http://www.energystar.gov/ia/business/15best.pdf

- AR 415-15 Army Military Construction Program Development and Execution

- AR 420-10 Management of Installation Directorates of Public Works

- AR 420-70 Buildings and Structures

- TM 5-600 (Series) Preventive Maintenance and Repair Series

- Energy Star General Procurement Language http://www.energystar.gov/index.cfm?c=bulk_purchasing.pr_proc_generic

Product Specifications The Whole Building Design Guide (WBDG) website contains the Unified Facilities Guide Specifications (UFGS) for use in specifying the construction guidelines for the military and the USACE. Design specifications applicable to the installation of the proposed *Energy Demand Management and Control System* include ANSI standard 709.1 communications protocol, and:

- DDC guide specification UFGS 23 09 23 (previously UFGS 15951): Direct Digital Control for HVAC and Other Building Systems

- UMCS guide specification UFGS 25 10 10 (previously UFGS 13801): Utility Monitoring and Control System (UMCS)

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Produced as part of the 2030 USACE Integration Project

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Attachment A:

Life Cycle Costs Analysis

O&M Performance & Portfolio Management

- *Dedicated Performance Team*
  - Monitors, evaluates, & proactively improves metering/tracking/tasking systems & methodology
  - Ensures active portfolio and O&M management, in accordance with organizational energy-performance policy & guidance
  - 1 O&M Manager / Supervisor ($120/hr)
  - 1 Admin / IT Support / DPW Liaison ($50/hr)
  - 3 Engineering / Systems Specialists @ 0.33 FTE each ($100/hr)
  - Team training & ramp-up
    - 80 hrs*5 members * $270/hr DPT burdened rate = **$108,000**
  - Ongoing DPT Expenses (DPT Burdened)
  - (120+50+100)/hr*2000hrs/yr = **$540,000/yr**
  - Recurrent Training
    - 1 day/quarter = 32 hrs/yr*270/hr = **$8,600/yr**
  - Building Data Acquisition & Management
    - 2 USACE / Design Firm & DPW PMs ($100/hr)
    - 2 Engineering / Data Technicians ($60/hr)
    - 80 PM hrs*$100/hr + 160 Tech hrs*$60/hr = $17,600/Building*400 Buildings = **$7,040,000**
  - Coordination w/ SMTs, costs*1.05

IT Equipment & Support

- *Computing Resources*
  - Additional workstations & supporting infrastructure
  - $2000*(3) DPT FTEs*15 yrs/3 yr replacement intervals = **$30,000**
  - Supporting IT infrastructure = 1.05*DPT Burdened ($504,000/yr) = **$25,000/yr**

- *Contracted IT Support*
  - $20/hr*1.1 travel overhead*1.15 system & problem familiarization*1.35 operator profit margin = **$34/hr**
  - Support cost range:
    - 200hrs/yr*$34/hr = **$6,800/yr**
    - 800hrs/yr*$34/hr = **$27,000/yr**

- *Dedicated IT Personnel*
  - 10 hrs system specific training w/system trainer = 8hrs*2 personnel*$50/hr burdened cost = $500/wk = **$26,000/yr**

- *IT Coordination (all options)*
  - 1.05*Recurring IT Expenses

Systems & Maintenance Personnel

- *Maintenance Modernization Program*

- Initial Training Cost Model
  - 1 O&M Manager ($120/hr)
  - 3 Systems-level Technicians ($100/hr)
  - 8 Maintenance Personnel ($30/hr)
  - = 1 SMT / 3000 Installation personnel (Brigade) @ $660/hr
- Fort Leonard Wood = 90,000/3,000*$660/hr burdened*40 hrs = **$792,000**
- Recurrent Training
  - 1 day/quarter = 32 hrs/yr*$660/hr = $21,000/yr * 10 yrs = **$210,000**
- Equipment Modernization
  - Budget for new/improved maintenance equipment recommended for advanced appliances & metering systems
  - $10,000/SMT*30 teams = **$300,000**
  - Equipment Replacement
    - $300,000*10yrs/3 yr replacement intervals = **$1,000,000**

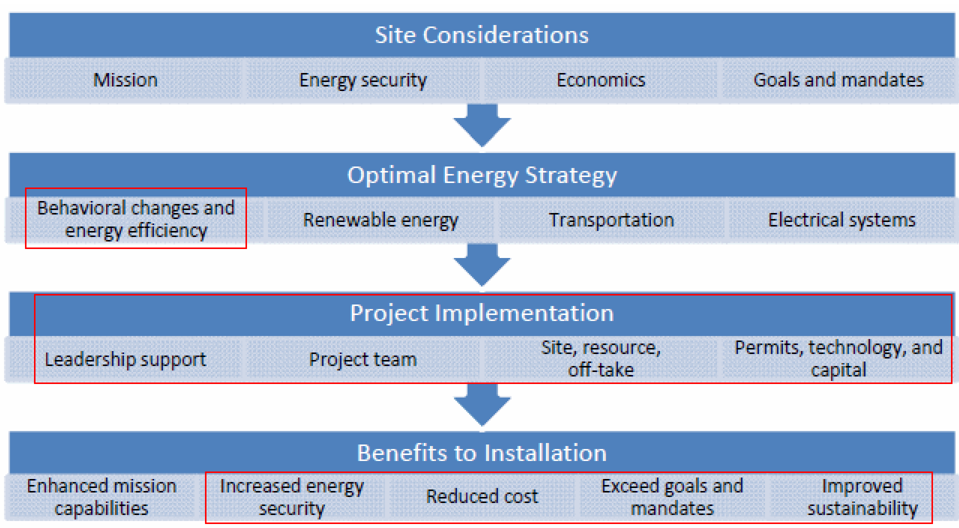


Figure 1. Net zero energy strategy, implementation, & benefits scope – Image adapted from the National Renewable Energy Laboratory

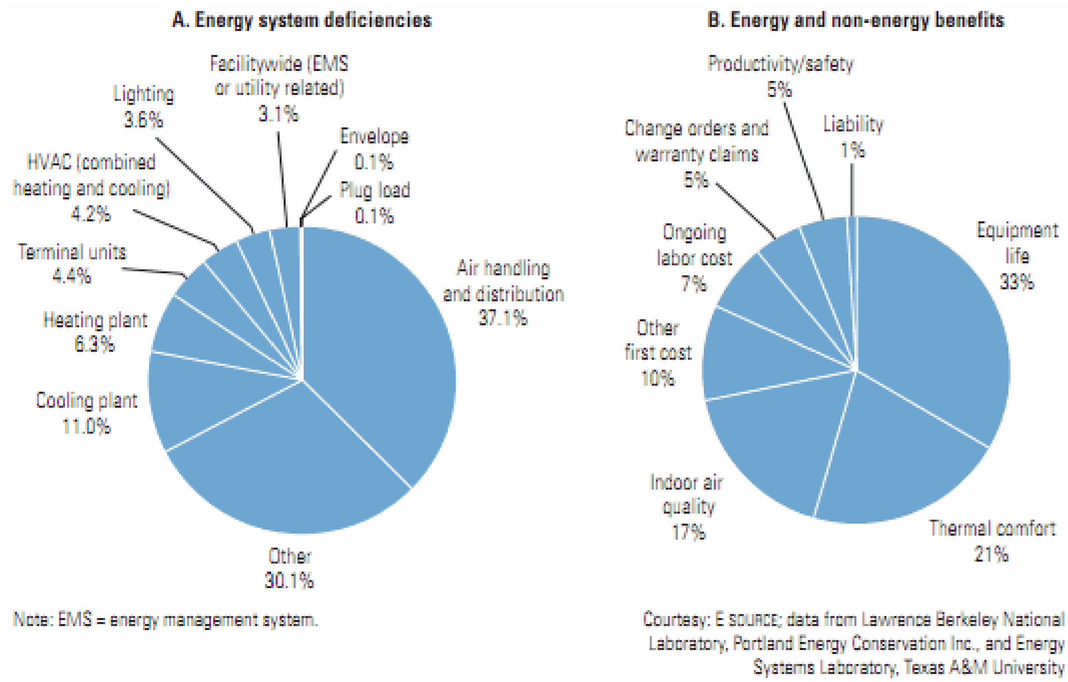
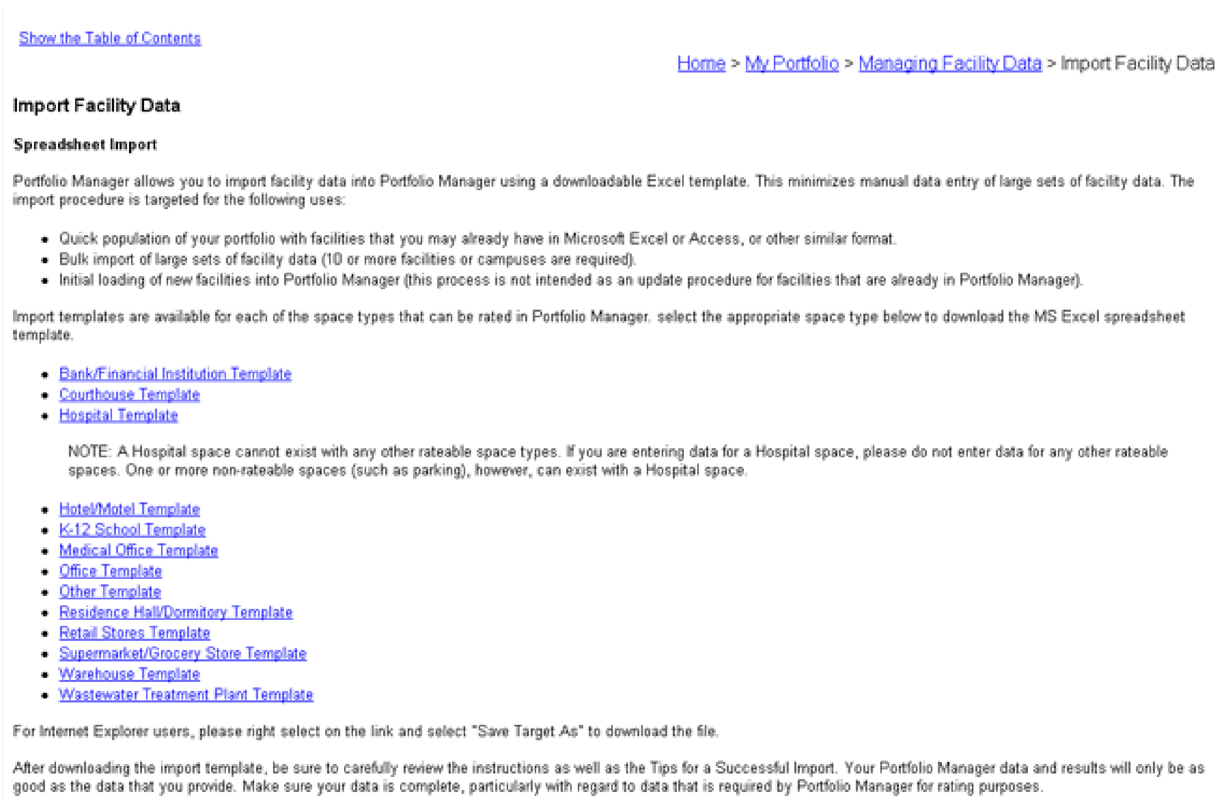


Figure 2. Common Energy Star Program performance outcomes – Charts courtesy of the US Environmental Protection Agency, Energy Star program



Show the Table of Contents

Home > My Portfolio > Managing Facility Data > Import Facility Data

Import Facility Data

Spreadsheet Import

Portfolio Manager allows you to import facility data into Portfolio Manager using a downloadable Excel template. This minimizes manual data entry of large sets of facility data. The import procedure is targeted for the following uses:

- Quick population of your portfolio with facilities that you may already have in Microsoft Excel or Access, or other similar format.
- Bulk import of large sets of facility data (10 or more facilities or campuses are required).
- Initial loading of new facilities into Portfolio Manager (this process is not intended as an update procedure for facilities that are already in Portfolio Manager).

Import templates are available for each of the space types that can be rated in Portfolio Manager. select the appropriate space type below to download the MS Excel spreadsheet template.

- Bank/Financial Institution Template
- Courthouse Template
- Hospital Template

  NOTE: A Hospital space cannot exist with any other rateable space types. If you are entering data for a Hospital space, please do not enter data for any other rateable spaces. One or more non-rateable spaces (such as parking), however, can exist with a Hospital space.

- Hotel/Motel Template
- K-12 School Template
- Medical Office Template
- Office Template
- Other Template
- Residence Hall/Dormitory Template
- Retail Stores Template
- Supermarket/Grocery Store Template
- Warehouse Template
- Wastewater Treatment Plant Template

For Internet Explorer users, please right select on the link and select "Save Target As" to download the file.

After downloading the import template, be sure to carefully review the instructions as well as the Tips for a Successful Import. Your Portfolio Manager data and results will only be as good as the data that you provide. Make sure your data is complete, particularly with regard to data that is required by Portfolio Manager for rating purposes.

Figure 3. Importing Facility Data into ESPM - Image courtesy of the US Department of Energy, Energy Star

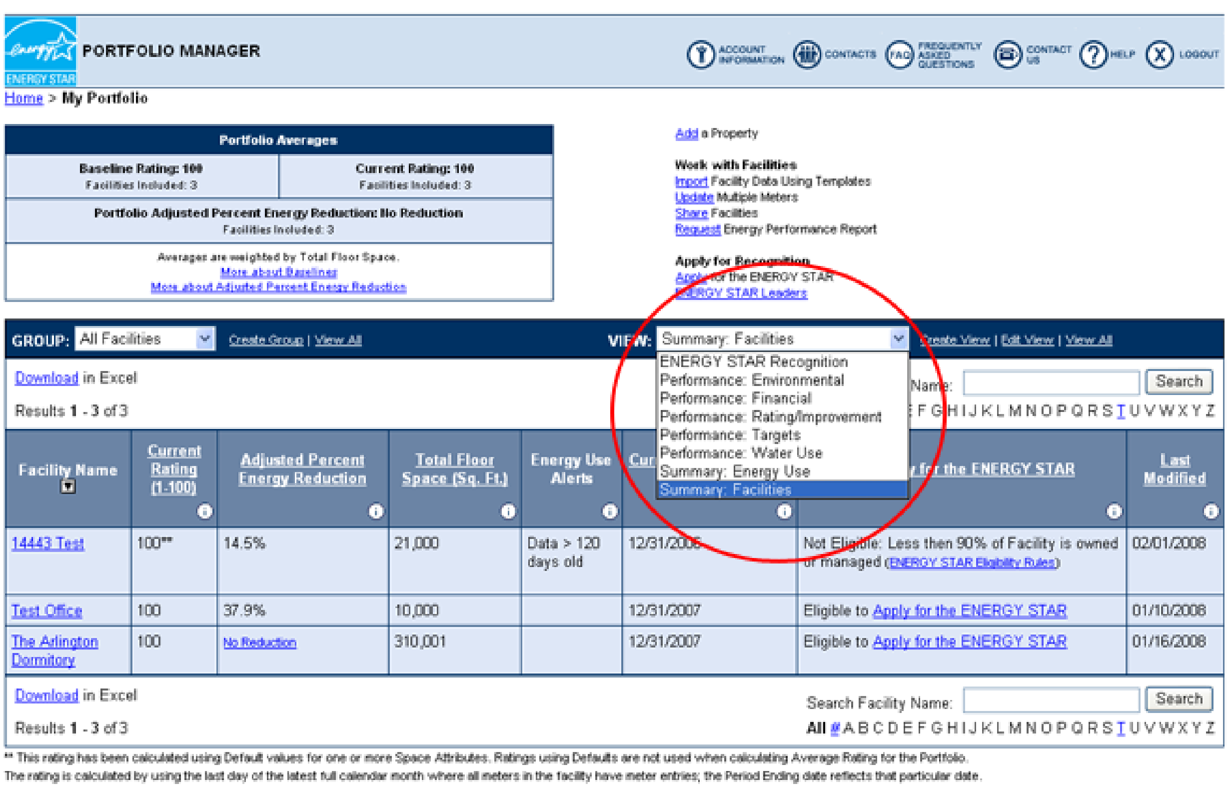


Figure 4. ESPM Portfolio Management - Image courtesy of the US Department of Energy, Energy Star

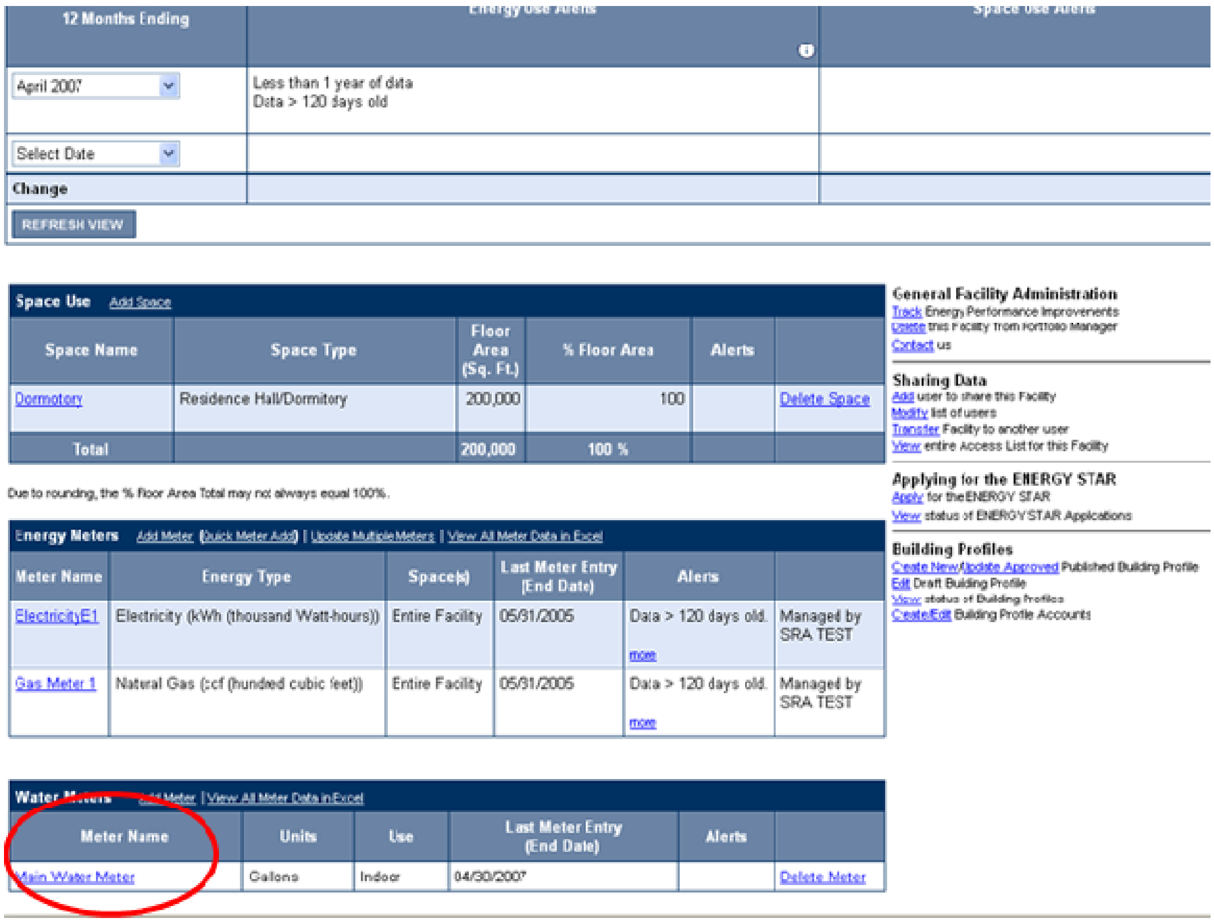


Figure 5. ESPM Metering Configuration & Management - Image courtesy of the US Department of Energy, Energy Star

Attachment B: Energy Star Energy Management Assessment

ENERGY STAR® Facility Energy Management Assessment Matrix

Facility Name:	Fort Leonard Wood	Assessment Date:	2/27/2011	
	Little or no evidence	**Some elements/degree**	**Fully implemented**	**Next Steps**
Commit to Continuous Improvement				
Site Energy Leader	None assigned.	Assigned responsibilities but not empowered. 20-40% of time is devoted to energy.	Recognized and empowered leader having site manager and senior energy manager support.	Assign an NCO site energy leader, 25% FTE
Site Energy Champion	None identified.	Senior manager implicitly supports the energy program.	Senior manager actively supports the energy program and promotes energy efficiency in all aspects of site operations.	Identify & cultivate a ranking officer or respected civilian, w/ an energy background, & established ties to installation management & culture.
Site Energy Team	No site energy team.	Informal organization with sporadic activity.	Active cross-functional team guiding site energy program.	Formalize & establish a vanguard Site Energy Team. Empower w/ capabilities & opportunities for training & collaborating w/ complementary teams.
Energy Policy	No energy policy or awareness of organizational policy.	Organizational policy in place. Little awareness by site energy team and limited application of policy.	Organizational policy supported at site level. All employees aware of goals and responsibilities.	Allocate additional funding & communications emphasis on 2030 Energy Policy.
Site Energy Plan	No written plan.	Informal plan not widely known.	Written formal plan endorsed, distributed, and verified.	Fund & task creation of a formal written plan, w/ follow-through on commander endorsement, distribution.
Accountability	No energy budgeting and accountability.	Estimates used for allocating energy budgets.	Key users are metered separately. Each entity has total accountability for their energy use.	Deploy smart metering test/pilots on as many representative sites as funding allows. Test pilot incentive programs, leveraging findings from test site projects. Formalize & standardize successful programs.
Participation Levels	No reporting of energy performance data internally or involvement in external organizations.	Some participation, sharing, mentoring, and professional memberships. Annual reporting of performance.	Participates in energy network/organizations. Shares best practices/mentors other sites. Reports usage quarterly.	
Assess Performance and Opportunities				
Track & Analyze Data	Limited metering or tracking. No demand analysis or billing evaluation.	Some metering, tracking, analyzing, and reporting. Energy bills verified for accuracy.	Key loads metered, tracked, analyzed, and reported. Facility peak demand analyzed. Adjusts for real-time demand.	Deploy smart metering test/pilots on as many representative sites as funding allows. Ensure data collection employs best industry methods for precision & accuracy, in an interoperable format, w/ continous O&M database logging.
Documentation	No manuals, plans, designs, drawings, specs, etc. for building and equipment available.	Some documentation and records available. Some review of equipment commissioning specs conducted.	Critical building and equipment documentation available and used for load surveys/recommissioning/efficiency goals.	
Benchmarking	Energy performance of systems and facilities not benchmarked.	Limited comparisons of specific functions, or only same-site historical comparisons.	Key systems/sites benchmarked using comparison tools like Portfolio Manager/Energy Performance Indicators.	Scope, fund, & implement Energy Star Portfolio Manager, or other performance mgmt platforms, as appropriate. Survey & identify PM platforms with successful case studies.
Technical Assessments	No formal or external reviews.	Limited review by vendors, location, or organizational and corporate energy managers.	Extensive regular reviews by multi-functional team of internal and external professionals. Full assessment every 5 years.	
Best Practices	None identified.	Ad hoc or infrequent monitoring of trade journals, internal databases, and other facilities' best practices.	Regular monitoring of trade journals, internal databases, and other facilities. Best practices shared and implemented.	Link Engineer training & personal development w/ structured continuing professional development program(s), w/ associated best practices research & communications work.
Set Performance Goals				
Goals/Potential	Energy reduction goals not established.	Loosely defined. Little awareness of energy goals by others outside of site energy team.	Potential defined by experience or assessments. Goals roll up to unit/site/corporate/organization and status posted prominently.	Establish & fund an Energy Goals communication program.
Career Development	No career development. No opportunities available.	Exposure to other energy programs. Some temporary or project assignments available elsewhere.	Energy professionals have established career paths that are reviewed annually. Opportunities for growth encouraged.	
Energy Team Incentives	No ties between energy efficiency improvement and compensation.	Spot awards or luncheons for employees on a project.	Accountability tied to performance reviews, compensation, and personal and plant bonuses.	Once formal energy teams have been implemented & recognized, tie larger/team awards to performance against Army-wide benchmarks. Performance-based funding is an optional, longer-term strategy to ensure proactive management.
Create Action Plan				
Improvement Planning	No upgrade plan.	Upgrades implemented sporadically. Some compliance with organizational goals and standards.	Upgrade plans established; reflect assessments. Full compliance with organizational EE design guidelines and goals.	Establish additional professional relationships & enhanced communications between Planners, O&M Managers, & improvement implementers. Ensure authoritative plans are identified, regulary updated, & readily available to relevant personnel.
Roles and Resources	Not addressed, or addressed on ad hoc basis only.	Informal interested person competes for funding. Little support from organizational program.	Internal/external roles defined and funding identified. Organizational or corporate program support secured.	Organizational program needs to be established, w/funding directed in a logical manner.
Site Planning Integration	Impact on energy from changes not considered.	Decisions impacting energy considered on first-cost basis only.	Projects/contracts include energy analysis. Energy projects evaluated with other investments. Lifecycle costing applied.	Ensure LEED & intial life-cycle analysis are conducted on *every* future project. This can be achieved through additional contract requirements, however, in-house energy/life-cycle review is more appropriate, given the multidiscplinary nature of this task.

Implement Action Plan					
Communication Plan	Site plan not developed.	Periodic communications for projects. Some reporting of energy use information.	All stakeholders are addressed on regular basis.		Develop a Communication Plan. Allocate communications specific funding for relevant projects
Energy Awareness	None conducted.	Occasional energy efficiency awareness campaigns. Some communication of energy costs.	Planned outreach and communications. Support organizational initiatives. Employees aware of site energy costs.		Establish Energy as a specific program within regular Installation personnel & public relations efforts.
Building Staff Capacity	No training offered.	Some vendor training for key individuals and operators.	Broad training/certification in technology and best practices. Networking opportunities actively pursued.		Aim for >50% training/certification in most current technologies & best practices. Add requirements to maintenance personnel development plans. Fund & provision relevant training to meet, if not exceed, a 50% of relevant staff threshold. Once new training regime is established, begin implementation of mentoring & skills-sharing programs to bring staff certification above 75%.
Contract Management	Contracts are renewed automatically without review.	Occasional review of supplier contracts.	Energy-efficient procurement policy in place. Vendors for replacements on standby. Regular review of suppliers.		Ensure all new & contracts under consideration for renewal comply with, and are given competitive consideration based upon, installation energy policy.
Incentives and Rebates	Not researched or pursued.	Occasional communication with utility representatives. Limited knowledge of incentive programs.	Researches rebates and incentives offered regionally and nationally. Communicates often with utility representatives.		
Evaluate Progress					
Measuring Results	No reviews.	Historical comparisons. Some reporting of results.	Compare usage & costs vs. goals, plans, other sites. Results reported to site and organizational or corporate management.		Utilize a Dedicated Performance Team (DPT) to actively monitor, communicate, and control oeprational energy outcomes.
Reviewing Action Plan	No reviews.	Informal check on progress.	Revise plan based on results, feedback and business factors. Best practices shared with other sites / organization or corporate program.		Enhance existing review requirements and increase intervals.
Recognize Achievements					
Site Recognition	Not addressed.	Occasional recognition of projects and people.	Recognition system in place. Awards for projects pursued by operators.		Task DPT-DPW admin/liason with implementing and operating a site recognition program
Organizational Recognition	Not sought.	Occasionally when prompted by senior management.	Senior management acknowledges site successes.		Coordinate w/ Army leadership to recognize installation and major unit achievement of energy policy objectives.
External Recognition	Not sought.	Occasional trade magazine and vendor recognition.	Government and third-party recognition highlighting achievements sought. ENERGY STAR label for facility awarded annually.		Form & fund interdisciplinary task-force teams to conduct special applied research projects. Submit results to appropriate academic, private, and government competitive contests/publications.

Table 1. Energy Star Management Assessment Matrix

US Army Corps of Engineers

2030 USACE Integration Project

8.32 Porous Pavement

porous pavement

TECHNOTE

Recommendation

As part of implementing Low Impact Development (LID) at Fort Leonard Wood (FLW) as a stormwater solution, porous pavements have been proposed to help control the quantity and quality of stormwater on the installation. Porous pavements are pavements that allow water to flow through them instead of flow on top of them as do traditional concrete and asphalt. Porous pavements come in three primary varieties: Pervious Concrete, Porous Asphalt, and Permeable Pavers. All of these types of pavements perform the same function of cleaning and slowing stormwater runoff. These pavements are all engineered to retain stormwater volumes and to have stormwater run through them to clean out sediment, trash, and to increase the time of concentration. New stormwater requirements for all federal facilities now require retention of the 95th percentile storm. Porous pavements, specifically pervious concrete and porous asphalt, are recommended ways to help Fort Leonard Wood meet these new stormwater requirements because they are successful in a variety of soil types, including the dense clay soils at Fort Leonard Wood.

Location & Scale

Porous paving should be implemented at the **site scale**. Porous pavements are designed to be used on low speed areas like parking lots, pedestrian areas, and fire lanes. Porous paving could slowly move out toward street parking once green streets are implemented, but it should always be in low traffic, low volume, privately owned vehicle (POV) areas. Porous paving can double as a detention or retention area for a project, so ideally every project would have porous paving incorporated as part of the treatment for stormwater on individual sites.

Phasing

This system is projected as part of the **2015 Phase** and is recommended for all sites where there is low speed POV traffic.

Initial Cost

The cost of a typical porous pavement system has been estimated to be **two to three dollars per square foot**. First costs of porous paving are significantly higher than conventional paving because they require more sub-base and are typically harder to install because they are a specialized item with which not all contractors are familiar.

