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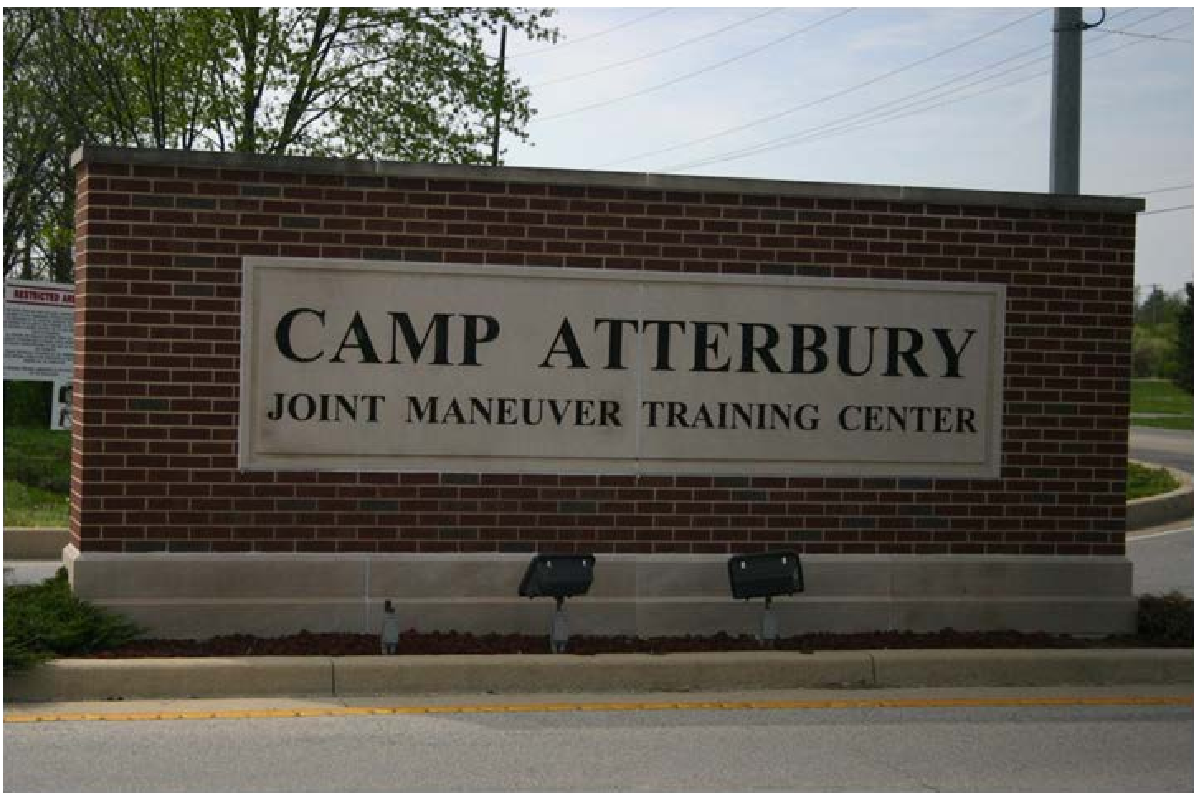
Installation Technology Transition Program (ITTP)

Integrated Water Planning for Army Training Areas

Elisabeth M. Jenicek, Laura Curvey, Ira Mabel, Rachel Phillips, Amy L. Vickers, and Gonzalo Perez

October 2012



Construction Engineering Research Laboratory

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Final Report

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Abstract

Many Army installations within the United States are located within watersheds that are highly vulnerable to issues of water supply or demand stress. Army testing and training ranges are at particular risk to issues of water scarcity due to the fluctuations in population and the transient nature of residents. Additionally, testing and training areas offer the opportunity to expose soldiers to the importance of water efficiency and conservation because 500,000 soldiers pass through these facilities in any given year. Commercially available water conservation technologies can be implemented to realize water savings in Army testing and training 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 demonstration/validation of the shower trailer plumbing fixtures, bulk water point, and composting toilet at training sites and water systems at the Camp Atterbury Joint Maneuver Training Center (CAJMTC), IN. Surveys were employed to determine general attitudes about water conservation and how these were affected by the conservation retrofits.

