



**US Army Corps  
of Engineers®**  
Engineer Research and  
Development Center



# Calendar Year 2013

## Center for the Advancement of Sustainability Innovations

**Work Plan**





# Contents

<b>INTRODUCTION</b>	<b>1</b>
<b>ANTICIPATING EMERGING ISSUES</b>	<b>6</b>
<b>SUSTAINABILITY APPROACHES, EDUCATION AND KNOWLEDGE MANAGEMENT</b>	<b>9</b>
<b>SUSTAINABLE REGIONAL PLANNING</b>	<b>12</b>
<b>SUSTAINABLE ENERGY SOLUTIONS</b>	<b>16</b>
<b>SUSTAINABLE WATER &amp; WASTE RESOURCES</b>	<b>22</b>
<b>SUSTAINABLE NATURAL INFRASTRUCTURE</b>	<b>28</b>
<b>CLIMATE CHANGE</b>	<b>30</b>
<b>GREEN REMEDIATION AND REUSE</b>	<b>33</b>
<b>SUSTAINABLE FORWARD MILITARY OPERATIONS</b>	<b>36</b>
<b>SUSTAINABLE FACILITIES AND INFRASTRUCTURE</b>	<b>40</b>
<b>ACRONYMS AND ABBREVIATIONS</b>	<b>48</b>
<b>REPORT DOCUMENTATION PAGE (SF 298)</b>	<b>52</b>



# Introduction

The Center for the Advancement of Sustainability Innovations (CASI) was established by the US Army Engineer Research and Development Center (ERDC) as a new capability in 2006, hosted at the Construction Engineering Research Laboratory (CERL) in Champaign, IL. CASI's mission is to focus ERDC expertise, technologies and partnerships toward helping the US Army Corps of Engineers (USACE), the Army and the Department of Defense (DoD) achieve more sustainable missions, facilities and operations. CASI provides the military with capabilities that enhance national security through more effective use of limited resources and improved coordination and partnerships with host communities and stakeholders in the US and across the globe.

In all efforts, CASI teams strive to measure sustainability innovations against the Triple Bottom Line of mission, environment and community. In addition, CASI focuses on cost savings, innovation, collaborative solutions and continuous learning, all of which directly link sustainability to Army Business Transformation and the Army Campaign Plan.

This 2013 work plan is the sixth published for CASI. Previous work plans were published in 2008-12. These publications are referenced below, with links provided to the documents (all of which are located on the CASI website under the "Library" section).

*Fiscal Year 2007 Annual Report, Center for the Advancement of Sustainability Innovations*, William Goran, ERDC/CERL Technical Note (TN-08-02), May 2008, (CASI Work Plan for 2008),  
[http://libweb.erdcd.usace.army.mil/uhtbin/cgiisirs/HRRyiAVdXf/ERDC\\_VBG/273630010/523/1087](http://libweb.erdcd.usace.army.mil/uhtbin/cgiisirs/HRRyiAVdXf/ERDC_VBG/273630010/523/1087)

*CASI Work Plan Fiscal Year 2009*, William Goran, Annette Stumpf, and Michelle Hanson, ERDC/CERL Special Report 08-21, November 2008,  
<https://casi.erdcd.usace.army.mil/library/?contentRegion=Item&id=57335>

*Center for Advancement of Sustainability Innovations: 2010 Work Plan*, William Goran, et al., ERDC/CERL TN-10-1, April 2010, at either:  
<https://casi.erdcd.usace.army.mil/about/?contentRegion=Item&id=59415>  
<http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=8438&TOP=1>

*Center for Advancement of Sustainability Innovations: 2011 Work Plan*, William Goran, et al., ERDC/CERL TN-11-11, January 2011,  
<http://www.cecer.army.mil/td/tips/docs/2011WorkPlan-FINAL-sm.pdf>

*CASI Work Plan Calendar Year 2012*, William D. Goran, Michelle Hanson, Elon Zeigler, and Annette Stumpf, ERDC/CERL TN-12-1, January 2012.

The purpose of these work plans is to:

- provide a framework to capture the diverse activities being conducted as part of CASI
- help various sponsors, partners and stakeholders understand the scope of activities and expertise offered through CASI
- identify areas where activities can be leveraged for those with similar interests or ongoing investments
- suggest potential projects that have been conceived but not yet resourced by potential partners and sponsors
- enhance dialogue and teaming across the different technical focus areas for CASI
- document CASI activities.

The scope and number of CASI activities continue to grow each year. This year, we have added waste to the water technology focus area — to better align CASI technology focus areas with the Army’s Net-Zero Installations initiative and to capture the various waste projects we have underway.

## Technology Focus Areas

One of the key values of CASI is to provide “systems level” expertise to address complex sustainability issues. Installations and communities engage across a wide range of economic, environmental, social, and mission issues that interact in multiple temporal and spatial dimensions. Most of the issues addressed in this work plan cross over multiple technology focus areas. The focus areas are simply useful “bins” for planning suites of projects and joining groups of experts. These technology focus areas also indicate the explicit topical areas where CASI has selected teams of experts from within and beyond ERDC. As the sustainability challenges of the US military change, these technology focus areas will also change. Currently, the 10 CASI technology focus areas are:

- Anticipating Emerging Issues
- Sustainability Approaches, Measures, and Knowledge Management
- Sustainable Regional Planning
- Sustainable Energy Solutions
- Sustainable Water & Waste Resources
- Sustainable Natural Infrastructure
- Climate Change
- Green Remediation and Reuse
- Sustainable Forward Military Operations
- Sustainable Facilities and Infrastructure.

## Coordination and Outreach

### Website

The CASI website is supported by the Engineering Knowledge Online (EKO) portal, which, at this writing, is temporarily unavailable due to a security intrusion. Enhanced security and safety measures are being implemented and the EKO site will be brought back up as soon as possible. Once EKO is back on line, the CASI website will be restored as well.

The website includes a calendar of events, information on each of the 10 technology focus areas, a library with all available CASI documents and publications, and links to other related sites. Several CASI technology focus areas manage additional web resources supplementing the information on CASI’s website, with links from the CASI website.

### Marketing Materials

The CASI brochure and poster are available for download on the CASI website. A CASI display supports marketing activities at conferences, job fairs, and other venues. Paper copies can also be requested via the CASI website, or by emailing the CASI Director at: [casidirector@usace.army.mil](mailto:casidirector@usace.army.mil).

### Electronic Copies

Electronic copies of the Work Plan are available at: <http://acwc.sdp.sirsi.net/client/default> (search “CASI”).

### Partnerships

CASI strives to bring the best team to any specific challenge and this often involves the creation of unique partnerships for each project. CASI has formal and informal partnership arrangements with many academic, industry, and government organizations. In many of the

descriptions of ongoing projects, these partner organizations are highlighted. Some partnership activities are also described in the “highlights” section to follow.

## Projects in This Work Plan

The work plan is an important tool for CASI to share information and create dialog across multiple stakeholders and organizations. While CASI projects are usually funded by an individual sponsor, in most cases these projects are also of interest to other sponsors. The work plan allows for all sponsors to learn about and follow the progress of any project of interest, and where appropriate, to acquire access to the project outcomes. In addition, a project sponsored by one organization may help create the dialog necessary to initiate a related or follow-on effort tailored to another organization.

This work plan discusses three project categories: Completed, Ongoing, and Proposed. While each project is identified within a specific technology focus area, many of these projects are relevant across multiple technology focus areas.

Completed projects were finished either late in 2011 or during calendar year 2012. The immediate outcomes could be a service (e.g., a new web capability), a forum (e.g., the Inter-Agency Climate Change Impacts and Adaptations forum sessions in 2012), a demonstration of a capability, and/or a publication or presentation. However, for many CASI initiatives, the long-term outcomes are improved understanding of system relationships and tradeoffs, and/or the identification of new pathways to achieve more efficient and sustainable military operations.

Ongoing projects are those efforts currently in progress, with some phase of the work underway. Ongoing projects may already exhibit outcomes (e.g., services, forums, or reports), while activity in these projects continues.

Proposed projects are ideas, not yet funded by any sponsor, but many are actively being discussed with a sponsor. There is no certainty that the proposed projects in the CASI work plan will be funded; some proposed projects described in the 2012 work plan have become ongoing projects in the 2013 plan, some proposed 2012 projects have been dropped, and others are still seeking sponsors.

## 2012 Highlights

### **Sustainability Innovations Speaker Series**

In 2010, the University of Illinois at Urbana-Champaign (UIUC) Sustainability Office, currently led by UIUC Vice-Chancellor for Outreach, Dr. Pradeep Khana, and CASI established a new speaker series. Approximately once each academic semester, an invited speaker visits Champaign-Urbana to give presentations at selected UIUC venues and also at the Champaign facilities of ERDC. This speaker series started in Spring 2011 with Dr. James Harris of Cranfield University speaking on ecosystem services at Salisbury Plain, the United Kingdom Ministry of Defence’s primary military training area near Stonehenge. In November 2011, Dr. Chris Pyke, Vice-President for Research, US Green Building Council, spoke on Accelerating Green Building Market Transformation with Information Technology. In the Spring 2012, Majora Carter from New York City gave presentations entitled “Hometown Security,” in which she described community transformations in New York City and elsewhere. For the 2012-13 academic year, Dr. Richard Moss (University of Maryland and Department of Energy) will give presentations on climate risk management in January 2013, and Dr. Michael Webber, University of Texas, will give a presentation on sustainable system engineering in April 2013.

## **USACE Energy and Sustainability Centers**

In late 2011, the Corps of Engineers issued an operational order authorizing the creation of a network of “energy, sustainability and life-cycle cost assessment” centers. The purpose of these centers is to increase Corps of Engineers capabilities in these technical areas. During 2012, 21 centers were designated at various Divisions across the Corps of Engineers. These include expertise for lighting, commissioning, renewable energy sources, water systems, etc. Through CASI, ERDC is supporting these new centers and has designated technical liaisons for each of the 21 centers.

## **USACE Efficiency Study**

This work, conducted with support from HQUSACE, examined the entire set of USACE sustainability goals to determine total investments required over multiple years to achieve the agency’s overall sustainability goals. Various alternatives and timelines were presented.

## **Army Climate Change Vulnerabilities Assessment**

CASI is providing the Army Climate Change Working Group support in understanding vulnerabilities of Army missions and assets to changing climates, and analyses for integrating changing environmental circumstances into Army planning processes. For 2013, CASI will be supporting two planning sessions that will address climate concerns at selected Army bases.

## **Net-Zero Partnerships**

The Army Installations research program has invested in a toolbox of analysis and modeling capabilities for net-zero installation analysis. Several preliminary applications of these capabilities is already underway at sites including Fort Carson, CO, West Point, NY, and Fort Leonard Wood, MO. Planning charrettes at these and other bases have been aimed at helping base staff to sort through complex net-zero decisions. CASI also supported Army workshops on Net-Zero Water (NZW) and Net-Zero Waste in 2012. Also, during 2012, sessions on planning for net-zero capabilities were held at professional meetings, such as the Federal Planning Division (FPD) and the American Planning Association (APA).

## **CASI Webinars**

In 2012, CASI supported two complementary webinar series, one partnered with the Corps of Engineers Environmental Community of Practice (ECoP), and the other with the Engineering and Construction Community of Practice (Sustainability and Energy Webinars).

The CASI HQUSACE ECoP series included six webinars. Sessions, which were open to all Corps team members, were held on Wednesdays and Thursdays from 12 noon – 1pm ET to facilitate knowledge sharing across and among the USACE CoPs. CASI researchers conducted presentations on the following topics:

- “Army Climate Change Assessment,” March 28
- “Options for Reducing USACE Greenhouse Gas Emissions and Energy Use,” April 4
- “Planning for Net-Zero Water,” April 18
- “Strategic Minerals and Metals,” May 17
- “Low Impact Development on Military Lands,” June 14
- “Green and Sustainable Remediation,” July 12.

ERDC-CERL organized a Tuesday/Thursday series of USACE-Wide “Sustainability and Energy” webinars of interest to the Corps of Engineers and Army Installation personnel who are involved in sustainable building design, construction, commissioning, renovation, and operation. The series was comprised of 30 different webinars and speakers. A sampling of the topics included:

- “Low Impact Development Fundamentals,” March 22
- “Life-Cycle Cost Analysis,” March 29 and May 1
- “Army Policy and ASHRAE 189.1,” April 5 and July 11
- “Energy Modeling 101,” June 12 and September 11
- “Rainwater Harvesting and Rain Gardens,” April 24 and July 24
- “Managing and Maintaining Building Envelopes,” March 27 and May 29



- “Waste Reduction,” May 22 and August 21
- “Solar Thermal System Design,” June 7 and September 6
- “Toward Net-Zero Building Design,” June 28
- “Measurement and Verification,” September 26.

## CASI Leadership



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# Anticipating Emerging Issues

**Leads:** William Goran, Michael Case and Natalie Myers, CERL.

**Description:** The purpose of this focus area is to engage stakeholders through forums, white papers, publications, and other means regarding emerging sustainability issues; to interpret how these emerging issues might impact military and national security activities and operations; and to initiate a dialog about potential courses of action to respond to these issues.

## Publications and Presentations

*Emerging Challenges and Opportunities in Building Information Modeling for the US Army Installation Management Command*, Beth A. Brucker, E. William East, Lance R. Marrano, Michael P. Case, William D. Goran, Allan Carroll, and Gus DeJesus, ERDC/CERL SR 12-8, July 2012, <http://acwc.sdp.sirsi.net/client/search/asset/1007740>

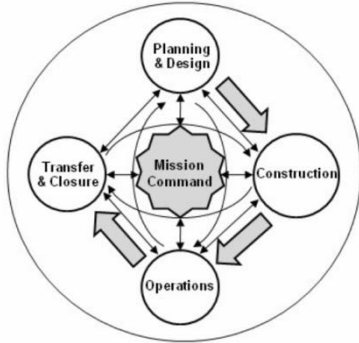
BIM (Building Information Model) is the process of generating and managing building data during the building's life cycle. New BIM standards for computable building information could serve as the foundation for automation and transformation of many current Installation Management Command (IMCOM) activities. As with any emerging technology, there is a question about when adoption of BIM across IMCOM makes the most economic sense. When is the right time for IMCOM to make initial planning and pilot investments? Due to the 50-75 year life expectancy of facilities and the potential to have as-is facility data at a moment's notice, the most significant share of benefits from BIM will accrue to facility owners and occupants. However, work is needed to examine, anticipate, and prepare for these benefits at military installations. The goal of this report was to help IMCOM determine an appropriate posture for adopt building information technologies. (Also see the "Sustainable Facilities and Infrastructure" section in this plan.)



*Technology Futures: IMCOM Futures, Water Conservation for Army Installations: An Evaluation of Technologies for Improving Water Security*, Elisabeth M. Jenicek, et al., ERDC/CERL Draft Technical Note, 2013.

Issues of water supply, demand, and quality are threatening water security for Army installations. A common definition of water security is the capacity of a population to ensure continued access to potable water. Installations share their water resources with surrounding regions and share responsibility for regional water security. Issues that threaten these supplies — population growth, extended drought, pollution, over-allocation of supply, climate change — could place military missions at risk through lack of this vital resource. (Also see the "Sustainable Water Resources" section.)

*Contingency Basing and the Problem of Sociocultural Context*, David A. Krooks, Lucy A. Whalley, and H. Garth Anderson, ERDC/CERL TN-12-2, July 2012, <http://acwc.sdp.sirsi.net/client/search/asset/1007741>



*The Contingency Base Life Cycle*

Over the past 10 years, the United States has established hundreds of contingency bases of all sizes in Iraq, Afghanistan, other allied nations in Southwest Asia, and other theaters where the United States has strategic interests. In large measure, DoD has, until recently, addressed the effects of contingency bases from the perspective of the physical environment alone. Nevertheless, the process of building, operating, and closing these bases can profoundly affect the local community. This report considers the range of impacts (economic, cultural, and social) that the life cycle of a contingency base has on the nearby community.

*Emerging Issues* lecture in a course entitled *Preserving Strategic Options for the Future: Sustainability Considerations for Strategic Leaders*, Army War College, Carlisle, PA, May 29, 2012.