Life Cycle Cost

The life cycle cost analysis (LCCA) of porous pavements can be tougher to justify as with any Low Impact Development practice. Porous pavement is two to three times the cost of conventional pavements, but porous pavements typically have a longer design life. Life cycle cost analysis for pavements are typically very site specific because some sites require stormwater infrastructure, geotextiles, deeper sub-base, underdrains, etc. For the most part, though, porous pavements have been shown to have sixty to ninety percent less maintenance costs than traditional asphalt over a period of twelve to fifteen years. More porous applications also have a design life of thirty to fifty years as opposed to a fifteen year design life of asphalt. To get a proper LCCA for Fort Leonard Wood, an analysis must be done for each site to see an accurate life cycle cost. Porous pavements also have environmental and aesthetic benefits that cannot be fully seen in an LCCA. Porous pavements work as part of LID to clean stormwater, help prevent erosion, and support recharge of groundwater. Aesthetically, porous pavements can be designed into pedestrian hardscapes and if designed properly can enhance the appearance of an area.

Maintenance

Porous pavement maintenance is very simple. Roughly two times per year, once after the fall and once in early spring, the porous pavement should be cleaned. Cleaning of a porous pavement typically involves using a vacuum sweeper truck and sweeping the porous pavement areas. Permeable pavers require a little more work as they may need to be re-sanded after they are swept. However, porous asphalt and pervious pavement hold most of their contaminants in the top two inches of media and a vacuum truck is effective at removing the majority of those contaminants. Porous pavements being swept two times per year is the most ideal, but once per year is very common practice.

For ice / snow removal, a snow plow can be used on porous pavements. The plow blade should just be adjusted a little higher than how it is typically used on conventional pavements; if the blade gets too low it can chip off pieces of the porous pavement. The blade also must be level with the road. If the blade comes in at an angle and accidentally hits the road it can create a large gouge. Porous pavements should also never be sanded. Salt will not damage the pavement, but a benefit of porous pavements is that they don’t have the same icing problems as conventional pavements because the water infiltrates into the sub-base instead of freezing on top.

Feasibility

Porous pavements are extremely feasible to be implemented at Fort Leonard Wood. Although there are soil design constraints on the installation, porous pavements can be used on most soils that do not infiltrate well. Porous pavements also work very well in freeze / thaw conditions because the void space is so large that ice can freeze its way into the voids instead of cracking and raveling the pavement. Therefore, the pavement is relatively inexpensive to construct and maintain.

Porous pavements should be properly designed and constructed to accommodate the local geological conditions. The clay type soils found at Fort Leonard Wood will heave and swell into the sub-base. The porous pavement must have a geotextile under the sub-base to prevent the clay soil from clogging up the sub-base. The pavement will likely be designed to have an overflow or a perforated drain because infiltration rates at Fort Leonard Wood are very slow. Once a pavement is placed, proper planning must be done to ensure that it is not used for staging of any equipment and that heavy equipment doesn’t drive over it. Maintenance of porous pavements is a consideration when installing them. They don’t necessarily require more maintenance than a conventional impervious area, but they do require more specialized tools and planning.

Porous pavements cannot be sanded in the winter. Sand will get into the voids and clog the system. Porous pavements can also only be effectively street swept with a vacuum type street sweeper. These street sweepers are readily available; they are typically newer, though, and might cost more than a typical street sweeper.

References See Attachment A

Stormwater Management Fact Sheet: Porous Pavement
http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Porous%20Pavement.htm

http://www.concretemaninc.com/pinehurst-safeway-in-seattle/

http://rogergosselininc.com/services/decorativearchitectural/pervious-concrete/essex-sidewalks-2/

http://www3.villanova.edu/vusp/bmp_research/pc_pa/pc_pa_st_event.htm

http://njwsawpu.blogspot.com/2011/06/permeable-pavement-epa.html

http://www.paver-inspirations.com/

http://www.stormh2o.com/september-2009/porous-pavements-qa-2.aspx

Funding Plan There are no known tax credits or incentives at this time. If the porous pavement is constructed as part of a larger building project as the drainage for the site, then the pavement may be able to be paid for using **MILCON funds**.

Contract Language Contracting language should be determined after the final design is submitted and should mirror similar construction contracting language.

Product Specifications There are no product specifications outside the final design.

Baseline Relation Porous pavements, like other LID practices, do not directly affect the water use baseline. Porous pavements do clean stormwater runoff and slow stormwater runoff. Porous pavements also provide a filter for trash, sediment, and car pollution (oil) to ensure that water moving toward the receiving waters is cleaner and will promote life in receiving waters. Through slowing down stormwater runoff porous pavements also help reduce river bank erosion.

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Attachment A: Reference Material

Key Terms:

95th Percentile Storm: This is a storm that happens 95% of the time there is a rain storm.

Pervious Concrete: This is a type of concrete that has no fines in the mixture. This concrete is only made up of coarse aggregate, cement, and water. Water can freely pass though this pavement.

Permeable Pavers: Pavers are interlocking bricks that have voids designed in-between the pavers. Pavers do not sit directly against each other and water can infiltrate between 2 blocks.

Porous Asphalt: This is asphalt that does not have fines in it. This asphalt is not compressed all the way and allows water to freely pass through it.

Freeze/Thaw: This is the process that happens during the winter time and it gets warm enough in the daytime to thaw ice and then at night it refreezes. Since water expands when it freezes it can become a big issue in pavements. If pavements are not designed properly the freeze/thaw cycles in the winter can crack up pavements and ruin them.

Filtration: Filtration is the process by which a liquid, in this case water, is passed through a substance such as the porous pavement, which then collects suspended impurities.

Infiltration: Infiltration is the process of water to move vertically through the ground.

General Porous Pavement Questions:

How does Porous Pavement resist Freeze/Thaw Cycles?
When conventional pavements are designed in areas where a lot of freeze/thaw is a concern they are designed to have a certain percentage of voids space to allow areas for the freezing water to expand to. Porous pavements act in the same manner. There may be more water inside of a porous pavement, but the substantial amount of void space allows freezing water to freely expand without breaking or cracking the pavement. Porous pavements have been used in Canada and are even becoming more desired in freeze thaw regions because the water will drain before it has a chance to become ice and a hazard to pedestrians and cars.

Can porous pavement be plowed?
Porous pavements can be plowed by a snow plow but extra caution must be taken by the plow driver not to dig the plow into the pavement. Ideally the plow would be run above the pavement to avoid contacting the pavement and raveling or chipping the pavement.

What are the risks associated with hydrocarbon (oil) contamination?
Letting oil into a porous pavement's voids is the whole idea in water-quality improvement. In the pavement, naturally occurring microorganisms biodegrade hydrocarbons before they migrate to the bottom of the pavement. The constituents go off as carbon dioxide and water vapor, and very little else; the hydrocarbons cease to exist as water-quality pollutants. An example of the research suggesting this, accessible on several Web archives, is C. Pratt's 1999 paper, "Mineral Oil Bio-Degradation Within a Permeable Pavement: Long Term Observations." (7)

Should porous pavement be avoided where trees are present? Should overhanging trees be removed?

The only thing overhanging trees do to porous pavements is deposit their annual drop of organic debris. The debris decomposes to a minute fraction of the volume it started with. Vacuuming might be called for after a number of years, to reopen the pavement's pores. Trees are immensely helpful for water resource management, counteracting the urban heat island, shading urban open spaces, and absorbing carbon, and they should not be discouraged.

<u>What's the use of porous pavement on a clay soil, or where there is a shallow water table, and water cannot be absorbed into or treated in the soil? Is a subdrain necessary to ensure good performance? Can a porous pavement work here?</u>

On clay soils, permeable pavements do not make the 100-year storm disappear; a perforated drainage pipe is ordinarily required to discharge excess water. But most of the water-quality benefit of any permeable pavement occurs within the pavement structure, without regard to the underlying soil; the soil is only a redundant "backup" system. Porous pavements on clay soils do:

- Reduce runoff coefficient and impervious cover
- Detain peak flows
- Treat water quality
- Recharge aquifers by gradual infiltration of rainwater from small, frequent, year-round storms

US Army Corps of Engineers

2030 USACE Integration Project

8.33 Radiant Floor Heating

radiant floor

TECHNOTE

Recommendation

Conventional heating systems warm spaces through convection heating, warming and circulating the air within the space. Radiant floor heating systems circulate warm air or hot water through the floor to heat it. The heated floor radiates heat to the building occupants and surrounding air in the occupied zone. Commercial and industrial radiant floor heating systems typically use water as the working fluid. Radiant floor heating systems are especially beneficial when installed in buildings or spaces with high ceilings or large infiltration loads. Since the floor is warmed and radiating heat in the occupied zone, occupants tend to feel warmer at lower ambient air temperatures, less energy is lost by heated air leaving the building through doors, and energy is not wasted heating air near the ceiling of the space.

Location & Scale

This system is implemented at the **building scale**. Radiant floor heating can be installed in new building floor slabs. The radiant floor heating system can be coordinated with other energy saving technologies such as condensing gas boilers, solar hot water, or waste heat from other processes to further increase efficiency.

Phasing

This system is projected as part of the **2015 Phase**. It can be pursued for new buildings where the technology provides a benefit over conventional heating systems. Typically, these locations would be buildings with high ceilings or those that open and close exterior doors often such as vehicle maintenance facilities, guard houses, and hangars. A radiant floor heating system is already in the U.S. Army Corps of Engineers (USACE) standard design for the tactical equipment maintenance facility (TEMF) maintenance bays.

Initial Cost

A radiant floor heating system requires a system to generate hot water and a circulating pump. The piping system includes a manifold and tubing run within the building floor slab. Tubing can run up to **three dollars per square foot** of heated floor with manifolds costing up to **$500** depending on the number of circuits that it manages.

Life Cycle Cost

Radiant floor heating can reduce heating energy consumption dramatically. Since occupants typically feel warmer at lower ambient air temperatures when heated by radiant floor heating systems, space thermostats can be lowered and ventilation air can be brought in at lower temperatures. Since radiant heaters do not heat the air, less energy is lost when loading dock or roll-up doors are opened. Radiant heaters reduce fan energy consumption by eliminating the need to circulate air, although ventilation air is still required.

Maintenance Maintenance requirements for a radiant floor heating system would include normal maintenance of each of its components such as the boiler, thermal solar panels, and circulating pump. The installed piping is very similar to a domestic water piping manifold and requires minimal maintenance.

Feasibility Radiant floor heating systems would typically be included as a design feature in new buildings to replace conventional air heating systems. The greatest benefit would be realized by installing radiant heating units in buildings or spaces that have high ceilings or a high infiltration heating load such as vehicle maintenance facilities, loading docks, and access control points. This technology contributes to the **2030 Net Zero Energy** goals.

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Funding Plan Radiant floor heating systems would be a part of the original build-out and be funded under the main construction contract of the building in which it is being installed.

Contract Language Piping layout, manifolds, heating equipment, valves, and floor construction must be coordinated during design to ensure that the radiant floor heating system performs correctly. Connections between the manifold, piping, and fittings must be compatible to minimize the chances of leakage within the system.

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2030 USACE Integration Project

8.34 Rainwater Harvesting

Recommendation

Rainwater is captured from the building roofs and stored in onsite cisterns. This water is reused to supplement potable water demands for flushing toilets and irrigation. The rainwater storage cisterns will be located below the ground frost depth to prevent freezing of the harvested rainwater during the winter and will be placed strategically adjacent to each building.

Rainwater storage cisterns contribute to the 2030 net zero plan for military installations by reducing the amount of potable water required within buildings, alleviating flooding, and supporting rainwater management initiatives by keeping rainwater where it falls. The cisterns will be custom designed for each type of building to collect specific volumes of water and supplement specific water demands.

The recommendation is to install a decentralized cistern system so that each building will have its own cistern. The recommendation is to install an 11,000 gallon, a 14,000 gallon, and a 16,000 gallon cistern, respectively, for the Basic Combat Training (BT) Barracks/Company Operations Facility (BCOF), Battalion Headquarters (BNHQ), and Dining Facility (DFAC) buildings. The recommendation is to install a 15,500 gallon, a 6,000 gallon, and a 16,000 gallon cistern for the Advanced Individual Training (AIT) BCOF, BNHQ, and DFAC buildings, respectively. The cisterns can reduce toilet water usage by as much as 34% for the AIT BCOF building. The cisterns will also reduce the total BT and AIT complexes potable water usage by at least 1% overall.

Location & Scale

Rainwater cistern use is implemented at the **building scale**. The cisterns would need to be concrete and located underground below the frost line to prevent freezing of the rainwater during the winter. The application can also be expanded to an **installation scale** where each type of building roof area and demand water usage would need to be analyzed for an appropriately sized cistern system.

Phasing

The use of rainwater cisterns should begin with the new construction of the BT and AIT buildings during the **2015 Phase**. Rainwater cisterns should be installed by all existing large roofed buildings over 20,000 square feet by the **2020 Phase**. By **2025 and 2030**, the installation and use of rainwater cisterns should be expanded to include all new large roofed building construction and existing large roofed buildings not included in the 2020 phasing plan.

Initial Cost

An initial estimated cost for the BT BCOF, BNHQ, and DFAC cistern systems for toilet flush water is about $156,250, $103,000, and $125,000, respectively per building. The initial cost for the AIT Complex buildings are $314,125 for each BCOF, $45,000 for the BNHQ, and $110,000 for the DFAC per type of building. These estimates are based on an assumed cost of $1500 per toilet fixture connection and the cost of the underground concrete cistern at $5.75 per gallon which includes excavation, dewatering, ballast for buoyancy, and reinforced concrete for the cistern.

Life Cycle Cost

The life cycle cost is not easily justifiable because potable water from the Big Piney River is very inexpensive, according to Fort Leonard Wood's (FLW) Directorate of Public Works (DPW). Currently, Fort Leonard Wood pumps and treats river water to serve potable water demands throughout the installation. Rainwater cisterns will help Fort Leonard Wood comply with the Energy Independence Security Act (EISA) Section 438 stormwater requirements and the latest requirements under ECB No. 2011-1. Cisterns can also be used to support the environment by reducing potable water usage through capturing rainwater for flushing toilet water and reducing erosive impacts to streams.

Based on the EPA 2008 Municipal Handbook Rainwater Harvesting Policy, case studies are documented in the table below along with a comparison of the AIT and BT Complexes buildings as recommended. Reduction in potable water percentage and amount in gallons vary greatly depending on supply from geographical areas, demand from use, roof collection areas (not shown), and size of cisterns. For example, a case study in Missouri showed that a 38,000 gallon cistern reduced the potable water usage by 70% or 500,000 gallons. Somewhat similarly, the AIT 's three BCOF buildings of 15,500 gallon cistern each totaling 45,000 gallons reduces about 527,000 gallons of potable water usage per year. These don't provide a life cycle cost, but a general idea as to the size of cisterns and amounts of potable water reduction annually.

Case Study Name and Location	Cistern Size	Usage	Annual Water Reduction
King Street Center, Seattle, WA	3ea - 5400 gallon cisterns	toilets or irrigation	reduce 60% toilet flush potable water or 1.4 million gallons
Alberici Corporate Headquarters, Overland, MO	38,000 gallon cistern	toilets and bldg cooling tower	reduce 70% potable water or 500,000 gallons
The Solaire (27 story Residential) Battery Park City, NY	10,000 gallon cistern	toilet, make-up, & green roof	reduce 50% potable water
Lazarus Building (750,000sf Retail), Columbus, OH	40,000 and 50,000 gallon cistern	toilet, irrigation, and HVAC	reduce potable water by several million gallons
Stephen Epler Hall (62,500sf Student Housing), Portland State University	study doesn't say	toilet and irrigation	reduce potable water by 110,000 gallons

Comparison with BT and AIT Cistern Recommendations			
BT BCOF (21,567 sf)	11,000 gallon cistern	toilet	reduce 1% potable water or 124,800 gallons
BT BNHQ (23,500 sf)	14,000 gallon cistern	toilet	reduce 41% potable water or 143,080 gallons
BT DFAC (31,195 sf)	16,000 gallon cistern	toilet	reduce 1% potable water or 180,300 gallons
AIT BCOF (31,000 sf)	15,500 gallon cistern	toilet	reduce 1% potable water or 178,100 gallons
AIT BNHQ (12,300 sf)	6,000 gallon cistern	toilet	reduce 15% potable water or 69,700 gallons
AIT DFAC (33,760)	16,000 gallon cistern	toilet	reduce 2% potable water or 190,100 gallons

As an estimate of life cycle cost assuming $2.35/1000 gallons of potable water, there is no monetary payback period for the BT complex of cisterns based on a savings of $2,225 per year. The first cost annual maintenance of $10,000 will put the system operating balance at an annual deficit of $7,775.

As an estimate of life cycle cost assuming $2.35/1000 gallons of potable water, there is no monetary payback period for the AIT complex of cisterns based on a savings of $2,285 per year. The first cost annual maintenance of $14,000 will put the system operating balance at an annual deficit of $11,715.

Based on the life cycle cost analysis of the BT and AIT complexes, the cost of water per 1,000 gallons would need to be much higher than $2.35 in order to have positive economic benefits from such a system. However, this life cycle estimate may change if annual maintenance is much less than the assumed cost.

Maintenance

Debris should be removed from the roof and gutters. Gutters should be cleaned at least twice a year. The most critical time to clean gutters is during the mid to late spring; flush when there are pollen deposits from surrounding trees. The months of September, November, January, and April are typically the most critical months for cleaning. Cleaning gutters should include screens on top of downspouts which should be maintained in good condition. Storage tanks should be inspected and debris removed periodically as needed. Cleaning storage tanks would involve rinsing the inside surface with a chlorine solution of 1 cup bleach to 10 gallons of water at least twice a month to discourage algae build-up or per manufacturers recommendations for cleaning. Maintenance also involves allowing the first flush rainwater to be released via automatic sensor hose bib and cleanout plug after an initial significant rainfall event, such as one-tenth of an inch per hour. Maintenance will also involve inspecting the pump stations for low lubricant oils.

Maintenance of the concrete cistern will also be needed to patch up cracks within the concrete. Building interior pressurized tanks should be inspected for proper operating pressure. Check valves, shutoff valves, and plumbing lines to toilets should also be inspected at least once a year. The assumed maintenance cost will be $10,000 for the BT complex and $14,000 for the AIT complex.

Feasibility

The use of cisterns contributes to the **2030 Net Zero Energy and Water** goals by collecting rainwater from roofs of building structures and making it available for non-potable needs, such as toilet flushing. Thus, the use of cisterns to collect rainwater will reduce the amount of potable fresh water taken from the Big Piney River. The usage of rainwater cisterns for toilet flushing will reduce the amount of building water usage for both the BT and AIT complexes buildings. The goal of net zero water is to recapture, repurpose, or recharge an amount of water equal to or greater than the amount of water that is consumed. Excess rainwater that may exceed the capacity of the cisterns can be channelled into slotted pipes and used to support other net zero initiatives by recharging the groundwater in the Fort Leonard Wood area via bioretention / wetland / rainwater recharging areas.

The assumed potable water usage for the BT complex is 259,650 gallons per day (gpd) based on a population of 1,731 people multiplied by 150 gpd per person. The 150 gpd/person estimate is based on a Black and Veatch study. The rainwater cistern catchment system recommended will provide 2,563 gpd of toilet flush water. This will reduce the BT complex potable water system usage by about 1%.

The assumed potable water usage for the AIT complex is 209,100 gpd based on a population of 1,394 people multiplied by 150 gpd per person. The 150 gpd/person estimate is based on a Black and Veatch study. The rainwater cistern catchment system recommended will provide 2,675 gpd of toilet flush water. This will reduce the AIT potable water system usage by about 1%.

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Diagrams

It is recommended that the installation obtain a copy of the ARCSA Rainwater Catchment Design and Installation Standards, 2009, and review diagrams included for basic rainwater harvesting approaches.

Funding Plan

Funding for cisterns could be provided by **Military Construction Army (MCA) funds** which are regulated by AR 420-1, which prescribes policies, procedures, and responsibilities for Department of the Army (DA) military construction (MILCON).

There are no known tax incentives being provided by the state of Missouri for the use of rainwater capture and cistern use. However, Executive Order 13514 which includes EISA 2007 contains language that will require the Federal Government to keep the predevelopment hydrology even after development for the 95-percentile rainfall. An even more stringent requirement is ECB No. 2011-1 dated 19 January 2011 which requires the predevelopment hydrology to be the same up to the 2-yr, twenty-four hour storm (LEED 6.1).

Further stringent requirements come from the Army's vision from the Office of the Assistant Secretary of the Army. This vision is to achieve **2030 Net Zero Water**. This means that installations are to limit potable water usage by either capturing water, repurposing water, or recharging an amount of water equal to or greater than the amount of potable water that is consumed. This can be done by capturing rainwater for toilet flush which will reduces the amount of potable water usage. Consideration for use of this captured rainwater should also be given to non-potable uses such as laundry washing as well to further reduce the potable water usage. Rainwater off impervious areas can be diverted to bioretention and wetland areas around the base to recharge the groundwater source. The combination of these two methods of capturing and recharging rainwater to the ground will meet the definition of net zero water for the installation.

Contract Language

See ARCSA Rainwater Installation Standards 2009

Product Specifications

Custom designed underground cisterns with manhole access ports, ladders, and sediment chamber to separate sludge and sediment build up. This sludge and sediment can be vacuum pumped out during maintenance periods. Clean Rain Ultra Downspout Filter and Diverter (or approved equal) to a three inch schedule 40 pipe to cistern after first flush. Provide riprap and erosion protection for overflow downspouts downstream of first flush diverters. Include building design specific pump stations. Check valves, gate valves, and piping to be sized according to the pump and system curves.

Baseline Relation

The current baseline water use of 150 gpd/person at Fort Leonard Wood will be impacted by approximately 1% through the use of rainwater collected and stored in cisterns. This is largely due to the fact that collected rainwater will be used for toilet flushing in the AIT and BT complexes. The use of rainwater to supplement 20% and 12% of water demand for toilet flushing in each AIT and BT complex, respectively, reduces the overall potable water demand. This supports Fort Leonard Wood's efforts to achieve net zero water use by 2030. The potable water reduction values are based on assumptions made on operational supply after a daily first flush, system demand, and catchment efficiency.

Risks:

Risks for the use of cisterns revolve around design (cistern size and pump station and appurtenances based on the pump and system curve), installation, and maintenance of the cistern system. Geotechnical soil issues relating to sink holes, high ground water table, and frost depth in the Fort Leonard Wood area should be carefully assessed during design. Periods of long drought can also be a concern for constant demand and supply requirements as historic rainfall data will not necessarily be a perfect indicator for predicting future rainfall. A separate potable system discharging to the cistern can supplement periods of drought.

Components:

Cisterns installation consists of five basic components: catchment roof surface, gutters and downspouts, leaf screens and roof washers including first flush diverters, a cistern storage tank, and a delivery system consisting of gravity fed and / or pumping station.

For cisterns, an automatic first flush diverter must be used to rinse out the roof and gutter system from an initial flush via a hose bib sensor and cleanout plug with any overflow rainwater going into the cistern. For first flush diverters, a rule of thumb is to divert 10 gallons for every 1,000 square feet of collection surface. The cistern storage tank material will need to be concrete and placed at least three feet below the ground surface for frost depth protection.

The cisterns for the various buildings will require a separate piping system for the toilets from the cisterns along with flush valves, pressure tanks, pumps, and check valves. The rainwater cistern usage is for toilet flush water and therefore will not require any special treatment of the water other than physical screening, sedimentation of large particulates, and diluted detergent chlorine.

Cistern Sizing:

Sizing of cisterns was based on an initial trial and error optimization calculation of the system based on roof catchment area, daily first flush loss, efficiency, demand usage, and costs. From this optimization scheme, adding additional cistern volume capacity beyond the optimized volume would provide higher costs for less rainwater capture volume and thus be less and less economical. The only way to capture more rainwater economically would be to increase the roof catchment areas which will allow an increase to the cistern volumes. Capturing the runoff from all other impervious areas will help.

It is not feasible to base cistern size on the 95th percentile 24-hour rainfall requirement to meet EISA Section 438 to capture predevelopment hydrology runoff in excess of 1.8 inches. This is because the amount of rainwater that would have to be captured to achieve this would be over 24,200 and 34,782 gallons per BT BCOF and AIT BCOF, respectively, requiring an extremely large cistern that would cost tens of millions of dollars. Also, toilet water demand would not be enough to drain such a large cistern system over a 24-hour period to allow for the required storage.

If the entire cistern system were treated to potable water status, the supply of rainwater would not be sufficient enough to meet the total demand for toilet flush, showers, faucets, dishwashing, and laundry. Added rainwater capture capacity can only be obtained by increasing roof catchment areas resulting in a larger sized cistern(s).

Instead, the cistern system will be sized to an optimized volume (roof catchment area dictated; cost dictated; water for toilet flushing usage dictated) and will help to reduce the usage of the potable water system for flushing toilets and urinals which will help to meet the net zero water goal.

Rainwater Potential:

To meet EISA Section 438 stormwater requirements, the 95th percentile rainfall must be retained. The 95th percentile was calculated as <u>1.8 inches</u> based on Waynesville Airport rain gage having data from 1942 through 2010 and obtained from Army Crews of Fort Leonard Wood. The soil type for Fort Leonard Wood is mostly SCS soil type "C" which will have a calculated 24-hour infiltration rate of

3.43 inches based on the National Resource Conservation Service (NRCS) soil survey website data and infiltration calculation methodology from the EISA Section 438 Technical Guidance found in Appendix A. Therefore the predevelopment runoff is zero inches and the amount required to retain is the infiltration amount over the 24-hour period up to the EISA 95-percentile statistic which is 1.8 inches.

Also, this is required to meet sustainability requirements for LEED Sustainable Site Credit 6.1 (SSc6.1). Under SSc6.1, the development hydrology is not to exceed the predevelopment hydrology for the 2yr-24-hour precipitation frequency duration.

For Fort Leonard Wood this turns out to be 3.7 inches of rainfall based on TP40 and using the infiltration rate from the EISA technical guidance for “C” type soils of 3.43 inches, only 0.27 inches is runoff for the 2-yr, 24-hour storm. In other words the minimum amount of rainfall required to be retained based on this ECB will be at least 3.43 inches for all impervious areas over a 24-hour period for “C” type soils in Fort Leonard Wood; this will become superseded as more detailed site specific information is known regarding soil infiltration from geotechnical reports and time of concentration calculations from site specific development plans.

The graph below summarizes the median monthly total rainfall for the Waynesville Airport rain gage from 1942 to 2010. The Waynesville Airport is on the southern edge of the cantonment area of Fort Leonard Wood. Rainfall is consistently available from this graph and most prevalent during the months of March through October.

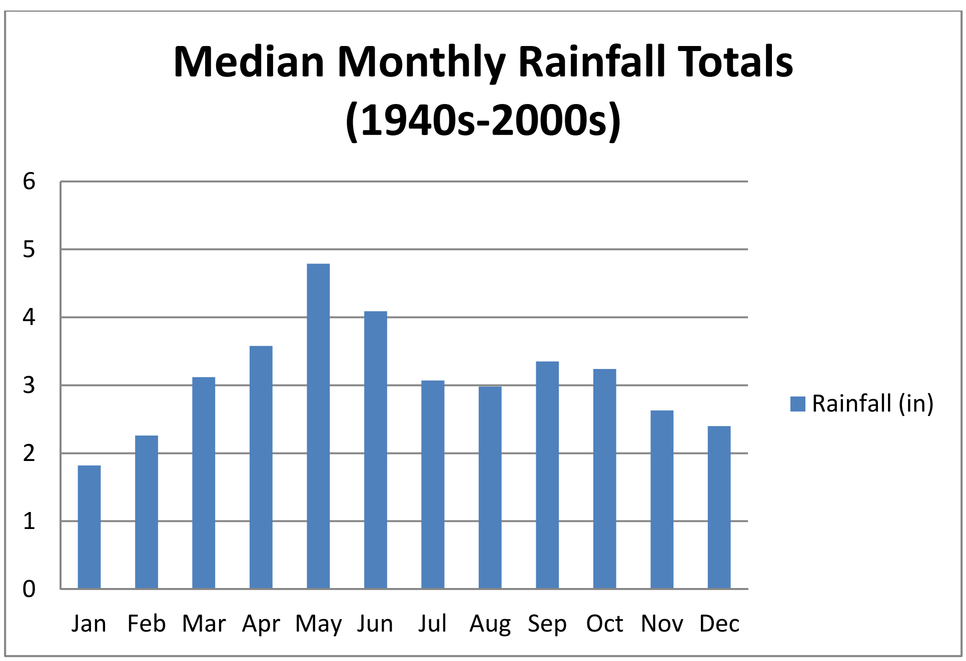

Figure 1. Chart courtesy of USACE, Honolulu District

The tables below summarize the minimum requirements for cistern sizes for the various BT complex buildings in order to capture a limited supply of rainfall for toilet flush water and to reduce the amount of potable water consumption.

Data for the BT complex buildings were obtained from the BT website, https://eportal.usace.army.mil/sites/COS/BTOSUTC/default.aspx, in March 2011. An efficiency of ninety percent of rainwater capture is assumed due to losses from excessive splash and evaporation and a first flush loss of ten gallons per 1,000 square feet of roof. Based on the rain gage data, there appears to be enough rainwater for flushing toilets up to three times per day after the system is initially supplied with fifty percent of cistern capacity potable water for twenty four-percent of the time for the BT BCOF buildings. The other three times per day of flushes is assumed to be used at the DFAC.

The recommendation is to install an 11,000 gallon, a 14,000 gallon, and a 16,000 gallon cistern for the BT BCOF, BNHQ, and DFAC buildings, respectively. Demand for toilet water can be provided by these cisterns, which will be sized at 900gpd, 1,020gpd, and 1,300gpd of toilet water for the BT BCOF, BNHQ, and DFAC buildings based on roof catchment area, first flush, and rainwater capture efficiency.