Executive Summary

Changing precipitation patterns, coupled with population growth, aging infrastructure, and unsustainable water extraction rates make many US regions vulnerable to water scarcity. In fact, such regional water scarcity is already occurring, even in areas of the United States that were long assumed to be water rich. 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 in Army testing and training ranges on both the supply and demand side. These technologies are widely applicable across DOD installations, in dry as well as non-arid regions that increasingly face localized droughts and other types of water shortages. Moreover, while the efficient use of water (i.e., conservation) should remain the top priority, alternative sources of water should also be considered a part of the water supply mix —including those sources available at the building level. Combining water conservation with water reuse on the building level can demonstrate the effective use of water, at the amount and quality required, within a building.

This work demonstrated and documented the effectiveness of using a holistic approach to identifying water inefficiencies and water waste, and to improving water conservation at training sites and downrange practices at Camp Atterbury, IN by retrofitting the following facilities with technologies that support reduced potable water consumption through conservation and building greywater reuse:

- *Fixtures*. Estimates of water savings achieved at FOBs 2 and 3 by the fixture retrofits installed in the two experimental connexes compared to the control connexes suggest that water conservation is being achieved at Camp Atterbury. Changes in data collection practices and also possibly reconfiguration of the control and experimental connexes are needed in the next phase of this project so that fixture water use and related changes from installed retrofits can be reliably identified, measured, and reported.

- *Bulk Water Distribution Points*. This work began to meter and track water consumption through bulk water distribution points. Data collection is ongoing and results will be published at a later date.
- *Composting Toilets*. This work showed that the use of composting toilets at remote training locations is feasible and should be considered; compared with the use of porta-potties, the use of composting toilets potentially offers cost savings and environmental benefits.

Specific recommendations were made to improve water conservation practices at Camp Atterbury, IN.

Table of Contents

List of Figures and Tables

Figures

Tables

Preface

This study was conducted for the US Army Assistant Chief of Staff for Installation Management (ACSIM) under Installation Technology Transition Program (ITTP) Project FY11-18, "Integrated Water Planning through Building Level Cascade of Water Use: Training Area Water Conservation." The technical monitor for ACSIM was Philip R. Columbus, DAIM-ODF.

The work was managed and executed by the Energy Branch (CF-E) of the Facilities Division (CF), US Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). The ITTP Program Manager was Debbie J. Lawrence, CEERD-CV-ZT. The CERL principal investigator was Elisabeth M. Jenicek. The Assistant Investigator was Laura Curvey. Part of this work was completed under contract W9132T-10-D-0002 0019 with The Pertan Group and contract W9132T-10-C-0010 with University of Illinois at Urbana Champaign. Subcontractors of The Pertan Group were Amy Vickers of Amy Vickers, Inc., Don Mills and Brian Barry of Clivus Multrum, and Chris Dearborn of Ferguson Waterworks. Special appreciation is owed to the following installation personnel and other points of contact for providing information and coordination that was invaluable to this demonstration and for reviewing this report: 1LT Jerry Hartley, Laura Cunningham, Rod Yaden, CPT William Boehmer, 1LT Christopher Eaton, LTC Steven Breckenridge, 1SG Robert Derringer, SFC Bell, and SSG Albert. Frank H. Holcomb is Chief, CEERD-CF-E and L. Michael Golish is Chief, CEERD-CF. The Technical Director for Installations is Martin J. Savoie. The Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the US Army Engineer Research and Development Center (ERDC), US Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Kevin J. Wilson, and the Director of ERDC is Dr. Jeffery P. Holland.

1 Introduction

1.1 Background

Changing precipitation patterns, coupled with population growth, aging infrastructure, and unsustainable water extraction rates make many US regions vulnerable to water scarcity. In fact, such regional water scarcity is already occurring, even in areas of the United States that were long assumed to be water rich. This growth in regional water demand is worsened by transformation-driven increases in water requirements. As demand for water threatens to outstrip supply, water costs rise. Nevertheless, price is a lagging indicator; the cost of water may not rise precipitously (and thereby lower demand) until emergency conservation measures are needed. This regional and seasonal variance in the availability of water resources places some Army installations in positions of water scarcity. An Army study (Jenicek et al. 2009) found that nearly 100 of 411 (23%) US installations 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.