This lecture focused on the emergence of adaptation science, the extent to which adaptation science borrows from military strategies, and the potential impacts of adaptation science on the military.

### **CASI White Papers**

CASI white papers represent one of the key contributions of the center. This ERDC-CERL funded series addresses at least one topic per year. These white papers are posted on the CASI website and usually become part of an associated briefing that is presented in multiple forums. For example, copies of the tradeoffs with renewable energy projects report, completed in 2010, were distributed to military attendees to the GovEnergy conference in 2010, and the report recommendations have been briefed in over a dozen different venues. The 2011 white paper, *Net-Zero Water for Army Installations, Considerations for Policy and Technology* (July 2011), has been used in ASA(IE&E) workshops relating to Net-Zero Water. The 2012 topic was "Contingency Bases and the Problem of Sociocultural Context." This white paper, completed in July 2012, examined the interactions and impacts of contingency bases on their host communities and regions, and considers pathways for sustainable approaches that help to build local capacity and enhance security. The 2013 topic "Considering System Impacts of Biofuel Production" will address biofuel production on Army lands and the risks and tradeoffs associated with this alternate land use.

### **Ongoing Projects**

Besides the 2012 CASI white paper on sociocultural impacts of contingency bases, two other CASI white paper efforts were initiated in 2012:

*Multiple Stressor Concept*, drafted by William Goran, Andrew Bruzewicz, Steven Hearne, Swarthy Veeravalli, and William Meyer.

This paper explores how multiple stressors can be integrated into ongoing disaster preparedness training and preparedness collaborations with our partner nations. With changing climates, there is an increased likelihood of natural disasters (storms, droughts, coastal inundations, heat waves) occurring more frequently and co-occurring with other stressors (earthquakes, corruption, illicit trafficking, migration, terrorist activities, etc.). The relatively low cost, small footprint approach involves

using scenario analysis capabilities within and supplemental to existing Defense programs (Defense Environmental International Cooperation [DEIC] and Civil Military Emergency Preparedness [CMEP]). These programs (and others) already reach many dozens of partner nations each year, but they do not necessarily make the linkage with other stressors or with climate vulnerabilities.

*USACE Systemic Sustainability Communications*, drafted by Chris Rewerts, Richard Detsch, William Goran, Paul Loechl, and Donna Schell.

This white paper is focused on the diverse and rapidly evolving virtual technologies for three primary purposes: (1) to reduce costs associated with face to face interactions across distances; (2) to reduce emissions associated with travel for meetings, workshops and projects; and (equally important) (3) to enhance the way in which we interact virtually, to better match virtual opportunities with communication strategies. The target of this effort, initially, is to develop and apply criteria that will enhance the use of a range of virtual communications technologies (webinars, emails, podcasts, social networks, virtual reality environments, websites, etc.) to advance the Corps of Engineers strategic sustainability plan. These criteria should also be relevant to the use of these tools by any organization – especially large organizations that are spread across diverse locations.

## **Proposed Projects**

### **Biomaterials Harvesting for Fuel**

Understanding thresholds of tolerance for biofuel production from military landscapes and neighboring communities. Many military bases are using (or considering the use of) biomaterials for fuel. While there are many opportunities to obtain fuel from biomaterials, these materials also play a critical role in ecosystem health — maintaining soil nutrients, water infiltration capacity, and important biotic communities. Bases that elect to use biomaterials for fuel should have a strong, scientifically based framework to understand harvesting capacities and degradation thresholds.

# Sustainability Approaches, Education and Knowledge Management

**Leads:** Michelle Hanson, Chris Rewerts, and David Krooks, CERL.

**Description:** This focus area concentrates on improvements in sustainability metrics and reporting, advancements in sustainability education and learning resources, and management and sharing of sustainability approaches and knowledge.

## Publications

*Sustainability Indicators for the Army Installation Management Command*, Chris Rewerts, et al., ERDC/CERL Technical Report TR-11-11, March 2011,  
[http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1005780](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1005780)

*USACE Inventory Management Plan*, Paul Loechl and Michael Kemme, 2011.

*Installation Strategic Planning Guidebook*, Kathleen Vann, David Della-Rovere, Paul Loechl, and Harold Balbach, ERDC/CERL Special Report SR-12-4, May 2012,  
[http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1010940](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1010940)

*Initial Integrated Strategic Sustainability Plan for Fort Leonard Wood*, Kevin Palmer, Sarah Nemeth, Annette Stumpf, and Susan Bevelheimer, ERDC/CERL Special Report SR-12-7, May 2012,  
[http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1008500](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1008500)

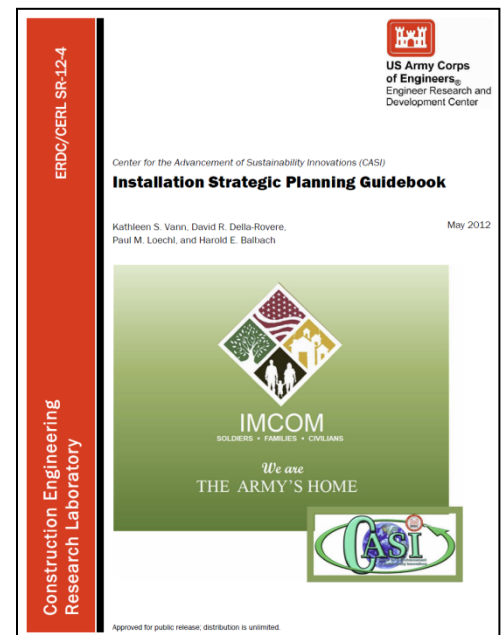
*Energy and Greenhouse Gas Emission Reduction Opportunities for Civil Works Projects Unique to the US Army Corps of Engineers*, Michael Kemme and David Underwood, ERDC/CERL TR-12-19, October 2012.

*Resource Efficiency in the US Army Corps of Engineers: Examination of Strategies To Reduce Energy Use and Greenhouse Gas Emissions*, Paul Loechl, Michael Kemme, Payal Shah, and William Goran, ERDC/CERL Technical Report TR-12-17, October 2012,  
[http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1011787](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1011787)

## Ongoing Projects

### Support for the US Army Corps of Engineers Strategic Sustainability Performance Plan (SSPP)

The objective of this work is to provide technical and operational support to HQUACE for updating the USACE SSPP for fiscal year 2013 (FY13), assistance in training USACE Division and District staff in Greenhouse Gas (GHG) and other data collection and reporting relevant to the plan, data analysis and visualization tool development, facility energy management guidance, criteria for submitting and evaluating GHG and energy and water reduction project submissions to the FY13 USACE budget process, sustainability behaviors training course development, and support for other sustainability initiatives relevant to achieving the objectives of the plan. CASI leads this USACE support team, which includes participants from





*Energy and Water Conservation Assessments: A Field Guide outlines common, practical energy-saving technologies available to federal facilities.*

several ERDC laboratories, USACE Environmental and Munitions Center of Expertise (EM-CX), Institute for Water Resources (IWR), Huntsville Engineering and Support Center (HESC), and other Corps organizations.

**Sponsor:** HQUSACE

**Point of Contact (POC):** Paul Loechl, CERL

### **Fort Leonard Wood Sustainability Initiative**

CASI has entered a fourth year of partnering with Fort Leonard Wood to develop, evaluate and accelerate the integration of sustainability into installation facilities, operations and activities. As part of its strategic sustainability vision, Fort Leonard Wood seeks to meet Army Net-Zero objectives. The purpose of the current CASI project is to collect and analyze baseline data for water and waste and to conduct energy modeling and analysis of metering data to develop

an integrated portfolio of appropriate, cost-effective strategies, approaches, and technologies to help Fort Leonard Wood implement its strategic vision. The information provided should help Fort Leonard Wood decision-makers compare and evaluate feasible options to identify its best long-term profile that will keep its resource use costs low and provide secure energy with a decreased impact on natural resources.

**Sponsor:** Fort Leonard Wood

**POCs:** Susan Bevelheimer and Annette Stumpf, CERL

### **Analysis of Army Sustainability Trends and Reporting**

The Army Strategy for the Environment (2004) established a sustainability vision for the Army. Since then, the Army has been taking numerous steps to make Army activities and operations more sustainable. In September 2008, the Army published its first annual Army Sustainability Report (ASR), providing an overview of the Army's sustainability posture using data from 2007 (ASR 2007). This was followed by ASR 2009 (published in May 2010 using data from 2008), by ASR 2010 (published in September 2011 using data from 2009), and ASR 2012 (published September 2012 using data from 2010 and 2011).

The *Army Sustainability Campaign Plan* (ASCP, May 2010), was developed in 2009-2010 to integrate sustainability across the Army enterprise. The ASCP identified strategic tasks to fully integrate sustainability into each Core Enterprise. In 2011-2012, implementation of many of the ASCP's strategic tasks was reflected in the Army's implementation of DoD SSPP and the Army Campaign Plan (ACP).

The purpose of this work is to analyze the Army's sustainability reports and submissions against the requirements of DoD SSPP, DEPARC, Sustainable Range Program, and other sustainability requirements to identify trends and gaps. This analysis will improve both the Army's future sustainability performance and its reporting on that performance.

**Sponsor:** DASA(IE&E)

**POC:** David Krooks

## **Products**

*CRAFT: Corps-Wide Green House Gas Accounting Web-Tool*, Richard Detsch, et al., 2011.

*Draft Army Fugitive Refrigerant Gas Emissions Tracking*, K. James Hay and Michael Kemme, 2012.

*Draft Greenhouse Gas Emission Inventory from Army Landfills*. Stephen Cosper and Giselle Rodriguez, 2012.

*Draft Greenhouse Gas Estimations from Army Commuting*, K. James Hay and Michael Kemme, 2012.

## **Proposed Projects**

### **Fugitive Refrigerant Gas Emissions for Air Quality Compliance and Greenhouse Gas Reporting**

Equipment on installations emits fugitive GHGs and ozone depleting substances subject to tracking and reporting under the Clean Air Act and Executive Order (EO) 13514. Most of the gases are fluorinated (F-gases) and are used in refrigeration equipment. Repair and re-charge of this equipment is handled by installation staff or through contracts. There is, however, no effective method to track and report the amount of refrigerant lost through leakage. A tracking and reporting method is needed to account for these fugitive emissions within existing data call procedures. This project will identify where information is lacking and how it may be obtained in the future. The project will develop standard wording to be included in future maintenance contracts to ensure that contractors track and report fugitive emissions to installation staff.

**Proposed to:** Assistant Chief of Staff for Installation Management (ACSIM)

**POCs:** K. James Hay and Michael Kemme, CERL

### **Landfill Air Emissions Inventory**

Under EO 13514, federal agencies must report a comprehensive inventory of absolute GHG emissions annually. Municipal solid waste landfills are one of the GHG emission source types that must be included in GHG inventories. The GHG Mandatory Reporting Rule will also require these facilities to determine the GHG emissions for on-site landfills. The objectives of this project are to develop data describing open and closed solid waste landfills, to calculate GHG emissions, and to document a process to facilitate annual reporting.

**Proposed to:** ACSIM

**POC:** Stephen Cosper, CERL

### **Data Sources for Estimating Army Commuting Greenhouse Gas Emissions**

EO 13514 requires the reporting of GHG emissions from commuting. The emission estimates are based on modes of transportation, distances traveled (by mode), number of trips (by mode), and the number of passengers (by mode). One method for obtaining this data is through commuter survey questionnaires that poll a statistically significant portion of a population. However, these surveys would be difficult and expensive for the Army to conduct because of the large number of responders and the data analysis requirements outlined in the *CASI 2012 Work Plan*. An alternative to commuting surveys is to use information that has already been gathered that may apply to Army civilian and military populations. These other data sources include the Army Stationing and Installation Plan, zip code level location information for commuters, regional and national transportation surveys, and US census data. This project will identify potential sources of data needed to make commuting GHG emission estimates and to determine their applicability to Army commuters and their behavior.

**Proposed to:** ACSIM

**POCs:** K. James Hay and Michael Kemme, CERL

# Sustainable Regional Planning

**Leads:** James Westervelt and Elisabeth Jenicek, CERL.

**Description:** The continued ability of a military installation to support current and future missions relies on the availability of regional built and natural resources. This focus area supports planning and stakeholder coordination at a regional or “shared resource” scale. Regions are defined as shared resources in a watershed, ecosystem, military operating area, air shed, transportation network, and economic impact area. Capabilities developed in this technology focus area are designed to enhance collaboration, improve stakeholder engagement and understanding, simulate potential future scenarios, and integrate diverse data into environments to enhance coordinated planning and decision-making.

## Publications

*Review of USACE Institutional Information Related to Evaluation of Incremental Changes in Water Resources Planning*, Larry Canter, Manroop Chawla, and Carl Thomas Swor, ERDC/CERL TR-11-3, March 2011, [http://www.cecet.army.mil/techreports/ERDC-CERL\\_TR-11-3/ERDC-CERL\\_TR-11-3.pdf](http://www.cecet.army.mil/techreports/ERDC-CERL_TR-11-3/ERDC-CERL_TR-11-3.pdf)



*Proctor Lake, TX, constructed by the Corps of Engineers to provide flood control, drinking water, and recreation*

## Products

### Anticipating Climate-Induced Ecosystem Shifts

As climate continues to change, local ecosystem support conditions will favor some species and disfavor others; in some cases, this will result in shifts to different ecosystems. Available PowerPoint-ready images show ecosystem shift potentials and forecast average monthly rainfall and temperature. This project analyzes climate conditions forecast through this century by general circulation models (GCMs) to identify potential ecosystem shifts on/near military installations. Results for each installation can be viewed at: <http://earth.cecet.army.mil/> (click on “Climate Change”).

## Ongoing Projects

### CONUS-Wide Regional Sustainability Analysis

The Sustainable Installations Regional Resource Assessment (SIRRA) web-based analysis tool provides a simplified national assessment of sustainability across 10 issues: (1) air quality, (2) air space, (3) energy, (4) urban development, (5) threatened and endangered species, (6) location, (7) water, (8) economy, (9) quality of life, and (10) infrastructure. The SIRRA methodology rates the regions surrounding 308 military installations in terms of vulnerability due to 48 individual sustainability indicators. The SIRRA tool uses existing science- and measurement-based national data sources. The data is then mapped into geographic information system (GIS) coverages for individual indicators coded as red, amber, or green. The database was recently updated and relocated to a more flexible web environment, available through: <http://datacenter.leadgroup.com/sirra/>

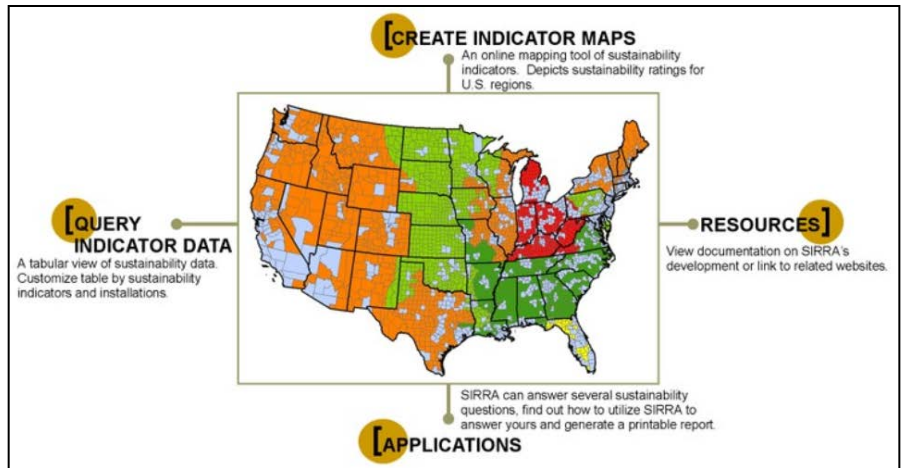


## Fort Riley Urban Encroachment Impact Analysis

This project is part of a multi-county effort to forecast the costs and benefits of proposed regional planning initiatives in the counties surrounding Fort Riley, KS. This effort will demonstrate the capabilities of a web portal that allows a community of planners to individually run regional growth and environmental impact scenarios and to then discuss and build on the results. The model is currently being used as part of a US Department of Housing and Urban Development (HUD) sustainability grant in the Fort Riley area. It is anticipated that this work will be integrated in the proposed metropolitan planning organization (MPO) and will be used directly inform Fort Riley's next Joint Land Use Study (JLUS).