Estimated costs are based on $1,500 multiplied by the number of toilet / urinal fixtures plus the cost of the concrete cistern and all appurtenances. They are 62, 15, and 22 plumbing (toilet and urinals) fixtures for the BT BCOF, BNHQ, and DFAC buildings, respectively.

BT Building Type	**BCOF**	**BNHQ**	**DFAC**
Roof (sf)	21567	23500	31195
Allowable Supply (gpd)	900*	1020**	1300***
PN	296	251	2600
Cistern Size (gal)	11000	14000	16000
U/G Cistern Dimension (ft) w/1 ft Freeboard	16' x 16' x 7'	17' x 17' x 7'	19' x 19' x 7'
Allowable Supply Met (days/%time)	12499/50%	12432/50%	12428/50%
EISA (gal)	24200	26370	35000
Cistern > EISA Req't (days/%time)	0/0%	0/0%	0/0%
Reduce Toilet Water % (gpd) / Reduce Potable Water %	24% (342gpd) / 1%	41% (392gpd) / 41%	4% (494gpd) / 1%
Cistern Only Installation Estimated Cost	$ 63,250.00	$ 80,500.00	$ 92,000.00
Total System Estimated Cost	$ 156,250.00	$ 103,000.00	$ 125,000.00

* BT BCOF includes first flush of 10 gallons per 1000sf of roof area – 216gpd
** BT BNHQ includes first flush of 10 gallons per 1000sf of roof area – 235gpd
*** BT DFAC includes first flush of 10 gallons per 1000sf of roof area – 312gpd

BT Bldg Usage	Baseline Toilet Potable Water Usage (GPD) // Baseline Total Potable Water Usage (GPD)
BT BCOF	**1,421gpd** (296PN x 1.6gpflush x 3 flushes/day)* / **44,400gpd** (296PN x 150gpd)
BT BNHQ	**952gpd** (11PN Full Time x 1.6gpd x 5 flushes + 240 Students x 0.75 x 1.6gpd x 3 flushes) // **same**
BT DFAC	2600PN x 1.6gpflush x 3 flushes/day = **12,480gpd** // 2600PN x 17.8gpd (13gpd faucet/dishwater/PN and 4.8gpd for toilet) = **46,280gpd**

The tables below summarize the minimum requirements for cistern sizes for the various AIT complex buildings: BCOF, DFAC, and BNHQ in order to capture a limited supply of rainfall for toilet flush water and to reduce the amount of potable water consumption.

Data for the AIT complex was extracted from the following website, https://eportal.usace.army.mil/sites/COS/AITC/default.aspx, in February 2011. An efficiency of ninety-percent rainwater capture is assumed due to losses from excessive splash and evaporation and a first flush loss of ten gallons per 1,000 square feet of roof. Based on the rain gage data, there appears to be enough rainwater for flushing toilets up to three times per day for thirty-four percent of the time after the system has been initially filled with fifty percent potable water in the cistern. The other 3 times per day of flushes is assumed to be used at the DFAC.

The recommendation is to install a 15,500 gallon, a 6,000 gallon, and a 16,000 gallon cistern for the AIT BCOF, BNHQ, and DFAC buildings, respectively. Demand for toilet water can be provided by these cisterns, which will be sized at 1,285gpd, 505gpd, and 1,380gpd of toilet water for AIT BCOF, BNHQ, and DFAC based on roof catchment area, first flush, and rainwater capture efficiency.

Estimated costs are based on $1,500 multiplied by the number of toilet / urinal fixtures plus the cost of the concrete cistern and all appurtenances. They are 150, 7, and 12 plumbing (toilet and urinals) fixtures for the AIT BCOF, BNHQ, and DFAC buildings, respectively.

AIT Building Type	**BCOF**	**BNHQ**	**DFAC**
Roof (sf)	31000	12300	33760
Allowable Supply(gpd)	1285*	505**	1380***
PN	300	194	1300
Cistern Size (gal)	15500	6000	16000
U/G Cistern Dimension (ft) w/1 ft Freeboard	19' x 19' x 7'	12' x 12' x 7'	19' x 19' x 7'
Allowable Supply Met (days/ %time)	12454/50%	12476/50%	12536/50%
EISA (gal)	34782	13800	37879

Cistern > EISA Req't (days/%time)	0/0%	0/0%	0/0%
Reduce Toilet Water % (gpd) / Reduce Potable Water %	34% (488gpd) / 1%	15% (191gpd) / 15%	8% (521gpd) / 2%
Cistern Only Installation Estimated Cost	$ 89,125.00	$ 34,500.00	$ 92,000.00
Total System Estimated Cost	$ 314,125.00	$ 45,000.00	$ 110,000.00

* AIT BCOF includes first flush of 10 gallons per 1,000sf of roof area – 310gpd
** AIT BNHQ includes first flush of 10 gallons per 1,000sf of roof area – 123gpd
*** AIT DFAC includes first flush of 10 gallons per 1,000sf of roof area – 338gpd

AIT Bldg Usage	Baseline Toilet Potable Water Usage (GPD) // Baseline Total Potable Water Usage (GPD)
AIT BCOF	**1,440gpd** (300PN x 1.6gpflush x 3 flushes/day*) // **45,000gpd** (300PN x 150gpd)
AIT BNHQ	**1,315gpd** (14PN Full Time x 1.6gpd x 5 flushes + 180 Students x 0.75 x 1.6gpd x 3 flushes) // **same**
AIT DFAC	1300PN x 1.6gpflush x 3 flushes/day = **6,240gpd** // 1300PN x 17.8gpd (13gpd faucet/dishwater/PN and 4.8gpd for toilet) = **23,140gpd**

An alternative analysis for a centralized cistern system for the BT and AIT complexes was also conducted. However, it was determined that such a system would be even less cost effective than a decentralized system of one cistern per building. The result for a centralized system would produce a similar daily toilet flush supply for both the BT and AIT complexes, but total costs would more than double based on an estimated $300 per linear foot cost of construction of trench gravity and pressure lines to and from the centralized cistern to the various buildings. This estimate cost is $300 because of dewatering requirements from a high water table for each trench which will hold both a gravity line from the building to the cistern and a pressure line from the cistern back to the building toilet fixtures. The table below summarizes this analysis. These results can also change and be refined with more accurate cost data. The benefit for such a system would be a centralized area for maintenance, but the first costs far outweigh the advantage of the maintenance benefit.

Building Complex	**AIT Complex (4BCOF, 1BNHQ, 1DFAC)**	**BT Complex (5BCOF, 1BNHQ, 1DFAC)**
Roof (sf)	170060	162530
Allowable Supply (gpd)	7050*	6750**
PN	1394	1731
Cistern Size (gal)	85000	82000

U/G Cistern Dimension (ft) w/1 ft Freeboard	44' x 44' x 7'	43' x 43' x 7'
Allowable Supply Met (days/ %time)	12456/50%	12448/50%
EISA (gal)	190810	182360
Cistern > EISA Req't (days/ %time)	0/0%	0/0%
Reduce Toilet Water % (gpd) / Reduce Potable Water %	20% (2675gpd) / 1%	12% (2563gpd) / 1%
Cistern Only Installation Estimated Cost	$ 488,750.00	$ 471,500.00
Total System Estimated Cost	$ 2,467,250.00	$ 1,832,000.00

* AIT includes first flush of 10 gallons per 1000sf of roof area - 1700gpd
** BT BNHQ includes first flush of 10 gallons per 1000sf of roof area - 1625gpd

<u>Summary of Recommendations and Other Considerations</u>

Recommendation Table (Considers Costs)
*Supply for toilet flushing will be less as these numbers include daily first flush estimates.

Roof Catchment Area (sf) and Building Type	*Cistern Size (gal)*	*Cistern Size Dimensions*	*Supply * (gpd)*	*Bldg Potable Demand (gpd)*	*Cost Estimate*
21567 BT BCOF	11000	16'x16'x7'	900	44400	$156,250.00
31195 BT DFAC	14000	17'x17'x7'	1020	952	$103,000.00
23500 BT BNHQ	16000	19'x19'x7'	1300	46280	$125,000.00
31000 AIT BCOF	15500	19'x19'x7'	1285	45000	$314,125.00
12300AIT BNHQ	6000	12'x12'x7'	505	1315	$110,000.00
33760 AIT DFAC	16000	19'x19'x7'	1380	23140	$45,000.00

A Recommended Cistern and Roof Area Sizing is based on sensitivity analysis as shown in Attachment A.

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Attachment A: Sensitivity Analysis

A sensitivity analysis was conducted between roof area, cistern size, and rainwater supply. The graph below shows cistern size versus allowable supply based on the Waynesville airport rain gage daily period of record from 1942 to 2010: The larger the roof area the steeper the curve. The smaller the roof area the curve flattens out faster. A steeper curve means a greater percentage of supply increases by having a larger roof area. Increasing the cistern size will have a smaller percentage increase in supply as each curve tends to eventually flatten out. The larger the roof size, the longer the curve will take to flatten out allowing for a larger cistern and more supply following a steeper curve as compared to a smaller roof size, which will allow a smaller cistern before the curve starts to flatten out.

A minimum established supply should always be available for toilet flushing such as 300 gpd; it doesn't make sense to have an efficient cost effective system that supplies fifty gpd of toilet flush water. Most of the AIT and BT buildings have a roof area of about 20,000 to 30,000 square feet. Thus for a 20,000 square foot roof area, a cistern size of 10,000 gallons would provide allowable daily supply of toilet flush rainwater of 300 gallons. Similarly a 30,000 square foot roof area with a cistern size of 15,000 gallons can supply about 475 gallons per day of toilet flush rainwater. In general the AIT and BT complex buildings demand 1,000 to 1,500 gpd of toilet flush water (with the exception of the DFACs) and thus designing a large enough cistern to support such demands for a 20,000 to 30,000 square foot roof would not be cost effective as the curves in the above graphs tend to flatten out. If rainwater could be captured and collected from hardstand or other impervious surfaces nearby it would greatly increase the volume of a cistern and could create more efficient cisterns with larger capacity. Therefore the ideal cistern size to impervious area would be a point on the curve that is an inflection point or a major change between the steepest part of the curve and the flatter portion of the curve.

The attached below is a graph showing roof area percentage increase versus allowable supply. The roof area percentage increase versus the allowable supply graph show that increasing the roof area is more effective in increasing the supply of toilet flush rainwater if using a larger sized cistern because the slope of the curve is steeper for a larger sized cistern.

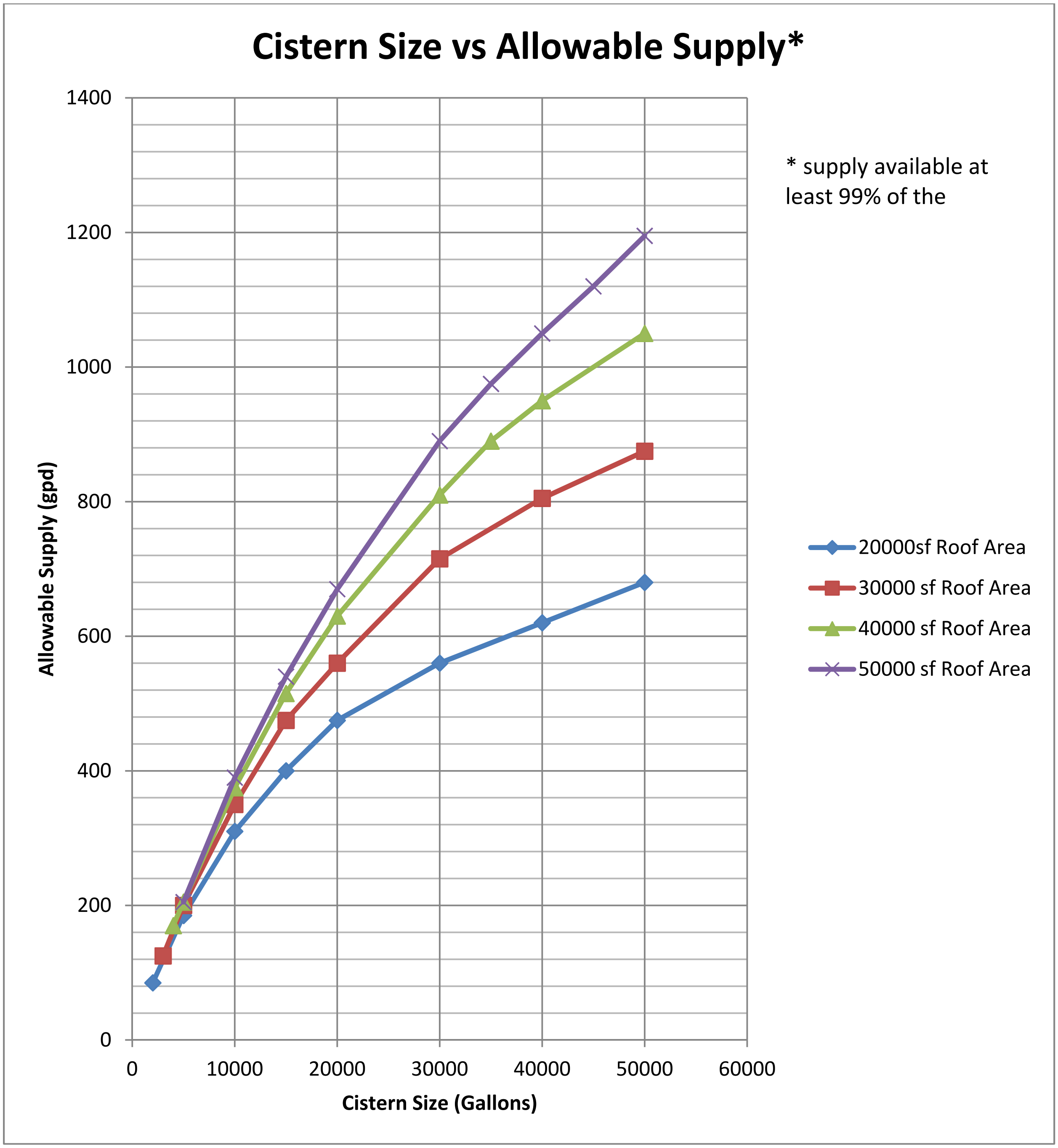

Figure 2. Chart courtesy of USACE, Honolulu District

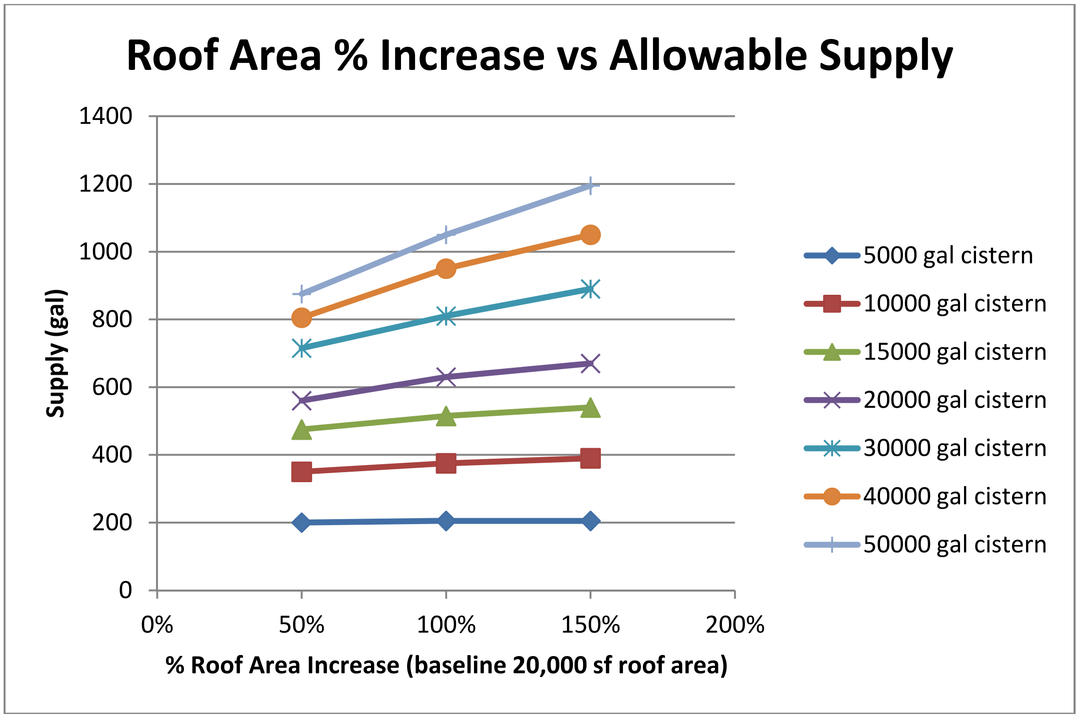

Figure 3. Chart courtesy of USACE, Honolulu District

Also attached below is another graph showing the cistern size increase versus allowable supply. This graph shows that increasing the cistern size for each set of roof area square footage will only keep the curve flat for 20,000 sf area roof. However increasing the cistern size following a 50,000 square foot roof area will allow the curve to be steeper and thus gain more supply for a smaller percentage increase in cistern size.

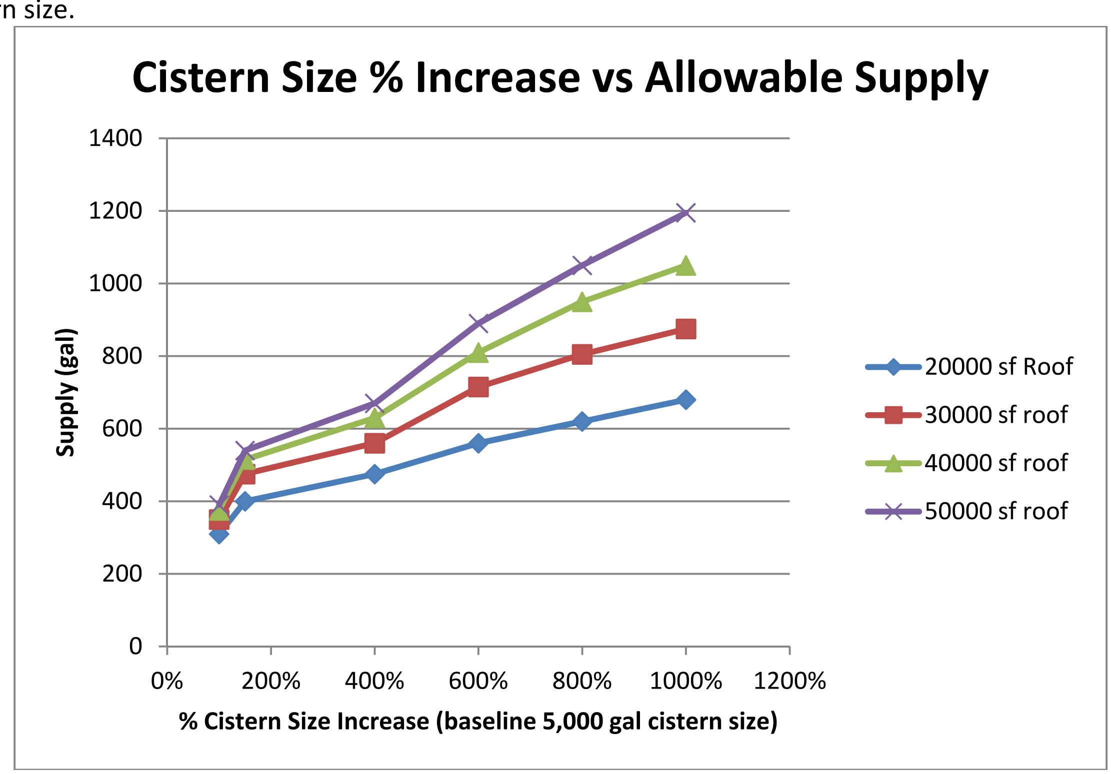

Figure 4. Chart courtesy of USACE, Honolulu District

Attachment B: Fort Leonard Wood Assumed Water Costs and Daily Usage from Angela Curtis Email 11 March 2011.

Li, Eric H POH

From:	Curtis, Angela SWL
Sent:	Tuesday, March 01, 2011 11:48 AM
To:	Simmons, Kenneth C NWK; Dorgan, Tracy H NAE; Brauch, Daniel P NWK; Li, Eric H POH; Ruf, Laura MVS; Campbell, Leslie E MVN
Cc:	Torres, Cambrey M NWO
Subject:	water

Team,

FLW Water baseline (as good as it gets right now):
150 gallons per person per day
Water consumption intensity: 90.4 GAL/SF (annual) or about 0.247 GAL/SF (daily)
Cost: $2.35/1000 gallons (double checking this; so, this could change) Daily base usage: 2.5 MGD (excluding housing)

Cambrey is using 10.25 million square feet for FLW (excluding housing). Using that, water consumption 10,250,000 sf x 0.247 gal/sf/day = 2,531,750 gpd.

Angela D. Curtis, P.E.
Little Rock District, U.S. Army Corps of Engineers
Office Phone (501) 324-5623 Ext. 1634

US Army Corps of Engineers

2030 USACE Integration Project

8.35 Recycling

recycling

TECHNOTE

Recommendation

Provide training for recycling best practices (cleaning and separation), recycling programs available, and additional infrastructure for occupants of the installation to increase materials recycling in daily operations. Recycling drop-off is currently at one location on post and, to improve waste diversion from landfills, drop-off areas should be decentralized in convenient locations around the base where pick-up can be made regularly on a bi-weekly schedule or as recycling volumes require. Establishing a pick-up schedule for Fort Leonard Wood (FLW) from decentralized drop-off locations will encourage increased recycling activity while diverting waste from landfills, reducing carbon emissions and fuel costs from individual drop-offs to a single recycling center location, and increase revenue to Fort Leonard Wood from recycling.

Location & Scale

This would be implemented at the **installation scale** to improve participation across the entire installation.

Phasing

Decentralized pick-up locations should be implemented as part of the **2015 Phase**. The Directorate of Public Works (DPW) should conduct a study to determine changes to waste stream content and waste diversion rates after expansion of the recycling program to compare before and after for making informed adjustments by the **2020 Phase**.

Initial Cost

Sites will need to be selected and the DPW could either contract pick-up service or manage vehicles for recycling pick-up and hauling to the central recycling center on base.

Life Cycle Cost

Recycling brings in revenue for Fort Leonard Wood and is an effective way to avoid costly disposal fees as landfill space becomes scarcer. The cost of adding drop-off stations and pick-up service in order to expand the program participation on base for increased waste diversion should be offset by recycling revenues directly paying for the program.

Maintenance

Maintenance would be required on vehicles if pick-up service and will be run through the DPW Operations rather than contracted service.

Feasibility

Fort Leonard Wood currently has a recycling program established with a single recycling center drop-off location for materials at Building #2549 Ordnance Drive (see Attachment B) that is open twenty-four hours per day. Fort Leonard Wood manages recyclables through the Qualified Recycling Program (QRP) and utilizes various collection initiatives including acceptance of wood pallets (in good condition), scrap metal, and used oil during business hours. All proceeds from recycling are returned to Fort Leonard Wood and a majority of the funds are used by Army Morale, Welfare, and Recreation (MWR).

Adding training and expanding recycling initiatives on base to include a pick-up route on a bi-weekly schedule that could coincide with garbage pick-up would only improve the program and help Fort Leonard Wood be a **Net Zero Waste** installation initiatives and resiliency while increasing revenue for the base.

References

See Attachment A

Environmental Protection Agency (EPA). "Recycling." *Wastes – Resource Conservation – Reduce, Reuse, Recycle.* 14 April 2011. Web. 24 July 2011. http://www.epa.gov/osw/conserve/rrr/recycle.htm

Fort Leonard Wood Official Site. "Solid Waste and Recycling." Feb 2010. Web. 24 July 2011. http://www.wood.army.mil/wood_cms/3197.shtml

University of Oregon. "The Recycling Process After Collection". Web. 24 July 2011. http://pages.uoregon.edu/recycle/after_collection.html

Diagrams

See Attachment B

Funding Plan

In accordance with 10 U.S.C. 2577 sale proceeds of recyclables shall first be used to cover the costs directly attributable to installation recycling programs.

Baseline Relation

Currently, Fort Leonard Wood's recycling program is set up to accept glass, aluminum, steel / tin, white and colored paper, junk mail, magazines, phone books, cardboard, corrugated cardboard, paper board, plastic types 1 and 2, newspaper, wood pallets, scrap metal, and used oil. Coordination with outside collectors is required for waste diversion of rechargeable batteries, cellular phones, and packaging material (expanded polystyrene).

The most recent Standard Operating Procedure (SOP) for Recycling and Solid Waste Diversion on Fort Leonard Wood was written 31 Aug 1999 with an objective for the recycling program to reach a diversion rate for recyclable material from non-hazardous waste stream of forty percent or greater by 2005. Current diversion rates should be evaluated for achievement and new target goals should be established. Training in recycling practices and the value of recycling has been shown to improve waste diversion and decrease contamination of sorted recyclable collection in offices.

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Attachment A:

Recycling

Recycling turns materials that would otherwise become waste into valuable resources. Collecting used bottles, cans, and newspapers and taking them to the curb or to a collection facility is just the first in a series of steps that generates a host of financial, environmental, and social returns. Some of these benefits accrue locally as well as globally.

Benefits of Recycling

- Recycling protects and expands U.S. manufacturing jobs and increases U.S. competitiveness.
- Recycling reduces the need for landfilling and incineration.
- Recycling prevents pollution caused by the manufacturing of products from virgin materials.
- Recycling saves energy.
- Recycling decreases emissions of greenhouse gases that contribute to global climate change.
- Recycling conserves natural resources such as timber, water, and minerals.
- Recycling helps sustain the environment for future generations.

Steps to Recycling a Product

Recycling includes collecting recyclable materials that would otherwise be considered waste, sorting and processing recyclables into raw materials such as fibers, manufacturing raw materials into new products, and purchasing recycled products.

Collecting and processing secondary materials, manufacturing recycled-content products, and then buying recycled products creates a circle or loop that ensures the overall success and value of recycling.

Step 1. Collection and Processing

Collecting recyclables varies from community to community, but there are four primary methods: curbside, drop-off centers, buy-back centers, and deposit/refund programs.

Regardless of the method used to collect the recyclables, the next leg of their journey is usually the same. Recyclables are sent to a materials recovery facility to be sorted and prepared into marketable commodities for manufacturing. Recyclables are bought and sold just like any other commodity, and prices for the materials change and fluctuate with the market.

Step 2. Manufacturing

Once cleaned and separated, the recyclables are ready to undergo the second part of the recycling loop. More and more of today's products are being manufactured with total or partial recycled content. Common household items that contain recycled materials include newspapers and paper towels; aluminum, plastic, and glass soft drink containers; steel cans; and plastic laundry detergent bottles. Recycled materials also are used in innovative applications such as recovered glass in roadway asphalt (glassphalt) or recovered plastic in carpeting, park benches, and pedestrian bridges.

Step 3. Purchasing Recycled Products

Purchasing recycled products completes the recycling loop. By "buying recycled," governments, as well as businesses and individual consumers, each play an important role in making the recycling process a success. As consumers demand more environmentally sound products, manufacturers will continue to meet that demand by producing high-quality recycled products.

Attachment B:

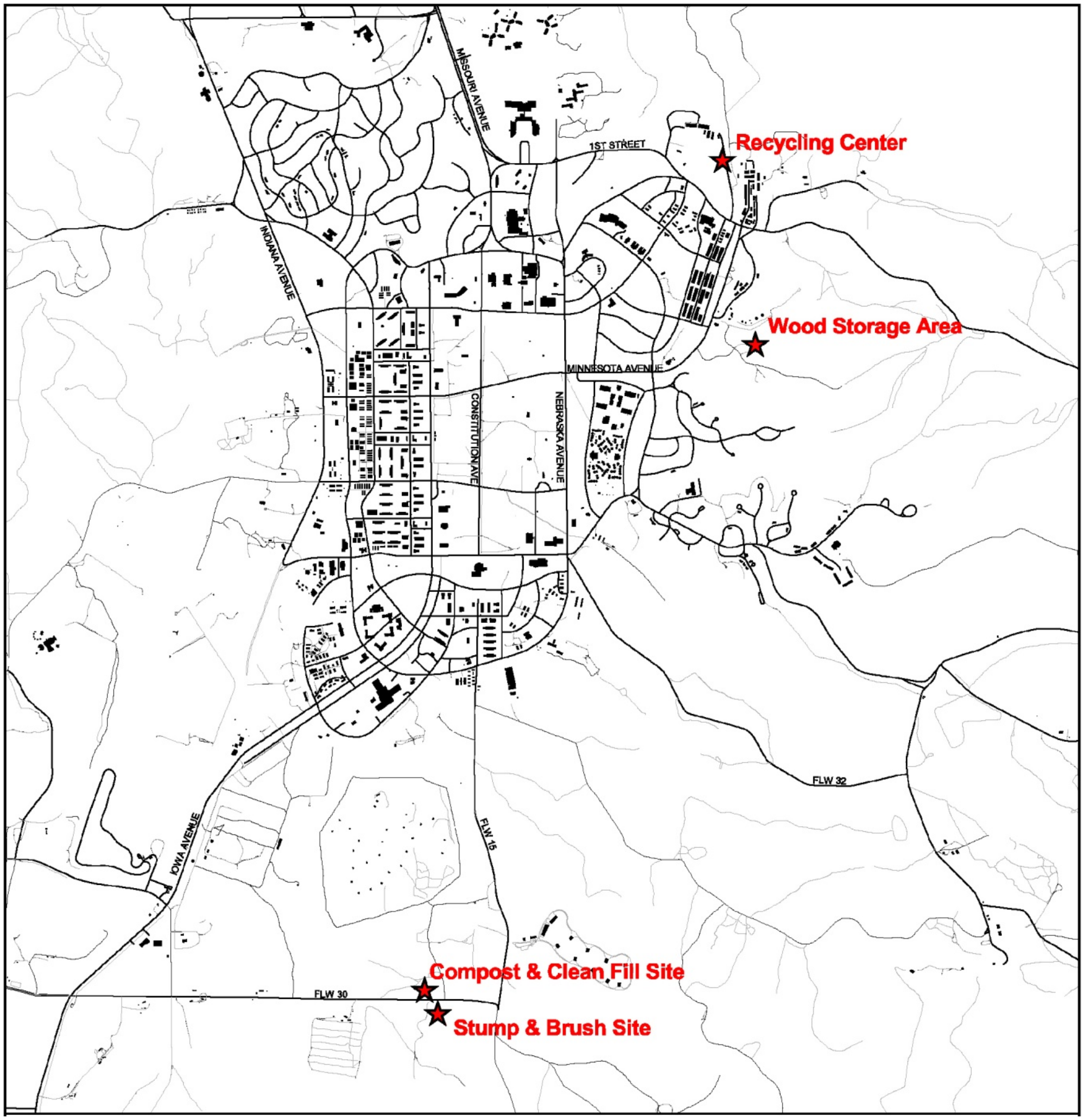

Figure 1. Fort Leonard Wood Map – Recycling Center

US Army Corps of Engineers

2030 USACE Integration Project

8.36 Res. Area Expansion & Mixed–Use Dev.

mixed use development

TECHNOTE

Recommendation

Due to demolition of aging housing and tornado damaged areas, there is abundant opportunity to increase housing density, livability, and walk-ability by creating mixed-use developments in lieu of segregated zoning communities. This can all be done in the existing residential footprints to the northwest and southeast of Fort Leonard Wood. As the need for additional housing arises, the installation should develop dense walk-able streets with two and/or three story housing units comprised of double and multiple family complexes with retail space on the first floor. Developments should be integrated and incorporate the following planning considerations:

- For every thirty families, one community garden will be built.
- For every thirty families, one automatic bike rental kiosk will be built at the location of a transit stop.
- For every ¼ mile of residential development along a major transit route, one transit stop will be built.
- Each block of mixed-use housing that is built will provide lease space to a post exchange (PX), a barber shop, a convenience store, a coffee / sandwich shop, and a restaurant contractor or other retail outlet.
- Each new block of buildings (thirty families or more) will be centered on a pedestrian zone that links to major amenities.
- For every fifty families, a playground and off leash dog park will be provided.