Army installations must meet mandatory water reduction requirements, such as those specified in Executive Order (EO) 13514, the Energy Policy Act of 2005 (EPAct 2005), and the Army's Net Zero Installations initiative. The Army's "Net Zero Water" (NZW) strategy, along with the Department of Defense's (DoD's) "Installation Technology Transition Program" advance proactive policies and measures to promote sustainable water use at installations. Many water conservation technologies can be implemented to realize water savings in Army testing and training ranges on both the supply and demand side. These technologies are widely applicable across DOD installations, in dry as well as non-arid regions that increasingly face localized droughts and other types of water shortages. Moreover, while the efficient use of water (i.e., conservation) should remain the top priority, alternative sources of water should also be considered a part of the water supply mix —including those sources available at the building level. Combining water conservation with water reuse on the building level can demonstrate the effective use of water, at the amount and quality required, within a building.

Nevertheless, even though such technologies are commercially available, they are not yet in widespread use on Army installations. Unfamiliarity with these technologies and the lack of Army "success stories" that illustrate their successful implementation have been impediments to increased adoption of these technologies by installations. This work was undertaken to demonstrate and validate the retrofit of existing facilities with technologies that support reduced potable water consumption through conservation and building greywater reuse, 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.

1.2 Objectives

The objectives of this work were to demonstrate and document the effectiveness of using a holistic approach to identifying water inefficiencies and water waste, and to improving water conservation at training sites and downrange practices at Camp Atterbury, IN by retrofitting existing facilities with technologies that support reduced potable water consumption through conservation and building greywater reuse.

1.3 Approach

The objectives of this work were completed through the following steps:

1. Researchers made a series of phonecons and site visits to Army training areas to select the initial site.
2. Once the project site was selected, a project scope of work was developed and an Indefinite Delivery/Indefinite Quantity (IDIQ) contract was awarded for execution of the retrofits.
3. The preliminary contractor demonstration site survey identified sites, utilities, buildings, and technologies that could be retrofit with water efficiency and conservation measures. The contract included retrofit and monitoring of these locations and technologies.
4. Water use was measured and metered for 3 months before retrofit.
5. Systems were retrofit with efficient technologies.
6. Post-retrofit water use was monitored and metered for 6 months. During this time, additional information, including maintenance requirements, was collected.

During the water use survey and technology retrofit, an awareness and survey program was also initiated. Participants at Camp Atterbury were surveyed in person during scheduled training cycles. An awareness campaign was designed based on conclusions drawn from an analysis of the collected information. The multi-component campaign was then introduced at the study locations. Follow-up surveys measured how well the campaign impacted behavior.

1.4 Scope

Although this work was performed at CAJMTC, other potential first users include installations in regions already experiencing water scarcity and those affected by transformation "plus-ups," and could apply for centralized funding —such as Energy Conservation Investment Program (ECIP) to support implementation of water projects.

1.5 Mode of technology transfer

It is anticipated that the results of this work will inform decisions about policy and technology related to water conservation and efficiency across Army installations, and specifically, at Army training areas. The findings from the assessment are the basis for recommended demand- and supply-side water efficiency measures at Camp Atterbury.

It is also anticipated that this information will support changes to policy and specifications, e.g., whole building design guides and UFCs. Data accrued from post-construction building monitoring will be used to inform Return on Investment (ROI) calculations for water best management practices (BMPs). Demonstration results will be provided to the Building Design Standardization community and will be made available to the general user community via the US Army Corps of Engineers (USACE) Environmental Community of Practice, the Sustainable Design and Development Water Conservation website, and the Water Management Toolbox. This information will also be disseminated through Engineer Technical Letters (ETLs); Engineering and Construction Bulletins (ECBs); Engineer Instructions; such journal publications as the *Public Works Digest* and *Corps Environment*; and at workshops and symposia. This report will be made available through the World Wide Web (WWW) at URL:
http://www.cecer.army.mil

2 Army Training Area Water Challenges

Army training offers both challenges and opportunities for water conservation, both in implementing technologies and in reaching a broad cross-section of soldiers for water awareness education.