**Sponsor:** Fort Riley, Army Small Business Innovation Research (SBIR) Program

**POCs:** James Westervelt, CERL, and Jeff Terstriep, LEAMgroup



*SIRRA maps visually communicate to the public, officials, and installation managers those areas in need of further study and attention to the management of local resources.*

## Army Chesapeake Bay Protection and Restoration

ACSIM prepared the Annual Army Chesapeake Bay Action plan to provide the framework for the Army to maintain its course in supporting the protection and restoration of the Chesapeake Bay and over time, to track progress toward achieving the goals, objectives, and targets of the Army Chesapeake Bay Strategy. In FY10, several projects were funded to provide inventory and baseline information for Army stakeholders in the Chesapeake Bay area to facilitate compliance with the Army Strategy. The projects included:

- developing a nutrient and sediment management plan template to include best management practices and guidance for establishing baseline conditions
- identifying and developing corrective actions for marina erosion and general pollutant runoff
- identifying, inventorying, and classifying Army shoreline along the Chesapeake Bay and major tributaries
- identifying historical and potential submerged aquatic vegetation
- assessing the impact of invasive species on the Chesapeake Bay watershed
- using indigenous plants to prevent erosion in the Chesapeake Bay watershed
- identifying installations with suitable habitat for oyster restoration.

A team leader from ERDC was assigned to each of the projects. The project leads were tasked with ensuring that the appropriate Army components were contacted for each activity and were also instructed to conduct site visits as necessary to help with data collection and assessments. The reports produced from this effort provide the baseline information and recommendations necessary to enhance ecosystem management activities critical for Bay restoration. Each Army installation and facility within the Chesapeake Bay watershed can use these reports to assess potential opportunities to help comply with the Army Chesapeake Bay Strategy.

**Sponsor:** ACSIM

**POC:** Patrick Deliman, EL

### **Alternative Futures at the Range Complex Level: Southwest United States**

This effort, being conducted by David Mouat and Judith Lancaster of the Desert Research Institute (DRI), and Scott Bassett with the University of Nevada, Reno, engages stakeholders from the communities surrounding selected southwestern bases and from the bases in a geospatial examination of the various development alternatives. Studies include the Las Vegas/Nellis Air Force Base region, the California/Arizona region around Yuma, and an area surrounding the town of Twentynine Palms, CA. The study also examines how the development alternatives are likely to impact biodiversity and hydrology in those regions.

**Sponsor:** Office of the Secretary of Defense (OSD) Sustainable Ranges Program

**POC:** James Westervelt, CERL

### **White Sands Missile Range Maneuver Area Comparison Tool**

As the installation increases its support of maneuver activities, the natural resource office wants to ensure optimal short and long-term activity support. This project is analyzing a wealth of installation GIS maps and imagery to create a tool that will help select the best areas for each activity event.

**Sponsor:** White Sands Missile Range

**POC:** Natalie Myers, CERL

## **Proposed Projects**

### **Desert Ecosystems Training Impact Analysis Tool**

This project will establish and test the Army Mission Environmental Assessment for Deserts (AMEA-D) at White Sands Missile Range (WSMR). This installation is particularly important in that it is possible to characterize the installation in its nearly native state in a very short time. AMEA-D consists of: (1) A regular analysis of the health and resiliency of maneuver areas through the analysis of readily available satellite imagery, and (2) a fusion of those analyses with relevant installation maps within the technology that supports Army Mapper. This decision support tool will allow trainers and natural resource managers to track the health, sustainability, and resiliency of ranges to support tracked vehicle maneuvers.

**Proposed to:** The Legacy Program

**POC:** Natalie Myers, CERL

### **Regional Influences on Military Installations: Scenarios for Change to 2040**

For a select region in the United States, this project will address these three questions:

- What might the region look like in 2020, 2030, and 2040 (considering social, technology, land patterns, transportation, communication, climate, and demand on natural resources, agriculture, and economy)?
- What regional installation opportunities will be gained and lost? How well will installations within the region continue to meet their mission?
- What recommendations might improve the ability of the installations to address mission requirements?

**Proposed to:** ASA(IE&E)

**POC:** James Westervelt, CERL

### **Army Compatible Use Buffer Initiatives**

Several proposals are in place, including taxonomy of encroachment effects, encroachment correlation with population density, Army Compatible Use Buffer (ACUB) cost-benefit analysis approaches, and the Readiness and Environmental Protection Initiative (REPI) scoring process. These projects are proposed to increase the effectiveness of the ACUB program and the funding available to it.

**Proposed to:** DAIM-ISE

**POC:** James Westervelt, CERL

### **Southeast Asia Urban Growth**

As Southeast Asia continues to develop and prosper, its cities continue to grow. The US Agency for International Development (USAID) seeks to track the rate and type of growth over time to help identify stresses that USAID can address. In particular, the ability to forecast urban growth over the next 5-10 years will assist in the execution of more effective planning

**Proposed to:** USAID

**POC:** James Westervelt, CERL

### **Recognizing Regional Stability in the Growth Patterns of Megacities**

The Megacity Reconnaissance, Surveillance, and Intelligence (M-RSI) Project will explore novel community- and city-level remote sensing techniques that allow more accurate sociocultural analyses of areas that affect and are affected by rapid urbanization. M-RSI will also explore new methods to understand the changes in population composition in rapidly urbanizing areas. These methods will improve sociocultural analysis at the community- and city-level using remotely sensed information.

**Proposed to:** The Joint Staff

**POC:** Charles Ehlschlaeger, CERL

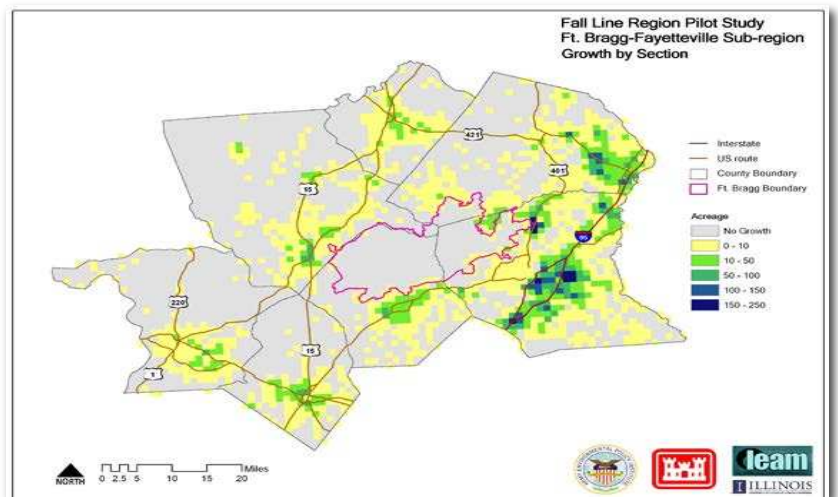
### **Forecasting Urban Growth around Installations: Supporting Regional Impacts on Military Installations**

The objective of this proposal is to create a modeling tool with a web-based interface that will allow regional planners to:

- graphically identify an area of interest around any Continental United States (CONUS) installation or range complex
- review and modify forecast population projections
- add/subtract soldiers and families
- run an urban growth forecast based on these inputs
- review and share results in the form of maps, movies, text, graphs, and charts.

**Proposed to:** IMCOM

**POC:** James Westervelt, CERL



# Sustainable Energy Solutions

**Lead:** Franklin Holcomb, CERL.

**Description:** From a military capability systems support perspective, power and energy are critical to sustainability. They are a consideration in many facets of military operations. The purpose of this technology focus area is to identify the sustainability needs associated with integration of power and energy into military missions.

## Products

*Design Guides for Military Buildings to Meet EPA 2005 Energy Reduction Requirements*, Alexander Zhivov, available on Whole Building Design Guide website, [http://www.wbdg.org/references/pa\\_dod\\_energy.php](http://www.wbdg.org/references/pa_dod_energy.php)

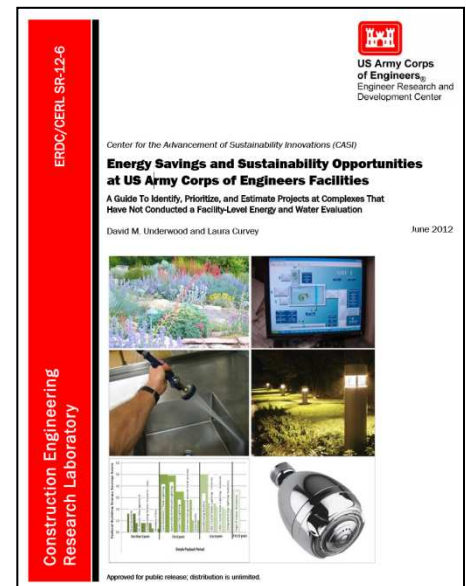
*Energy Savings and Sustainability Opportunities at US Army Corps of Engineers Facilities*, David Underwood and Laura Curvey, ERDC/CERL SR-12-6, June 2012, <http://acwc.sdp.sirsi.net/client/search/asset/1007412>

*Energy and Water Conservation Design Requirements for Sustainment, Restoration and Modernization (SRM) and MILCON Construction Projects*, Alexander Zhivov, [http://www.wbdg.org/references/pa\\_dod\\_energy.php](http://www.wbdg.org/references/pa_dod_energy.php)

*Best Practice Guidelines for Using Energy Performance Contracts To Improve Government Buildings*, Alexander Zhivov, [http://www.annex46.org/preliminary\\_results/](http://www.annex46.org/preliminary_results/)

*Energy and Process Assessment Protocol*, Alexander Zhivov, read-only version: [http://www.annex46.org/preliminary\\_results/](http://www.annex46.org/preliminary_results/)  
print version available for purchase from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) at: [http://www.techstreet.com/cgi-bin/detail?product\\_id=1703577](http://www.techstreet.com/cgi-bin/detail?product_id=1703577)

*Annex 46 Case Studies*, Alexander Zhivov, [http://www.annex46.org/preliminary\\_results/](http://www.annex46.org/preliminary_results/)



## Publications

*Early Design Energy Analysis Using Building Information Modeling Technology*, Annette L. Stumpf, et al., Technical Report ERDC/CERL TR-11-41, November 2011, [http://www.cecer.army.mil/techreports/ERDC-CERL\\_TR-11-41/ERDC-CERL\\_TR-11-41.pdf](http://www.cecer.army.mil/techreports/ERDC-CERL_TR-11-41/ERDC-CERL_TR-11-41.pdf)

*Renewable Energy Systems Demonstration Project at the "22 Bunkers Complex," Kabul, Afghanistan*, John Vavrin, et al., Technical Report ERDC/CERL TR-11-4, December 7, 2011.

*Electro Decomposition of Ammonia into Hydrogen for Fuel Cell Use*, Gerardine G. Botte and Carl A. Feickert, Technical Report ERDC/CERL TR-12-1, January 2012, [http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1006361](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1006361)

*Operational Energy Base Camp Studies: Literature Review of Findings and Recommendations*, William T. Brown, et al., Technical Report ERDC/CERL TR-12-2, February 2012, <https://www.us.army.mil/suite/doc/36350121>

*Energy Supply Options for Fort Carson Combat Aviation Brigade*, Alexander M. Zhivov, et al., Technical Report ERDC/CERL TR-12-12, August 2012.



*ERDC/CERL TR-12-2 reviews technologies and practices that save energy and reduce the logistical burden of operating FOBs.*

## Ongoing Projects

### Net-Zero Installations Technical Support

The Army's vision is to appropriately manage natural resources with a goal of Net-Zero Installations. Today the Army faces significant threats to energy and water supply requirements both at home and abroad. Addressing energy security and sustainability is operationally necessary, financially prudent, and mission essential. The goal is to manage installations not only on the basis of Net-Zero Energy (NZE), but of Net-Zero Water and Net-Zero Waste as well. CERL personnel are providing technical assistance to the Net-Zero Pilot Installations to help them achieve their goals of NZE, Net-Zero Water, Net-Zero Waste, individually and in combination.

**Sponsor:** Deputy Assistance Secretary of the Army for Energy and Sustainability (DASA[E&S])

**POCs:** Alexander Zhivov (Energy), Elisabeth Jenicek (Water), and Stephen Cosper (Waste), CERL

### Technical Management for JCTD SPIDERS

CERL researchers are providing technical management of the FY11-13 Joint Capability Technology Demonstration (JCTD) Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) Program. The 3-year JCTD SPIDERS program will deploy microgrid technology to Joint Base Pearl-Hickam, HI, Fort Carson, CO, and Camp Smith, HI. The deployed microgrids will ensure critical missions have a reliable and secure electric power supply. The project will address the advanced controls needed for utility-connected and islanded modes of operation, cyber security risk mitigation, and transition of microgrid technology to standards.

**Sponsors:** Multiple – Joint OSD, Services

**POCs:** Harold Sanborn, Melanie Johnson, and Tarek Abdallah, CERL

*Note that the following ongoing efforts have CASI applications, but were managed by ASAALT and funded as Research, Development, Test and Evaluation (RDT&E) projects.*

### Modeling and Mitigation of Energy Losses in Building Envelopes

CERL is developing the capability to characterize energy losses through building envelopes and potential mitigation strategies using advanced materials to meet mandated energy reduction goals. This project will provide improved models and algorithms—incorporating advanced materials—to mitigate energy losses in facilities designed to meet mandated Energy Independence and Security Act (EISA07) energy efficiency requirements. This research is addressing the need to predict long-term performance of advanced materials for building envelopes based on degradation mechanisms such as moisture absorption, diffusion of oxygen, and chemical reactions. The development of new capabilities to analyze, design,

and construct more energy-efficient buildings is expected to result in applications for retrofit of existing facilities.

**Sponsor:** ASAALT

**POC:** Richard Liesen, CERL

### **High-Performance Building Operations**

CERL is developing an intelligent framework that describes interrelationships and synergies among energy efficiency, component maintenance and renewal, and mission requirements for an integrated investment strategy that minimizes Total Cost of Ownership. The results of this research will be: (1) SRM decision models that maximize effectiveness of facility retrofits, specifically for energy performance, (2) information fusion models to identify energy costs attributable to improper occupancy behavior, operations and component degradation, and (3) performance benchmarking algorithms to identify facility energy use exceptions.

**Sponsor:** ASAALT

**POC:** Lance Marrano, CERL

### **Elimination of Mold and Reduction of Energy Consumption in Army Barracks Using Improved HVAC Systems**

This research seeks to provide the Army with a validated, standard renovation concept for eliminating mold problems and significantly reducing energy consumption in existing Army barracks using innovative heating, ventilating, and air-conditioning (HVAC) and building envelope technologies. HQIMCOM has an ongoing renovation program at Fort Polk, LA, to eliminate mold and improve the energy performance of 31 Volunteer Army barracks. Accordingly, this CERL project will provide the Army with information from the ongoing Fort Polk mold elimination project to ensure that solutions implemented at Fort Polk can be adapted to other Army barracks and facilities.

**Sponsor:** ACSIM Installation Technology Transition Program (ITTP)

**POC:** Dale Herron, CERL

### **Building-Scale Direct Current (DC) Power System with Renewable Energy Integration**

A research team will install and demonstrate a DC power system with solar panel integration for a single control room at Fort Huachuca, AZ. Research will address the economic feasibility of DC power systems at Army installations. It will also monitor energy efficiency, energy security, and power quality improvements associated with the DC power system. Based on the findings in the project analysis, recommendations will be made for new construction and retrofitting of Army buildings with DC power systems. These systems can be implemented in any building with substantial DC loads, which makes the project results broadly applicable to Army installations.

**Sponsor:** ACSIM ITTP

**POC:** Melanie Johnson, CERL

### **Integration of Energy/ Sustainable Practices into Standard Designs**

Broad targets of this research aim to help the Army become NZE ready. The technical objective is to investigate building features and construction methods and materials to optimize the selected standard designs with regard to energy reduction and sustainability and, at a minimum, to ensure that the selected standard designs meet all applicable energy reduction and sustainable design policies (e.g., Leadership in Energy and Environmental Design (LEED) Silver, Energy Policy Act [EPA] 2005, EISA07, EO 13423 and EO 13514).