These recommendations will allow residents to access needed services without driving their vehicles. This reduces Carbon Dioxide (CO_2) emissions, should minimize road maintenance costs, and improves community security and cohesiveness.

Location & Scale

This will be implemented at the **installation scale**. Locations should be stitched into pre-existing residential communities in order to support the retail that will be integrated with the apartment complexes. Therefore an ideal location for new mixed-use residential developments would be along the main residential street entrances at the residential clusters to the northwest and the southeast of the center of the installation.

Phasing

Depending upon the housing needs of the installation, this could be phased several ways. If there is no immediate need for housing, then the plan for mixed-use developments could be integrated to the northwest residential community and townhouses could be added to the southeast residential cluster by **2020** (Phase 1). If the mixed-use developments in the northwest are successful, then another could be planned for the southeast once the residential density has increased enough to support more retail in **2025** (Phase 2).

Feasibility

As previously stated, the residential portions of the installation are aging or are in need of repair. While typical contracting and programming procedures may not lend themselves towards mixed- / shared-use facilities, alternative contracting methods may allow for this type of organization.

References

http://www.minneapolisfed.org/publications_papers/pub_display.cfm?id=3097

Refer to the master planning and Infill Strategies Tech Notes for additional information.

Funding Plan

The use of privatized housing contracts offers opportunities to integrate the above requirements. Enhanced use leasing should also be considered for mixed-use developments.

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2030 USACE Integration Project

8.37 Resource Master Planning System

Recommendation

First, acquire the Common Army Master Planning System (CAMPS) already in use at Fort Hood since 2006. CAMPS is a decision support tool providing the ability to model future facility utilization at the Brigade, Battalion, and Company levels, while considering facility demolitions, new construction, and major renovation projects. The system imports and leverages existing information from the Installation Status Report (ISR), Integrated Facilities System (IFS), Real Property Planning and Analysis System (RPLANS), and other Army databases, as well as installation-specific CADD and GIS resources. CAMPS uses an interactive browser based GIS-visualization tool to see current and future facility requirements, existing and planned facilities, and facility shortfalls over time, while overlaying and analyzing all available variables, allowing immersive '4D' scenario planning and design.

Second, deploy a Bentley ProjectWise (PW) implementation at the installation level. ProjectWise provides a common environment and folder structure for engineers, designers, planners, management, and stakeholders to collaborate on complex / highly dynamic projects. By provisioning and enforcing a tightly integrated document management system, teams bypass versioning / quality and distributed tasking / travel limitations that typically lead to significant increases in project costs, delayed deliverables, and delayed (or canceled) plan execution.

Location & Scale

These systems are implemented at the **installation scale**.

Phasing

These systems are implemented in the **2015 Phase**, though **2020 Phase** implementation is an option.

Initial Cost

An E&E representative quoted CAMPS licensing and adaptation costs for a single installation at **$180,000**. This system could be implemented with Directorate of Public Works – Network Enterprise Center (DPW-NEC) and other Garrison or project **'information system' designated funds.**

The Army already has an Enterprise License Agreement (ELA) with Bentley which includes effectively unlimited concurrent PW use licenses. Costs for a new implementation are limited, with a single network administrator day (8 hrs*$90/hr burdened = **$720**) required.

Life Cycle Cost

Ongoing costs are concurrent with Garrison information systems infrastructure overhead. A marginal three to five percent IS overhead charge would apply for owners / operators not already participating. Data acquisition intervals and efforts will have to be funded as the Garrison / DPW identifies and funds priorities. Additional technical support from Fort Hood E&E will require project funding on a case-by-case basis.

Maintenance

Commissioning and maintenance of the CAMPS and PW systems involves several components:

- Additional or completely new computing infrastructure
- Existing IT staff system briefing and familiarization
- Systems troubleshooting and resolution coverage
- Front-end user and team training (initial and recurring)
- Project-related take-off / overhead

Alternatives and cost break downs are detailed in the paragraphs below. Preferred alternatives and options are **Cloud IAAS** and **Dedicated IT Personnel**. These options, in addition to **User Training** and **Project Take-Off**, total to initial costs of **$121,000**, with ongoing expenses of **$57,000/year.**

Strategic Computing Infrastructure / Support

- *Cloud Infrastructure as a Service (IAAS)*
    - Amazon EC2 high-memory instances available @ $1/hr
    - $2000/3-year reserved instance, rates <$0.24/hr
    - Reserved Instance = $700/yr + (30 Personnel*15 hrs/wk*50 wks*$0.24/hr = $5,400/yr) = **$6,300/yr**

- *Enterprise Solutions*
    - Cisco offerings:
        - Unified Computing
        - Smart Care Services
    - Relatively expensive, **$50k - $500k/yr**, scale dependent

IT Professional Readiness & Capabilities

- *Dedicated IT Personnel*
    - 10 hrs system specific training w/system designer = 10 hrs*3 personnel*$50/hr burdened cost = **$1,500**
    - 10 hr/wk support availability = $500/wk = **$26,000/yr**

- *Contracted IT Support*
    - $20/hr*1.1 travel overhead*1.15 system & problem familiarization*1.35 operator profit margin = **$34/hr**
    - Support cost range:
        - 200hrs/yr*$34/hr = **$6,800/yr**
        - 800hrs/yr*$34/hr = **$27,000/yr**

- *IT Coordination (either option)*
    - 1.05*Recurring IT Expenses

User Training & Applications

- *User Training Program*

- Initial Cost Model
    - 1 Operations Manager ($120/hr)
    - 1 Planner / Project Manager ($105/hr)
    - 1 Designer / Technical Specialist ($70/hr)
    - = (3) Personnel / 3000 Installation personnel (Brigade) @ $100/hr
    - Fort Leonard Wood = 90,000 / 3,000*$100/hr burdened*40hrs = **$120,000**
- Recurrent Training
    - 1 day/quarter = 32 hrs/yr*$100/hr = **$3,200/yr**
- Applications / Project Take-Off
    - 1.05*90/3 Teams*45hrs/wk*50 wks = **$23,600/hr**

Feasibility

This system formalizes, promotes, and enforces Installation-scale planning and operations activities, ensuring that planners, project delivery teams, and operations managers are all looking at and working with the same virtualized representation of the installation space. Efficiencies are achieved by reducing duplication of work, reducing formal enterprise communications workload and complications, and establishing a 4D full-spectrum awareness of existing conditions vs. proposed plans and actions. When integrated with existing program and project management systems (P2, Primavera, etc.) as well as facilities / O&M management systems (Maximo), CAMPs becomes a force multiplier and, more importantly, provides a medium of translation and exchange for non-budget and technical type professionals, who play key roles in base operations and planning.

Equally important to planning and tracking, however, is project collaboration and execution. ProjectWise delivers, with an engineering project team collaboration system that helps teams improve quality, reduce rework, and meet project deadlines, even when widely dispersed. Proven on projects across all scales, local to international, ProjectWise increases productivity and reduces costs, and is singular in its demonstrated provision of integrated solutions for content management, content publishing, design review, and asset lifecycle management. The US Army Corps of Engineers and prominent AE firms, nationally and globally, have signed multi-million dollar Enterprise License Agreements (ELAs) with Bentley, ensuring unlimited access to critical business process software and infrastructure.

Key ProjectWise Capabilities:

- Enterprise-level engineering content management
- Optimization for geographically distributed project teams
- Design review environments for content creators, collaborators, and consumers
- Multi-channel publishing tools for project deliverables
- Business Intelligence for lifecycle asset management and compliance
- Seamless integration with engineering and office desktop applications
- Flexible access and deployment options for teams of all shapes and sizes

References See Attachment A

Diagrams See Attachment B

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Attachment A: The following screenshots showcase key CAMPs and ProjectWise features.

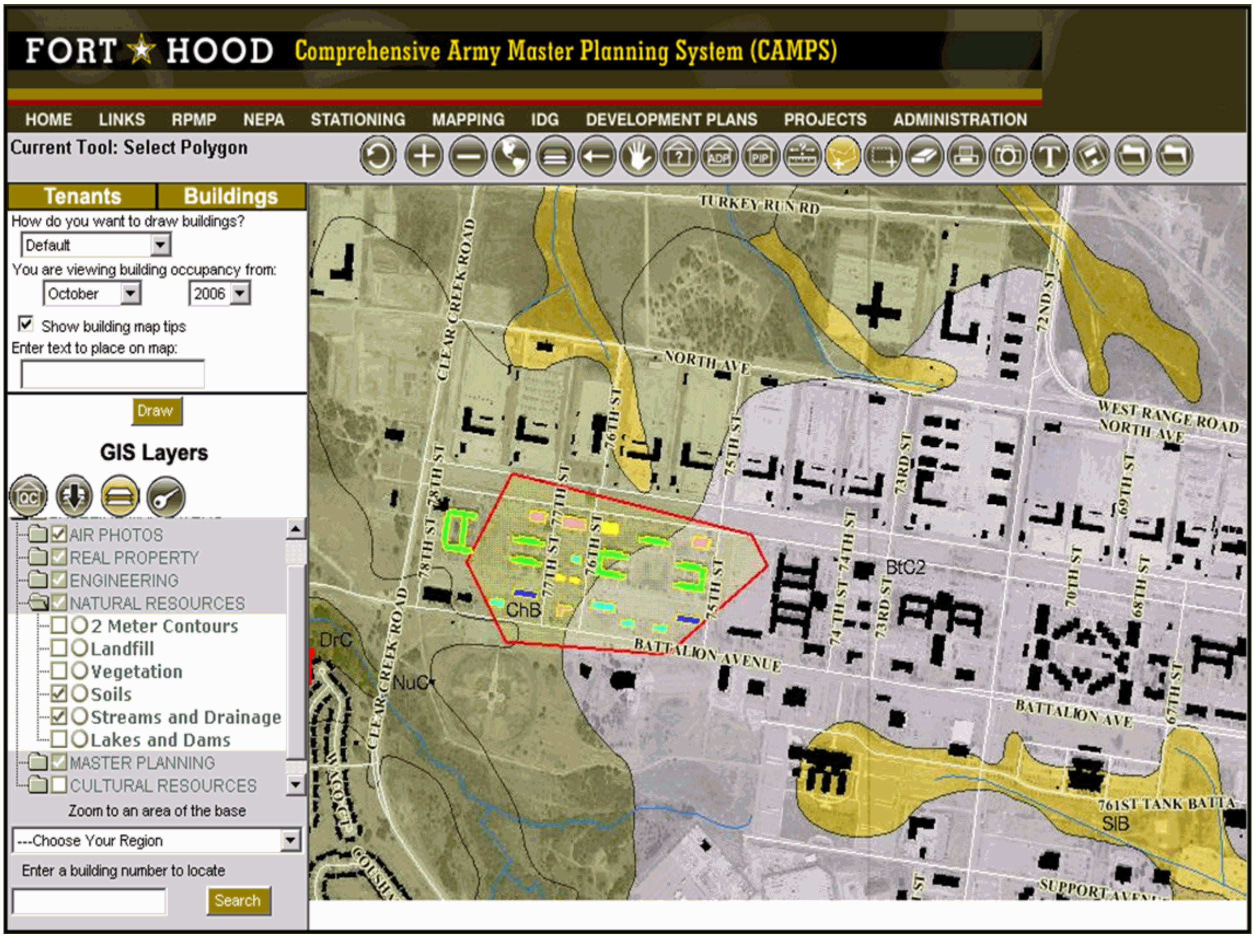

Figure 1. CAMPS GIS-Mapping Interface – Image courtesy of the US Army, Fort Hood

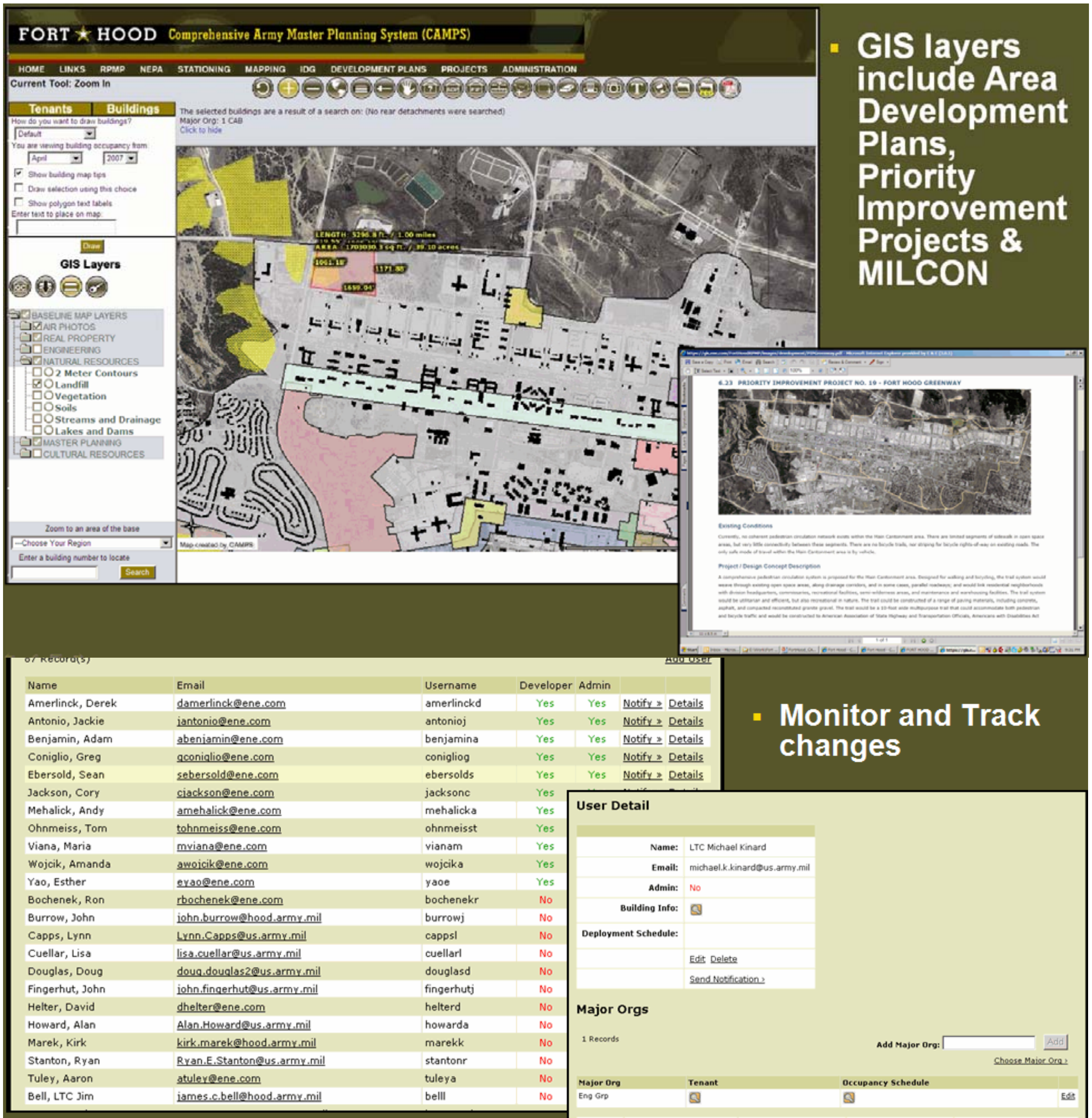

Figure 2. CAMPS Planning Tools – Image courtesy of the US Army, Fort Hood

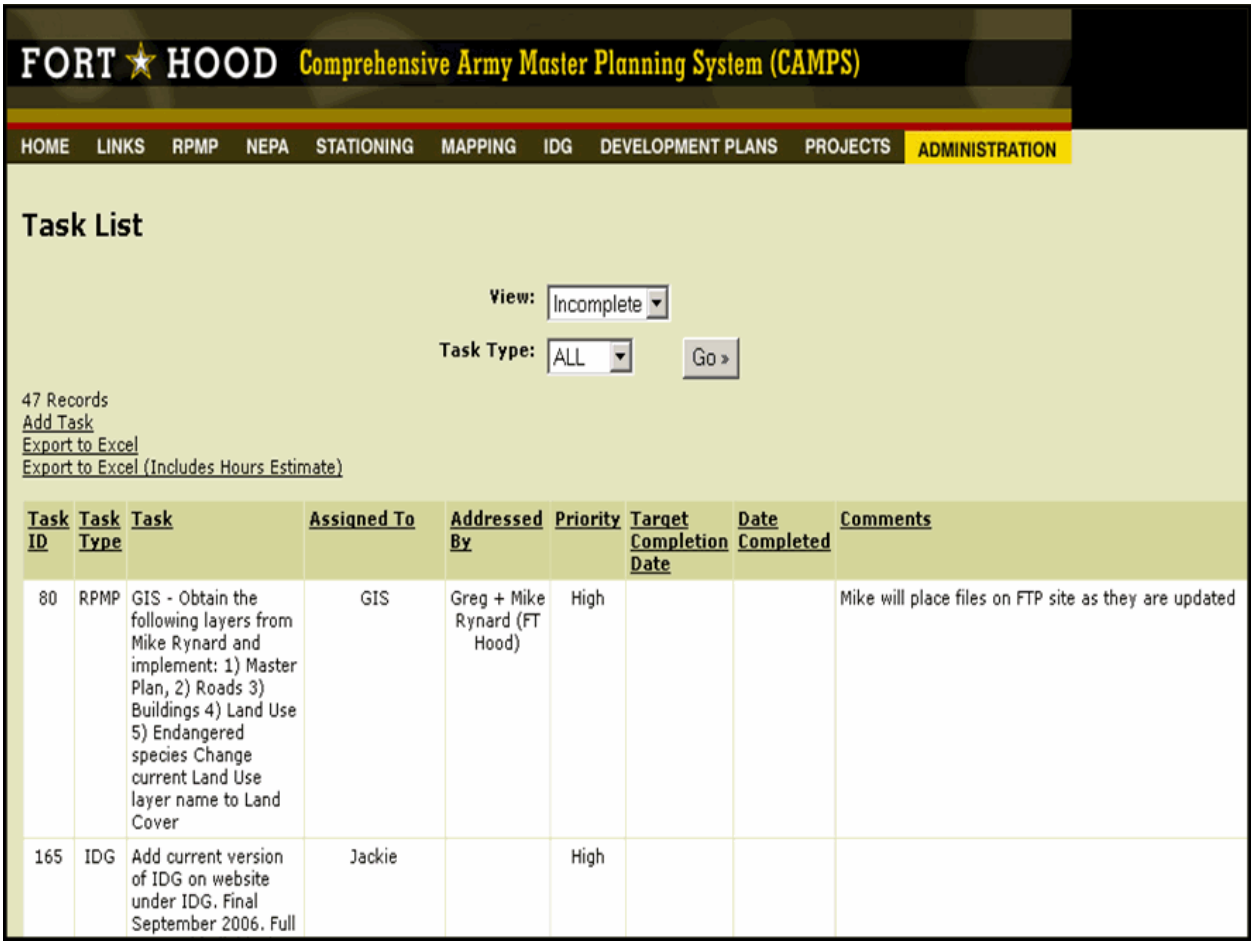

Figure 3. CAMPS Tasking & Project Management – Image courtesy of the US Army, Fort Hood

- CAMPS Contacts:
  - o Fort Hood – Alan Howard, alan.howard@us.army.mil, 254-618-7048
  - o Ecology & Environment – Sean Ebersold, sebersold@ene.com, 706-379-3543 (office), 706-618-7083 (cell)
- Bentley ProjectWise site: http://www.bentley.com/en-US/Products/projectwise+project+team+collaboration/
- Bentley White Papers: http://www.bentley.com/en-US/Engineering+Architecture+Construction+Software+Resources/Bentley+Software+Publications/Bentley+Software+White+Papers/
- Bluebeam ProjectWise + MS Sharepoint integration: http://www.bluebeam.com/us/products/revu/integration.asp

Attachment B:

Figure 4. CAMPS Process - Image courtesy of the US Army, Fort Hood CAMPS web site

US Army Corps of Engineers

2030 USACE Integration Project

8.38 Solar Hot Water

TECHNOTE

solar hot water

Recommendation

Install evacuated-tube type solar collectors in active, closed-loop water heating systems of various sizes on rooftops to serve all new buildings for the Advanced Individual Training (AIT) and the Basic Combat Training (BT) facilities. An active, closed-loop system heats a heat-transfer fluid (non-toxic, high temperature antifreeze in an indirect freeze-protection system is recommended for this scenario) in the collector and uses a heat exchanger to transfer the heat to the water supply.

For the AIT complex site, install evacuated-tube collectors on the Dining Facility (DFAC) roof and 3,400 square-feet (sf) on each combined Barracks and Company Operations Facility (BCOF). The Battalion Headquarters (BNHQ) will tie into the nearest building's system for hot water. Also, install tank(s) with total estimated capacity of 1000-gallons for the DFAC, and total tank capacity of 5,000-gallons for each BCOF. Storage tanks should be preferably located near the collectors' locations.

For the BT complex site, install evacuated-tube collectors on each BCOF roof. The BNHQ will tie into the nearest building's system for hot water.

Location & Scale

This system is implemented at the **building scale**. Each new structure (sans BNHQs) shall have collectors located on the roof as close to fixtures as possible, storage tank(s) located in appropriate mechanical / utility rooms or below grade (per design of each building), and plumbing and electrical connections as necessary for the designed system.

Phasing

This system is projected as part of the **2015 Phase**. It should be installed in conjunction with each new building. Existing structures should be evaluated prior to retrofit of solar water heating systems to determine whether installation is cost effective, etc.

Initial Cost

The installed cost of the estimated system for each BCOF is approximately **$331,000.**

Life Cycle Cost

This system will require significant maintenance or replacement in twenty to thirty years. The project is lifecycle cost effective if the payback period is less than fifteen years. Lifecycle costs would need to be completed on a building by building basis as it is specific to hot water demand per building.

Maintenance

The system will require annual inspection to ensure the antifreeze fluid is adequate and that the system is free of leaks, issues, etc. This inspection must be performed by a person qualified by the Solar Rating and Certification

Corporation (SRCC). Recommend this annual service be included in a maintenance contract with the installer for five years with the option to renew. Estimated annual maintenance costs are fifty dollars per year, including supplies. Estimated lifetime maintenance costs with no excessive or accidental damage are $1,000.

References See Attachment A

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Attachment A:

Key Terms:

Drainback system – A system in which water in the collector loop drains into a reservoir tank when the pump stops.

Draindown system – A system in which water flows from the collector loop and piping into a drain in freezing weather conditions. Historically, this is less reliable than a drainback system.

Integral collector/storage (ICS) system – Also called a "batch" or "breadbox" water heater, this system is appropriate for mild climates; it combines a collector and storage tank into one unit. Sun shining on the collector strikes the storage tank directly, heating the water. The water's large thermal mass, along with the insulation that reduces heat loss through the tank, prevents the stored water from freezing.

Recirculation system – Whenever freezing weather conditions occur warm water from storage is circulated through the collectors and exposed piping; the system is best for mild climates.

Thermosyphon system – Has a separate storage tank above the collector. Warm, less-dense liquid in the collector rises naturally above it and remains there until needed. As water cools in the tank, becoming denser, it naturally sinks back down to the collector.

BTU (or British Thermal Unit): The amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. BTU is used to signify the heating and cooling capacity of a system and the heat losses and gains of buildings and homes.

BTUH: The number of BTUs produced in one hour.

Fossil Fuel: Any of several types of combustible fuels formed from the decomposition of organic matter. Examples are natural gas, propane, fuel oil, oil and coal.

Payback: A method of calculating how long it will take to recover the difference in cost between two different heating and cooling systems by using the energy and maintenance-cost savings from the more efficient system.

Web links:

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- http://www.ehow.com/how_5848802_size-water-heaters-commercial-use.html
- http://www.nrel.gov/docs/legosti/fy96/17459.pdf
- http://www1.eere.energy.gov/buildings/ush2o/pdfs/life_cycle_costs_info_sheet.pdf
- http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf
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2030 USACE Integration Project

8.39 Solar Photovoltaics (PV)

Recommendation

Install a 5,500kW/h sized grid-interactive solar photovoltaic (PV) system in all new construction, and plan to retrofit existing buildings as possible and logical. With the possibility of building uses changing in the future, each structure must have an uninterruptable power supply (UPS) capable of operating a minimum of critical circuits during utility emergencies, unforeseen power loss, and to supplement other energy sources. In the grid-interactive solar PV system, the electric utility is still engaged as a back-up source when PV and other forms of renewable / stored energy are exhausted.

Location & Scale

This system is implemented at the **building and installation scales**. All new buildings will have the maximum square footage of PV integrated in their construction. Each existing facility on the installation will require analysis to ensure that their structure is capable of handling additional loads imposed by solar PV system. Also, centralized locations at each area will serve as a hub for the electrical / power connections, on-site storage and back-up, etc. At the Advanced Individual Training (AIT) complex site, this function will occur in or adjacent to the Navy facility, and in or attached to the new Battalion Headquarters (BNHQ) at the Basic Combat Training (BT) complex site.

Phasing

This system is projected as part of the **2015 and 2030 Phases**. With the speed that this technology is developing, upgrades in products and performance may be available by the 2030 date. For new buildings, the system should be designed and installed in conjunction with the roof systems, with wiring and utility connections aligned with each building's construction schedule. As analysis of existing structures develops, they should be retrofit with new systems as much possible (more towards 2030).

Initial Cost

Average installed costs for typical grid-interactive solar PV system are approximately seven dollars per watt. A 2.74-kW system specified would produce approximately 675 kWh per month at an estimated cost of **$19,160**.

Life Cycle Cost

Taking the installed cost of the system at $19,160:

Estimated Cost:	$19,160.11
Post Incentive Cost:	$13,412.07
Average Monthly Savings:	$13.57
25 Year Savings:	$6,780.54
25 Year ROI:	50.56%
Break Even:	37.16 years

- The “Estimated Cost” assumes the national average of seven dollars per watt, which includes parts and installation for systems above 2kW.
- “Post Incentive Cost” is an estimation based on the available credits/rebates for the area.
- “25 Year Savings” is based on the amount of electricity cost you save, assuming an annual four percent increase in utility rates.
- Number estimate a fifty percent utility offset.

Maintenance

The solar panels require little maintenance. Periodic washing with a water hose will be sufficient. Automated cleaning systems are available and may be a good choice if the area is especially susceptible to collection of dirt and debris.

Feasibility

The pay-back period for the solar array system is nearly forty years, which may fall outside of a prescribed period for the return on investment. However, the addition of the grid-tied solar array system is beneficial in many facets. Installation of the system will provide a source of renewable energy, decrease reliance on finite resources such as fossil fuels, and establish a new level of resiliency to Fort Leonard Wood’s (FLW) utility grid.

References

See Attachment A

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Attachment A:

Key Terms:

Balance of System Equipment (BOS): Includes mounting systems and *wiring systems* used to integrate the solar *modules* into the structural and electrical systems. Most systems include a combiner board since most modules require fusing for each module source circuit.

DC-AC Inverter: Takes the DC power produced by *PV Array* and converts it into standard AC power.

Metering: Includes meters to provide indication of system performance. Should measure kW/hr.

Module Mismatch: Difference of power output resulting from slight inconsistencies in performance from one module to the next. Generally amounts to at least a 2% loss in system power.

PV Array: A PV Array is made up of *PV Modules*, forming *PV Panels*.

PV Cells: The devices that convert sunlight to electricity.

PV Modules: Environmentally-sealed collections of *PV Cells*. The most common PV module is 5 to 25 square feet in size and weighs about 3-4 lbs/sf.

PV Panel: Usually, sets of four or more smaller *PV Modules*, framed or attached together by struts. They are typically around 20-35 square feet in area for ease of handling.