2.1 Army training areas

The Army's Training and Doctrine Command (TRADOC) trains and educates soldiers, leaders, and units across the Army. TRADOC maintains 32 schools throughout the continental United States at 20 different locations. More than 500,000 soldiers are trained at these facilities each year (TRADOC 2012).

2.2 Water use on training installations

The challenges of managing water consumption at training areas are different from such challenges at other Army installations. Water use on training installations includes some conventional end uses, but also includes special uses associated with training. Training populations come from many regions that vary in water availability; thus sensitivity to issues of water scarcity also varies. In addition, soldiers in training are often preparing for deployment to austere environments where water conservation is critical to the Army mission.

2.3 Camp Atterbury, IN

Camp Atterbury, located in Edinburgh, IN, is the host for training for active duty Army, Army Reserves and National Guard, Marine Corps, and other units that train and mobilize at the installation. Camp Atterbury has numerous types of live firing ranges and over 33,000 acres of maneuver training area. The Training Center also has headquarters facilities, and numerous operational, housing, and other facilities that support full-spectrum, integrated, live, virtual, and other training events for brigade combat teams. Over the past decade, Camp Atterbury and its partners, the 205th and 157th Infantry Brigades, have mobilized over 50,000 and demobilized over 30,000 soldiers, sailors, and airmen for duty in the United States and overseas. The Camp Atterbury staff includes over 700 soldiers, state employees, and contract personnel (Camp Atterbury 2011).

3 Technology Assessment

This Technology Assessment took the form of a pilot study at the Camp Atterbury Joint Maneuver Training Center (CAJMTC) in Indiana. Project components included observation of the current state of water infrastructure and water usage on the installation, a survey of training units on their attitudes and practices regarding water use, an upgrade to personal and communal water facilities with new technologies, and the implementation of an awareness campaign to promote conservation habits.

3.1 Demonstration site: Camp Atterbury, IN

Originally constructed in 1942 to serve as a training facility for World War II, Camp Atterbury was deactivated from 1948 until 1950, when it was reactivated to support efforts in the Korean War. The installation was deactivated again in 1954, after which it was used for various training purposes over the years until it was eventually turned over to the Indiana National Guard. Camp Atterbury was reactivated by the Army in 2003 to serve as a training and mobilization base for forces being deployed to Afghanistan and Iraq. Its current three-part mission is:

1. To serve as a Forces Command Power Generation Platform and 1A Mobilization Station – the designated mobilization site for many units of the National Guard and US Army Reserve
2. To serve as a premier training site for both individuals and units from all branches of service for both Reserve and Active Duty training and other special training events
3. To serve as a training site for all Public Service organizations such as Department of Homeland Security, State and Local Police, and other first responders (Camp Atterbury 2011).

3.1.1 Current configuration

Camp Atterbury is located near Edinburgh, IN, approximately 30 miles south of downtown Indianapolis (Figure 1). The installation straddles three counties (Johnson, Brown, and Bartholomew), which contain the bulk of the land.