**Sponsor:** USACE

**POC:** Alexander Zhivov, CERL

### **Systems Approach to Improved Facility Energy Performance**

This project will integrate three synergistic building technologies into an enhanced barracks system design. An innovative dedicated outdoor air system that incorporates energy recov-

ery from the building's exhaust air stream will be combined with improved building envelope air and moisture barriers to ensure that humidity levels within the building are adequately controlled. A radiant cooling/heating system will be included to maintain temperatures within the occupant rooms. Successful integration of these technologies is expected to result in improved building energy efficiency, reduced risk of mold and mildew, and reduced maintenance requirements without sacrificing occupant comfort.

**Sponsor:** DoD Environmental Security Technology Certification Program (ESTCP)

**POC:** James Miller, CERL

#### **Exhaust Hood and Makeup Air Optimization**

Exhaust hoods and makeup air units are often poorly designed and controlled. It is common for them to operate at constant flow rates for long periods of time, sometimes up to 24 hours per day. This large energy waste (up to 80% of energy used can be saved) results in uncomfortable working conditions in buildings such as dining facilities. Four buildings will be selected and retrofitted for optimization of exhaust hoods and associated makeup air flow rates. This work will be accomplished primarily through installation of temperature and opacity sensors connected to controllers and variable speed motor drives.

**Sponsor:** ESTCP

**POC:** David Underwood, CERL

#### **Converting Constant Volume, Multizone (MZ) Air Handling Systems to Energy-Efficient Variable Air Volume Multizone Systems**

This project will demonstrate a low-cost technique to convert a constant volume MZ air handling unit (AHU) to an energy-efficient variable air volume MZ AHU. This technique converts the MZ system into a variable volume MZ system by focusing almost entirely on instrumentation and controls rather than the demolition and installation of ductwork and terminal units, and is thus accomplished for a lower first cost, with less system down time and with less disturbance of building occupants. This includes upgrading the system controls via programming changes or controller replacement and the installation of new and replacement actuators and sensors needed to support the conversion and to monitor and control the system.

**Sponsor:** ESTCP

**POC:** David Schwenk, CERL

#### **Field Validation of Microencapsulated Phase Change Material Slurry as Heat Transfer Fluid**

This project will demonstrate microencapsulated phase change material heat transfer formulations in a ground sourced heat pump system located at Fort Hood, TX. The proposed heat transfer fluid could reduce or save pumping energy by as much as 50%. Also, implementation and use of the fluid should provide a 5-year payback, depending on the level of use of the proposed product.

**Sponsor:** ESTCP

**POC:** Sean Morefield, CERL

#### **Energy-Efficient Phase Change Materials (PCM) Insulation**

This project will demonstrate and implement blown-in insulation, which incorporates PCM, to enhance the effective "R-value" of insulation, thus reducing energy transfer through walls while maintaining comfortable temperatures for building occupants. The cost savings due to the use of these insulating materials will be quantified and life-cycle costs will be compared to the current costs. Updates will be developed for applicable Unified Facilities Guide Specifications for use of the PCM-insulation to transfer the technology to other suitable locations.

**Sponsor:** ESTCP

**POC:** David Stephenson, CERL

### **Advanced, Energy-Efficient Shelter Systems (AEESS) for Contingency Basing and Other Applications**

AEESS is a joint Army/Air Force program to address energy inefficiencies associated with shelter systems, particularly tents. It will develop and demonstrate technologies for a new generation of energy-efficient shelters.

**Sponsor:** Office of the Assistant Secretary of Defense (ASD), Operational Energy Capabilities Improvement Fund (OECIF)

**POC:** Ashok Kumar, CERL

Note that the following research efforts have CASI applications, but were managed by ASAALT and funded as RDT&E projects.

### **Lightweight Systems for Improving Building Envelope Efficiency of Standard Semi-Permanent Theater Structures**

The goal of this project is to evaluate a number of lightweight thermal liners and wraps that can be adapted to B-Hut construction or retrofit. Wraps will increase the air-tightness of the building envelope while liners can greatly increase the thermal efficiency. This effort will evaluate a number of commercially available wraps and liners to include modified liners developed for military tents. Those selected for field testing will be evaluated at the Contingency Basing Integration Technology Evaluation Center (CBITEC) at Fort Leonard Wood, MO.

**Sponsor:** ASAALT

**POC:** Kurt Kinnevan, CERL

### **Indigenous Materials for Military Facility Construction**

Standard military facility construction materials are expensive to transport and can be inappropriate for the regional climate. Since up to 50% of a base camp's power demand comes from building heating and cooling, identifying building methods and materials that improve energy efficiency can greatly reduce overall power demand. Locally available or indigenous construction materials can fill this need, and can also reduce the logistical footprint of the base, thereby reducing the risk to convoy personnel who transport these materials. The use of indigenous materials can offer long-term cost benefits, and can also foster an increase in regional economic, social, and environmental autonomy. This study develops adaptable criteria for an austere military design based on locally available or indigenous construction materials and techniques suited to the environment and climate conditions.

**Sponsor:** HQUSACE

**POC:** Garth Anderson, CERL

### **Energy Monitoring Power Metering and Monitoring System for Contingency Base Energy Management**

The goal of this project is to evaluate commercially available power metering and monitoring systems (not currently used by the military) for suitability to adapt and apply to a contingency environment. This project will evaluate both hardware and software solutions. A candidate system will be selected for field testing and evaluation at the CBITEC at Fort Leonard Wood, MO. The facility replicates a theater contingency base including a company-size set of B-Huts, latrines, showers, and power generation and will have the basic infrastructure to allow full metering and monitoring. In addition, the project will evaluate the system under actual training or mission use by Soldiers during both winter and summer conditions.

**Sponsor:** ASAALT

**POC:** CPT Charles Decker, CERL

### **SmartBED Architecture and Testbed**

This is a collaborative project between the (lead) Army Research Laboratory and (partner) CERL. The project will produce a laboratory based capability to investigate emerging com-



ponents for performance in grid environments, to include the following features: (1) local grid connectivity (multiple ac distribution); (2) multiple generation/ power sources/ energy storage units at various sizes (60kW and lower); (3) renewable sources integration/ emulation; (4) networked distribution with relays for automated reconfiguration; (5) representative programmable loads; and (6) Instrumentation, software, Hardware In the Loop (HWIL) Modeling and Simulation (M&S) for intelligent power management.

**Sponsor:** ASAALT

**POCs:** Bruce Geil, US Army Research Laboratory (ARL), and Melanie Johnson, CERL

### **Scalable Solid State Transformer (SSST)**

This is a collaborative project between the (lead) ARL and (partner) CERL. The objective of this project is to design and produce a prototype SSST for tactical, operational, and military bases that will serve contingency operations, disaster relief, and homeland security. Transformers currently in use are limited in that they are designed to operate a single input voltage, requiring large numbers of varying size, have little or no intelligence, and are logistically difficult to handle due to bulk and weight. The goal of the SSST is to create the capability to support multiple input voltages from 480V to 13.8 kV through the use of interconnected modules. The use of electronic switches for voltage transformations also provides for power scaling and intelligent operation and monitoring.

**Sponsor:** ASAALT

**POCs:** Bruce Geil, ARL, and Melanie Johnson, CERL

### **ROOFER Energy Performance Assessment and Course of Action (COA) Analyses**

The objective of this proposed project is to demonstrate COA analysis methods and techniques that employ the ROOFER Sustainment Management System (SMS) and its information database to enable facility managers to evaluate energy-saving options as part of developing roof repair and replacement projects. Full implementations of an enhanced version of ROOFER will be performed at selected DoD installations to demonstrate the utility and benefits of integrating these options into their roof asset management program.

**Sponsor:** ESTCP

**POC:** David Bailey, CERL

### **High Efficiency Dehumidification System**

Many DoD facilities are located in humid areas that are prone to mold growth problems resulting from the installed HVAC designs that are incapable of maintaining proper humidity control. The objective of this proposed project is to demonstrate a HVAC system based on a High Efficiency Dehumidification System (HEDS)/Cooling Recovery Coil (CRC) design. The HEDS system can reduce peak energy consumption by up to 33%, while reducing humidity and mold problems.

**Sponsor:** ESTCP

**POC:** Dahtzen Chu, CERL

## **Proposed Projects**

### **Performance Optimization of HVAC Systems**

The objective of this proposed project is to implement and demonstrate a Load Based Optimization System (LOBOS) in conjunction with an existing building automation system that will offer the potential for 30-50% energy efficiency gains in desert and hot/humid climates, automated demand response capability, and continuous commissioning capability.

**Proposed to:** ESTCP

**POC:** Dahtzen Chu, CERL

# Sustainable Water & Waste Resources

**Leads:** Elisabeth Jenicek, Laura Curvey, Richard Scholze, Stephen Cospers, Giselle Rodriguez, and Annette Stumpf, CERL; Kathleen White, IWR; and Dr. Victor Medina, EL.

**Description:** This focus area relates to the access to, and sustainable use of water resources, and to the management of Army relevant waste materials. Activities include evaluating water resources status (quantities and qualities); and developing conservation approaches and technologies, water reuse technologies and approaches, and other capabilities to improve and enhance the availability and quality of water as a sustainable resource. Activities also include developing new technologies for managing Army relevant waste materials and providing technical assistance to individual installations and the ASA(IE&E) Net-Zero program.

## Publications

*Implementing a Water Conservation Program at Army Installations*, Richard J. Scholze, Public Works Technical Bulletin (PWTB) 200-1-104, available through the Whole Building Design Guide website, September 30, 2011, [http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb\\_200\\_1\\_104.pdf](http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_104.pdf)

This PWTB describes how to implement a water conservation program and provide procedures to accomplish supporting tasks such as conducting an installation water audit or implementing a water loss prevention program.

*Water- Efficient Installations*, Richard J. Scholze, PWTB 200-1-105, available through the Whole Building Design Guide website, September 30, 2011, [http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb\\_200\\_1\\_105.pdf](http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_105.pdf)

This PWTB describes methods and technology to support water conservation and water efficiency, gives a brief review of regulatory and other drivers, and describes lessons learned from installations. This guidance will enable installations to determine the potential for water conservation at their facilities as part of a sustainable water program and will identify a variety of opportunities.



*Bulk water card reader at Camp Atterbury, IN*

*Graywater at Army Installations*, Richard J. Scholze, PWTB 200-1-101, available through the Whole Building Design Guide website, September 30, 2011, [http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb\\_200\\_1\\_101.pdf](http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf)

This PWTB transmits general information on the topic of graywater application at US Army installations. This PWTB will enable installation personnel to determine the potential to recycle graywater or to institute graywater applications at their facilities as part of a sustainable water program.

“Planning for Energy and Water Savings – Together,” *Public Works Digest*, Elisabeth Jenicek, May/June 2012,  
[http://www.imcom.army.mil/Portals/0/hq/about/publications/pwd\\_digest/PWDMay-Jun%2012WEB.pdf#page=6](http://www.imcom.army.mil/Portals/0/hq/about/publications/pwd_digest/PWDMay-Jun%2012WEB.pdf#page=6)

This article describes the many linkages between water and energy and suggests ways that installation staff can make best use of limited manpower by planning for energy and water savings together.

*Integrated Water Planning for Army Training Areas*, Elisabeth Jenicek, Laura Curvey, Ira Mabel, Amy Vickers, Rachel Phillips, and Gonzalo Perez. Technical Report ERDC/CERL TR-12-15, October 2012.

Many Army installations within the United States are located within watersheds that are highly vulnerable to water crisis situations. Army testing and training ranges are at particular risk to issues of water scarcity. Commercially available water conservation technologies can be implemented to realize water savings at those ranges on both the supply and demand side. This work was undertaken to demonstrate and validate the retrofit of existing facilities with technologies that support reduced potable water consumption through conservation, by performing an on-site assessment of the water use efficiencies of plumbing fixtures at training sites and water systems at the Camp Atterbury Joint Maneuver Training Center (CAJMTC), IN.

Draft “Case Studies of Scenario Analysis for Adaptive Management of Natural Resource and Infrastructure Systems,” Hamilton, Thekdi, Jenicek, Harmon, Goodsite, Case, Karvetski, and Lambert, *Special Issue of Environment, Systems, and Decisions on Scenario Analysis*, expected publication February 2013.

Scenario analysis is essential in sustainable management of water resources and other infrastructure systems. In a context of systems engineering, scenario analysis can provide an integrated and timely understanding of emergent conditions and can help to avoid regret and belated action. This paper addresses scenario analysis for several resource and infrastructure systems, including: (1) water resources (2) land use corridors, (3) energy infrastructure, and (4) coastal climate change adaptation. Scenario analysis and systems analytics must be integrated with social science expertise in a decision support context to facilitate a participatory approach. Scenario analysis helps illuminate relative merits of alternative strategies for long-term sustainability of natural resource and infrastructure systems.

*Considerations for Net-Zero Water Installations*, Elisabeth Jenicek, et al, expected publication March 2013.

This report documents the first year of effort under the RDT&E project “Integrated Installation Energy, Water, and Waste Modeling.” Previous modeling efforts were reviewed as a means to selecting/developing the models to be used to support modeling for energy, water, and waste. The scale of models reviewed includes installation/city scale, regional scale, and watershed scale. Additional reviews were conducted to document the range of water conservation/efficiency measures that could be used to achieve Net-Zero. Several of the selected models were applied to the Fort Carson region, using a set of identified measures and associated assumptions, to demonstrate and document their effectiveness for this project.

## Events

*Water Smart Innovations*, 4-October 7, 2011, Las Vegas, NV, “The US Army and Graywater – Current Status,” Richard J. Scholze.

*GreenGov Conference*, October 31, 2011, Washington, DC, “Planning for Sustainable Water Supplies for Army Installations,” Elisabeth Jenicek.

*American Water Resources Association, National Conference*, November 10, 2011, Albuquerque, NM, “Net-Zero Water for U.S. Army Installations,” Elisabeth Jenicek.

*Army Net-Zero Installations Conference*, January 2012, Chicago, “Net-Zero Research Initiative and Water Demonstration Project Findings,” Elisabeth Jenicek; “Water Related Decision Support Modeling at Fort Carson,” Laura Curvey; “Regional Water Balance Modeling at Fort Carson,” Mike Follum, and “Water Reuse to Support Net-Zero Water for Installations” (Richard J. Scholze). “Net-Zero Food Waste,” Stephen Cosper and Dick Gebhart; “Waste to Energy Infrastructure Concerns,” Stephen Cosper.

*USACE Environmental Community of Practice Webinar Series*, April 18, 2012, “Planning for Net-Zero Water,” Elisabeth Jenicek and Laura Curvey.

*Environment, Energy, and Sustainability Symposium*, May 21-24, 2012, New Orleans, LA “Irrigation Alternatives to Meet Army Net-Zero Water Goals” Richard J. Scholze, H. Garth Anderson, and Dick L. Gebhart.

*American Water Works Association (AWWA) National Conference*, June 2012, Dallas, TX, “Net-Zero Water Modeling Program and the Army,” Richard J. Scholze et al.

“Net-Zero Water Modeling Program and the Army,” Richard J. Scholze, Michael P. Case, Laura Curvey, Clint Wilson, and Mark D. Ginsberg, *American Water Works Association National Conference*, June 11-14, 2012, Dallas, TX.

*WaterReuse National Conference*, September 9-12, 2012, Hollywood, FL, “Water Reuse for US Army Contingency Bases,” Richard J. Scholze and H. Garth Anderson.

“Water Reuse for US Army Contingency Bases,” Richard J. Scholze and H. Garth Anderson, *WaterReuse National Conference*, September 9-12, 2012, paper in proceedings, Hollywood, FL

*Water Smart Innovations*, October 3-5, 2012, Las Vegas, NV, “Water Conservation at a National Guard Training Base: Camp Atterbury, IN,” Elisabeth Jenicek.

*American Water Resources Association (AWRA) National Conference*, November 14, 2012, Jacksonville, “Water Efficiency Demonstrations at Army Installations,” Elisabeth Jenicek.