Uninterruptable Power Source (UPS): Will include batteries & battery enclosures, battery charge controller, and a separate subpanel(s) for critical load circuits.

Wiring systems: Include disconnects for the DC and AC sides of the inverter, ground-fault protection, and overcurrent protection for the *PV modules*.

BTU (or British Thermal Unit): The amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. BTU is used to signify the heating and cooling capacity of a system and the heat losses and gains of buildings and homes.

BTUH: The number of BTUs produced in one hour.

Fossil Fuel: Any of several types of combustible fuels formed from the decomposition of organic matter. Examples are natural gas, propane, fuel oil, oil and coal.

Payback: A method of calculating how long it will take to recover the difference in cost between two different heating and cooling systems by using the energy and maintenance-cost savings from the more efficient system.

2030 USACE Integration Project

8.40 Stormwater Management

Recommendation

Fort Leonard Wood (FLW) should implement a new stormwater management plan installation wide. Fort Leonard Wood's existing stormwater infrastructure consists mostly of grassed swales along roads and concrete trapezoidal channels which convey large volumes of polluted water into the Big Piney River and erode the river banks. Sedimentation is also a problem because erosion control plans are not used and several bare soil areas are evident on the installation (Attachment B, Photo 2). Some of the existing stormwater conveyance structures present safety hazards for pedestrians and vehicles (Attachment B, Photo 1). There is also concern that Fort Leonard Wood may become subject to regulatory fines as polluted stormwater from the installation is allowed to compromise the environmental integrity of the Big Piney River.

Fort Leonard Wood's new stormwater plan should include evaluating and renovating the existing stormwater infrastructure, making more impervious disconnections, establishing new erosion control guidelines, and implementing stormwater management guidelines for new construction. The plan should also reference the base's approved Low Impact Development (LID) techniques for construction that will help meet federal mandates for stormwater. *(For examples and pictures of LID, see Attachment C.)*

This Tech Note outlines a plan to improve stormwater management for Fort Leonard Wood. This plan includes a guide for the addition of natural, sustainable features which will effectively remove stormwater from the streets, improve water quality, prevent river bank erosion and river pollution, and improve safety for pedestrians and vehicles. It was created in conjunction with the Master Planning, Green Streets, Bioswales, Water Source, and Water Wells Tech Notes as part of the 2030 Integration Project at Fort Leonard Wood.

Location & Scale

The new stormwater system should begin at the **site scale and grow to the installation scale.** The goal of site implementation is to mimic natural hydrology of the site and promote infiltration for all stormwater. Installation should start in the cantonment area with replacing grassed swales and concrete ditches with bioswales and bioretention areas.

Phasing

The new stormwater system is projected as part of **all phases.** This will be an ongoing project that should start as soon as possible and be implemented as part of all future Fort Leonard Wood construction / renovation plans. Planning should begin immediately with an evaluation of the existing stormwater system and development of an installation-wide plan for renovating the stormwater system. This plan should be implemented in the following phases.

In the **2015 Phase,** continue to enforce regulatory erosion control plans with all construction contractors and ensure that sediment is staying on site during all construction projects at Fort Leonard Wood. All erosion control plans must be implemented to their fullest extent and inspected periodically to ensure that they are meeting current regulatory standards. For the 2015 phase, new building designs will be required to meet Energy Independence and Security Act (EISA) Section 438. Section 438 of EISA pertains to stormwater; this mandate requires retaining the volume of the 95^{th} percentile storm which is very near to the two year recurrence interval storm or also a storm that has a fifty percent chance of occurring on any year. Retaining all this water can be done within construction limits but it is not necessary for this law and can be done on a different area of the installation.

Fort Leonard Wood should purchase a street sweeper or contract street sweeping the installation as part of a maintenance contract. Sediment and trash accumulates on streets even if there is not construction nearby and the current plan is to allow this sediment and trash to accumulate until a large rainstorm washes it away. Streets and other areas of pervious concrete should be cleaned regularly to prevent stormwater from washing this sediment and trash into receiving streams and pushing the problem farther downstream.

Impervious disconnections should be implemented on old buildings and all new buildings. Typical new construction practice is to tie the gutters from the roof into a pipe that runs off site (Attachment B, Photo 5). Impervious disconnections take this impervious connection and break it by instead making the gutter water run across the ground instead and then surface flowing off site. LID practices should be implemented on new sites with rainwater harvesting from roofs and pervious concrete on site, where applicable.

For the **2020 and 2025 Phases,** Storm Water Prevention Protection Plans (SWPPP) will be implemented and adhered to in all new construction. As part of the SWPPP, erosion control will be periodically inspected and maintained after storms to ensure that works properly. Renovation of existing stormwater infrastructure should begin in an effort to meet EISA Section 438. Problem areas that were identified in the initial stormwater system evaluation should be addressed in new renovation projects. Concrete trapezoidal channels should be demolished and replaced with bioswales and vegetative channels. New trails will follow these new stormwater conveyance areas as running and biking trails, creating a creek pathway that will run through flood areas. This pathway in the floodplain utilizes area where buildings should not be built and may be easier to fund with multiple, diverse, beneficial outcomes. These areas will be utilized and designed to flood to detain larger storms that do not fall under EISA 438. The twenty-five year to fifty year storm detention area will be these floodplains.

Green streets will start to become part of new projects and will be designed as part of the stormwater management. Bioretention will also start to be implemented on the ranges to help filter the water that runs off of ranges that is lead contaminated. LID practices will also be implemented moving installation wide. Current grassed swales should be engineered to effectively infiltrate and slow down water by use of some soil amendments and checkdams.

For the **2030 Phase**, all of the concrete channels have now been replaced with grassed swales that slow down the water, clean it, and provide better flood management. The new pedestrian areas will be connected to the new green streets, and bioretention / prairie restoration areas will all be established areas that serve as a running / bike trail. During large rains, these areas will all be able to flood.

Initial Cost

First costs of these stormwater systems will be extremely diverse. Therefore, refer to separate LID tech notes to find costs for elements of the stormwater plan.

Approximate Costs:

Stormwater Feasibility Study:	$250,000
Vacuum Street Sweeper:	$150,000
Impervious Disconnection:	$200 per roof disconnection
Concrete Demolition and Haul off:	$0.50/sq ft

Stream trail, plants, and stormwater conveyance systems: $10 Mil (approx.)

Stormwater Master Planning Study

Stream Study:	$30,000
Range Stormwater Study:	$50,000

Life Cycle Cost

A stormwater management plan's Life Cycle Cost Analysis (LCCA) should be measured in more ways than money. This stormwater management plan for Fort Leonard Wood will drastically improve the quality of stormwater leaving the installation, which will also improve the quality of receiving waters from the installation. Sediment loads and velocities of receiving waters will be reduced, slowing erosion of streams and river banks. This will also slow the amount of trash (bottles, cans, paper, etc) moving off site by stormwater. The stormwater management plan would significantly improve the quality of life for animals in the area as well. Less sediment will be carried into the receiving waters, reducing negative impacts on aquatic species and communities that use the Big Piney River downstream from Fort Leonard Wood. Stormwater management strategies proposed in this plan will help ensure that cleaner water reaches the aquifer and prevent contaminated water from entering the aquifer. Better pedestrian access will provide happier and healthier residents.

One of the biggest financial areas that stormwater management will impact is in flooding costs and drainage problems. LID stormwater costs will be about the same as conventional stormwater costs on post, if not a little cheaper. An effective stormwater management plan will help prevent flooding and reduce potential flood damage. Even though Fort Leonard Wood is on higher ground and has limited flooding concerns, flood damage downstream will be minimized if communities upstream have effective stormwater management techniques. Fort Leonard Wood could also benefit from avoiding fines when federal law and/or any future state regulations are imposed. Controlling stormwater flow rates will alleviate drainage issues, lengthen the services years, and reduce the repair costs for stormwater conveyance systems. Reduction of drainage problems will prevent erosion beneath hard surfaces, drainage patterns appearing on landscaping, and structural foundation problems.

Another potentially serious stormwater-related issue for Fort Leonard Wood is lead contamination of potable water sources from the post's artillery ranges. Runoff from the ranges flows into the Big Piney River upstream of Fort Leonard Wood's water treatment facility intake. This potential issue alone is significant enough to warrant implementation of LID practices, specifically bioretention. Bioretention has been shown to remove 90% of heavy metals in stormwater.

Maintenance

The current stormwater system at Fort Leonard Wood allows all trash and sediment to quickly run off site where it is, 'out of sight and out of mind.' Current maintenance is lacking and mostly relies on cutting the vegetation that catches the trash down so trash doesn't get caught in vegetated swales. Any trash that does get stuck is eventually flushed out by large storms that effectively clean out the stormwater systems. A large storm will flush a lot of sediment and trash downstream and eventually off post. All of the new stormwater management plans will require more maintenance than that, but this is maintenance that currently should be done. With new plans, trash and sediment will be kept in the stream in the middle of post and will have to be cleaned out periodically. Ideally this trash could be eliminated at the source, but at some point some trash will make its way into the stormwater system. With more strict erosion control, contractors will have to keep all erosion control measures up to date and will have to clean them after rains and ensure that they are all functioning properly. An SWPPP is incorporated in all construction plans. LID features implemented as part of the new stormwater plan will have to be cleaned periodically to ensure that they are functioning properly. LID elements are excellent at cleaning stormwater, such that the sediment and trash that no one knew even existed will now be collected in LID features. Because of this, LIDs will eventually be full of sediment and trash and must be regularly cleaned to ensure they function properly. Best Management Practice (BMP) systems should be cleaned out at a minimum of once per year. To clean all BMP systems every year would cost approximately $200,000.

Feasibility

The new stormwater management plan for Fort Leonard Wood supports the installation's efforts to meet **Federal Mandate EISA Section 438,** which requires the retention and treatment of runoff from every 95th percentile storm. With EISA 438, stormwater management is allowed to be done inside or outside of construction boundaries. Therefore, "mitigation" work could include contractors / designers meeting EISA 438 requirements by completing off site stormwater management at specified problem areas on post.

A new erosion control plan should be implemented as well. Stricter sediment controls, testing, inspection, and enforcement should be in this new erosion control plan. Quality Assurance (QA) staff at Fort Leonard Wood should be well versed in this new plan and should have the authority to walk the site with a Superintendent or contractor representative and determine what erosion control features need to be installed or maintained after a rainstorm. This should be a priority on site and should be consistently reviewed by the QA.

For these new plans to work, Fort Leonard Wood's staff will need to be very strict on what is done, and be experts on SWPPPs and BMPs. The contractors must be liable for their actions and unless Fort Leonard Wood is serious about making sure it gets done, then it will just go unnoticed. It will require work from the U.S. Army Corps of Engineers and Directorate of Public Works (DPW) to ensure that we actually move forward with correcting stormwater issues.

References See Attachment A

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Diagrams Attachment B: Current Fort Leonard Wood Maps and Photos

Attachment C: LID Example Photos

Baseline Relation Sustainable stormwater infrastructure will help Fort Leonard Wood meet the requirements of EISA Section 438. EISA Section 438 also has other side effects that would be a benefit for Fort Leonard Wood. If water from wells may be used as potable in the future, sustainable stormwater practices will lower the risk of aquifer contamination. Cleaner and slower stormwater runoff can revitalize streams and rivers, reduce sediment, trash, and degradation of streams, and provide more wildlife in the area which would all provide better hunting and fishing for nearby areas. Sustainable stormwater infrastructure is also much more natural and will provide green space. Adding trails in these natural areas that are pedestrian and bike friendly can help with the overall wellness of the installation residents.

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Attachment A:

Key terms:

SWPPP: Stormwater Pollution Prevention Plan. This plan is required for all new projects and it lays out how erosion control will be done on site. This is a requirement as part of permitting.

BMPs: Best Management Practices. These are the current practices that are used to clean stormwater and keep erosion to a minimum. These are always evolving and are constantly getting better. BMPs can be found on the Environmental Protection Agency (EPAs) website (3).

LID: Low impact development. This is the new way to manage stormwater. LID aspects include pervious pavement, bioretention, bioswales, rainwater harvesting, and green roofs.

EISA Section 438: As part of the Energy Independence Security Act, section 438 mandates new stormwater regulations that now require all federal projects to treat and retain the 95th percentile storm. LID techniques are the way for new projects to meet this act.

Porous Pavements: Porous pavements replace standard concrete and asphalt that are totally impervious. These new pavements allow pollutants to filter and stick in the pavement instead of running off into stormwater. Porous pavements come in 4 different varieties: Pervious concrete, porous asphalt, permeable pavers, and grassed pavers.

Green Streets: Green streets are a new way that streets are designed that allow for better pedestrian access, and have bioretention areas built into the street design. Typically these streets are slower speeds and they are designed to slow traffic down and be aesthetically pleasing.

Bioretention: These are areas where water is retained in a planted area where plants will use the water faster than it would just evaporate and the water is also filtered by the plants.

Bioswales: These are bioretention areas that are used as a means or conveying stormwater so it can be filtered by grasses and swales. These also slow stormwater down and hold some back in the soil that in the past would be rushed off site by either pipes or concrete channels.

Rainwater Harvesting**:** Through cisterns and pumps rainwater that falls on roofs of building is stored and uses to flush toilets and potentially irrigate lawn areas. This is also referred to as Greywater.

Greywater**:** See rainwater harvesting.

General Stormwater Questions:

What are the current problems with stormwater on Fort Leonard Wood?
Fort Leonard Wood currently has a lot of large concrete channels that quickly convey large stormwater quantities off site that are dirty and full of sediment. A lot of areas have large impervious areas that flow from an impervious area to a pipe to one of these channels and off site. This creates issues for the receiving creeks and streams and the large quantities of water moving quickly through these streams causes a lot of erosion in these creeks. Faster moving water also tends to carry more sediments because

they don't have a chance to settle out so more sediment and trash is also carried off site where it just becomes someone else's problem. Erosion control standards also seem to be lacking at Fort Leonard Wood. Numerous areas where there should be grass have just been covered in straw and it appears that once erosion control measures are erected they are not maintained.

Have the problems been identified by the DPW?

Yes. After speaking with the DPW, the 3 main issues for stormwater are: Velocity of stormwater, sediment/trash in stormwater, and lead contamination from the ranges.

What are the limiting factors for these new stormwater management techniques?

Fort Leonard Wood has clay soils over karst bedrock. Anywhere we are planning on retaining large amounts of water should be determined that we are not recharging large amounts of water to karst. Karst can erode and sinkholes can become a problem if we are not careful with where we retain water. With clay soils, LID really is used mostly for cleaning the water as infiltration rates are so low. With this in mind, our LID practices must be installed correctly and designed accordingly. The biggest limiting factor for implementing new stormwater management is purely in changing the mindset of Fort Leonard Wood. Conventional stormwater management does not work for what we need anymore and for us to meet our requirements and for us to have less of an environmental impact we need to change how we view stormwater. Conventional methodology views stormwater as a nuisance and flushes it away as fast as possible. Stormwater instead needs to be viewed as a very beneficial, free commodity that can be useful to help provide better development.

Attachment B: Current Fort Leonard Wood Maps and Photos

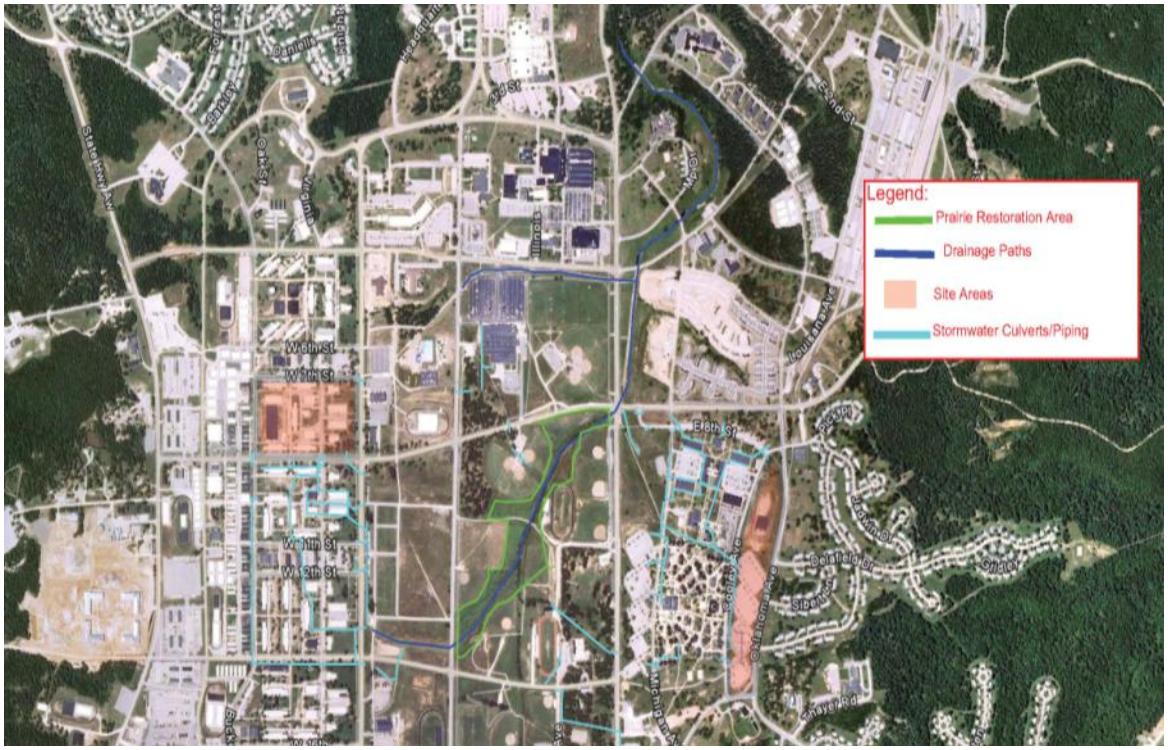

Figure 1. Drainage Map for AIT and BT Complex Sites – Image adapted from Google Earth (© 2011 Google)

Photo 1. Current Stormwater Conveyance Method (Corner of Nebraska and Minnesota) – Photo courtesy of USACE, Kansas City District

Photo 2. Current Erosion Control Problems (Corner of Nebraska and Minnesota). No silt fences, standing water, and large amounts of sediment. – Photo courtesy of USACE, Kansas City District

Photo 3. Current Flooding Problem Area (Corner of Nebraska and Minnesota) – Photo courtesy of USACE, Kansas City District

Photo 4. Current Prairie Restoration Area (Western Side, Where Restoration Starts) – Photo courtesy of USACE, Kansas City District

Photo 5. Example of Impervious Connections (BT Complex Roof Drain) – Photo courtesy of USACE, Kansas City District

Photo 6. Road debris will end up in storm system (Corner of 5th and Michigan) – Photo courtesy of USACE, Kansas City District

Photo 7. Poor Seeding of Grass (if any) with minimal straw covering. Construction of this complex is complete and the facility is operational, but this is all just mud with straw on top (BT Complex). – Photo courtesy of USACE, Kansas City District

Attachment C: LID Example Photos

Photo 8. Bioswale Example – Photo courtesy of USACE, Kansas City District

Photo 9. Bioretention System with Grasses – Photo courtesy of USACE, Kansas City District

Photo 10. Bioswale / Bioretention Areas with Checkdams – Photo courtesy of USACE, Kansas City District

Photo 11. Green Street Example. Pedestrian friendly and bioretention characteristics – Photo courtesy of USACE, Kansas City District

US Army Corps of Engineers

2030 USACE Integration Project

8.41 Traffic Analysis

traffic analysis

TECHNOTE

Recommendation

Fort Leonard Wood (FLW) shall conduct a new traffic study to include observation of permanent party, trainee, and visitor traffic patterns. Updated information is needed as the 2005 traffic study suggested locations of stop lights and focused predominantly on privately owned vehicle (POV) traffic. The new study will also develop strategies to efficiently handle an increased density of troops to the south of the cantonment area as the U.S. Army Forces Command (FORSCOM) area expands. Recommendations shall be made about the implementation of mass transit including bus and light rail amenities.

Location & Scale

This study is implemented at the **installation scale** for the base. Fort Leonard Wood's population lives, trains, and works primarily in the main cantonment area but is accessed from two main gates at the west and north. At peak travel times many soldiers travel across the cantonment due to the separation of permanent party and training areas, and currently there is limited access to the ranges which generates congestion at peak times. Key areas to be studied include routes such as the main gate to the Maneuver Support Center (MANSCEN) complex and parade grounds, the west gate to the ranges, and from the Unaccompanied Enlisted Personnel Housing (UEPH) housing area to FORSCOM complexes.

Phasing

This study is projected as part of the **2015 Phase**, but should be repeated again at the **2025 Phase** to account for potential unplanned growth areas and the expansion of mass transit networks implemented in the 2015 phase. The study should be conducted as soon as possible, but not before the completion of FY13 and FY14 FORSCOM projects to allow for proper study of a new growth area.

Initial Cost

The cost of this study is approximately **$35,000**, to rent equipment and analyze traffic data for 1 month assuming one person would work full time for the duration of the study plus two additional weeks. Typically this system would be implemented with **FY15 Operations and Maintenance, Army (OMA) project funds**.

Life Cycle Cost

Currently, Fort Leonard Wood soldiers and civilians use POVs for transportation and trainees are travel in diesel fueled buses. The results of a traffic study will increase efficiency and reduce the amount of time vehicles idle on post. Indirect savings for fuel may result in a **payback period of as little as one year** (assuming 17,000 vehicles each saved just one gallon of gas in a year).

Maintenance

Rather than installing a system that would monitor constant traffic flows during all times of the year, a rental system is recommended. This system would include data recorders mounted at traffic lights or other utility poles. Road tubes would be used to track vehicle numbers and axle lengths. These tubes are not successful during snow seasons because road clearing will damage them. For a one month study, minimal maintenance would be required. The person or team in charge of the study would spend 2 hours per week downloading information from each traffic recorder.

Feasibility

Traffic studies and analysis contribute to the **2030 Net Zero Energy** goals by providing accurate baseline information such that master planners and traffic engineers can modify existing traffic patterns for efficiency. At the outset, the increased efficiency will minimize the amount of fossil fuels burned by POVs and diesel buses. The data will also provide accurate information regarding the routes that soldiers are taking across the installation which will in turn provide guidance for the placement of mass transit systems. This is a cost effective option that will provide information specific to Fort Leonard Wood and serve as a foundation for future decisions regarding energy efficient transportation.

The traffic study carries minimal risk as it is intended to include temporary equipment that can be removed as soon as enough data has been collected.

References

http://www.jamartech.com/traxapollyon.html

http://www.metrocount.com/

Diagrams

See Attachment A

Funding Plan

The Army Installation Technology Transition Program (ITTP) may fund projects to evaluate effectiveness for possible implementation at other installations. Therefore, this study may be conducted after the implementation of one-way traffic route changes and a mass transit network.

Contract Language

Department of the Army provides traffic studies through installation support; therefore, private contracts may not be necessary.

Manufacturers

TRAX Apollyon Automatic Traffic Data Recorder should be used in conjunction with EZ Belt Road Tube technology and TRAX Pro analysis software or similar and equal products and software; or MetroCount Vehicle Classifier system should be used in conjunction with MetroCount Traffic Executive software or similar and equal products and software. Installation personnel should define goals and metrics early in the process to determine an appropriate product to use for data collection that is the most cost effective. For example, data that must be manually downloaded on a regular basis may not work due to limited personnel on post.

Baseline Relation

Fort Leonard Wood shall continue to monitor and study the implications of traffic congestion on the installation. The implementation of strategies to reduce traffic volumes reduces the carbon footprint of the installation. As soldiers and civilians become more acquainted with new traffic flows, it is important to analyze new patterns and look for more efficiency. The creation of pedestrian use zones make communities more inhabitable and reduce the need for vehicles, and these elements should be placed in appropriate areas of growth over time.

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Attachment A: Diagram referencing Fort Leonard Wood Traffic Routes Tech Note

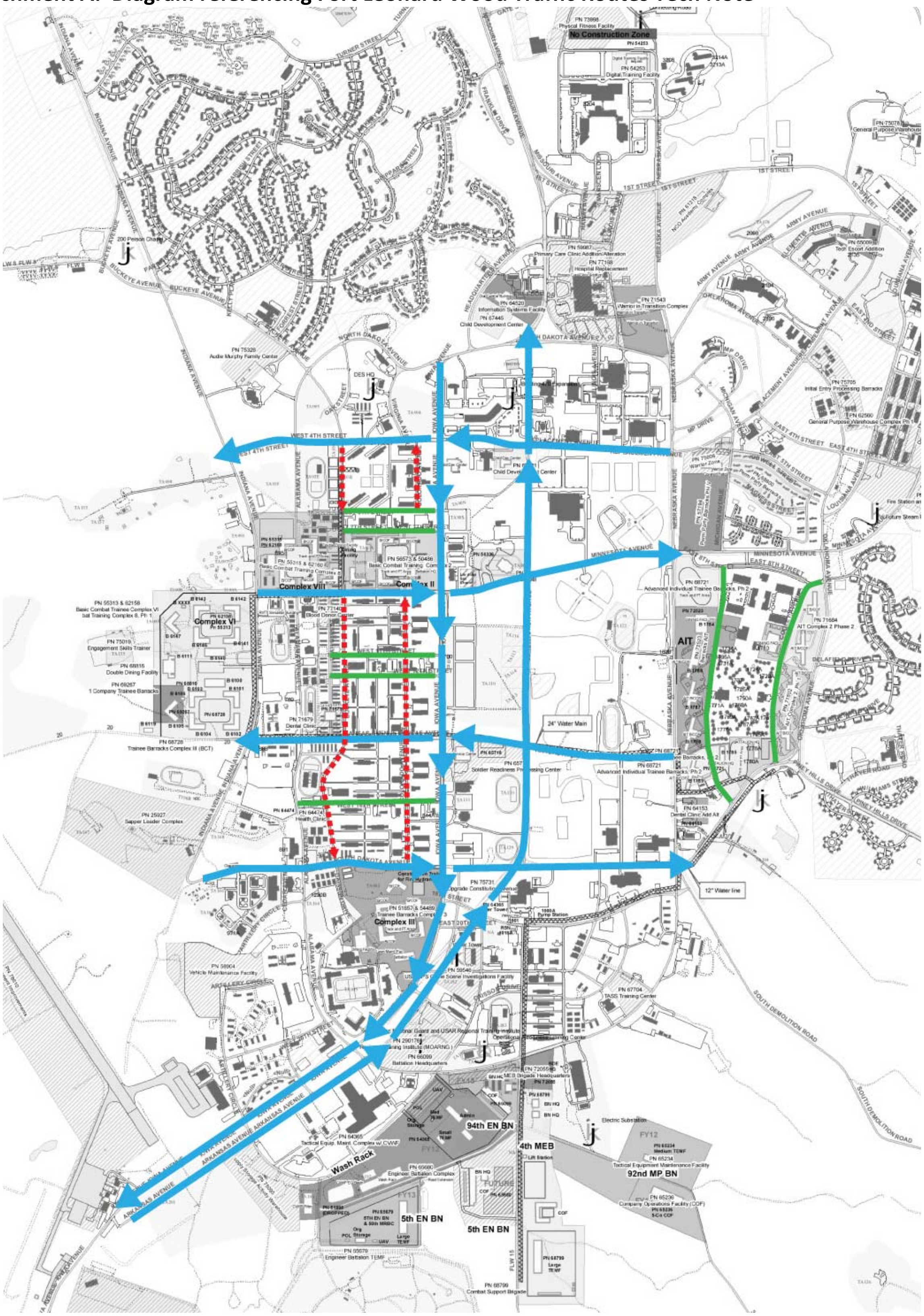

Diagram 1. Future Traffic Route Plan

US Army Corps of Engineers

2030 USACE Integration Project

8.42 Traffic Routes

TECHNOTE traffic routes

Recommendation

Fort Leonard Wood (FLW) shall modify existing streets such that some are widened to carry larger volumes of traffic and some are converted to one-way traffic. Access roads shall be provided in areas of dense military traffic and Arkansas Avenue shall be extended and connect to Constitution Avenue, creating one-way corridors that cross the cantonment area. These strategies should be executed in accordance with the results of an updated traffic study and any changes to the cantonment master plan. Preliminary analysis suggests these modifications:

- The following streets shall be converted to one-way with double-loaded, angled parking at certain locations:
  - Iowa (southbound until airport)
  - Arkansas (northbound) to Constitution Avenue (northbound)
  - South Dakota (eastbound)
  - Kansas (westbound)
  - 4th Street / Replacement Avenue (westbound)
  - Minnesota (eastbound)
- The following streets shall be widened to accommodate a higher volume of traffic and provide space for angled parking in some areas:
  - Arkansas Avenue (to align with Constitution)
  - Constitution Avenue (angled parking)
  - 4th Street / Replacement Avenue (between Iowa and Nebraska)
  - Indiana Avenue
  - Nebraska (angled parking)
  - Iowa Avenue (south of Alabama, angled parking)
  - Minnesota Avenue
- The following roads shall be converted to pedestrian and / or bicycle friendly infill areas:
  - Buckeye (after a southbound one-way conversion)
  - Colorado (after a northbound one-way conversion)
  - 6th, 7th, 11th, 12th, and 16th Streets
  - Michigan Avenue
  - Cooley Avenue

Access roads should be provided where there is dense military traffic. Currently, an access road(s) is needed in the south of the cantonment area, possibly along

Winchester Road / Fort Leonard Wood-1. Tank trail construction may be acceptable at some locations and could be constructed with crushed aggregate from future demolition projects. Where heavy military transport is used, asphalt or concrete paving is acceptable as long as strategies for effective stormwater management are implemented.