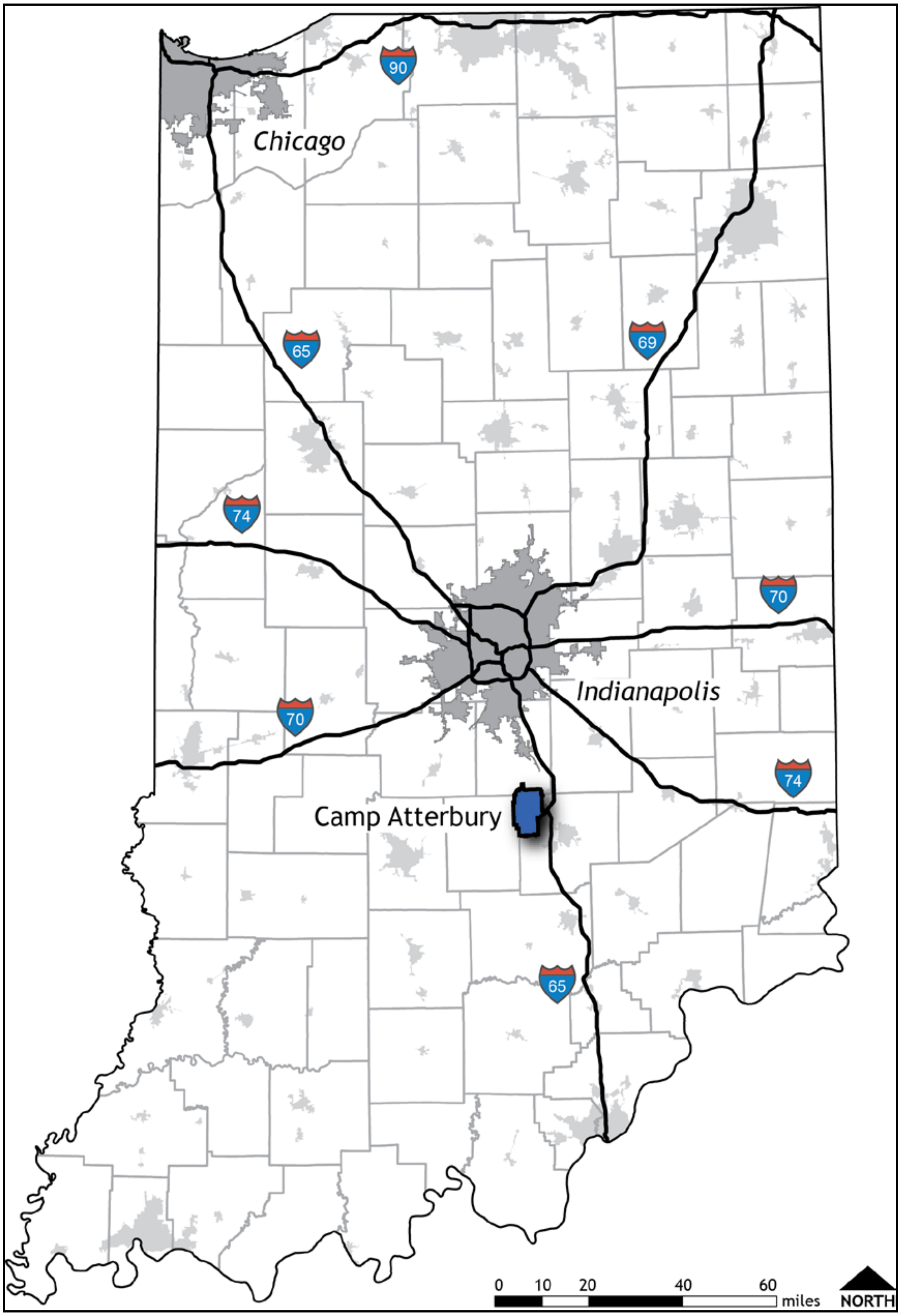

Figure 1. Location of Camp Atterbury in Indiana.

Camp Atterbury currently controls over 33,000 acres of maneuver training area and many live firing ranges (Figure 2). The primary assets used by training units for long-term stays are three Contingency Operating Locations, or Forward Operating Bases (FOBs). The FOBs include barracks, classrooms, shower and bathroom facilities, and dining facilities (DFACs). (This report uses the term “FOB” to refer to the training camp locations.)

Other facilities in the cantonment area include offices, Army and Air Force Exchange Service (PX), medical clinic, fire station, conference center, recreation center, gym, museum, swimming pool, laundromat, and barbershop.

3.1.2 Historical strength

Tenant presence at Camp Atterbury varies throughout the year (Figure 3). The FOBs provide the most versatility to units and can accommodate multiple units at the same time. They are therefore the most heavily used assets on the installation in terms of raw personnel. The summer months are busier for the FOBs and the installation overall, but training activities happen year-round.