## Ongoing Projects

### **Integrated Installation Energy, Water, and Waste Modeling**

This RDT&E project is in the second of 4 years. The first year reviewed and demonstrated existing water models on several scales: technology, installation, region, and watershed. Life-cycle costing factors were developed for a suite of water conservation and efficiency measures. Subsequent years will integrate the water data and tools into the existing Net-Zero Installation Tool. This model integrates energy, water, and waste resources to develop optimized solutions for net-zero Army installations.

**Sponsor:** USACE RDT&E

**POC:** PM-Michael Case; NZW lead-Elisabeth Jenicek, CERL

### **Integrated Water Planning through Building Level Cascade of Water Use**

This project, in its second year, is demonstrating the retrofit of existing facilities with technologies that reduce potable water consumption through conservation and building graywater reuse. Conservation measures apply to sinks, showers, and toilets. Graywater reuse systems will range from 200 to 5000 gal/day. The demonstration will retrofit technologies at a Remote Unit Bivouac Area (RUBA) and an Army Fitness Center at Fort Irwin, CA.

**Sponsor:** James Galvin, ESTCP

**POC:** Elisabeth Jenicek, CERL

### **Water Conservation for Training Areas**

This project demonstrated and validated water conservation strategies at a training area at Camp Atterbury, IN. Technologies that encourage water conservation in training include automated bulk water dispensing facilities, composting toilets, and efficient fixtures. Water consumption was monitored both prior to and after the retrofits to document savings. Concurrent to the technology retrofits, a water awareness education program was carried out. Data collection will continue through January 2013. The results of this demonstration will be used to inform water efficiency programs at other Army training bases.

**Sponsor:** ACSIM ITTP

**POC:** Elisabeth Jenicek, CERL

### **Demonstration of a Modular Wetland Treatment System for Parking Lot and Motor Pool Runoff**

This project is evaluating off-the-shelf “modular wetland” technologies for storm water runoff treatment under military unique conditions.

**Sponsor:** ACSIM ITTP

**POC:** Heidi Howard, CERL

### **Greenwall Demonstration for Energy Conservation**

This project demonstrated and validated “off-the-shelf” greenwall technology at Fort Hood.

**Sponsor:** ACSIM ITTP

**POC:** Heidi Howard, CERL

### **Smart Water Conservation Systems for Irrigated Landscapes**

The Naval Facilities Engineering Service Center (NFESC) is the lead on this 2010 ESTCP project. Rainwater collection and smart irrigation controls are being demonstrated at one Navy site (NFESC, Port Hueneme, CA), and one Army site (Fort Hood, TX).

**Sponsor:** James Galvin, ESTCP

**POCs:** Elisabeth Jenicek and Annette Stumpf, CERL

### **Water Sustainability Studies at Four Net-Zero Water Installations**

This project is applying the methodology developed in the Army Installation Water Sustainability Assessment to four additional Net-Zero Water Installations: Aberdeen Proving Grounds, MD; Fort Buchanan, PR; Camp Rilea, OR; and Tobyhanna Army Depot, PA. The study will project and evaluate the sustainability of water supply and demand over a 30-year time period.

**Sponsor:** ASA(IE&E)

**POC:** Marc Kodak, ASA(IE&E)

### **Water Planning Project Tracking Tool**

This project will provide a reference database by which both resident units and operators can capture the efficiency standards and conservation measures already in place. Additionally, it will maintain an accurate demand profile of Army installations as they progress toward Net-Zero Water.

**Sponsor:** ASA(IE&E)

**POC:** Marc Kodak, ASA(IE&E)

### **Methane Recovery Evaluation of Army Wastewater Treatment Plants (WWTPs)**

This project will assess methane recovery potential at Army Wastewater Treatment Plants to quantify their methane gas generation rates; evaluate those rates against current methane gas recovery technologies, and complete a preliminary analysis to determine the WWTPs that have the potential and cost to install and operate a recovery system vs. existing local utility rates.

**Sponsor:** Wanda Johnsen, DASA(IE&E)

**POC:** Richard Scholze, CERL

### **Rotary Gasification of Solid Wastes for Base Camps**

This project will develop a deployable waste to energy system that will provide mixed waste disposal and a gaseous fuel to power a standard diesel generator.

**Sponsor:** Strategic Environmental Research and Development Program (SERDP)

**POC:** Stephen Cospers, CERL

### **Fort Polk Compost Plan**

This project will develop a plan to process all organic wastes generated at Fort Polk into a valuable soil amendment to be applied to training lands.

**Sponsor:** Fort Polk Directorate of Public Works (DPW)

**POC:** Dr. Victor Medina, EL

### **Net-Zero Compost Technologies**

This project will review compost technologies that would be applicable to the eight Net-Zero Waste installations. It will study material compatibility, throughput, cost, equipment, and labor requirements for each approach.

**Sponsor:** Ms. Wanda Johnsen, ASA(IE&E)

**POC:** Stephen Cospers, CERL

### **Evaluation of Plasma Waste to Energy Systems**

This joint project between CERL and ARL will evaluate the state of the art for plasma waste gasification systems. Researchers will evaluate the Technology Readiness Level (TRL) status of the system under development in comparison with commercially available technologies.

**Sponsor:** ASAALT

**POC:** Benjamin Masters, CERL

### **Anaerobic Digestion for Base Camp Organic Wastes**

This project will perform laboratory and pilot scale testing of co-digestion of food and latrine wastes to determine the feasibility and methane output of the process.

**Sponsor:** Leonard Wood Institute

**POC:** Dr. Victor Medina, EL

### **Efficient Water Reuse Technology for Contingency Operating Bases**

This project will integrate new water filtration materials/systems to produce a more robust and operationally-efficient graywater reuse module for Army contingency operating bases (COBs) with 600-1000 personnel (~ 22,000 gallons per day [GPD]).

**Sponsor:** ASAALT

**POC:** PM-Martin Page, CERL

## **Proposed Projects**

### **Satellite Reclamation of Wastewater**

This project will demonstrate the use of wastewater scalped from a sewer system and treated with a membrane bioreactor for use as irrigation water or aquifer recharge.

**Proposed to:** ITTP

**POC:** Richard Scholze, CERL

**Demonstration of RecycleMatch**

This project will demonstrate the use of an online marketplace to efficiently market recyclables at three Net-Zero Waste installations.

**Proposed to:** IMCOM

**POC:** Giselle Rodriguez, CERL

**On-board Scale System to Track Waste Collection**

This project will install and monitor on-board, automated weighing systems for collection of mixed wastes and recyclables at Fort Hood.

**Proposed to:** ITTP

**POC:** Giselle Rodriguez, CERL

# Sustainable Natural Infrastructure

**Leads:** Timothy Hayden and Alan Anderson, CERL.

**Description:** The purpose of this focus area is to engage stakeholders through forums, white papers, publications, and other means about DoD-related concerns with natural resources in terms of managing DoD assets and natural resources to support sustainability of training and testing missions on military lands, as they relate to international and national security and stability.

## Publications

“Protecting Critical Benefits from Ecosystems, Version 3.2.” *Foresight Bulletin*, June 2011, <http://www.aepi.army.mil/docs/whatsnew/FINAL%20ECOSYSTEM%20FORESIGHT%20BULLETIN%20-%20Foresight%202011%20-%20final.pdf>

This bulletin was produced to generate discussion and invite collaboration within the military, and between potential participants in science, academia, industry, and other organizations, on emerging ecosystem services science and policy that will affect DoD. Partners in this effort were AEPI, CERL, and Concurrent Technologies Corporation (CTC).

*Relevance of Emerging Ecosystem Science and Policy to the United States Department of Defense*, Elizabeth Keysar, ERDC/CERL CR-11-1, September 2011.

This report summarizes the latest literature on ecosystem services in science and policy, and describes ways in which emerging applications of this concept may impact military planning and policy.

## Ongoing Projects

### Alternative Term Subsidy Program for Private Land Development

The ACUB program funds acquisition of permanent easements to mitigate encroachment problems in proximity to installations. Under some conditions, permanent easements may not be desirable or economically feasible. This project is evaluating the economic efficacy and viability of developing policies and mechanisms for term easements. ACSIM is the sponsor for this effort and partners are CERL and the University of Illinois. Anticipated publication of an ERDC/CERL technical report is November 2012.

**Sponsor:** ACSIM

**POC:** Timothy Hayden

### INRMP Guidance for Incorporating Advanced Management Capabilities and Dynamic Changes in Future Mission, Climate and Land

Integrated Natural Resources Management Plans (INRMPs) are the primary natural resource planning and management document for land resources on Army and DoD lands that support the military mission. This report will identify some of those developing requirements and areas of emphasis, with a further emphasis on those elements that may have the most direct bearing on INRMPs. It will provide information and direction on how these new and developing requirements and considerations might be incorporated into INRMP planning and implementation processes. In the context of national renewable energy initiatives and developing climate change adaptation approaches, this report addresses the relevance of recent national, DoD, and Army policy guidance and directives for INRMP review and imple-



mentation; provides recommendations for ACSIM(ISE) policy guidance for INRMP revision to address evolving natural resources management policies and regulatory requirements; and evaluates processes for incorporating best practices and capabilities in INRMPs to meet land management challenges in the face of dynamic and uncertain future conditions. Anticipated publication of an ERDC/CERL technical report is January 2013.

**Sponsor:** ACSIM

**POC:** Timothy Hayden

### **Streamlining the Installation/ USFWS Consultation Process and Evaluation of Army Terms and Conditions**

US Army installations annually engage in numerous, routine US Endangered Species Act (ESA), Section 7 consultations with the US Fish and Wildlife Service (USFWS). Most of these programmatic and project consultations are completed with minimal disruption to project and program schedules and do not result in unanticipated costs. However, some recent high-profile Army Section 7 consultations with USFWS were delayed well beyond the timeframes established under the implementing regulations of the ESA, which resulted in increased project and consultation costs for the Army and delays in implementing proposed actions. The delays and costs associated with some recent Army consultations have resulted in visibility at high Army command levels and motivated a review of factors that contribute to delays and costs associated with ESA compliance actions. This report evaluates Army consultation processes through case studies to provide recommendations for enhancing the efficiency of Army ESA consultations, and provides recommendations for negotiating and evaluating Army Biological Opinion Terms and Conditions (BO T&Cs). Anticipated publication of an ERDC/CERL technical report is January 2013.

**Sponsor:** ACSIM

**POC:** Timothy Hayden

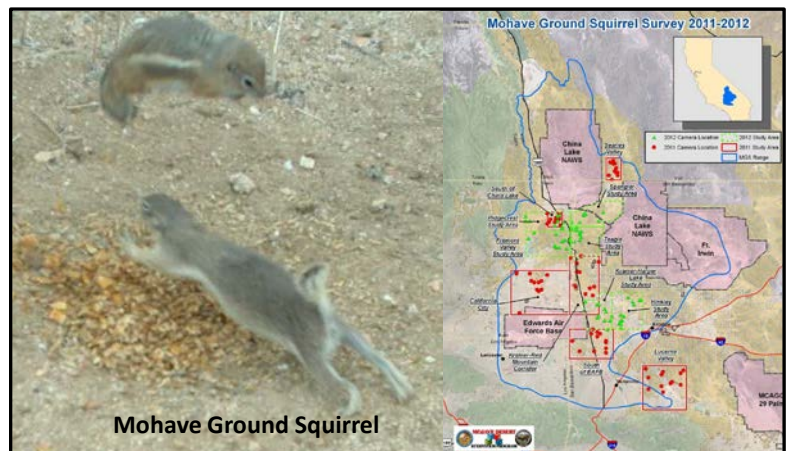
### **Proposed Projects**

#### **Alternative Management Strategies for Threatened and Endangered Species (TES) on Military Lands**

More than 240 candidate species on DoD installations are eligible for federal listing under the ESA, and more than 700 petitioned species will undergo USFWS review by 2018. DoD will require management options beyond the current primarily single species management approaches to address the potential management cost and compliance burdens caused by this possible wave of newly listed species. This project will identify and provide recommendations for alternative approaches to TES management on military lands to would mitigate future management and compliance costs for future listed species.

**Proposed to:** ACSIM

**POC:** Jinelle Sperry



# Climate Change

**Leads:** Timothy Hayden and William Goran, ERDC-CERL, with input and review from Kevin Knuuti (ERDC-CRREL), Kelly Burks-Copes (ERDC-EL), Andrew Bruzewicz, Kathleen White, and Jeff Arnold, IWR; and I. Sam Higuchi, National Aeronautics and Space Administration (NASA).

**Description:** This focus area relates to the impacts of climate change on public resources and how managers adapt to these impacts. This aspect of CASI is broadly “inter-agency” focused, as these impacts and adaptations are relevant to all public resource managers, not just US military activities and missions. However, the 2008 Defense Authorization bill included language that requires DoD to identify the impacts of climate change on military facilities, ecosystems, and missions. In addition, the 2010 Quadrennial Defense Review and the 2011 Defense Science Board Report on Climate Change and National Security further commit DoD to assessing the impacts of climate change on assets and operations. The *Department of Defense FY 2012 Climate Change Adaptation Roadmap* provides a framework and action plan to integrate climate change considerations into existing planning processes and to partner with federal agencies and allies on the challenges of climate change.

## Publications

“Sustainable Security and Fragile States,” Steven Hearne, Jeremy Alcorn, and William Goran, book chapter in *Sustainable Security and national Security*, pp 85-126, January 2012.

*Initiating the Dialogue, a Workshop To Inform Future Coordination within the DoD Research Community and between the Research and Policy Communities: Proceedings and Recommendations*, W.D. Goran served as contributing author (of the chapter on adaptation) and a member of the planning team for the workshop that convened July 19–21, 2011, in Aurora, CO. The workshop proceedings were posted in January 2012 (accessible through the “Workshop Report” tab) at:

<http://www.serdp.org/Featured-Initiatives/Climate-Change-and-Impacts-of-Sea-Level-Rise>

## Presentations

“Assessing Impacts of Changing Climate on Land Training Operations,” SERDP/ESTCP *Partners in Environmental Technology Symposium*, William Goran, Washington, DC, November 2011.

“Pathway between Natural Resources and Social Instability,” session entitled “Sustainable Security, Fragile States and Climate Assessment,” Steven Hearne, Andrew Bruzewicz, Josh Busby, Jeremy Alcorn, and William Goran, *Environmental and Security Conference*, National Council for Science and Environment (NCSE), Washington DC, January 2012.

*National Security and Climate Change*, “Mitigating Risks and Seizing Opportunities in a Rapidly Changing Global Environment: Concepts for Integrating Adaptation,” William Goran, Association of Climate Change Officers, Washington, DC, March 30-31, 2011.

“Military Installations Challenges and Opportunities, Climate and Energy Roundtable: Future Demand, Supply, Disruption and Adaptation,” *GreenGov 2012 Symposium*, Washington DC, September 26, 2012.

## Events

### *Inter-Agency Forum on Climate Change Impacts and Adaptations*

This forum meets periodically in the Washington, DC, area, and participants also joining by telephone and website. William Goran, ERDC-CERL, and Sam Higuchi, NASA, are the co-chairs. A working group website is maintained on FedCenter (<http://www.fedcenter.gov/programs/greenhouse/ccforum/>). The forum has been meeting since November 2007 and has grown steadily. Forum activities are scheduled for half-day sessions every 6 to 8 weeks. Persons interested in attending this forum, seeking information on upcoming or past forums, or requesting access to the FedCenter briefings should contact [ccforum@fedcenter.gov](mailto:ccforum@fedcenter.gov). This inter-agency forum has support from FedCenter through the US Environmental Protection Agency (USEPA). In 2012, sessions were scheduled in January, March, April, June, September, October, and November. A similar number of sessions are planned for 2013.

## Ongoing Projects

### **Army Climate Change Assessment Framework**

A CASI team from three ERDC laboratories is helping the Army develop a framework to assess climate change vulnerabilities across Army lands, facilities and operations. This effort is being guided by a newly formed Army Climate Change Adaptation Working Group and involves the analysis of relevant policy, guidance and training, as well as a high-level assessment analysis. In 2012, this project developed an Army high-level climate change vulnerability assessment, and a framework roadmap for five important Army processes (master planning, integrated natural resources management planning, strategic and sustainability planning, range complex master planning, and critical infrastructure assessments) that will incorporate changing climatic conditions into future plan versions.