Location & Scale

This system is implemented at the **installation scale** for the Fort Leonard Wood. Heavy traffic congestion exists along major thoroughfares and should be eased with wider traffic corridors and effective implementation of one-way streets to reduce the number of left turn bottlenecks. The densest traffic areas are in the main cantonment area, bounded by the Maneuver Support Center (MANSCEN) Building at the north and the airport to the south.

Phasing

This system is projected as part of the **2015 Phase**, but the widening of existing streets should not progress until the completion of a comprehensive stormwater management study and a comprehensive traffic study such that shared infrastructure may be improved simultaneously.

Improvements should phased to fix areas with larger problems first. For example, current congestion happens along most streets that run north and south. Therefore, the conversion of streets to one-way shall be implemented first to lower congestion caused by left hand turns and fewer lanes of traffic. As traffic patterns adjust, streets shall be widened to accommodate additional traffic lanes, angled parking, and future biking lanes. With the implementation of more efficient traffic routes and a mass transit system (see Mass Transit Tech Note), traffic congestion and privately owned vehicle (POV) usage will decrease and additional streets may be demolished or converted to pedestrian and/or bicycle friendly zones.

Initial Cost

The costs of these changes are as follows:

- Addition of one lane of traffic: **Varies by topography**
- Conversion of a street to one-way by restriping typical two lane road: **$10,000** per mile
- Arkansas / Constitution alignment: **$2.5M** (2009 Fort Leonard Wood Traffic Study)

Typically this system would be implemented with **FY15/20 Military Construction (MILCON) project funds**.

Life Cycle Cost

Currently, Fort Leonard Wood soldiers and civilians use personally owned vehicles (POVs) for their transportation needs and trainees are moved around by use of diesel fueled buses. In accordance with the completion of a comprehensive traffic study, modification to existing infrastructure will provide more efficient movement of traffic on post. Although direct life cycle costing is not attainable with such varied first costs, benefits received will include safer streets and a reduction in carbon dioxide emissions.

Maintenance

Additional maintenance would be in accordance with current programs in place by the Directorate of Public Works (DPW), which may require the addition of road crews and equipment.

Feasibility This strategy attributes to the **2030 Net Zero Energy** goals by modifying existing infrastructure and expanding upon it to provide for more efficient traffic flows through the installation. The re-routing of some traffic is also a preliminary step in the process of relying on mass transit and more walk- able communities, with an end goal of dramatically reducing the use of POVs.

The risk in implementing this system will be feedback from users that want to continue paths through the installation that they believe to be efficient for them. The move from a POV dominant network of transit to one where POVs seem out of place takes many phases, but over time users will adapt to new ways of travelling.

References *Fort Leonard Wood Traffic Engineering Study (2009).* Prepared by Military Surface Deployment Distribution Command Transportation Engineering Agency (SDDCTEA) and Gannett Fleming.

Diagrams See Attachment A for proposed one-way street locations and directions.

Funding Plan The Army Installation Technology Transition Program (ITTP) may fund projects to evaluate effectiveness for possible implementation at other installations.

The Energy Conservation & Investment Program (ECIP) funds projects that reduce energy consumption on existing facilities. Emphasis is placed on reducing greenhouse gas emissions, which is a direct result of more efficient traffic flows.

The primary focuses of the Utilities Modernization Program (UMP) are on energy plants, thermal distribution systems, and water distribution systems. Depending on Fort Leonard Wood's implementation of net zero energy and water strategies that coincide with roads, any roadway that is affected by the replacement of utility distribution systems may have the cost of repair and/or replacement covered by this program.

Contract Language Contracting language will need to be coordinated with the following Tech Notes as many of the spaces overlap:

- Traffic Analysis
- Green Streets
- Low Impact Development (LID) & Bioswales
- Urban Park Development

For example, the addition of one lane of traffic to each side of Constitution Avenue may also provide an opportunity to create a series of channels to divert stormwater from current drainage swales. Additionally, since this main traffic corridor splits the parade grounds and softball field areas, the section of road may also need the addition of bicycle / walking paths which may require specific permeable construction materials. Although unlikely, one contractor may perform all of the tasks but contract language should allow for the development of these streetscapes in phases.

Product Specifications In accordance with "Contract Language" above materials should be coordinated.

Baseline Relation The implementation of a mass transit network influences many of the goals of the master plan for Fort Leonard Wood. Initially, soldiers and civilians are introduced to "green thinking" through the example that the installation sets by providing greener modes of transportation. Fort Leonard Wood's support of net zero goals makes it easier for patrons on post to modify lifestyles that collectively make larger impacts. As the transit system immediately reduces the carbon footprint of the installation, Fort Leonard Wood is making its surrounding environment more liveable. As traffic congestion reduces on the installation, the sub-communities become more walk-able which allows the reduction in carbon emissions to grow exponentially. Due to reduced maintenance on the roadways, funding once previously used for repair may be channelled to other roadway improvements as nearby green streets and other low impact development strategies are accepted.

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Attachment A: Proposed locations of modified traffic routes

Conversion to one-way streets (blue, 2015)
Conversion to pedestrian and bicycle friendly streets (green, 2015)
Conversion to one-way streets first that become pedestrian and bicycle friendly streets (red dash, 2020)

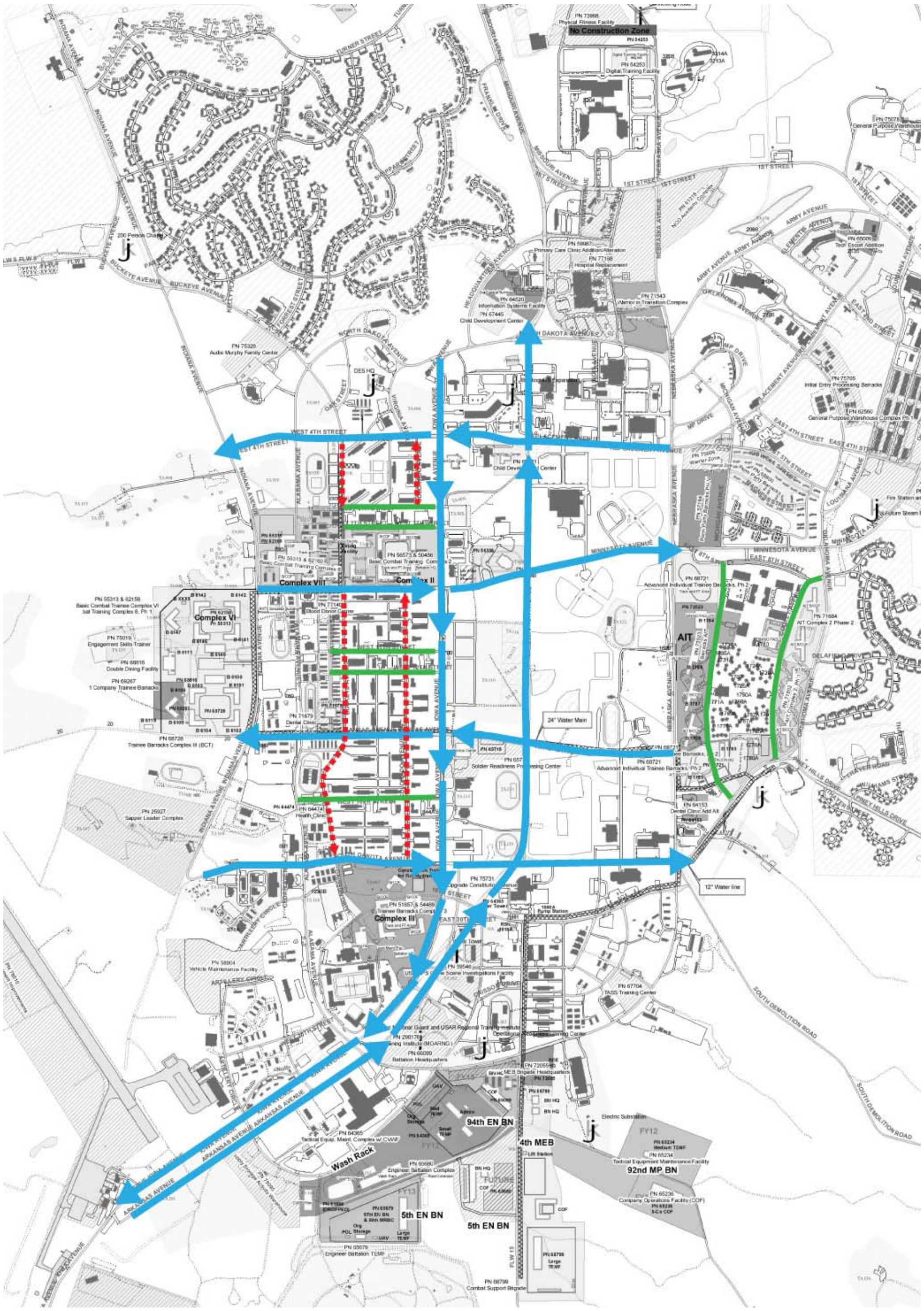

Figure 1. Future Traffic Plan for Fort Leonard Wood

US Army Corps of Engineers

2030 USACE Integration Project

8.43 Ultra Low Flow Faucets

ultra low flow TECHNOTE

Recommendation

Install aerating ultra low flow faucets in all new buildings and retrofit existing facilities as applicable. Bathroom fixtures should have automatic sensors while kitchen type fixtures should have manual operation. Fixtures should be Environmental Protection Agency's (EPA) WaterSense® certified and meet its water performance requirements. WaterSense® certified fixtures use a flow rate between 0.5 and 1.5 gallons per minute (gpm) of water when measured at a flowing water pressure of sixty pounds per square inch (psi). Implementing these types of fixtures will maximize water conservation with minimal impact to fixture and system costs.

Location & Scale

This would occur at the **building scale** and is recommended for **all applicable buildings.**

Phasing

This system is projected as part of the **2015 Phase** in all new construction. As various other buildings on the installation are renovated, old fixtures should be replaced with new units of this type or retrofit with water aerator fittings.

Initial Cost

Including purchase price and installation (average cost in Missouri) of a moderate ultra low flow bathroom faucet with automatic sensor, each unit's initial cost would likely be between **$550** and **$700**. These figures depend on the specific fixture selected and the installer's labor wage. Initial cost for a retrofit fixture installed would be about the same, but would require removal and disposal of old components.

Components which are different than or in addition to the standard plumbing system for faucets in the cost consideration may include the electrical wiring, batteries, aerator attachments, and ultra low flow faucets themselves.

Life Cycle Cost

Life Cycle Cost of this type of faucet would include maintenance and water use costs along with possible battery or electric power in addition to the initial costs for each fixture. An ultra low flow faucet's typical life span is usually close to twenty years. The total estimated Life Cycle Cost of (1) one standard bathroom faucet is about $2,000. The total estimated Life Cycle Cost of (1) one ultra low flow sensor faucet, which uses approximately 8,350 fewer gallons per year of water than a standard sensor faucet, is estimated at **$2,700***.

Operations costs would be minimal as the cost of water is inexpensive. Maintenance costs would be greater than that of standard faucets due to their need of more frequent cleaning. Maintenance, cleaning and most repairs, could be performed by Fort Leonard Wood (FLW) building maintenance staff, coming to about $100/year. Each unit is assumed to provide about ten minutes per day of water use (1,825 gal/fixture/yr). Fort Leonard Wood water cost is currently estimated at $2.30/1,000 gallons. The estimated annual water costs for one ultra low flow sensor faucet is approximately five dollars. Total annual operations and maintenance (O&M) costs, excluding energy use, would be approximately **$105***.

An average ultra low flow sensor faucet costs $540, with installation cost of about $100. Total installation and initial cost would be approximately **$640** per fixture. Ultra low flow manual faucets will cost less but it would then be up to the users to conserve water as efficiently as a sensor does automatically.

**At current dollar values (no inflation included), and if all estimates and assumptions of fixture use and water costs are accurate.*

Maintenance

This system will not require significant maintenance unless plumbing problems arise. Minor repairs and regular cleaning should be within the ability of the Fort Leonard Wood building maintenance staff, but large issues with the system are no different than problems and maintenance of standard faucets.

Feasibility

This system contributes to the **2030 Net Zero Water** goals. Ultra low flow faucets have the same plumbing design as standard sensor faucets, with the differences being in the faucet itself. Maintenance is very similar to standard fixtures and WaterSense ultra low flow units should use anywhere from forty to seventy percent less water than a standard fixture. If incorporated into the design process and confirmed in specifications, these types of units can be an extremely efficient way to conserve water while maintaining functionality.

Installing ultra low flow sensor faucets may yield a considerable reduction in energy to deliver and treat the hot water used for in lavatories. However, the energy difference may not be as noticeable if the sensor operated fixtures selected uses a lot of power to function.

References

See Attachment A

Environmental Protection Agency (EPA). "WaterSense® High-Efficiency Lavatory Faucet Specification." Version 1.0. 1 October 2007. Web. 18 July 2011. www.epa.gov/watersense/docs/faucet_spec508.pdf

"Ultra-Low-Flow Faucets." *High Performance Technology Strategy Templates.* Revision 0. 31 October 2010. Web. 18 July 2011. http://mrsi.usace.army.mil/cos/TechNotes/08%20Fixtures%20Ultra%20Low%20Flow%20Faucets%2010-31-10.pdf

Whole Building Design Guide. "Federal Green Construction Guide for Specifiers, Section 22 40 00 Plumbing Fixtures." 4 January 2010. Web. 18 July 2011. www.wbdg.org/ccb/FEDGREEN/fgs_224000.pdf

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Sloan. "Keeping it clean with the wave of a hand." *Sloan, Sensor Faucets.* 2011. Web. 18 July 2011. www.sloanvalve.com/Our_Products/Sensor_Faucets.aspx

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Niagara Conservation. 2010. Web. 18 July 2011. www.niagaraconservation.com/water_conservation/products/aerators/detail?object=5310

Diagrams Please reference sample manufacturer product data for multiple diagrams to be used as tools during design phases.

Funding Plan This system would need to be funded with initial design/construction funds as awarded. Specifying ultra low flow, WaterSense faucets in place of standard faucets will not be a significant cost to the overall project, but may be a considerably higher first cost than standard units.

Contract Language Provide aerating ultra low flow faucets and lavatories for all bathroom, kitchen, etc. facilities in new buildings. Bathroom faucets shall be sensor operated, and kitchen fixtures shall be manually operated. All units, including retrofit fixtures, shall be tamper-resistant with a flow rate between 0.5 gpm and 1.5 gpm when measured at a flowing water pressure of sixty psi. All units must be certified under the EPA WaterSense program and labeled as required.

Product Specifications See Attachment A for generic specification.

Baseline Relation Standard faucets use approximately 2.5 gpm of water. An ultra low flow faucet uses anywhere from 0.5 - 1.5 gpm. Including sensor operation with this decrease in water consumption will further lower the demand for water used in lavatories. This technology should decrease water consumption of lavatories by forty to seventy percent.

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Attachment A: Ultra Low Flow Faucets Specifications**

**As adapted from the Whole Building Design Guide *Federal Green Construction Guide for Specifiers*

SECTION 22 40 00 (SECTION 15400) – PLUMBING FIXTURES

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Faucets and aerators
   2. Accessories

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
   3. Water efficiency: Indicate water consumption rates in gallons per minute (gpm) per unit for the following:
      a. Plumbing fixtures

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

1.3 QUALITY ASSURANCE

A. Water flow and consumption rates for plumbing fixtures:
   1. Comply with requirements in Public Law 102-486, Energy Policy Act.
   2. Provide WaterSense labeled products for High-Efficiency Lavatory Faucets.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Fixtures:
   1. Water management: Provide ultra low flow fixtures and automatic, sensor operated faucets. Provide automatic, sensor operated faucets to comply with ASSE 1037 and UL1951.
      a. Faucets and aerators: WaterSense labeled. Minimum 0.5 gpm and maximum 1.5 gpm when measured at a flowing water pressure of 60 pounds per square inch (psi); and, minimum flow rate shall not be less than 0.8 gpm (3.0 L/min) at a pressure of 20 psi at the inlet, when water is flowing.
   2. Toxicity/IEQ:
      a. Traps: Provide traps with removable access panels for easy clean-out at sinks and lavatories.
      b. Water filter system: Provide filters for chlorine at sinks and lavatories.
      c. Low corrosion flux for copper pipe: Comply with ASTM B813.

2.2 ACCESSORIES

A. Labels: Provide labels for sensor operators at faucets. Include the following information on each label:
   1. The identification of the sensor and its operation with graphic, written, and Braille description.
   2. Range of sensor.

3. For batter operated units, the batter replacement schedule.

PART 3 – EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

1. Water Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

   a. Adjust automatic sensor operated faucets in accordance with the manufacturer's instructions. Comply with ASHRAE 90.1 for energy efficiency.

US Army Corps of Engineers

2030 USACE Integration Project

8.44 Urban Agriculture

TECHNOTE urbanagriculture

Recommendation

Provide high density greenhouses with a mixture of soil-based and hydroponic plants at each new dining facility to provide fresh produce throughout the year for all meals served at each. If this is successful, older dining facilities could be retrofit with greenhouses as well.

Provide an on-site greenhouse serving a green-grocer for every 100-person residential development to include retail lease space. One of the units should be a green-grocer supplied by that greenhouse. Locations of existing Army and Air Force Exchange Service (AAFES) facilities provide opportunities to partner with existing grocery infrastructure.

Provide a community garden with composting center for every thirty families. The garden would be used to supplement groceries during the warm season and provide a place for community interaction and activities. In addition, it can serve as a learning space for children on base. The composting center would provide free compost for the community garden and various greenhouses as well as diverting organic waste from the landfill. Animal feces should not be added to this compost because of a risk of nurturing salmonella in a greenhouse environment.

Location & Scale

This would occur at the **installation scale** as well as the **building scale**.

Phasing

A greenhouse could be added to the Dining Facility (DFAC) planned for **2015** (Phase 1). A greenhouse for the community could be added at **2020** (Phase 2) if the one for the DFAC proves successful. If both of these continue to thrive, then all of the dining facilities could be retrofit with greenhouses by 2030.

Community gardens could be part of the residential area expansion plans, thus occurring as the need arises. Future landscaping around dining facilities could include edible plants: a garden could be sown at the 2015 DFAC and, if it proves successful, all dining facilities could have seasonal gardens by 2030.

Coordination with Fort Leonard Wood's Army Morale, Welfare, and Recreation (MWR) department is encouraged to site new community gardens adjacent to new fitness centers, community parks, or child development centers.

Initial Cost

Greenhouses: $8/ft (Structure) * $2/ft (Materials)

Community Garden: $1/ft (Materials)

Life Cycle Cost The life cycle will gradually diminish as seeds are harvested and stored and compost is produced. Each greenhouse would require one full-time employee at about $30,000 per year.

Maintenance This would require more maintenance to be most likely completed by Fort Leonard Wood's Directorate of Public Works (DPW), but this could also be contracted out and provide more jobs for the surrounding community.

References http://www.wvu.edu/~agexten/hortcult/greenhou/grencons.htm

http://www.planning.org/newsreleases/2011/mar03.htm

Funding Plan Grant money for urban agriculture projects may be obtained from the following organizations:

- The Missouri Foundation for Health
- United Way
- Community Food Security Coalition
- USDA National Institute of Food and Agriculture gives $5 million dollars per year in grant money for Community Food projects

Contract Language Every dining facility shall be built with a greenhouse large enough to provide enough fresh produce for all three meals throughout the year.

For every new residential development serving over 30 families, one community garden shall be built connecting to a major pedestrian way.

For every mixed-use development serving over 100 individuals, a green-grocer must be included as part of the leased retail space. This green-grocer will be served by an on-site greenhouse.

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2030 USACE Integration Project

8.45 Urban Park Development

Recommendation

Fort Leonard Wood's (FLW) central stream, running from the southwest of the athletic fields to the northeast, is directed through a large culvert under the intersection of Nebraska Avenue and Minnesota Avenue. The stream is then diverted into a large concrete channel, which currently presents stormwater management concerns for flooding, high velocities, safety concerns, and water with a high sediment load. Removal of the existing concrete channel and restoration of the stream to a more natural state using native vegetation will help reduce the peak flow and improve the quality of water discharged into the Big Piney River, the installation's water source. The resulting streetscape can also be coupled with a longitudinal park system with running and biking trails to improve safety and functionality of the central recreation area for installation residents. Mitigation and restoration shall include:

- Demolition of the existing concrete stormwater conveyance to the southwest and northeast ends of the stream.
- Water breaks along the stream in the form of engineered bends in the stream, rocks, trees, and boulders.
- Planting of native vegetation to improve filtration of particulates from runoff.
- Planting of trees to provide shelter, shade, and a sense of enclosure.

Location & Scale

This occurs at the **installation scale.**

Phasing

This should be implemented in the **2015 and 2020 Phases**.

Initial Cost

Cost is **$50,000 per mile**, depending on the amount of site remediation needed.

Life Cycle Cost

Once this proposal is implemented there should be little additional maintenance required. Landscape maintenance should be minimal due to the use of native plant species. Mitigation and remediation of the stream should reduce future costs to repair areas of the installation eroded by flooding and high discharge rates.

Maintenance

Maintenance will be more intensive than concrete channels. Concrete channels require very little or no maintenance, while the naturalized stream will require some cleaning and replanting. The channel is designed to capture trash and sediment that a concrete channel would not capture, so all of this trash and sediment would have to be periodically removed. There may also be some maintenance with replacing or maintaining some of the natural vegetation.

Feasibility

Development of the Urban Park in conjunction with restoration of the stream contributes to the **2030 Net Zero Water and Waste** goals by reducing flood heights, improving water quality, reducing runoff and erosion, providing an environment for a diversity of plant and animal life, and helping sustain base flow of adjacent streams or rivers during drought conditions.

Currently, Missouri's wetland resource has diminished to approximately 10% of original extent. About fifty percent of Missouri's total plant species are associated with wetlands and more than twenty-five percent of Missouri's nesting and migratory birds depend on wetlands. Over 200 rare or endangered Missouri plant / animal species rely on wetlands.

Missouri has nine different wetland communities (not including man-made ponds and lakes). Native plant selection is dependent on the type of wetland.

- Marshes – develop in remnant river channels and around oxbow lakes and sloughs
    - Shallow – wet meadows or moist-soil wetlands with standing water present sporadically during the growing season:
        - Plants: smartweeds, nut sedges, and bur marigolds;
        - Animals: migratory ducks and shorebirds, Woodhouses and spadefoot toads;
    - Emergent – standing water for long periods during the growing season:
        - Plants: cattails, bulrushes, bur-reed, arrowheads, and sedges;
        - Animals: rare marsh birds including bitterns, sora and king rails, pied-billed grebes, and moorhens; common birds including redwing blackbirds; leopard frogs, muskrats, and dragonflies;
    - Deep – margin between open water and wetland, and almost always covered with standing water:
        - Plants: pondweeds, spatterdock, and water lilies;
        - Animals: grebes, ducks, geese, dragonflies, and fish.
- Shrub Swamps – impenetrable wetland thicket; near marshes, swamps, and bottomland forests:
    - Plants: buttonbush and short-statured willows;
    - Animals: yellow warblers and green herons.
- Bottomland Prairies – North- and West-Central Missouri; subject to flooding but standing water is present only briefly during the growing season:
    - Plants: prairie cordgrass, ripgut (sharp leaf edges), sedges, milkweeds, wild iris, and sawtooth sunflower;
    - Animals: northern harrier, western chorus frog, northern crawfish frog, and grassland crayfish.
- Bottomland Forests – periodic flooding:
    - Plants: cottonwood, willow, elm, sycamore, silver maple, hackberry, ash, oak species (e.g. pin oak), shellbark hickory, and pecan; shrubs such as pawpaw, spicebush, and deciduous holly; sedges cover the ground;
    - Animals: red-shouldered hawks, northern parula warblers, gray treefrogs, and nesting trees for bald eagles and great blue herons.
- Swamps – in ancient floodplains of the Mississippi River:
    - Plants: bald cypress, water tupelo, and water locust; water canna, swamp rose, and water violet;

    - Animals: black-crowned night heron, green treefrogs, swamp darters.
- Sinkhole Ponds – natural depressions containing water (rain, overland flow, groundwater); found in karst landscapes in the Ozarks:
    - Plants: outer ring of buttonbush; center is usually open water but dominated by sedges and grasses; some have swamp trees (e.g. water tupelo); may contain swamp loosestrife or other rare plants;
    - Animals: breeding habitat for spring peepers and many salamanders.
- Oxbow Lakes and Sloughs – standing water less than seven feet deep:
    - Plants: water lilies;
    - Animals: fish, crayfish, turtles, water snakes, great blue herons, egrets, and larval fish nurseries when connected to a river.
- Riparian Areas – spring fed via gravel bars, pools, and riffles:
    - Plants: mistflower, sycamore, witch hazel, blue beech, water willow, willows, cardinal flower, and blue lobelia;
    - Animals: belted kingfishers, river otters, Blanchard's cricket frogs, and Fowler's toads.
- Groundwater Seeps – relatively rare and are most commonly found along the bases of hillsides in the Ozarks; constant saturation of cool water; peat or muck deposits; karst landscapes:
    - Plants: sedges, bulrushes, wildflowers, Michigan lily, trees (more typical plants of north due to colder temperatures of water), sedges, swamp orange coneflower, golden ragwort, cowbane, grass of Parnassus, and orchids;
    - Animals: rare four-toed salamander uses fens as well as acidic seeps.

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See Master Planning and Low Impact Development (LID) & Bioswales Tech Notes for additional information.

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Funding Plan

The EPA State Wetland Protection Development Grant Program has funding available for development and restoration of wetlands.

The development of an Urban Park centered on the restoration of this stream could also be an in-kind benefit of an Enhanced Use Lease (EUL). There are many options available with this program limited only by the imagination of the Installation and the Developer. Some feasible strategies for EUL developments may include:

- Veterans Assisted Living Facility adjacent to the Installation Resiliency Complex
- Development of the entire installation park area to include free and fee based activities like a mini zoological park, outdoor theater, food concessions, miniature golf, ice / roller skating rink(s), skate park, batting cages, etc. to offset the cost of stream mitigation
- Other development by a private utility, manufacturer, or other light industrial activity at the periphery of the installation

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8.46 Waste–to–Energy (WTE)

Recommendation

Install a fluidized bed gasifier to convert biomass, municipal solid waste (MSW), and urban wood waste to a synthesis gas (syngas) to use in a gas-fired engine to generate electricity for Fort Leonard Wood (FLW). To improve the efficiency and to reduce the volume of the solid waste for transportation and storage, the solid waste pre-processer will pelletize the feedstock (waste) prior to gasification. The energy-yielding feedstock includes paper, plastic, wood, food, cardboard, agricultural waste, yard waste, and biomass. Pelletized feedstock consisting of paper (25%), plastic (35%), wood (5%), and food (35%) can result in 3070 Btu/lb after gasification (IST Energy, 2011). The syngas generated would be compatible with the natural gas power plants recommended in the Power Plant Technology Assessment prepared for the Directorate of Public Works (DPW), Fort Leonard Wood, Missouri (2011).

In the Power Plant Technology Assessment, Burns & McDonnell recommend a proposed natural gas fired reciprocating engine alternative consisting of four Wärtsilä 18V50DF reciprocating engines and generators located in a single facility. This alternative would generate 66 MW and consume a peak of 14,000 MCF of natural gas per day, with an estimated yearly fuel consumption of 2,545,298 million-Btu (MMBtu) (Burns & McDonnell Engineering Company, Inc., February 24, 2011). The report further notes that the reciprocating engines selected can also burn syngases created from the partial combustion (gasification) of renewable fuels. If all landfills within a sixty-mile radius from Fort Leonard Wood are considered, there is a total of 616,279 tons/year of feedstock available for use in waste-to-energy (WTE) conversion. After gasification, this waste can potentially result in 3,783,953 MMBtu of fuel that can be used to power the reciprocating engines and generators, eliminating the need to use natural gas.

Location & Scale

This technology is available for use at the **installation, site, or building scale**. At the installation scale, a five acre site near major roads, a utility substation, water, sewage, and an appropriate industrial infrastructure are required (DR Dixon, May 2009). A location previously identified for a large central electricity generating plant is shown in Attachment B. It would be on the eastern side of the installation, between Minnesota Avenue and Louisiana Avenue, just east of Oklahoma Avenue (Burns & McDonnell Engineering Company, Inc., February 24, 2011). To reduce required storage space for the feedstock and the traffic congestion created by transferring the MSW to Fort Leonard Wood, the feedstock can be pelletized at the collection location to reduce the volume occupied and transferred to the power plant via truck or rail.

If desired, this technology is also available at the **site and building scales**, by using a distributed modular waste-to-energy conversion system. Each unit consists of a containerized unit and can process up to 3 tons of raw material a day, first pelletizing the feedstock and then using a downdraft gasifier to produce syngas to power a modified diesel generator with an output of 120 kW (Cushman, 2009). The containerized units require that they are positioned near the building or site to tie into the electrical lines or, if being used for heating, to tie into the HVAC system. The units do not require access to water or sewage, making them ideal for sites separated from the existing infrastructure.

Phasing

The installation scale implementation of this technology requires the construction of an on-site power plant that can utilize the syngas produced. The Power Plant Feasibility Study determined that the lowest cost for onsite generation would be the 66 MW Reciprocating Engine alternative. The estimated first full year of operation for the power plant option is 2018 (Burns & McDonnell Engineering Company, Inc., February 24, 2011). To incorporate the waste-to-energy technology into this option, the phasing recommended for this technology is the **2020 Phase**.

The site and building scales modular WTE system will be available for implementation during the **2015 Phase**. The technology is currently in the Environmental Security Technology Certification Program (ESTCP) and a demonstration at Andrews Air Force Base in California will be completed this year (Cushman, 2009).

Initial Cost

The installation scale waste-to-energy gasification option to generate electricity utilizing all local landfills has a total plant cost of **$3003.8/kW**.