3.1.3 Overview of range training facilities at Camp Atterbury

Range training facilities at Camp Atterbury include three FOBs: FOB 1–Warrior; FOB 2–Bayonet; and FOB 3–Nighthawk.

Each FOB maintains two Remote Mobile Shower (ReMS) units, commonly referred to as “connexes” (also “trailers”). Soldiers and other units use the connexes for showering and sink washing activities while on location at the testing and training ranges. The six connexes at the three FOBs were evaluated for this assessment (Figures 4 and 5).

3.1.4 Sources of water supply

Potable water is supplied to Camp Atterbury by Prince’s Lakes Water Department, a public water supplier located in adjacent Nineveh Township, IN. Two water mains supply the installation, and each is master metered. There is also a master meter to FOB 3.

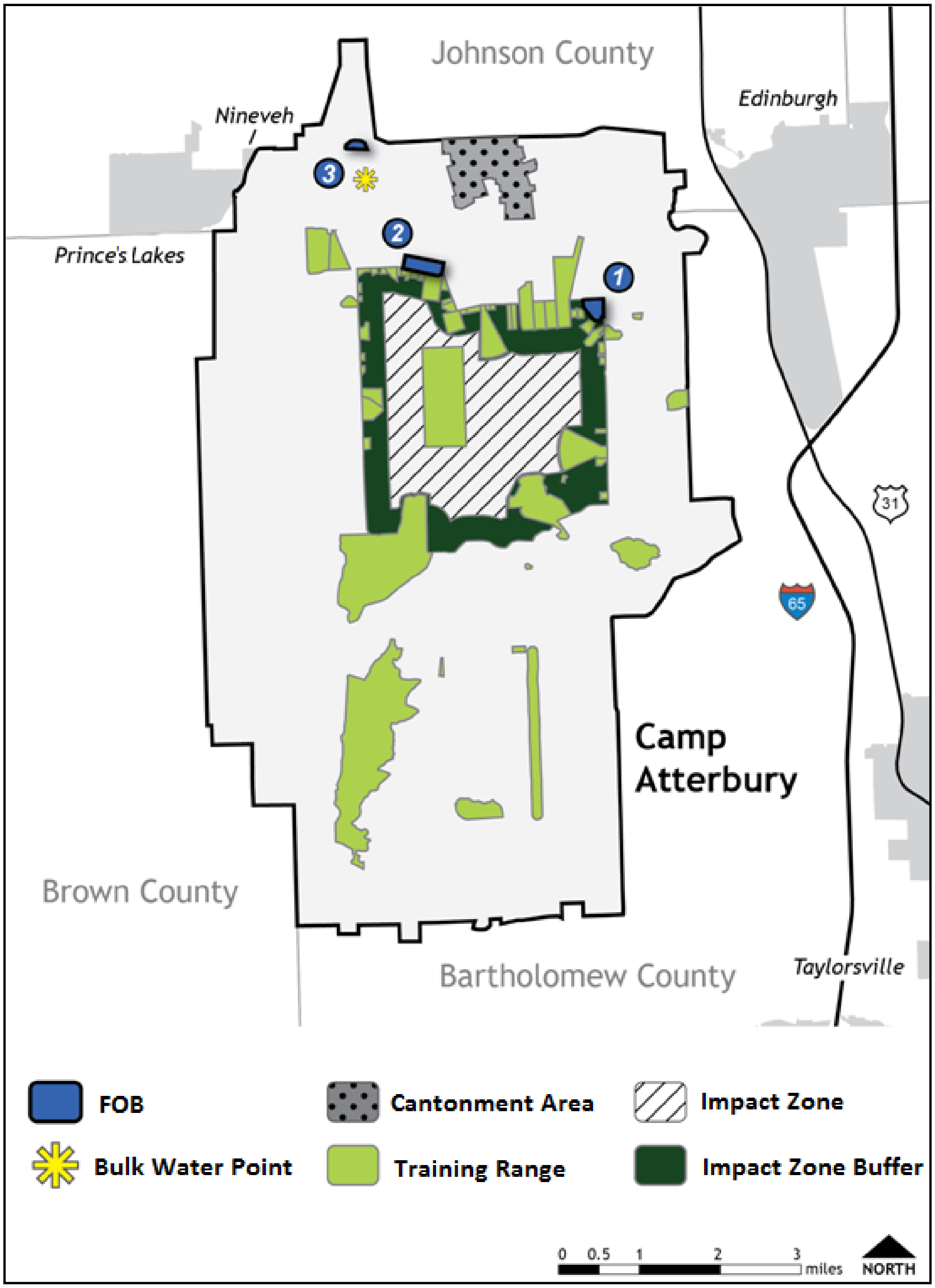

Figure 2. Camp Atterbury configuration.

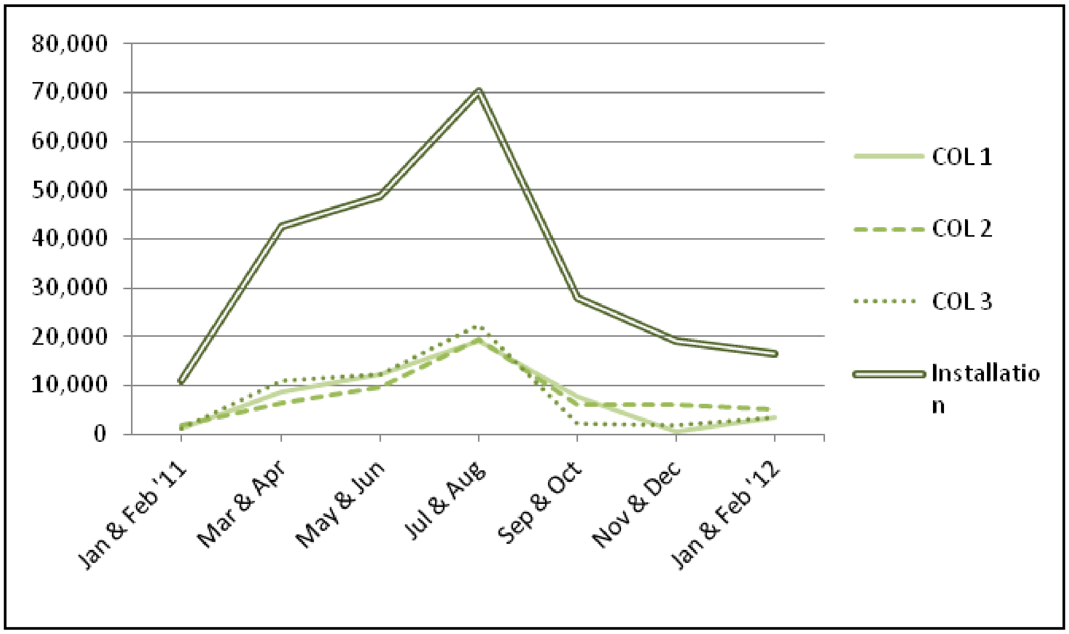

Figure 3. Training personnel at Camp Atterbury in 2011.

Figure 4. Remote Mobile Shower (ReMS) unit exterior.

Figure 5. ReMS interior.

The connexes in FOBs 1 and 3 are supplied with potable water directly from the installation's underground water distribution main. FOB 2 connexes were not directly piped into the distribution main, but instead are serviced by a bulk water tank located (at the beginning of this study) inside the connexes (Figure 6). The tanks were replenished as needed from one of the two potable bulk water facilities located at Camp Atterbury. However, the water supply line was connected to installation water before the technology retrofits.

3.1.5 Wastewater disposal

Wastewater is generated by the FOBs from different devices and is dependent on the FOB. FOB 1 has a 2600-gal greywater tanks that are buried beneath the ground. The tank is pumped out by a contractor at intervals that depend on the training schedule.

Figure 6. Bulk water tank in FOB 2 ReMS.