**Sponsor:** ASA(IE&E)

**POC:** Timothy Hayden, CERL

### **Global Change Sustainability**

A CASI team is providing support to the IWR program relating to climate change adaptation for water resources management. Current efforts focus on data development and analyses to assess implications of IWR adaptation planning for water sustainability and resource management for facilities and operations across civil works business lines. Continuing efforts will focus on civil works adaptation pilot locations. A major objective of this support is to help USACE “bridge the stovepipes” across Military and Civil Works programs.

**Sponsor:** IWR, oversight by Dr. Kathleen White.

**POCs:** Timothy Hayden and Anne Dain-Owens, CERL

## Proposed Projects

### **Revision of Army Planning Guidance to Incorporate Climate Change Considerations**

FY12-13 efforts to develop an Army climate change adaptation planning framework will provide guidance for integrating climate change consideration in established Army installation planning processes. This guidance will require follow-on policy formulation for installations to consistently implement guidance recommendations. This effort will assist ASA(IE&E) in identifying and revising appropriate policy guidance for installation planning processes to effectively integrate climate change considerations.

**Proposed to:** TBD

**POC:** Timothy Hayden, CERL

### **Data and Technology Support Requirements for Climate Change Vulnerability and Adaptation Planning Processes**

This work will support implementation of current ASA(IE&E) projects to integrate climate change adaptation in current decision processes frameworks and to support mainstreaming climate change considerations in higher-level decision processes at the Service and DoD levels. This effort would identify technical support needs of installations for actionable climate data relevant to installation decision processes and analyses of potential impacts on installation facilities, operations, and natural infrastructure. The *DoD FY12 Climate Change Adaptation Roadmap* calls for a “coordinating body to address climate change.” This effort would also investigate technical information requirements and delivery mechanisms for such a coordinating body.

**Proposed to:** TBD

**POC:** Timothy Hayden, CERL

### **Stationing Implications of Climate Projections**

Changes in climatic conditions that are already taking place and are projected to occur over future decades may have significant impacts on future decisions about where to locate specific units and specific types of missions (e.g., equipment and weapon testing, troop training, munitions production and storage). This study would also help inform an analysis of how and where current locations might be vulnerable to new stressors; and how, where, and when global changes might be altering analog climatic, ecological, and social conditions for US training locations.

**Proposed to:** TBD

**POC:** Timothy Hayden, CERL

# Green Remediation and Reuse

**Lead:** Carol Lee Dona, EM-CX.

**Description:** The purpose of this focus area is to increase awareness and activity across USACE and the Army for incorporating sustainable practices into their environmental remediation and reuse activities.

## Publications

*Final Installation Restoration Program (IRP) and Military Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of Green and Sustainable Remediation (GSR) Practices in Army Environmental Remediation (Report)*

The EM-CX conducted a GSR Study for the Army Office of the Assistant Chief of Staff for Installation Management (OACSIM) to provide OACSIM with information for the consideration and development of Army GSR policy and guidance. The study has been completed and the report has been posted on the USACE CERL CASI web site and the Federal Center on the Cleanup Program page, respectively:

[https://casi.erdc.usace.army.mil/focusareas/green\\_remediation/?contentRegion=Item&id=63675](https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=63675)  
[http://www.fedcenter.gov/Documents/index.cfm?id=22322&pge\\_prg\\_id=2739](http://www.fedcenter.gov/Documents/index.cfm?id=22322&pge_prg_id=2739)

The study report describes the results from the 12 Army pilot projects where GSR consideration and incorporation were followed. The report also includes an approach that can be used by Army and USACE project teams to include GSR, and a number of templates that project teams can use to document GSR inclusion, including GSR Best Management Practice Tables, GSR metric comparison tables, a GSR Remedial System Evaluation (RSE) checklist, and a template GSR Evaluation report. In addition, numerous lessons learned from the study are included, as well as contract language for inclusion of GSR in a variety of contract types, including performance-based contracts.

## Presentations

USACE Northwestern Division (NWD) Environmental Summit presentation, “Green and Sustainable Remediation in the USACE,” Seattle, WA, January 21, 2012.

Army Materiel Command Environmental Workshop, Huntsville, AL, April 26, 2012, Presentation “Green and Sustainable Remediation: Army Policy and Implementation.”

Battelle Monterey, CA Conference, May 21, 2012, Presentation “Incorporation of GSR into Army Environmental Remediation: Pilot Project Performance for Formulation of Army GSR Policy,” also co-chair of Conference Session “Incorporating GSR Practices into Remedy Selection and Design.”

Army National Guard Environmental Liabilities Training, session on “Green and Sustainable Remediation within the Army,” Denver, CO, July 11, 2012.

ECoP/CASI Webinar, July 12, 2012 presentation “Green and Sustainable Remediation.”

EPA Engineering Forum Webinar Presentation, October 3, 2012 “Lessons Learned from Incorporation of GSR into Army Environmental Remediation, Pilot Project Results.”

FUDS [Formerly Used Defense Sites] Louisville District Training, "Green and Sustainable Remediation," On-site training, October 17, 2012.

Federal Remediation Technology Roundtable (FRTR) Pilot web-based, GSR hands-on training, Washington DC, November 13, 2012

## Ongoing Projects

### Quantifying Life-Cycle Environmental Footprints of Soil and Groundwater Remedies

The purpose of this project is to validate the two publicly available DoD GSR tools, *SiteWise*, developed jointly by the Navy, Army, USACE, and Battelle, and the US Air Force Sustainable Remediation Tool (SRT). The tools were validated on six military sites (three Air Force [SRT application], two Navy, and one Army [SiteWise application]). The DoD tools, which are spreadsheet-based and use literature referenced values to convert remedy information into GSR metric information, were validated by comparing their results with those from a full Life-Cycle Analysis (LCA) process as defined by International Standards Organization Standards 14040 and 14044. The LCA was performed with SimaPro, a commercially available LCA software package. The tool application to the six validation sites has been performed and the results are now being compiled, with the focus on determining the reliability and consistency of results from the two DoD tools. Recommendations for improvements to SiteWise have been formulated and are in the process of being implemented. It is expected the project will be complete Spring 2013.

**Sponsor:** ESTCP

**POC:** Carol Dona, EM-CX

### Incorporation of GSR into the Optimization Process within Army Periodic Reviews

The EM-CX is performing a periodic review on a Southern US Army installation. As part of the optimization within the periodic review, a process will be developed and piloted to incorporate GSR considerations into the optimization. This process is expected to be used on other, future periodic reviews.

**Sponsor:** The GSR inclusion in the optimization is funded as part of the funding from Active Army for the periodic review

**POC:** Carol Dona, EM-CX

### Ongoing Green and Sustainable Remediation Training

The following GSR Training is scheduled for FY13:

- Army Environmental Command GSR on-site training, March 2013
- USACE Northwest Division, GSR training, 2013
- American Society of Military Engineers, Presentation, ACSIM Study Results, Spring 2013
- Battelle Jacksonville, FL Conference, June 2013 (three abstracts submitted for platform presentation considerations):



*Top-counter-clockwise: (1) Phytoremediation of arsenic at Spring Valley FUDS site, Washington DC; (2) wind turbine powered groundwater recirculation well at the Former Nebraska Ordnance Plant Superfund Site, Mead, NE; (3) passive samplers, used across many Corps sites*

- “Incorporation of Green and Sustainable Remediation Considerations into Army Environmental Remediation”
- “Constraints on Implementation of Green and Sustainable Remediation Recommendations from Follow up on an Army Remedial System Evaluation”
- “Multiple Tools Developed from Army GSR Pilot Projects for Evaluating and Comparing GSR Considerations in Remedial Decision-Making,” including:
  - \* USACE GSR panel representation
  - \* USACE session co-chair.

## **Proposed Projects**

### **Environmental Sustainability Evaluation Tool — Development of Data File Format Output for Direct Loading into Army Databases**

With US Army and US Navy, the EM-CX is exploring the development of the format for SiteWise output data files so the GSR metric output from SiteWise can be directly uploaded to the new Army Headquarters and existing Navy data bases.

**Proposed to:** Army and Navy

**POC:** Carol Dona, EM-CX

### **Follow-up on Implementation of Recommendations from Remedial System Evaluation (RSE) Optimizations on Ongoing Operating Remedies**

The USACE RSE remedy optimization program, where the performance of an existing remedy or combination of existing remedies is optimized with respect to cost, risk, time to remedy close-out, resource consumption, and other site-specific considerations, was developed by the USACE EM-CX in the late 1990s, with more than 50 RSEs performed by the EM-CX to date. Of these RSEs, the last five RSEs have included GSR consideration within the optimizations.

The recommendations from the RSEs, GSR opportunities, have indicated significant potential cost and resource savings. The implementation of the RSE recommendations has not been tracked so it is not known the extent to which the recommendations, and the related cost and resource savings, have been realized. Piecemeal information indicates, however, that the implementation of the RSE recommendations is limited, with some RSEs not finalized because of lack of feedback from the installations on the draft RSE reports. The purposes of this study would be:

1. To follow up on and document the status of implementation of recommendations on selected installations where RSEs have been performed
2. From the information gained from the study, develop procedures for tracking implementation of RSE recommendations, including GSR opportunities, that would encourage consideration and implementation of the RSE recommendations and the associated cost and resource savings
3. Develop any recommendations to the RSE process that could improve reception and implementation of the RSE results.

**Proposed to:** OACSIM

**POC:** Carol Dona, EM-CX

# Sustainable Forward Military Operations

**Lead:** Kurt Kinnevan, CERL.

**Description:** This focus area relates to full spectrum contingency operations, from disaster response and humanitarian assistance through stability operations and conflict or post-conflict reconstruction. This aspect of CASI directly supports:

- new designs for contingency bases and updating the Army Facilities Components System – Theater Construction Management System being led by USACE
- support to OSD, Department of the Army (DA), and Services with regards to planning, design, operations, management, construction, policy and Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) of contingency bases
- effort to develop a programmatic approach to contingency basing being led at Army and Joint levels, and coordinated internationally through the North Atlantic Treaty Organization (NATO) and others
- Army Campaign Plan Directive 2-8, Institutionalizing Contingency Bases, being led by ASA(IE&E).



- Improved Deployability
- Reduced Resource Requirements/Better Systems Management
- Modular/Scalable
- Reusable/Durable/Reliable
- Enhanced Survivability

## Publications

*Operational Energy Base Camp Studies: Annotated Bibliography*, William T. Brown, III, et al., ERDC/CERL SR-11-8, ERDC-CERL, Champaign, IL, <http://www.cecer.army.mil/td/tips/pub/details.cfm>

*Contingency Bases and the Problem of Sociocultural Context*, David A. Krooks, Lucy A. Whalley, and H. Garth Anderson, ERDC/CERL TN-12-2, July 2012 (also listed in “Anticipating Emerging Issues” focus area (p 6).

DRAFT *Analysis of Policy and DOTMLPF as it Pertains to Sustainability and Environmental considerations during Overseas Contingency Operations*, David Krooks, et al.; Draft ERDC/CERL TR, 2012 (in final review).

## Ongoing Projects

**Note:** While the CASI work on contingency bases was initiated with a series of studies, starting in 2007, at the beginning of FY11 (October 2010), the ERDC began research efforts with Army research and development funds to address key knowledge gaps identified by a Army Training and Doctrine (TRADOC) analysis of contingency bases. The various CASI studies helped contribute to this TRADOC analysis and to the subsequent research efforts. By 2013, this research work is progressing in several dimensions – a foundational project to develop a virtual simulation environment for contingency base, a large scale testing and demonstration facility at Fort Leonard Wood, and numerous efforts to develop and test



specific technology solutions for energy, water, waste, and operations of contingency bases. These efforts are managed within the ERDC Environmental Quality/EQI business areas, with linkages to Military Engineering and other ERDC business areas. These research efforts, funded by various research programs, are not reported in detail in this work plan. The CASI work plan only identifies the projects funded directly by sponsor organizations that task CASI to perform specific studies or analysis.

### **Analysis of Policy and DOTMLPF As It Pertains to Sustainability and Environmental Considerations during Overseas Contingency Operations**

This effort involves a detailed analysis of US policy — and looking at some international agreements with the European Union and NATO — Army and Joint Doctrine, as well as the DOTMLPF aspects as they pertain to supporting or mandating sustainability during contingency operations.

**Sponsor:** US Army Engineer School Directorate of Environmental Integration.

**POC:** Kurt Kinnevan, CERL

### **Virtual Forward Operating Base Planning Tool**

This effort is designed to convert and update the older *GeoBEST* application to an application that can be used to perform contingency base planning and design, and to link it with a resource use algorithm to provide a dynamic resource and waste inventory.

**Sponsor:** Program Manager Force Sustainment Systems

**POC:** Kurt Kinnevan, CERL

### **NATO Net-Zero Base Camp**

CERL provides the US Delegation team leader to a NATO effort to explore the economic and military benefits of reducing the resource requirements and waste footprint of military base camps in an operational environment. This project will increase the knowledge base and communications among nations, encouraging the innovative integration of technologies that will contribute to the ultimate goal of a sustainable (“zero footprint”) military compound in a rational and holistic way.

**Sponsor:** OSD, Installations and Environment

**POC:** Kurt Kinnevan, CERL

### **Sustainability Criteria for Contingency Bases**

AEPI is funding a study for CERL to conduct research, to evaluate the value and relevance of sustainability criteria for contingency basing design and operations, and to provide the results of this research and evaluation in a summary report. This evaluation will consider multiple criteria types, their applicability and limits in terms of forward basing and forward operations, and the potential value of these criteria from the perspective of mission support, operational efficiencies in base operations, Soldier and civilian effectiveness, and host nation interactions. The process will result in a list of criteria considered most relevant and valuable for expeditionary sites of different types and durations. These criteria are not intended to be prescriptive, but to provide helpful considerations and references for contingency basing planners.

**Sponsor:** Stephen Hearne, AEPI

**POCs:** Garth Anderson and Annette Stumpf, CERL

### **Contingency Basing Integration Technology Evaluation Center (CBITEC)**

Army G4 Logistics Innovation Agency provided funding to USACE (CERL and Kansas City District) to design, construct and operate a full scale contingency base at Fort Leonard Wood to conduct a demonstration, assessment, and evaluation of contingency basing capabilities and technologies (power, environmental, sustainable construction, and force protection) that support Army requirements and future acquisition decisions. This facility will also provide a training venue to military units and Engineer School students to learn sustainable base operations. CERL supports the Maneuver Support Center of Excellence by preparing a

CBITEC master plan and a technology evaluation plan, and by providing a project manager, to be located at Fort Leonard Wood, for the long-term operation of the facility.

**Sponsor:** Army G4 Logistics Innovation Agency

**POC:** Garth Anderson, CERL

### **Prototype Development of Detailed Component Analysis Model (DCAM)**

This project funds the development of the DCAM into a flexible/standalone user tool. This work consists of designing/developing the framework that can first convert the currently available modeling capabilities (Force Provider based) into a standalone version. Then the required user interface components/modeling algorithms will be developed to allow for generation of variable Operational Tempo (OPTEMPO) sensitivity analyses based on various new/existing technologies.

**Sponsor:** Program Manager Force Sustainment Systems

**POCs:** Kurt Kinnevan, Dr. Ahmet Soylemezoglu, and Dr. Nathan Putnam, CERL

### **Support Program Manager Force Sustainment Systems with Armed Forces Australia Exercise**

The Program Manager Force Sustainment Systems (PM FSS) has requested that CERL support their planned exercise with the Armed Forces of Australia during fiscal year 2013 (FY13). This support will take the form of planning and design of contingency bases, and addressing operational issues.

**Sponsor:** PM FSS

**POC:** Kurt Kinnevan, CERL

## **Proposed Projects**

### **UK Collaborative Effort on Contingency Bases**

CERL met with representatives of the UK MOD to discuss potential collaboration on technology assessment with regards to contingency basing needs. The discussion also suggested expanding the talks with both Canadian and Australian military efforts.