The modular system for the site and building scales has an initial cost of **$1.1 million** or **$9166.7/kW**. The high initial cost to kW suggests that the waste-to-energy option would be more economical if implemented on the larger scale.

Life Cycle Cost

The Renewable Energy Opportunities at Fort Leonard Wood report prepared by Pacific Northwest National Laboratory lists that the installation scale waste-to-energy (WTE) gasification option utilizing all landfills in the area has a savings-to-investment ratio of 3.1 and a **simple payback period of 4.7 years**.

The life cycle cost for the modular WTE conversion system will be available from ESTCP at the end of the demonstration period. A success criterion for the modular WTE conversion system is a simple payback period of 5 years, which is the payback estimate provided by the manufacturer.

Maintenance

The fixed operations and maintenance (O&M) cost for the installation scale waste-to-energy (WTE) gasification option utilizing all landfills in the area is **$41.0/kW**. Maintenance considerations for the WTE system include greasing bearings, changing filters, and removing ash (approximately five to seven percent of original mass). Ash recovered from the gasifier can be returned to the soil as a soil conditioner or returned to a landfill. Staffing for the fluidized bed gasifier is minimal and can be supplemented by the staff required for the power plant.

The modular WTE system requires approximately four hours of maintenance per week, primarily related to cleaning filters. The modular system can be monitored remotely so it does not have to be staffed by personnel at all times.

Feasibility

This system attributes to the **2030 Net Zero Energy and Waste** goals by utilizing waste generated on site and in the surrounding communities as a resource and using it to generate electricity. This renewable energy source has the potential to offset all of Fort Leonard Wood's annual energy usage if all the Municipal Solid Waste sites identified in Table 1 (Attachment A) can be utilized. In addition to using a renewable energy source, waste-to-energy (WTE) technology can divert thousands of tons of trash annually from landfills, reducing emissions from decaying trash. It also reduces the number of trucks needed to haul trash to landfills resulting in fewer trucks, lowered fuel use, less leaching of toxins into the groundwater, and lower greenhouse gas emissions. Finally, WTE diverts and converts trash into heat and electrical energy, so it carries a negative carbon footprint while reducing reliance on costly external energy sources.

The risks for the system revolve around a stable source of waste materials to use as feedstock. Area landfills have been identified in this report, but agreements would have to be arranged with them to provide the waste. Transportation of the feedstock to the gasification site can also pose logistical problems, as can storage of the material. Typically, this type of plant would be constructed next to a landfill. Access to rail and pelletizing the feedstock should help alleviate these problems. In addition, while gasification itself does not produce any emissions into the air, permitting would be required for the emissions created by the reciprocating engines used to power the generators.

References

See Attachment A

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Diagrams See Attachment B

Funding Plan Funding options and resources are available through the U.S. Department of Energy's Federal Energy Management Program (FEMP). FEMP provides technical assistance and resources to help Federal agencies evaluate and implement renewable energy technologies. These activities span Federal Requirements, Renewable Resources and Technologies, Project Planning, Resource Maps and Screening Tools, Purchasing Renewable Power, Case Studies, Training, Working Group, and Contacts (U.S. Department of Energy, 2011).

Two funding sources that have the best returns on federal investments are investment by an independent power producer (IPP) and Energy Conservation Investment Program (ECIP) funding. Under an IPP scenario, a power producer will generally fund, construct, and operate a renewable energy facility, selling power into the competitive marketplace and/or directly to the site that hosts the energy project. The ECIP is one standard DoD approach for making energy efficiency and renewable energy investments using federally appropriated funding. ECIP investment awards are made based upon savings-to-investment ratio (SIR) and simple payback criteria. ECIP funding is limited and is awarded on a competitive basis within the Army – only the most economic projects can be assured funding (DR Dixon, May 2009).

Available tax incentives reduce the first-year costs of qualified renewable projects. The lower first cost also reduces the amount of money that must be borrowed to develop a project and thus, the associated interest and carrying costs. The combination reduces the delivered cost of power if developed by a private party with a tax obligation. Government-owned projects do not benefit from tax-based incentives (DR Dixon, May 2009).

State Incentives for Renewable Project Development:

- Fort Leonard Wood is located in Missouri where incentives are minimal. However, in November 2008, voters passed a mandatory Renewable Electricity Standard (REC; similar to a renewable portfolio standard, or RPS) stating that investor-owned utilities must provide 15% of their electricity from renewable resources by 2021. Additionally, while utilities are allowed to purchase RECs from out-of-state sources, a 25% multiplier exists on the REC for in-state energy generation. This new RPS will help create a strong market for RECs in Missouri, which will improve the economics for renewable energy projects (DR Dixon, May 2009).

Federal Incentives for Renewable Project Development:

- Federal incentives for renewable energy include investment tax credits for corporations, significantly accelerated depreciation of equipment, and production tax credits. A 10% tax credit is available for geothermal and biomass electricity projects, with no incentive limits. The credits may be taken on equipment placed in service prior to January 1, 2017. The tax basis for depreciation must be reduced by the amount of any federal subsidy used in the financing of the eligible equipment (DR Dixon, May 2009).

The renewable energy production tax credit (PTC), originally established in 1992, provides a tax credit for each kilowatt-hour of electricity produced. The PTC is 1.0¢/kWh for electricity produced from open-loop biomass and municipal solid waste resources and can be taken for 5 years. The PTC has been allowed to lapse and then been renewed several times. All of the analysis assumes it will be available when the equipment is placed in service (DR Dixon, May 2009).

Contract Language

Technical issues related to waste-to-energy projects

Waste Preprocessing, Receiving, and Handling: The facility must be explosion resistant and not susceptible to "log-jamming" in the material flow. A two-to-three day waste holding capacity should be provided. The material handling system must be of a proven design for the intended service.

Ash Removal: The ash drag-out system generally is both maintenance and labor intensive. Utilization of ash removal systems with good operational histories is essential.

System requirements

The facility must have the ability to process up to 1,700 tons/day of Municipal Solid Waste.

Product Specifications

Installation scale system: Custom designed processing plant. Pelletized waste using IST Energy's technology scaled up from the GEM 3T120. Fluidized Bed Gasifier technology providers include High Temperature Winkler (HTW), KBR Transport Gasifiers, Great Point Energy, and Gas Technology Institute U-GAS®.

Modular WTE system: GEM 3T120 produced by IST Energy.

Baseline Relation

The four reciprocating engines alternative would generate 66 MW and consume a peak of 14,000 MCF of natural gas per day, with an estimated yearly fuel consumption of 2,545,298 MMBtu (Burns & McDonnell Engineering Company, Inc., February 24, 2011). In 2010, the average price paid by Fort Leonard Wood for natural gas was $11.64/MMBtu, which is a bundled service price including all reservation, transportation, and distribution charges. At the current natural gas prices, if the power plant alternative mentioned above were put into service, the estimated yearly spending on natural gas would be $29,627,268.72.

Utilizing the gasification of MSW in place of the natural gas would cut out that yearly spending completely. Using data obtained from the Renewable Energy Opportunities Report, it is estimated that Operations and Maintenance costs of approximately $3.5 million per year would be offset by tipping fees received for obtaining the feedstock, resulting in a profit for the plant of $15 million per year if all landfills are utilized (DR Dixon, May 2009). Actual project economics will depend on the availability and price of waste, plant size, capital costs, and operating costs.

Development by an independent power producer (IPP) would not generate a profit for Fort Leonard Wood, but would eliminate the upfront fees required to fund, construct, and operate a renewable energy facility. In addition, Government-owned projects do not benefit from tax-based incentives, but development by an IPP can benefit, which would reduce the delivered cost of power. Furthermore, private developers value renewable energy credits (RECs) and letting the developers retain the RECs can further reduce the cost of energy to the installation (DR Dixon, May 2009).

Utilization of Waste-to-Energy (WTE) gasification technology will satisfy the Energy Policy Act (EPAct) Section 203 requirement stating 7.5% of the installation's total electricity consumption be provided by renewable electricity by FY 2013. WTE technology will also satisfy the national Defense Authorization Act, which codifies DoD's voluntary goal of 25% renewable energy by 2025. This technology will allow Fort Leonard Wood to achieve its 2030 goals of net zero energy and waste.

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Attachment A: Reference Material

Key Terms:

Gasification: Gasification is the high-temperature conversion of combustible solids (e.g., wood, municipal waste, plastics, rubber, paper, etc.) into a gaseous bio-fuel mixture containing hydrogen (H2) and carbon monoxide (CO).

Syngas: Synthesis gas produced due to the gasification of a carbon containing fuel to a gaseous product comprising of hydrogen and carbon monoxide. Syngas has half the energy density of natural gas and can be burned in a commercial turbine or reciprocating engine to make electricity or heat.

Biomass: The term "biomass" refers to any regenerative organic material used as a fuel for energy production. Biomass fuel typically consists of agricultural residues, organic waste streams, energy crops, and forestry residue.

Municipal Solid Waste (MSW): Waste products comprised of residential and commercial discarded materials including glass, paper, food residues, yard trimmings, textiles, plastics, and other similar materials. The content and consistency of MSW can vary greatly based upon location. Household hazardous wastes and toxic chemicals can also be part of a MSW stream.

Urban wood waste: Wood waste including used lumber, shipping pallets, trees, branches, and other wood debris from construction and demolition clearing and grubbing activities

Pelletize: Shredding waste and densifying it into pellets approximately ½" in diameter which then can be converted into a clean synthetic gas.

Waste to Energy (WTE): Waste to energy refers to the use of waste products for fuel sources. Typical waste fuels include municipal solid waste (MSW), construction and demolition waste (C&D), landfill gas (LFG), and wastewater treatment sludge.

British thermal unit (Btu)**:** Btu is a measure of the heating value of a fuel. It is the amount of heat required to raise one pound of water one degree Fahrenheit at atmospheric pressure. Since BTUs are measurements of energy consumption, they can be converted directly to kilowatt-hours (3412 BTUs = 1 kWh) or joules (1 BTU = 1,055.06 joules). The higher the number of Btu's per pound of feedstock, the higher the heating value. For example, the heating value of bituminous coal is typically 10,000-12,500 Btu per pound, while municipal solid waste is in the range of 4,000-5,500 Btu per pound. Gasifiers are typically designed or rated by the heat input in Btu per hour.

Environmental Security Technology Certification Program (ESTCP): The DoD's environmental technology demonstration and validation program. The Program was established in 1995 to promote the transfer of innovative technologies that have successfully established proof of concept to field or production use.

General Waste to Energy Questions: (Honua Power, 2011)

What is Gasification?

Gasification is the high-temperature conversion of combustible solids (e.g., wood, municipal waste, plastics, rubber, paper, etc.) into a gaseous bio-fuel mixture containing hydrogen (H2) and carbon monoxide (CO). Depending on the production context, the gas mixture generated may be known variously as "syngas" or "synthesis gas", etc., through pyrolysis and substoichiometric processes.

Is Gasification a New Technology?

No, it's been around for over 100 years. Gasification was originally developed in the 1800s to produce town gas for lighting and cooking. Electricity and natural gas later replaced town gas for these applications, but the gasification process has been utilized for the production of synthetic chemicals and fuels since the 1920s.

The gasification process can convert forest residue, green waste, construction and demolition wood and waste, agricultural waste and energy crops - collectively called biomass - into a synthetic natural gas that is a direct substitute for natural gas.

Why do we need biomass gasification for renewable energy, isn't wind, solar or other forms of renewable energy enough?

Wind and solar power are key components to the future electricity generation mix because they are low maintenance and greenhouse neutral. Solar generation has the advantage of peaking at the same time as peak air-conditioning loads, and wind energy when networked sufficiently widely with appropriate interconnection can provide base-load generation. However, neither can provide on-demand generation for load-matching. Biomass gasification can provide this 24 hours a day, seven days a week, and, if supplied from sustainably-harvested fuel, it can be a truly greenhouse-neutral on-demand generation system to complement wind and solar in a carbon-neutral way.

What are the byproducts from the biomass gasification process?

A high-performance power gasifier is optimized to generate the maximum gas and little else. Byproducts of the process are a small amount of low-grade activated carbon, some inert ash and water. Ideally, these byproducts should be combined and returned to the soil as a soil conditioner. Waste heat is also produced by the process and can be used for water or space-heating, cooling, manufacturing processes, or for pre-drying the fuel for the gasifier.

What's the advantage of biomass gasification over production of biofuels?

A well-designed gasifier can accept a range of feedstocks and thus the technology supports a biodiverse resource base rather than a monoculture energy crop. However the energy density of the gas is far lower than that of liquid bio-fuels, making it more suitable for stationary applications than transport.

Biomass production also removes the same amount of CO2 from the atmosphere as is emitted from gasification. While other biofuel technologies such as biogas (from landfills) and biodiesel (from agricultural sources) are carbon neutral too, gasification can operate on a wider variety of input materials and can be used to produce a wider variety of output fuels.

What is in the gas that comes out of the gasifier?

The gas from the gasifier (Syngas) is basically composed of carbon monoxide (CO), hydrogen (H2), and nitrogen (N2). The CO and H2 are the combustible portions of the Syngas. It is used similar to natural gas, but it typically has lower energy content. Using the gasification approach to power production creates the opportunity to pre-treat the Syngas with systems that reduce emissions prior to burning it and afterwards, the exhaust is cleaned with state-of-the-art emissions control equipment. In this way, reliability of the control equipment and quality of the exhaust gas stream are assured to meet all applicable State and Federal air quality standards.

What can the gas produced in the gasifier be used for?
The gas mixture produced by the gasifier can be used as a replacement for natural gas or for process heating applications by operating the gasifier in a forced draft (positive pressure) mode and passing the gas directly to a burner on a boiler to make steam for an electrical turbine generator.

What is a Renewable Energy Portfolio Standard?
A Renewable Portfolio Standard (RPS) provides states with a mechanism to increase renewable energy generation using a cost-effective, market-based approach that is administratively efficient. An RPS requires electric utilities and other retail electric providers to supply a specified minimum amount of customer load with electricity from eligible renewable energy sources. The goal of an RPS is to stimulate market and technology development so that, ultimately, renewable energy will be economically competitive with conventional forms of electric power.

Municipal Solid Waste Near Fort Leonard Wood

Site	Collection Location	Miles from Fort	Tipping Fee ($/ton)	Assumed Fee Available ($/ton)	Available MSW (tons/year)	Potential Electricity Generation (MW)
Fort Leonard Wood	Fort Leonard Wood	0	$166.22 (average)	$83.11	10,053	1.1
Family Housing	Fort Leonard Wood	0	$197.50	$83.11	2,187	0.2
Black Oak Landfill	Hartsville	30	Unknown	$30.00	362,734	40
Jefferson City Landfill	Jefferson City	50	Unknown	$30.00	200,218	22
Prairie Valley Landfill	Crawford County	55	Unknown	$30.00	53,327	5.8
St. Robert Transfer Station	St. Robert	2	$48.50	$24.25	36,500	4.0
Phelps County Transfer Station	Phelps County	30	$43.10	$21.55	73,000	8.0
Waste Management of the Ozarks Transfer Station	Laclede County	30	$52.00	$26.00	Unknown	N/A
West Plains Transfer Station	Howell County	45	$40.00	$20.00	26,700	2.9
Mid-State Waste Transfer Station	Cole County	50	N/A	N/A	1,200	0.1
				TOTAL	**616,279**	**68**

Table 1. Municipal Solid Waste within 60 Miles of Fort Leonard Wood (DR Dixon, May 2009)

Attachment B: Diagrams

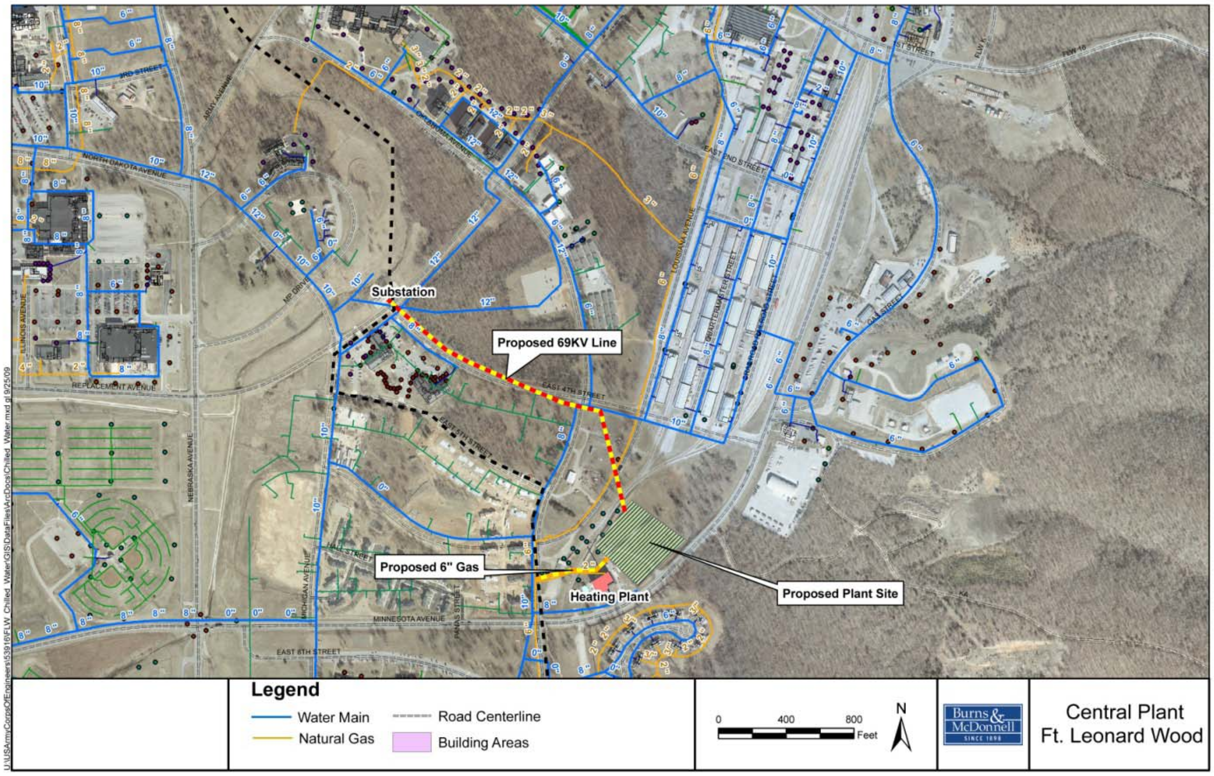

Figure 1. Central Plant Preferred Site (Burns & McDonnell Engineering Company, Inc., February 24, 2011)

US Army Corps of Engineers

2030 USACE Integration Project

8.47 Water Wells

water wells

TECHNOTE

Recommendation

Quality surface water for Fort Leonard Wood (FLW) is currently plentiful, affordable, and *vulnerable*. The Big Piney River supplies 98% of the installation's estimated 2.5 million gallons per day (MGD) water demand. However, any compromise of the quality or quantity of the Big Piney River water could force Fort Leonard Wood to rely on alternative sources to meet its potable water demand; which are not readily available.

New water wells should be drilled within Fort Leonard Wood's boundaries and used to meet the potable water demands of the installation. Water wells, properly located and maintained, would support Fort Leonard Wood's security and resiliency and help the installation achieve 2030 net zero water goals.

Location & Scale

Water wells should be strategically located on the installation to efficiently access and deliver high quality potable water to meet the base's water demands. Water well drilling should be implemented at the **installation scale.**

Phasing

Hydro-geological research with test drilling should be conducted by the **2015 Phase** to determine the feasibility of water wells at Fort Leonard Wood. The research should quantify the volumes and quality of groundwater, recommend ideal locations for wells, and provide detailed cost estimates for installation and operation of new wells. If the hydro-geological research confirms wells are feasible for Fort Leonard Wood, potable water well drilling should begin soon after the research is complete and funding is secured. Well development should be completed by the **2020 Phase** to supply all of the installation's potable water needs. In addition to water conservation, wells recharge and reuse water, firmly positioning Fort Leonard Wood to achieve net zero water goals by 2030.

Initial Cost

First cost for wells to provide 2.5 MGD of water is **$700,000.**

Drilling: Total of $80,000

- $20/LF for well drilling.
- $20/LF for well casing and average well depth of 1,000 feet = $40,000.
- $40,000 was added for drill rig mobilization, permits, bladder, sealing.

An average well yield of 500 gpm (72,000 gpd) was assumed. Fort Leonard Wood requires 2.5 MGD. Thus at least four wells with the 500 gpm capacity each would be necessary to meet existing water demand. Four wells at an estimated cost of $80,000 plus two redundancy wells equals $480,000. An additional twenty five percent contingency was added for unforeseen costs, bringing the total costs for wells to $600,000. A 10,000 foot pipeline system was added to the well cost to supply water from the wells to the existing pipe network = $100,000. The total first cost for wells is estimated to be $700,000.

Caveat: The cost to dig a well depends on numerous elements, including the substructure formations, depth, difficulty of drilling, casings, and pumps necessary to withdraw substantial reserves of water. Other components such as the pump equipment required for the job and materials for installing the well also influence well drilling costs. Set-up charges for mobilization of equipment along with state water well permits may also influence well costs. Thus, costs for the potable water wells could fluctuate significantly from this estimate.

Pumps: Total of $390,000

- $65,000 per pump, six pumps to be used
- Six pumps assumed by using four, 500 gpm pumps with two pumps for redundancy. Pumps are all assumed to have a 10 year operating life.

Life Cycle Cost

Annual well pumping, water cleaning, Operations and Maintenance (O&M) is $**653,875.**

- Energy costs for well pumping is $416,275.
  - Based on 500 gpm pumps, estimated 70% efficiency.
  - $0.088/kWh for electricity, 1,000 head on pumps, (0.000189*gpm*head*power rate/efficiency) to get $11.88 energy cost per hour per pump.
  - 365 days x 24 hours per day operation for four pumps to deliver 2,500,000 gallons per day to Fort Leonard Wood.
- Maintenance costs are estimated at $87,600 per year.
  - Personnel spend one hour per day per well to manage O&M needs. This includes pipeline and pump repair.
  - Estimated rate of $60 per hour for O&M personnel.
- A well-water filtration, cleaning, and testing system is estimated to cost **$150,000** annually.
- Fort Leonard Wood's water cost is currently estimated at $2.30**/1000 gallons. At 2.5 MGD, current water costs for Fort Leonard Wood are approximately$**2,098,750** annually.

The payback period for installation of water wells would be less than one year.

***Clarification is needed for actual water cost, daily water use for Fort Leonard Wood, housing, irrigation, and whether or not cost includes O&M.*

Maintenance

Pumps will require monitoring to ensure seals are intact and motors are working properly. Any broken elements will need to be replaced. Well water will require weekly testing for contamination indicators.

Feasibility

New potable water wells would contribute to the **2030 Net Zero Water** goals by utilizing groundwater resources within its boundary to supply potable water needs and reducing the base's reliance on outside sources for potable water.

Hydrogeological research at Fort Leonard Wood indicates plentiful subsurface water is available to the installation. Fort Leonard Wood has two water-bearing formations: the Roubidoux Formation and the Potosi Dolomite. Both of these formations can yield from several tens to several hundreds of gallons of water per minute. Ground water depths in these formations may be as deep as 750 to 1,200 feet deep. Thus, wells may need to drill exceptionally deep.

Additional hydrological research will need to be conducted to verify the feasibility and locations for the wells. If research indicates wells could provide adequate volumes of high quality water at a reasonable cost, Fort Leonard Wood should move forward to begin well drilling by 2015.

Initially, new water wells would serve as a supplement to the existing Big Piney River water. Eventually, the wells should supply all of Fort Leonard Wood's potable water needs. The existing intake at Big Piney River and the surface water treatment facility should be kept available for use as an ancillary water resource for post.

Fort Leonard Wood currently obtains and treats surface water from the Big Piney River to supply 98% of the estimated two and a half MGD water demand. Currently the water treatment facility is only operating at about fifty percent capacity while outputting a daily amount of two and a half to three million gallons. A single potable water well is currently used to supply approximately two percent of that water demand. Additional small wells are located in remote areas of Fort Leonard Wood to supply water to specific areas.

Well Locations and Risks: Sinkholes in several locations around Fort Leonard Wood should be avoided. The installation's GIS reports show a layer indicating the mapped sinkholes and main orientation line. This information should be consulted prior to locating wells. The GIS layer could be used to intersect the solution cavity network and more transmissive fracture sets in order to locate higher yielding wells.

Wells would need to be located away from the numerous sources of contamination at Fort Leonard Wood. This would include locating wells at higher elevations than any waste water septic system or drainage system. The wells should also be located away from landfill sites to prevent contamination from leachate. Artillery and / or rifle ranges may contain lead; therefore, wells should not be located in these areas. The contamination risks and issues need to be fully understood prior to well drilling to avoid intersecting wells or pulling contamination to the wells via pumping stresses.

Factors that influence well locations:

- Aquifer water depths
- Accessible volumes and quality of well water
- Drilling depths
- Pumping costs
- Drawdown impacts
- Geological formations and stability

- Locations of contaminants and utilities
- Proximity to water users and existing water pipe infrastructure

Ideally, wells should be located conveniently to power supply and pipe installation, and be accessible for drilling rig and pump installing equipment.

State laws also specify minimum acceptable distances between wells and other structures. Old and abandoned wells should be filled and sealed by a licensed well driller to avoid contamination of new wells.

References See Attachment A

Regional Ground-Water Flow Directions and Spring Recharge Areas in and near the Fort Leonard Wood Military Reservation, Missouri. U.S. Department of the Interior – U.S. Geological Survey.

http://extension.umd.edu/environment/water/files/well.html

Geohydrologic Framework, Ground-water Hydrology, and Water Use in the Gasconade River Basin upstream from Jerome, Missouri, including the Fort Leonard Wood Military Reservation; Water-Resources Investigations Report 03-4165; Rolla, Missouri 2003. Douglas N. Mugel and Jeffrey L. Imes.

http://pubs.usgs.gov/wri/wri034165/pdf/complete.pdf

Diagrams See Website References

Funding Plan The Utilities Modernization Program should be considered as a funding resource for water wells.

Contract Language See Attachment B

Product Specifications Pumps: Vertical turbine pump for water supply from drilled. Vertical lineshaft deep well pumps with options of oil lubrication or water lubrication, underground or surface discharge. Column sizes from 2.5” to 24”. Capacities up to 100,000 gpm. Head up to 2,500 feet. Horsepower up to 5,000 HP. Ambient temperatures within limits for satisfactory equipment operation.

Baseline Relation The water baseline was estimated at 2.5 MGD installation wide, based on intake meter readings from the Fort Leonard Wood water treatment facility at the Big Piney River and information gleaned from Fort Leonard Wood water studies. The 2009 water use intensity, 90.4 gallons per square foot of building space per year, was used to estimate water usage per building. For water use estimates on a per person basis, 150 gallons per person per day was used.

It is not anticipated that installation of new potable water wells alone will reduce Fort Leonard Wood’s baseline water demands. The new wells will, however, support the installation in its efforts to achieve net zero water goals. The wells would also allow Fort Leonard Wood to become self-reliant, thereby promoting Fort Leonard Wood security and supporting net zero water goals. The wells will allow the base to obtain all of its potable water within its boundaries and not rely on outside sources.

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Attachment A: Reference Material

Water Wells / Springs / Hydrogeology Key Terms:

Karst – A landscape characterized by the presence of caves, springs, sinkholes and losing streams, created as groundwater dissolves soluble rock such as limestone or dolomite.

Cave – A natural cavity beneath the earth's surface. Caves are formed when slightly acidic water combines with limestone or dolomitic rock, and dissolves the rock, creating a cavity.

Spring – A natural discharge of water from a rock or soil to the surface.

Sinkhole – A rounded depression in the landscape formed when an underground cavity collapses.

Losing stream – A surface stream that loses a significant amount of its flow to the subsurface through bedrock openings.

Limestone – A sedimentary rock composed of calcium carbonate; a rock of marine origin derived from the lime mud and ooze that accumulated on calm, shallow sea floors.

Casing: A metal or plastic pipe used to line a portion of the bore hole. The minimum length (depth) of the casing is determined by State regulations based on the geology of the area. The casing must extend a minimum of 8 inches above the ground (24 inches in flood zones) to keep stormwater runoff out of the well.

Grout: Material used to provide a watertight seal between the bore hole and the casing to prevent surface water and contaminants from running down the side of the well. Grouting may be portland or quick-setting cement, or bentonite clay. The minimum depth or length of casing that must be grouted is also determined by state regulations.

Well cover: A cap that screws or clamps onto the top of the well casing to prevent contaminants from entering the well.

Screen: A pipe-like attachment at the bottom of the well. Well screens are usually not required when drilling in bedrock, but they may be necessary if loose sand or fragmented rock is encountered. The screen is sealed on the bottom and has openings along its length that allow water to enter the well, but keeps out sand and sediment.

Pump: Draws water from the bottom of the well and into the distribution system. Many types and sizes of pumps are available. The two most commonly used are submersible and jet pumps. Submersible pumps are installed in the well and can be removed relatively easily with the pull rope. Jet pumps have the motor located outside the well.

Pitless adapter: Provides a frost proof and sanitary hookup between the well and the household water distribution system. The pitless adapter must be located below the frost line.

Drilling Procedure Example:

Using a drill rig, well drillers begin by drilling a hole about 9" in diameter through the overburden sediment overlying bedrock. When bedrock is encountered, drilling continues until competent bedrock is reached, generally between 10 and 20 feet. Steel casing is then installed in this hole and sealed to the bedrock. This casing seals the well from potential contaminants from surface infiltration. Drilling continues through the bottom of the casing until water-bearing fractures are encountered. Ground water fills the well to a level based on local geologic conditions. A submersible pump is then lowered into the well to bring water to the surface. The well casing protrudes out of the ground surface and is covered with a sanitary cap to prevent contamination. The water in the well above the pump is in storage and is available to be pumped out when needed. A bedrock well with low yield can still provide enough water for household use if the well boring itself holds enough water in storage to meet periods of peak demand.