**Proposed to:** OSD, Installations and Environment

**POC:** Kurt Kinnevan, CERL

### **Prototype Graphical User Interface (GUI) for VFOB Models**

The Army G-4 Logistics Innovation Agency (LIA) has approached CERL regarding funding to develop a game based GUI for the Virtual Forward Operating Base (VFOB) suite of tools and models. This would be accomplished by LIA soliciting proposal from gaming application programmers based on specifications generated by the ERDC/CERL VFOB program team.

**Proposed to:** Army G-4 Logistics Innovation Agency

**POCs:** Kurt Kinnevan and Dr. Ahmet Soylemezoglu, CERL

### **Contingency Base Design and Construction Metrics for Transition from Initial to Temporary to Enduring Standards**

This proposed Army Study Program will determine the metrics that drive the tipping points to transition from one construction standard to another during contingency operations.

**Proposed to:** Army Study Program

**POCs:** Kurt Kinnevan or Garth Anderson, CERL

### **Universal Contingency Base Construction Standards**

This proposed Army Study Program effort will develop a consistent set of construction standards across all Combatant Commands (COCOMs) that will take into account potential environments, OPTEMPOs, missions, and Quality of Life standards.

**Proposed to:** Army Study Program

**POCs:** Kurt Kinnevan and Garth Anderson, CERL

**Contingency Base Sustainability Metrics Based on Mission Type and OPTEMPO**

This proposed Army Study Program effort will quantify the level of sustainability of a contingency base with respect to the OPTEMPO and type of mission being supported.

**Proposed to:** Army Study Program

**POCs:** Garth Anderson and CPT Tom Decker, CERL

# Sustainable Facilities and Infrastructure

**Leads:** Annette Stumpf and Richard Schneider, CERL.

**Description:** The purpose of this focus area is to help USACE, the Army, and DoD work toward achieving net-zero and sustainable planning, design and development goals. The focus area team leaders are part of the USACE Centers of Energy, Sustainable Design and Life-Cycle Cost Analysis. In this technology area, CASI also provides support and collaboration with the US Green Building Council (USGBC) and other organizations involved in sustainable design and development (SDD).

## Publications and Products

“Building Green,” Thomas Napier, et al., Book chapter in *Sustainability and National Security*, ISBN 978-0-9835119-1-4, US Army War College, Carlisle Barracks, PA, January 2012,

<http://www.csl.army.mil/usacsl/publications/SustainabilityandNationalSecurity%28webversion%29.pdf>

The chapter focuses on the Army’s efforts related to sustainable facilities and infrastructure. The chapter establishes the foundation for the Army’s approach to sustainable facilities in Army missions, provides a brief history of Army efforts since 1998, and addresses some of the research and development activities pertaining to Army sustainable facilities. It documents early efforts to establish metrics for the Army and discusses sustainability at the installation level along with sustainable Army master planning. It covers the maturity of Army Green Building Efforts in the adoption of LEED, ASHRAE 189.1 and continued progress toward high-performance sustainable facilities and a sustainable future for Army facilities.

“Market-Smart” *Deconstruction and Material Recovery at Brownfield Sites: How To Identify and Reuse Existing Materials Found at Brownfield Sites*, Annette Stumpf, et al., ERDC/CERL TR 11-18, June 2011,

[http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=\\$N/1011220](http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1011220)

As a member of the federal Brownfields Partnership, USACE supports USEPA and its brownfields grantees in their efforts to assess, remediate, and sustainably reuse brownfields. This project is based on the premise that communities have finite resources and that the sustainable practices of deconstruction and recycling/reuse can provide them with much needed economic and environmental benefits. The objective of this work is to develop tools and guidance for brownfields partners to assess the potential of extracting construction material assets from buildings, structures, and infrastructure on brownfield sites, and to reuse or recycle this material. This assessment will address the physical characteristics of the structures and materials present; the potential for extracting materials for recycling and reuse; economic considerations of extracting, processing, and reusing materials compared to landfill disposal; limitations due to contamination; industry resources; regulatory requirements and other practical considerations associated with construction material recovery. This report does not specifically address the already well documented brownfield characterization and remediation process. Instead, it focuses on helping the project team assess a brownfield site to determine what buildings, materials, and resources on the site may be saved, reused, recycled, or deconstructed and sold.

*Army LEED-Certified Projects: August 2008 – September 2012*, Richard Schneider and Justine Kane, ERDC/CERL SR-11-4, June 2011, <http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=9454&TOP=1>

All federal agencies are mandated to apply sustainable design principles to the siting, design, and construction of their facilities. Agencies are further required to certify the sustainability of 5% of the buildings constructed each year with an independent, third-party authority. The Army's certifier is USGBC using the LEED rating system. In FY11, ACSIM requested that CERL prepare profiles of all USGBC-certified Army projects adhering to USGBC presentation format. The profiles highlight project ratings for the Army's highest-priority LEED credits —Energy Optimization, Water Use Reduction, and Construction Waste Management— and cite the total points and score by LEED major credit area; provide a narrative summary of the project; list the participants; and provide general cost and scope data. The effort to prepare one page profiles for additional projects continued through FY12, and an effort initiated to post project case studies directly to the USGBC website.

*Opportunities to Increase Construction and Demolition Diversion*, Thomas R. Napier, USACE Public Works Technical Bulletin, PWTB 200-1-120, October 2012.

Economic and environmental burdens associated with landfill disposal of construction and demolition (C&D) materials are well documented, as are various agency directives aimed at the reduction of C&D waste. The Army's plan to achieve 25 net-zero Army installations by 2030 should leave no doubt as to the mandate for C&D waste reduction. Since implementing C&D waste diversion policies, the Army's green building practices, along with the construction industry's practices in general, have progressed significantly. According to Solid Waste Annual Reporting (SWAR) data, Army-wide C&D diversion rates have exceeded the minimum mandated at the time. However, this level of performance is not consistent throughout all installations or Army facility programs. Opportunities to improve diversion rates exist because the most successful practices to divert C&D materials are not being applied as broadly as they could be. This PWTB documents experiences gathered from USACE and installation DPW projects that involve demolition and new construction. The PWTB also includes input from DPW personnel at installations that represent the largest amount of Military Construction (MILCON), and feedback received from HQUSACE, USACE District, IMCOM, and OACSIM personnel involved with construction, demolition, and waste management activities. The resulting lessons learned are described and accompanied by recommended practices to improve C&D waste diversion performance.

Twenty Technical Notes ("TechNotes") were published for the Corps of Engineers Centers of Standardization to use as an outcome of the ESTCP Design, Monitoring, and Validation of a High- Performance Sustainable Building project. They are available at these two sites:

[http://www.wbdg.org/ccb/browse\\_cat.php?c=266](http://www.wbdg.org/ccb/browse_cat.php?c=266)

<https://mrsi.usace.army.mil/sustain/SitePages/TechNotes.aspx>

## Events

### **USACE-Wide Sustainability & Energy Webinars**

In 2012, ERDC-CERL organized a Tuesday / Thursday series of USACE-wide Webinars of interest to the Corps of Engineers and Army Installation personnel who are involved in sustainable building design, construction, commissioning, renovation, and operation. There were 30 different webinars and speakers in all. A sampling of the topics includes:

- Low Impact Development Fundamentals (March 22)
- Life-Cycle Cost Analysis (March 29 and May 1)
- Army Policy and ASHRAE 189.1 (April 5 and July 11)

- Energy Modeling 101 (June 12 and September 11)
- Rainwater Harvesting and Rain Gardens (April 24 and July 24)
- Managing and Maintaining Building Envelopes (March 27 and May 27)
- Waste Reduction (May 22 and August 22)
- Solar Thermal System Design (June 7 and September 6)
- Toward Net-Zero Building Design (June 28)
- Measurement and Verification (September 26).

## Ongoing Projects

### **Rapid Energy Modeling Workflow Demonstration Project**

This ESTCP proposal was submitted by Autodesk, Inc. in collaboration with CERL. Autodesk is testing a package of software tools, web services, and consulting expertise to assess and prioritize the energy reduction potential in new and existing DoD buildings. The proposed method will quickly capture existing building geometry, systems, and materials to generate data-rich 3D BIM. These BIM models will be used to predict building energy and water use, energy and water reduction opportunities, and to verify and monitor the modeled structure's performance. The goal is to demonstrate a cost-effective, repeatable, accurate and highly scalable method that serves DoD's immediate needs and also generates lessons to improve the method for broader adoption across other government agencies in the longer term. The ESTCP team is identifying 32 DoD buildings with at least 1 year of metering data in a variety of climates for this project. Each building will be visited and modeled; the team will then compare the results with actual metering data to validate the process.

**Sponsor:** ESTCP

**POCs:** John Sullivan, Autodesk, Inc., and Annette Stumpf, CERL

### **Model-Driven Energy Intelligence**

This ESTCP proposal was submitted by Honeywell International, Inc. in collaboration with CERL. The goal is to leverage BIM to enable more effective coordination of unintegrated management systems. The team will demonstrate the potential for DoD to maximize energy-saving initiatives by expanding model-driven, integrated decision-making across DoD real estate holdings, regardless of age. This will help DoD meet energy reduction requirements and simultaneously reduce the burden involved in the analysis and reporting required to track and measure these savings and to establish the required metrics. This demonstration will show that BIM is an effective tool to optimize multiple energy management initiatives and human resources responsible for accomplishing energy management goals.

**Sponsor:** ESTCP

**POCs:** Liana Kiff, Honeywell International Inc., and Lance Marrano, CERL

### **Army Sustainable Design and Development (SDD) FY12 Validation Review**

Funds were provided by ACSIM for CERL to coordinate FY12 USACE SDD Validation Team reviews to validate the Army's self-certification process for sustainability scoring of MILCON projects. A USACE SDD Validation Team comprised of experienced LEED Accredited Professionals from various Districts was selected to perform the reviews "virtually." The review team reviewed 11 certifiable projects at the close of FY12. Results of its evaluations will be reported to all Corps MILCON Divisions and Districts, as well as to ACSIM and IMCOM.

**Sponsor:** Vincent Kam, ACSIM

**POCs:** Richard Schneider and Annette Stumpf, CERL

### **Army Sustainable Design and Development (SDD) FY13 Validation Review**

Funds were provided by ACSIM for CERL to coordinate and conduct FY13 USACE SDD Validation Team reviews to validate the Army's self-certification process for sustainability scoring of MILCON projects for a sampling of remaining pre-FY13 projects. Additionally in FY13, reviews of installation minor construction projects will be initiated. A USACE SDD Validation Team comprised of experienced LEED Accredited Professionals from various Districts will be

selected to review MILCON projects virtually, with a limited team reviewing minor construction project in the field. Results of its evaluations will be reported to all Corps MILCON Divisions and Districts, as well as to ACSIM, IMCOM, and installation DPWs visited.

**Sponsor:** Vincent Kam, ACSIM

**POCs:** Richard Schneider and Annette Stumpf, CERL

#### **BUILDER High-Performance Sustainable Building Guiding Principles Integration**

Funds are provided by ACSIM for CERL to determine the points of intersection between the BUILDER Sustainment Management System (SMS), the requirements of the Guiding Principles for High-Performance and Sustainable Buildings (GP), the Installation Status Report, and how the systems feed into the Headquarters Information System (HQIIS) for proper reporting of federal mandates by the Army. This effort will determine the Army's implementation of GP for new, existing, and leased buildings. This is required for the Army to be on track to meet the 15% goal by 2015 by reporting at least X% of buildings greater than 5000 gross sq ft meet GP as reported in the Federal Real Property Profile. The X% is defined as 7% for 2011, 9% for 2012, 11% for 2013, 13% for 2014, 15% for 2015, and 15% constant through 2020 with a goal of 100% of the qualified buildings meeting the criteria. The product of this effort is documentation stating where information necessary for EO 13423 compliance is currently collected in Army systems. Where data is not currently collected, suggestions for the proper integration point with current Army systems will be addressed with the goal of HQIIS being the final portal and conduit for the Army's compliance submission.

**Sponsor:** Vincent Kam, ACSIM

**POCs:** Lance Marrano, Annette Stumpf, and Richard Schneider, CERL

#### **ACSIM SDD Activity General Support**

ACSIM provides funds to CERL for general support of its SDD activities. CERL facilitates the exchange of information among the Army, Air Force and Navy concerning SDD policies and activities; acts as the liaison between the Army and USGBC representing Army interests in USGBC practices and products development; coordinates Army individual membership in the USGBC; and most recently, is compiling project profiles for all Army projects that have achieved LEED Certification. CERL has also been asked to compare USGBC LEED standards with foreign standards in locations outside the United States where the Army has permanent facilities to determine if host nation standards are equivalent to or exceed Army sustainability requirements and to make recommendations on potential adoption.

**Sponsor:** Vincent Kam, ACSIM

**POCs:** Richard Schneider and Annette Stumpf, CERL

#### **USGBC Implementation Advisory Committee**

Funds are provided by ACSIM for CERL to represent the Army as a member of USGBC's Implementation Advisory Committee. This subcommittee of the LEED Steering Committee (LSC) is charged with assessing and recommending solutions to the LSC for review and approval. Its purpose is to advise USGBC staff on the scope, content, and rigor of technical resources and tools supporting LEED programs with the goal of maintaining LEED's integrity while also providing an effective, predictable, and satisfying LEED customer engagement. Implementation Advisory Committee members were recruited to represent Army interests in maintaining the LEED standards.

**Sponsor:** Vincent Kam, ACSIM

**POC:** Richard Schneider, CERL

#### **Design, Monitoring, and Validation of a High- Performance Sustainable Building**

The project team is finalizing an ESTCP Lessons Learned report describing the project outcome. The purpose of this 4-year research project is to demonstrate "whole building" design processes using off-the-shelf building materials and components to achieve higher building performance at no additional first cost. The team is working on a community emergency

services building designed and constructed at Fort Bragg, NC as a design/bid/ build project. Team members have been involved during the design, construction, commissioning, and operations of the building and are comparing the performance of the new building (high-performance design) with a conventional fire station at Fort Bragg. The project was submitted to the Green Building Certification Institute (GBCI) and was awarded a LEED-NC (LEED-New Construction) 2.2 Platinum rating. The CESS is the Army's first MILCON project to earn a LEED Platinum certification. Lessons learned were captured and shared with all services and with the USACE Centers of Standardization (COS) for Army facility types. Current activities include monitoring both the new building and existing fire station to measure performance, finalizing the ESTCP report, and transferring lessons learned to Tri-Service partners and COSs.

More information may be found at:

<http://www.estcp.com/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-200724>

LEED Certification information may be found at:

<https://new.usgbc.org/projects/community-emergency-service-station?view=overview>

**Sponsor:** ESTCP

**POCs:** Kim Fowler, Pacific Northwest National Laboratory, Annette Stumpf and Richard Schneider, CERL

### **Develop an Installation Sustainability Measurement Tool: Sustainable Communities**

The objective of this Tri-Service effort is to demonstrate and validate a method for assessing the sustainability of an installation and for creating a system that provides leadership with the ability to prioritize actions based on life-cycle cost effectiveness. The method will be based on asset management principles and the CERL-developed SMS. As credits are developed for an Installation Sustainability Measurement Tool, CERL will review them to determine if they meet the Army's needs and to identify potential alignment with existing Army data, initiatives, and programs. In addition, CERL will facilitate a field demonstration at one Army installation. More information on this effort may be found at:

<http://www.estcp.com/Program-Areas/Resource-Conservation-and-Climate-Change/RC-201116/RC-201116>

**Sponsor:** ESTCP

**POCs:** Christopher Kruzel, US Air Force, and Richard Schneider, CERL

### **C&D Waste Reduction: Technical Guidance and Technology Transfer**

CERL is involved with reducing waste from the Army's construction, demolition, and renovation programs. CERL personnel have participated with deconstruction projects at Army installations, performed cost and schedule analysis, analyzed the effects of residual lead on recovered wood and concrete materials, developed guidance documents contributing to Army and USACE policy, and conducted various technology transfer events. Guidance developed by CERL can be found at the Whole Building Design Guide (WBDG) website in the form of USACE PWTBs and at a WBDG resource page on C&D waste reduction. Recent activities include instructing at the 2011 E2S2, National Guard Environmental Workshop, and National Housing Management Association Conference, and conducting a 2-day workshop to establish a C&D reduction program at Fort Richardson, AK.

**Sponsor:** Malcolm McLeod, HQUSACE

**POCs:** Thomas Napier and Stephen Cosper, CERL

### **Resilient Home Program**

CERL is a partner in the Resilient Home Program (RHP). "Resilience" refers to the ability of residents to reduce damage to their homes inflicted by natural disasters, enabling them to resume routine activities sooner and communities to rebound more quickly. RHP was developed in partnership with the Department of Homeland Security, Department of Energy,



Southeast Regional Research Institute, Clemson University, and North Carolina State University. Accomplishments since FY07 include a gap analysis for resilient building design, retrofit, and technical transfer; database development for resilient home technologies; development of mold prevention and mitigation methods; minimum standards for inhabiting residential structures; various educational and outreach programs; testing of building materials for resilience; and moisture detection and mitigation technologies for building assemblies. The RHP team is developing a Residential Scoring Utility, or ReScU, for new construction and retrofitting of existing homes. The purpose of ReScU is to rate a home's construction for resilience, which will enable insurers and local authorities to provide incentives for resilient construction, such as discounts on insurance premiums.

**Sponsor:** Department of Homeland Security

**POC:** Thomas Napier, CERL

[http://www.resilientus.org/home\\_program](http://www.resilientus.org/home_program)

## Proposed Projects

### **Performance Testing of Extremely Energy-Efficient Blast Resistant Windows**

The primary objective is to provide the Army with blast test data for extremely energy-efficient windows (triple- or quad-paned) interpreted to correspond with Unified Facilities Code 4-010-01 levels of protection. Resulting data can be used in the future to revise blast resistant window design software to accommodate multiple air spaces. If any of the tested windows rate at very low, low, medium, or high levels of protection, an important secondary objective is to provide the Army with reliable window choices (including market availability and cost) satisfying the performance criteria for both extreme energy efficiency and blast resistance.

**Proposed to:** ACSIM ITTP

**POC:** Julie Webster, CERL

### **Cost-Benefit of High-Performance and Sustainable Buildings**

New buildings are designed for high performance and sustainability (HPS). Research is proposed to develop a process by which the Army can identify the costs of HPS features in new buildings, identify the longer term performance in environmentally related areas and calculate the overall cost-versus-benefit of HPS buildings. Major new construction programs are winding down and the Army will be devoting considerable resources to upgrade existing buildings. Assessing the "value of green" in existing building upgrades will also be included in this strategy and methods.

**Proposed to:** AEPI

**POC:** Thomas Napier, CERL

### **Guiding Principles for Sustainable Existing Buildings: Establishing Facility Operational Performance Goals for Energy, Water, Material Use and Recycling, and Indoor Environmental Quality**

EO 13514 directs each federal agency to implement high-performance sustainable federal building design practices in new and existing facility programs. Within these GPs are requirements to: assess existing conditions and operational procedures of buildings and major building systems and identify areas for improvement; establish operational performance goals for energy, water, material use and recycling, and indoor environmental quality; and ensure incorporation of these goals throughout the remaining life cycle of the building. A systematic method to assess existing buildings and develop performance goals is needed as the first step in conforming to these GPs.

**Proposed to:** TBD

**POC:** Thomas Napier, CERL

### **Best Practices for Recycling Asphalt Shingles (RAS)**

Waste asphalt shingles offer a major potential for recovery and recycling. Bitumen can be recovered from new shingle scrap and tear-off shingles from reroofing and demolition. Beneficial uses include hot mix asphalt, cold asphalt patch and waste-to-energy conversion. Until recently, asphalt shingle recycling has not been widespread throughout the United States. Today the infrastructure has expanded and methods have become more efficient, making shingle recycling much more practical than in the past. With the dramatic increase in petroleum prices, the economic feasibility has further improved. More C&D recycling businesses accept shingles, more bitumen manufacturers will take RAS, and more jurisdictions are including RAS in their paving specifications. Challenges still remain, such as complying with occupational and environmental regulations. The Army needs guidance to capitalize on this resource, especially in establishing realistic recycling criteria, composing workable contract requirements, developing opportunities with local recyclers and pavement authorities, and supporting contractors through the various construction and maintenance programs.

**Proposed to:** TBD

**POC:** Thomas Napier, CERL

### **Adaptive Space Configurations for Army Interior Construction Projects**

Administrative furnishings for Army garrisons have consisted of private office and open plan systems furniture, commonly referred to as “cube farms.” The Army’s facilities programs are transitioning from new construction to upgrading and continuing use of existing buildings. The ability to reconfigure spaces and supporting utilities will be critical to accommodating changing functional requirements. Guidance is needed to enable installation Directorates of Public Works and USACE personnel outfit buildings for adaptability and longevity of mission performance in a life-cycle cost-effective way. This project will develop a set of design guidelines for the integration of collaborative furniture layouts for operations, activities, programs, and organizational elements into interior construction projects.

**Proposed to:** TBD

**POCs:** Annette Stumpf and Thomas Napier, CERL

### **Sustainable Furnishings Project**

The Army needs an integrated, cost-effective means to train and help designers and customers to incorporate sustainable interior design principles and criteria when selecting furnishings, fixtures and equipment for both new construction and renovation projects. This guidance will help Army customers and designers understand and implement sustainability mandates and directives while earning the LEED credits related to furnishings and interior design. This proposed project will develop a Sustainable Furnishings Tutorial to help designers and customers identify sustainable furnishing alternatives when planning the furniture, fixtures and equipment design for new construction and renovation projects. The tutorial will offer guidance to help designers select appropriate furnishings that meet federal and Army sustainable policy objectives; comply with relevant criteria and standards governing procurement of sustainable furnishings; help projects earn LEED credits; and create a more productive, high-performance work environment.

**Proposed to:** TBD

**POCs:** Annette Stumpf and Thomas Napier, CERL

### **Balancing Daylighting and Energy Conservation for DoD Schools (Fort Knox Case Study)**

With 70% of its facilities considered to be in poor condition, the DoD Education Activity is embarking on a \$3.7 billion renovation and construction initiative to replace its aging schools with 21st century learning environments. The activity is capitalizing on the opportunity to not only redefine its own schools, but to provide a model for how schools will be built in the future. This is a rare opportunity to address sustainable design issues, evaluate the performance of implemented strategies and have a positive impact on the children of Service men and women worldwide. The study will have an immediate impact on the construction and

renovation of 134 schools over the next 5 years. An integrated design charrette process and building information modeling is proposed at Fort Knox, KY, to identify a range of daylighting strategies while providing balanced quality natural light conducive to learning.

**Proposed to:** TBD

**POCs:** Annette Stumpf and Richard Schneider, CERL

### **Daylighting Comparison of Two Headquarters Buildings**

Recommended illumination levels have been reduced in ASHRAE and LEED energy standards. In addition, EPA 2005 requires a 30-40% reduction in energy consumption below ASHRAE's goal for new facilities. This project will determine how effective the daylighting strategies are in providing adequate daylight and in reducing electrical lighting loads by: providing evidence-based design direction for USACE designs; measuring the amount of artificial light savings by introducing natural light; and evaluating the cost savings for future life-cycle cost analysis.

**Proposed to:** TBD

**POCs:** Annette Stumpf and Richard Schneider, CERL

### **Hybrid Solar Roofing Systems**

Solar energy systems have been available for several decades in both photovoltaic (PV) and thermal versions. Neither method of converting sunlight to usable energy has been cost-effective until recently. However, a Lawrence Berkley Laboratory study determined the cost of PV installations has declined greatly in the past 10 years. Thermal and PV solar systems have traditionally been treated as separate technologies, either one or the other being chosen for a particular application. This under-uses 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 alone. A combination or "hybrid" system makes greater efficiency of the heat collected by PV systems but not used to generate electricity. Tests have shown that hybrid PV/thermal systems can generate four times the energy from the same surface for a 25% increase in cost. Army installations have not yet approached the full potential of using fully renewable, essentially "free" energy that creates minimal environmental impacts. A demonstration is proposed to integrate both thermal and PV solar collection systems with a roofing system. By doing so, the weather barrier of the roof is not compromised by installation of an independent solar collection component, and the PV array contributes to the weather-resistant properties of the roofing materials. The PV array generates electricity for the building's power supply. If surplus energy is generated, it can be returned to the grid. The thermal medium can be either air or fluid. However, an air medium is recommended for this proposal because of greatly reduced maintenance requirements.

**Proposed to:** TBD

**POC:** Thomas Napier, CERL

### **Preserving Embodied Energy and Economic Benefits of Historic Buildings**

Historic properties are often perceived as energy and maintenance burdens. Economic analyses applied to these buildings are based on the lowest direct operating cost. The inherent environmental value of the building's embodied energy (the energy, measured in fossil fuels, consumed to make any product, bring it to market, put it to use, and then to dispose of it at the end of its useful life) is not included in these decision processes. The Advisory Council on Historic Preservation advises that replacing historic properties with new "green" buildings may actually create an energy deficit that will take much longer to recover than is commonly perceived. Another study concludes that new, "green" buildings could take up to 76 years to offset the embodied energy wasted by demolition. A process model is proposed to guide DoD installation planners and facility management personnel in assessing the economic and environmental values of historic and potentially eligible buildings.

**Proposed to:** TBD

**POCs:** Thomas Napier and Susan Enscoe, CERL

# Acronyms and Abbreviations

<u>Term</u>	<u>Definition</u>
ACP	Army Campaign Plan
ACSIM	Assistant Chief of Staff for Installation Management
ACSIM-ISE	Assistant Chief of Staff for Installation Management, Army Environmental Division
ACUB	Army Compatible Use Buffer
AEES	Advanced, Energy-Efficient Shelter Systems
AEPI	Army Environmental Policy Institute
AFRICOM	US Africa Command
AHU	Air Handling Unit
AMEA-D	Army Mission Environmental Assessment for Deserts
ARL	US Army Research Laboratory
ASA	Assistant Secretary of the Army
ASAALT	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
ASA(IE&E)	Assistant Secretary of the Army for Installations, Energy, and Environment
ASCP	Army Sustainability Campaign Plan
ASD	Assistant Secretary of Defense
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASR	Army Sustainability Report
AWRA	American Water Resources Association
AWWA	American Water Works Association
BIM	Building Information Model
BO	Biological Opinion
C&D	Construction and Demolition
CAC	Common Access Card
CAJMTC	Camp Atterbury Joint Maneuver Training Center
CASI	Center for the Advancement of Sustainability Innovations
CBITEC	Contingency Basing Integration Technology Evaluation Center
CERL	Construction Engineering Research Laboratory
CESS	Community Emergency Services Station
CMEP	Civil Military Emergency Preparedness
COA	Course of Action
COB	Contingency Operating Base
COCOM	Combatant Command
CONUS	Continental United States
COS	Centers of Standardization
CPT	Captain
CRC	Cooling Recovery Coil
CRREL	Cold Regions Research and Engineering Laboratory
CTC	Concurrent Technologies Corporation
DA	Department of the Army
DAIM-ISE	Army Environmental Division
DASA(IE&E)	Office of the Assistant Secretary of the Army for Installations, Energy and Environment

<b><u>Term</u></b>	<b><u>Definition</u></b>
DASA(E&S)	Office of the Assistant Secretary of the Army Energy and Sustainability
DC	Direct Current
DCAM	Detailed Component Analysis Model
DEIC	Defense Environmental International Cooperation
DEPARC	Defense Environmental Programs Annual Report to Congress
DoD	US Department of Defense
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
DPW	Directorate of Public Works
DRI	Desert Research Institute
ECoP	Environmental Community of Practice (ECoP)
EL	Environmental Laboratory
EM-CX	USACE Environmental and Munitions Center of Expertise
EMS	Emergency Medical Services
EO	Executive Order
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EQI	Environmental Quality and Installations
ERDC	Engineer Research and Development Center
ERDC-CERL	Engineer Research and Development Center, Construction Engineering Research Laboratory
ERDC-CRREL	Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory
ERDC-EL	Engineer Research and Development Center, Environmental Laboratory
ESA	US Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FRTR	Federal Remediation Technology Roundtable
FUDS	Formerly Used Defense Sites
FY	Fiscal Year
GBCI	Green Building Certification Institute
GHG	Greenhouse Gas
GIS	Geographic Information System
GP	Guiding Principles for High-Performance and Sustainable Buildings
GPD	Gallons Per Day
GSR	Green and Sustainable Remediation
GUI	Graphical User Interface
HEDS	High Efficiency Dehumidification System
HESC	Huntsville Engineering and Support Center
HPS	High Performance and Sustainability
HQIIS	Headquarters Information System
HQIMCOM	Headquarters, Installation Management Command
HQUSACE	Headquarters, US Army Corps of Engineers
HUD	US Department of Housing and Urban Development
HVAC	Heating, Ventilating, and Air-Conditioning
HWIL	Hardware In the Loop
IMCOM	Installation Management Command
IMCOM-SE	Installation Management Command-Southeast Region
INRMP	Integrated Natural Resources Management Plans
IRP	Installation Restoration Program

<b><u>Term</u></b>	<b><u>Definition</u></b>
ISBN	International Standard Book Number
ISSP	Integrated Strategic and Sustainability Planning
ITTP	Installation Technology Transition Program
IWR	Institute for Water Resources
JBLM	Joint Base Lewis-McChord
JCTD	Joint Capability Technology Demonstration
JLUS	Joint Land Use Study
LCA	Life-Cycle Analysis
LEED	Leadership in Energy and Environmental Design
LEED-AP	Leadership in Energy and Environmental Design – Accredited Professional
LEED-NC	LEED-New Construction
LIA	Logistics Innovation Agency
LOBOS	Load Based Optimization System
LP&VHPP	Lake Pontchartrain & Vicinity Hurricane Protection Project
LSC	LEED Steering Committee
M&S	Modeling and Simulation
MILCON	Military Construction
MMRP	Military Munitions Response Program
MOD	UK Ministry of Defence
MPO	Metropolitan Planning Organization
M-RSI	Megacity Reconnaissance, Surveillance, and Intelligence
MZ	Multizone
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCA&T	North Carolina State Agricultural and Technical University
NCSE	National Council for Science and the Environment
NFESC	Naval Facilities Engineering Service Center
NWD	Northwestern Division
NZE	Net-Zero Energy
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OECIF	Operational Energy Capabilities Improvement Fund
OPTEMPO	Operational Tempo
OSD	Office of the Secretary of Defense
PCM	Phase Change Materials
PM FSS	Program Manager Force Sustainment Systems
PNNL	Pacific Northwest National Laboratory
POC	Point of Contact
PR	Puerto Rico
PROSPECT	Proponent Sponsored Engineer Corps Training
PV	PhotoVoltaic
PWTB	Public Works Technical Bulletin
RAS	Recycled Asphalt Shingles
RDT&E	Research, Development, Test and Evaluation
REPI	Readiness and Environmental Protection Initiative
RHP	Resilient Homes Program
RSE	Remedial System Evaluation

<b><u>Term</u></b>	<b><u>Definition</u></b>
RUBA	Remote Unit Bivouac Area
SBIR	Small Business Innovative Research
SDD-DX	US Army Corps of Engineers Savannah District-led Directory of Expertise
SERDP	Strategic Environmental Research and Development Program
SERM	Sustainability, Encroachment, and Room to Maneuver
SIRRA	Sustainable Installations Regional Resource Assessment
SMS	Sustainment Management System
SPIDERS	Smart Power Infrastructure Demonstration for Energy Reliability and Security
SR	Special Report
SRM	Sustainment, Restoration, and Modernization
SRT	(US Air Force) Sustainable Remediation Tool
SSPP	Strategic Sustainability Performance Plan
SSST	Scalable Solid State Transformer
SWAR	Solid Waste Annual Reporting
TBD	To Be Determined
T&Cs	Terms and Conditions
TES	Threatened And Endangered Species
TN	Technical Note
TR	Technical Report
TRADOC	US Army Training and Doctrine Command
TRL	Technology Readiness Level
UK	United Kingdom
URL	Universal Resource Locator
US	United States
USACE	US Army Corps of Engineers
USAID	US Agency for International Development
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGBC	US Green Building Council
VFOB	Virtual Forward Operating Base
WBDG	Whole Building Design Guide
WSMR	White Sands Missile Range

# REPORT DOCUMENTATION PAGE

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