Pump Energy Usage and Costs:

Energy Savings
Calculations for Determining the Cost of Power
Vertical Turbines

Pumps are the second most utilized machines in the world. From studies carried out, it was shown that pumping systems account for nearly 22% of the world's electric motor energy demand. In certain plants over 50% of electrical energy used by motors can be for pumping systems (i). In our global marketplace, margins have been squeezed to the point where companies must operate at the highest levels of efficiency to maintain long term success. Anywhere pumps are employed to move liquid, there is a potential to conserve energy.

Industrial, municipal and many other sectors of world economies are **energy intensive**. Many savings programs and attractive paybacks are available to companies that seek efficiency improvements within motor-driven systems, especially with pumps.

Experts know that there's more to buying a pump than the initial cost of the pump. Many organizations only consider the initial cost of a system. It is in the best interest of the plant designer or manager to evaluate the (Life Cycle Costs) LCC of different solutions before installing major new equipment beginning a major overhaul. This evaluation will identify the most financially beneficial alternative.

Vertical turbine pumps for example can be high energy pumps with either large flows or high heads or a combination of both. Accordingly the motors to drive these pumps can be relatively large. These pumps are generally used on water services and operate at 3600 rpm which can also have dramatic effect on wear and the overall mechanical reliability of the pump.

Recent developments in the pump industry(i) and increasing awareness of the life cycle costs(ii) amongst users have prompted a growth in concern about energy usage from pumps. Vertical Turbine pumps are an important type, especially in the high power levels seen where the movement of large volumes of water are required, such as in municipal applications and process water systems. These pumps run 24-hours a day typically, hence power consumption is a vital consideration.

Vertical turbine pumps have a few unique features that can be specified in order to help with the reduction of overall power consumption and improved mechanical reliability.

Mitered discharge heads, reduced bearing spacing, larger diameter line shafts, column size, keyed couplings, dual bowl bearings, lateral seal rings will improve the mechanical reliability of the pump and ease of maintenance. In looking at a 20-year life cycle costs optimizing these components can reduce the overall cost of operating these pumps.

Pumping efficiency can be explained in the following manner. A pump is a mechanical device which delivers useful work when external power is applied. Work is defined as raising a given weight of fluid a given height, and power is the time rate at which work is done. One horsepower is equal to 550ft-lb/sec or about 746 watts (0.746kW).

The liquid horsepower delivered by a pump (WHP) = (Lbs. of liquid raised per min.) x (H in feet) / 33,000 = (GPM x Head (feet) x S.G.) / 3,960

WHP: water horsepower
S.G.: specific gravity, for water is 1.0
BHP: horsepower required to drive the pump
Head: feet
Pump Efficiency: as expressed as a dimensionless fraction= Output/ Input = WHP/ BHP

Pump Efficiency is the Net Efficiency Value when considering the Bowl (centrifugal pump itself) Efficiency, Column Losses, and Discharge Head Losses

BHP: GPM x Head x 1.0 / 3960 x Pump Efficiency

Electrical HP input to motor = BHP/ Motor Efficiency
= GPM x Head / 3,960 x Pump Efficiency x Motor Efficiency

kW input to motor = BHP x 0.746 / Motor Efficiency
= GPM x Head x 0.746 / 3,960 x Pump Efficiency x Motor Efficiency

Wire to Water Efficiency = Pump Efficiency x Motor Efficiency

kW consumed = GPM x Head x 0.746 / 3,960 x Wire to Water Efficiency

Total energy cost will be, of course, the number of kilowatts consumed in a given time period multiplied by the cost per kilowatt. The standard by which electrical consumption is charged to the customer is the kilowatt hour or kWh. Therefore, you may evaluate on the basis of one hour of operation or any hourly multiple. (Many companies also include demand charges in their power evaluations, which, for high power verticals can be significant, since this provides them with a “truer” energy consumption number)

When doing an energy evaluation of a pump / motor assembly it is important to determine the “wire to water” efficiency in real dollars. Below is an evaluation of seven (7) pumps operating over a period of one year:

Assume electricity costs are $ 0.10/kWh, and you are evaluating two pump options being proposed by the manufacturer, A & B for a run time of 6000 hours/year/pump. The rating in our example is 6,000 gpm @ 150 feet TDH.

Pump A has a guaranteed wire to water efficiency of 80%, whereas Pump B is only 75% then

Electrical cost for one year, Pump A= (6, 000 hrs)
6,000 x 150 x 0.746 ($0.10/hr) / 3,960 x .80
= $ 127, 159 x 7 pumps = $890, 113 per year

Pump B has a guaranteed wire to water efficiency of 75%, then

Electrical cost for one year, Pump B= (6,000 hrs)
6,000 x 150 x 0.746 ($0.10/hr)/ 3,960 x .75
= $ 135, 636 x 7 pumps= $949, 454 per year

The net savings for operating pump A instead of pump B is $59,341 in a one year period. If the price quote for pump B was $100,000 and for pump A it was $120,000, then, obviously, pump A would be a better choice. It would recover the higher initial cost in less than one year of operation.

Efficiency evaluation compares bids on the basis of total cost, not just initial cost. Maintenance costs are generally not comparable between manufacturers when the main components, like line shafts, coupling styles, bearing spacing, column size, and bearing materials and style are not the same. Power consumption is a very real portion of total operating cost, and in some applications accounts for 45% of the total life cycle costs(i). The savings over a 20 year period in a few points of wire to water efficiency can be significant.

The vertical turbine operating efficiency is a function of the surface roughness, internal clearances, desired curve shape, mechanical shaft seal losses, column and discharge head losses and the staging effect of multiple bowls. The overall pump efficiency will be less than the attainable bowl efficiency due to hydraulic losses in the column piping, discharge elbow losses, and bearing losses. Because of this variability in this style pump, the selection of these components needs to analyzed when selecting a vertical turbine for a particular application.

This has become such an important issue that Peerless Pump Company has DOE certified instructors on-staff and conducts in-depth technical review of this subject matter in their Total System Evaluation and Pump System Assessment Training workshops.

Vertical Turbine Optimization:

At Peerless Pump we offer an electronic selection program (RAPID) which provides the technical tools to optimize pump selection when considering both the initial costs and the operating costs.

How to offer an optimized pump with an electronic selection program?

First, you want to show the structure of main pump components of the offered pump (especially the ratio cost of hardware to cost of losses)

Cost of main pump components and their losses:

1. Motor
2. Discharge head
3. Column
4. Bowl assembly

The following are the values determined for this pump:

1. $55,918.48: Approximate cost of pump complete with motor
2. $570,241.77 Energy loss cost
3. $1,798,154.50 Cost of energy for lifting of fluid
4. $2,424,314.80: Sum of costs above
5. 27.40Gwh: Energy used

Key areas to lower total life cycle costs are in the following areas

- Higher efficiency of bowl assembly
- Higher diameter of column
- Fabricated discharge head with 3 segments instead of 90° or cast one
- Higher efficiency of motor

Proper selection of vertical turbine pumps and the design of the pumping system is complex and requires considerable engineering expertise, the use of electronic system design tools, and electronic pump selection tools to realize the lowest life cycle cost.

It is extremely important that a pump supplier provide the above technical data so that a proper pump selection can be made on a comparable basis and to realize the overall lowest operating costs.

By better understanding all components that make up the total cost of ownership, operators will be able to dramatically reduce energy, operational and maintenance costs. Excessive waste and energy usage are important factors in global environmental pollution.

- Variable Speed Pumping: A Guide to Successful Applications, Hydraulic Institute, Europump

- Pump Systems Matter is an organization that is focuses on **Energy Savings**, **Efficiency** and **Economics** of pumps and pumping systems. Industrial pumping systems account for nearly **25%** of industrial electrical energy demand. Pump Systems Matter aims to help lower the energy needs of North America while improving the bottom-line profitability of businesses by providing pump users with strategic, broad-based energy management and performance optimization solutions. Pump Systems Matter, www.pumpsystemsmatter.org

- Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems", Hydraulic Institute, Europump, and the US Department of Energy's Office of Industrial Technologies

- Hydraulic Institute Standards, www.pumps.org.

Notes: (iv)

Factors that can affect efficiency are:

- Effects of Accessories
    - Mechanical seals produce drag that varies with seal design and setting. The variation in seal drag can affect efficiency and power
    - Packing must be tightened manually to minimize leakage. Because this is a manual process there is a significant variation in the resulting drag between the packing and shaft which can affect power and efficiency.
- Surface Roughness
    - Efficiency increases due to improvements in waterway surface finish are very dependent on pump specific speed and size. Generally, surface finish improvements are economically justifiable for small and low specific speed pumps.

- Internal Clearances
    - Pump wear ring clearances can have a major influence on efficiency, particularly for low specific speed pumps (less than Ns = 1500 (29).
- Mechanical Losses
    - Bearings, lip seals, mechanical shaft seals, packing etc all consume power and reduce pump efficiency.
- Impeller Trim Diameter
    - Reduction in efficiency due to impeller diameter trim must be expected. Efficiency reductions can range from 1 to 6 points for impeller diameter trim to 80% of the maximum diameter. High specific speed pumps generally have greater reductions in efficiency due to trim than low specific speed pumps.
- Staging Effect
    - Due to hydraulic losses at the inlet and discharge of the pump, single stage attainable efficiency could be as much as 6 points below the bowl efficiency. This difference reduces as the number of stages increases. Typically this correction applies to 4 stages and less.

Other Factors Affecting Quoted Pump Efficiencies

- Liquid being pump
- Pump speed
- Blade angle setting on adjustable pitch pumps
- Materials of construction
- Standard of finish
- Testing tolerances
- Application of Penalties on Performance Guarantee

ATTACHMENT B: Contract Language

Sample Well Drilling Contract

AGREEMENT made this____ day of 2001 between XXXXXXXXXX Drilling Co., Herein after called the CONTRACTOR,

And____Herein after called the OWNER.

WITNESSETH:

The parties hereto covenant and agree as follows:

1. The CONTRACTOR agrees to commence drilling immediately or within a reasonable time a ___inch diameter well in a workmanlike manner in a location mutually selected by the OWNER and the CONTACTOR on the premises of the OWNER at:
(street) ____
(town) ____

2. The OWNER has, or will obtain, all applicable state and local permits covering the work and agrees to provide the CONTRACTOR with free and easy access to and from the drill site, And the OWNER further agrees not to hold CONTRACTOR responsible for any damage to OWNER'S property caused by the moving of CONTRACTORS equipment to and from the site or because any debris extracted during the drilling operation which debris will be removed of the expense of the OWNER>

3. The CONTRACTOR agrees to drill to the normal limits of the CONTRACTORS equipment. The OWNER may order drilling stopped of any depth.

4. THE CONTRACTOR EXPRESSLY MAKES NO EXPRESS OR IMPLIED WARRANTY OR GUARANTEE AS TO WHETHER OR NOT WATER WILL BE OBTAINED OR AS TO THE QUALITY OF WATER OBTAINED.

5. For such drilling the OWNER agrees to pay the CONTRACTOR

$______ Permit fee w/ runner

$______ Per lineal foot according to the depth reached, measured from the surface of the ground,

$______ Per lineal fool for casing required,

$______ For drive shoe or well screen per lineal foot

$______ Per hour for well developing,

$______ Well cap

$______ 4 hour pump test with standard chemical analysis,

$______ Minimum fee

$______ Per day 8 hours

6. The OWNER agrees to make payment us follows:

(A)A deposit of $________ paid by the owner upon the signing of this agrement, is hereby acknowledged by the CONTRACTOR and the balance shall be payable as

follows:____
____
____
____

(B) In the event that payment(s) are not made by the OWNER as called in 6(a) above, then the OWNER agrees that the unpaid balance shall bear Interest at the maximum rate permitted by law, computed and accessed monthly until fully paid and the OWNER also agrees to a reasonable attorney's fee and all other costs of collection in the event action is taken.

7. The OWNER represents that he/she has legal title to the property referred to in paragraph 1 above, or that he/she has the authority to execute this agreement on behalf of the titleholder.

8. THE OWNER HEREBY ACKNOWLEDGES THAT THIS AGREEMENT IS FOR DRILLING ONLY and that the cost of digging any trench, installing of any piping and the cost of any pump or installation thereof, although the some may be performed by the CONTRACTOR, is extra and such costs shall be borne by the OWNER.

**THE UNDERSIGNED ACKNOWLEDGES RECEIPT OF A TRUE COPY OF THIS CONTACT AND ACKNOWLEDGES THAT HE/SHE HAS READ AND KNOWS THE CONTENTS THEREOF, AND UNDERSTANDS THAT NO OTHER AGREEMENTS,VERBAL OR OTHERWISE, ARE BINDING UPON THE PARTIES THERETO ,AND THAT THE SAME CONTAINS THE ENTIRE CONTRACT BETWEEN THE PARTIES.

NOTICE TO THE BUYER--DO NOT SIGN THIS AGREEMENT IF BLANK. YOU ARE ENTITLED TO A COPY OF THE AGREEMENT AT THE TIME YOU SIGN.KEEP IT TO PROTECT YOUR LEGAL RIGHTSCONTRACTOR IS COVERED BY WORKERS COMPENSATION,PUBLIC LIABILITY AND PROPERTY DAMAGE INSURANCE
OWNER ____XXXXXXX DRILLING COMPANY
CO.____

Prior to selecting a water well contractor for a job, it is a good idea to obtain information about several contractors in the area before making a choice.

Here are some more considerations:

- Is the contractor licensed by the state? (Not all states require licensing.)
- Is the contractor certified through the National Ground Water Association? The highest level a contractor can achieve is MGWC (Master Ground Water Contractor), passing all specialty NGWA certification exams and a general exam.
- Does the contractor submit well logs?
- Does the contractor have adequate equipment in good condition to do the job?
- Does the contractor have adequate liability and worker's compensation insurance to protect you?
- Is the contractor familiar with applicable health and safety codes?
- What is the contractor's reputation with previous customers?
- Will the contractor furnish a written contract specifying the terms and conditions of the job?
- Is the contractor a member of the National Ground Water Association?
- Does he have a current NGWA sticker on his truck?
- NGWA members support the industry, have access to new technology and improved approaches, are dedicated to quality of workmanship, and promote and protect the ground water resource. They know their stuff and will work with you to get the job done right. You can contact the NGWA Customer Service Department at (800) 551-7379 or visit www.ngwa.org/forms/cont/list.htm for a list of member contractors in your area.

Written Contracts

It is important to obtain a written contract when preparing to have a well constructed. Unless you know what each contractor will do for his specified price, you cannot compare offers and decide which one to hire. NGWA makes available standard contract forms to its members. For a drilled well, the contract might include:

- Liability insurance coverage held by both the owner and the contractor.
- A statement that all work is to comply with local and state regulations and codes.
- The diameter and well thickness of the casing to be used.
- The type of well development and yield evaluation procedures to be used.
- The type of screen to be installed, where needed.
- The type of well cap or seal to be provided.
- The disinfection procedure.
- The cleanup after drilling, which includes all material abandoned without authorization at a drill site except drill cuttings and waste water.
- An anticipated date for start of drilling.
- A guarantee of materials and workmanship. The contract should specify that the contractor will return to do or to correct the initial work if necessary.

Costs

An itemized list of charges is better than a lump sum. The list could include:

- Cost of drilling per foot
- Cost of casing per foot
- Cost of other materials, such as drive shoe, grout, and well cap.

- Cost of other operations, such as grouting, developing (if longer than one hour, as in screened wells), test pumping, and disinfection.
- Cost of drilling deeper and/or second well, if required to ensure an adequate water supply.
- Cost of abandonment should it prove necessary (for instance, if salt water is encountered and another site is selected).
- What costs are not included in the specifications.

Finished Well Checklist

After the well has been constructed and before the contractor removes his equipment from the site, you should inspect the well.

Here is a list of items to check:

- **Well Depth** — This is easily done by tying a weight on a tape. Verify the measurement against the well construction report made out by the contractor.
- **Well Yield** — Ask the contractor at how many gallons per minute (gpm) the well was tested, what distance the water level dropped during the test, and how quickly the water level recovered after the test.
- **Well Cap** — Ensure that the well is capped and secure and that the cap is at least 6 inches above ground level.
- **Disinfection** — Ask the contractor if the well was disinfected.
- **Well Construction Record** — Make certain that you receive your copy of the well record. The contractor is required to deliver copies of the record to the owner. It would be advisable to keep your well record with your house deed so that the information is passed on to future owners.

Websites:

1) http://pubs.usgs.gov/wri/wri034165/pdf/complete.pdf
2) Missouri water well drilling company: http://www.yoakumdrilling.com/waterwellfaq.html
3) Jefferson County geological study: http://dnr.mo.gov/env/hwp/docs/risection3.pdf
4) NRCS
http://www.dnr.mo.gov/env/wrc/groundwater/education/provinces/salemplatprovince.htm
5) Minimum pump cost: http://www.pumpbiz.com/shopping_product_list.asp?pcid=6159
6) Karst: http://water.usgs.gov/ogw/karst/kig2002/mdk_synopsis.html
7) Vertical turbine pump : http://www.peerlessxnet.com/documents/B-1270.pdf
8) Hiring a well driller: http://www.fosterwelldrilling.com/documents/howtohire.htm
9) Example contract: http://www.sawyerwelldrilling.com/contract.htm
10) Pump energy usage example: http://www.peerlesspump.com/energy-savings.aspx
11) http://www.peerlesspump.com.mx/PIC/pdf/Vertical_14_30.pdf

2030 USACE Integration Project

8.48 Wind Turbines

Recommendation

Install forty-eight individual 1.5 MW wind turbines. In the Renewable Energy Opportunities at Fort Leonard Wood, MO report prepared by the U.S. Department of Energy (DOE), May 2009, the feasibility of installing forty-eight 1.5 MW wind turbines at the installation was examined. It was estimated that the project with a 27% capacity factor would generate about 19 MW and 170,000 MWh/yr. Recently, this technology was not recommended as the energy charge of $0.064/kWh was too low for the wind turbines to be economically feasible. However, due to rising energy costs, this is now a viable renewable energy resource and should be considered. The payback period was twenty-nine years but at the 2010 average energy cost of $0.088/kWh, operations and maintenance (O&M) cost of $60/kW/yr, and renewable energy production tax credit (PTC) for the first ten years, the payback would be eighteen years with five-year accelerated depreciation. Since wind is not a reliable resource, demand cost reduction research was not conducted. The estimated energy savings would be 69% based on 2010 usage.

Location & Scale

This system is implemented at the area development plan (ADP) level or the **installation scale**. The location of the wind turbines should be sited less than a mile to the 161-kV lines running along the two northern perimeter boundaries of Fort Leonard Wood so as to reduce transmission losses. Also, the wind turbines need to be at least 20,000ft away from the closest airport, in this case Waynesville Regional Airport. When siting the wind turbines, they should be located three rotor diameters when placed side to side and five rotor diameters behind each other. This is to minimize the wake of air left after it hits the front wind turbine. Assuming a worst case of 100m rotor for a 1.5MW turbine, placing an array of twelve by four rows of turbines with the array of twelve facing the ideal wind direction, this would give a land area of 1 ¼ miles x 2 ¼ miles. The only place where this is feasible is on the eastern side of the installation. However, this layout should be consulted with a wind developer as different turbine arrangements may be considered which optimizes the energy produced.

Phasing

This system is projected as part of the **2020 Phase** or later. This renewable resource should begin when other conservation means are implemented.

Initial Cost

The current cost for this project would be $2,277/kW (including incentives).

Life Cycle Cost

The proposed project would reduce the power by 19MW. Based on the Burns & McDonnell report, the power for the base will increase past 71MW, the ultimate maximum load, by 2018. Currently the load on the base is 53.9MW supplied through Substation 4. The wind turbines would alleviate a large part of this required load. The life cycle for a wind turbine is twenty-five years but other manufacturers believe it to be thirty years. The life cycle cost for all forty-eight turbines is $8,061,319 and has been accounted for in the payback cost. The renewable energy PTC will help with funding by supplying $3.4M a year for the first ten years by the government. If taken into account then the life cycle cost would be $6,012,149 for the first ten years.

Maintenance

Preventive maintenance includes the labor and parts needed to perform on-site work as specified by the maintenance schedule including:

- Visual inspection of the generator and its operating environment
- Inspection of the connections
- Checking of the generator mounting bolts and alignment
- Inspection, testing, and cleaning of the stator and rotor
- Condition monitoring of the bearings and lubrication
- Cleaning and checking the bearing shield insulation
- Inspection and cleaning of the slip ring assembly
- Cleaning of the cooling system
- Inspection and/or testing of the accessories
- Inventory of the generator spare parts
  Source: http://www05.abb.com/

Feasibility

With the increasing average energy cost of Fort Leonard Wood to $0.088/kWh, there is more incentive to look for areas to conserve and to implement renewable energy resources. Also, since the average energy cost has nearly doubled since the previous year, there is no definitive method to predict next year's increase in energy cost. As energy costs keep growing Fort Leonard Wood will need to reduce its dependence on its energy provider. A study should be performed by a wind development expert to collect actual wind data before determination is made to proceed with this project and to determine if a wind power project is viable with the give resources.

References

See Attachment A

Diagrams

See Attachment B

Funding Plan

"The renewable energy production tax credit (PTC), originally established in 1992, provides a tax credit for each kWh of electricity produced. The PTC is 2.0¢/kWh for wind and can be taken for 10 years." (Source: US DOE, 2009)

Product Specifications

See Attachment C

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Attachment A: Reference Material

Wind Energy Basics - Basic information on wind energy and wind power technology, resources, and issues of concern.

Wind Energy and Wind Power

Wind is a form of solar energy**.** Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity**.**

How Wind Power Is Generated

The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Wind Turbines

Wind turbines, like aircraft propeller blades, turn in the moving air and power an electric generator that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind Turbine Types

Modern wind turbines fall into two basic groups; the horizontal-axis variety, like the traditional farm windmills used for pumping water, and the vertical-axis design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

Turbine Components

Horizontal turbine components include:

- blade or rotor**,** which converts the energy in the wind to rotational shaft energy;
- a drive train, usually including a gearbox and a generator;
- a tower that supports the rotor and drive train; and
- other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

Wind turbines are often grouped together into a single wind power plant, also known as a wind farm, and generate bulk electrical power. Electricity from these turbines is fed into a utility grid and distributed to customers, just as with conventional power plants.

Wind Turbine Size and Power Ratings

Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high, and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. Utility-scale turbines range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

Wind Energy Resources in the United States

Wind energy is very abundant in many parts of the United States. Wind resources are characterized by wind-power density classes, ranging from class 1 (the lowest) to class 7 (the highest). Good wind resources (e.g., class 3 and above, which have an average annual wind speed of at least 13 miles per hour) are found in many locations (see the United States Wind Energy Resource Map http://windeis.anl.gov/guide/maps/map2.html).

Wind speed is a critical feature of wind resources, because the energy in wind is proportional to the **cube** of the wind speed. In other words, a stronger wind means a lot more power.

Advantages and Disadvantages of Wind-Generated Electricity

A Renewable Non-Polluting Resource

Wind energy is a free, renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

Cost Issues

Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a higher initial investment than fossil-fueled generators. Roughly 80% of the cost is the machinery, with the balance being site preparation and installation. If wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (counting fuel and operating expenses for the life of the generator), however, wind costs are much more competitive with other generating technologies because there is no fuel to purchase and minimal operating expenses.

Environmental Concerns

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, there is some concern over the noise produced by the rotor blades, aesthetic (visual) impacts, and birds and bats having been killed (avian/bat mortality) by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.

Supply and Transport Issues

The major challenge to using wind as a source of power is that it is intermittent and does not always blow when electricity is needed. Wind cannot be stored (although wind-generated electricity can be stored, if batteries are used), and not all winds can be harnessed to meet the timing of electricity demands. Further, good wind sites are often located in remote locations far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land,

and those alternative uses may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

For More Information

Much additional information on wind energy science and technology and wind energy development issues is available through the Web. Visit the Wind Energy Links page at http://windeis.anl.gov/guide/links/index.cfm to access sites with more information. In particular, the Department Of Energy's Wind Energy Technologies page at http://www1.eere.energy.gov/windandhydro/wind_technologies.html has good information on wind energy basics, and is the source for much of the information presented here. The American Wind Energy Association web site has an excellent FAQ page at http://www.awea.org/faq/index.html with information about wind technology, and the Danish Wind Industry Association web site at http://www.windpower.org/en/core.htm has extensive information about wind energy and technology, including a 28-minute video introducing wind technology.
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Attachment B: Diagrams

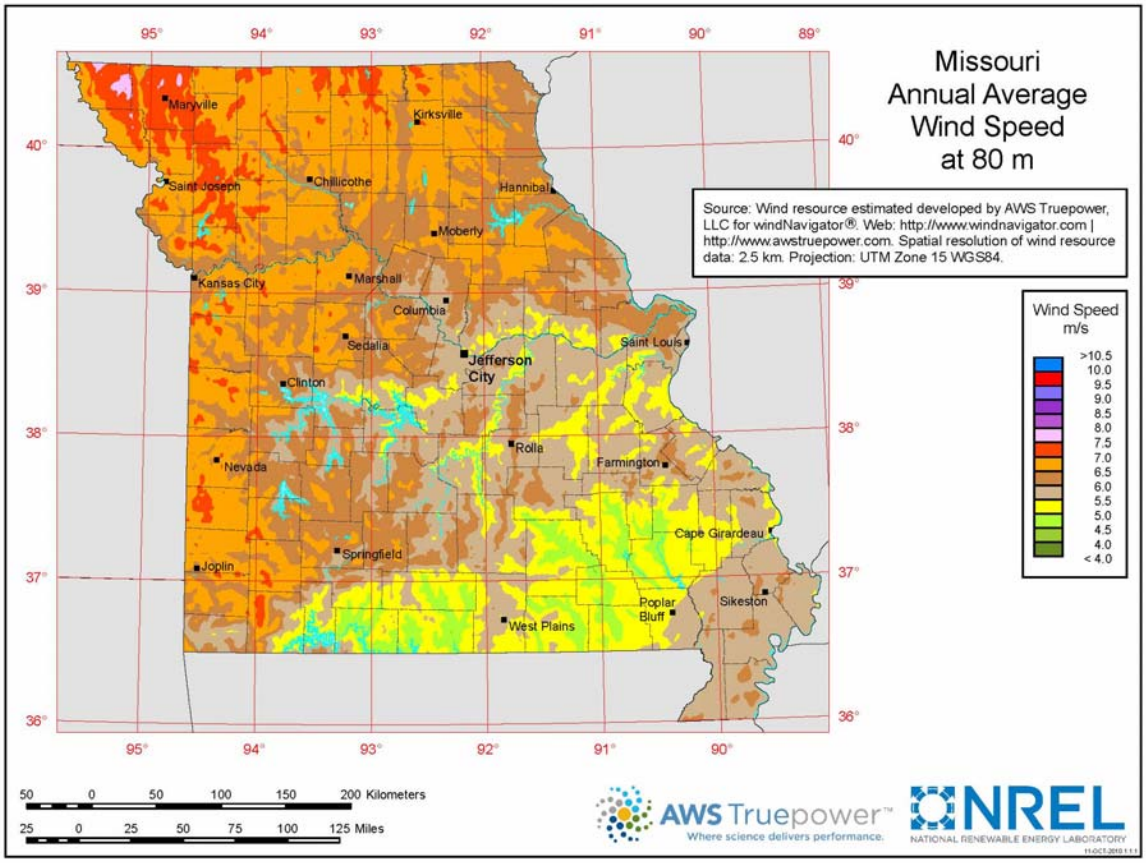

Figure 1. Average Wind Map of Missouri

Attachment C: Product Specifications

Below is a typical 2.5MW Turbine specification cut sheet. Due to the fact that this document is merely a Tech Note, the design has been omitted; however, when designing a wind turbine farm, the following items need to be taken into consideration and coordinated with a wind developer:

- Concept Design
    - Basic design parameters
    - Required design standard, certification rules and wind class
    - Definition of control and safety concept
    - Bladed model and baseline loads
    - Key component and sub-system selection and definition
    - Power train arrangement
    - Layout and general outline of all major structures and bearings
    - Dimensions and mass estimates of major components
    - CAD model of design concept.
- Blade Aerodynamic Design
    - Maximum chord length
    - Radial position of the maximum chord length
    - Maximum twist of the blade
    - Preferences for aerofoils
    - Structural loading and dynamics
    - Maximum deflection
    - Absolute or relative thickness distribution
- Performance and Load Calculations
- Control System Design
    - Fully functional Turbine Controllers to run on either PLC or industrial PC platforms
    - Implementation process
        - Hardware processing
        - Comms and I/O
        - HMI & SCADA interfaces
- Mechanical and Structural Design
    - Blade specification
    - Hub
    - Pitch mechanical system specification
    - Main bearing system specification (including housings)
    - Main shaft
    - Main frame including auxiliary frame
    - Gearbox specification, including main shaft coupling
    - High speed shaft and mechanical brake specification
    - Hydraulic system specification
    - Yaw system specification
    - Tower with foundation insert
    - Rotor lock specification
- Electrical System Design
- Reliability analysis
    - Reliability analysis of the control and safety system.

    - A functional Failure Mode and Criticality Effect Analysis (FMECA) is conducted and the findings are reported in a certification-friendly report. This service can be extended to include recommendations for design optimization.
  - Life cycle cost analysis.
    - Design concepts are analysed and reliability profiles defined in order to assess the impact on downtime and O&M costs for different site conditions. Life cycle cost analysis then provides important input for design optimisation and addresses the trade-off between revenue, O&M costs and capital cost.
  - Reliability quick scan.
    - A review of the reliability and availability of a given design to provide design recommendations.

  (Source: http://www.glgarradhassan.com/en/index.php)