3.2 Pre-retrofit water efficiency evaluations

A water efficiency evaluation of the six connex units at FOBs 1, 2, and 3 and their existing showerhead and faucet fixtures was conducted in October 2011. The following paragraphs describe the site evaluation approach, fixture flow measurements, and findings.

3.2.1 Description of ReMS connex units

Precision Products, Inc., based in Greenwood, IN, is the manufacturer of the six ReMS connex units at FOB 1, 2, and 3. The connex units, Model #45-6X6-MU, were installed at the FOBs between approximately late 2006 and early 2007. Figure 7 shows the manufacturer's exterior and interior views and a schematic of the connex model installed at Camp Atterbury.

Figure 7. ReMS connex (Precision Products Inc.).

Each connex at the FOBs was installed with the following plumbing fixtures, flow rates, water system components, and capacities (Precision Products 2007):

- 12 showers (with anti-scald valves), maximum 2.5 gpm
- 8 sink (manual) metering faucets, maximum 0.5 gpm per handle activation
- 1 utility/mop sink
- high-volume on-demand hot water heaters
- high-volume pumps
- 2600-gal potable water tank

- 2600-gal gray water holding tank
- city/outside water and sewer hookups
- 2-in. quick disconnect on outside fresh water connection
- 3-in. quick disconnect on outside gray water connection.

3.2.2 Data collection procedures and tools

Procedures for the evaluation of each showerhead and faucet in the ReMS included:

- Fixtures were visually inspected to evaluate functional condition, e.g., working or broken, missing parts or fixture, leakage, etc.
- Fixture flow rate markings (if shown) were noted.
- Flow rate measurements tests (3) were done, in units of average gallons per minute (gpm).
- For faucets, metering cycle length per hand activation (minutes) and volume of water delivered per handle activation were measured.
- For showerheads, average volume (gallons) of water delivered per minute was measured.
- Pictures were taken of all pre-retrofit showerheads, faucets, and related water system components in the connexes at FOBs 1, 2, and 3.

Water temperature and pressure conditions at the fixtures were also noted. Most showers delivered warm-to-hot water during the flow tests. None of the faucets delivered hot water; most were cold or room temperature. The hot water heaters appeared to be connected only to the showers and not the faucets. Water pressure was adequate in most of the connexes. Variations in pressure and hot water were observed in some connexes. These may have been due to low water volumes in the bulk water storage containers or the connex water pumps having been shut-off during a site evaluation while a vendor was servicing the connex.

Tools used to inspect, measure, and record fixture flows and related features for the site assessment included:

- data collection forms for showerheads (Figure 8)
- data collection forms for faucets (Figure 9)
- fixture flow measurement bag (Figure 10)
- leak measurement ruler (Figure 11)
- fixture inspection mirror, magnifying glass, and flashlight (Figure 12)
- digital camera.

COL/FOB NUMBER & NAME, CONNEX/TRAILER#:			
Data Collection	**SHOWER #1**	**SHOWER #2**	**SHOWER #3**
Date & time flow tests and pictures taken (appx):			
Year fixture installed:			
Flow rate marking on showerhead, gallons per minute (gpm):			
Flow rate measurement, avg. gpm (avg. of 3 flow tests)			
Difference in actual vs. rated flow, gpm:			
Leakage (yes/no; est. leak gpm):			
Condition of fixture			
good working order:			
poor/broken/clogged:			
Additional Notes:			

Figure 8. Showerhead data collection form (Vickers).

FOB NUMBER & NAME, CONNEX/TRAILER#:			
Data collection	FAUCET # 1	FAUCET # 2	FAUCET # 3
Date & time flow tests and pictures taken (approx):			
Year fixture installed:			
Aerator installed?			
Flow rate marking on faucet, gpm:			
Flow rate measurement, avg. gpm (avg. of 3 flow tests):			
Difference in actual vs. rated flow, gpm:			
Faucet metering cycle, seconds:			
Est. volume per cycle, gallons:			
Leakage (yes/no; est. leak gpm):			
Condition of fixture:			
good working order:			
poor/broken/clogged:			
Additional Notes:			

Figure 9. Faucet data collection form (Vickers).

Figure 10. Fixture flow measurement bag.

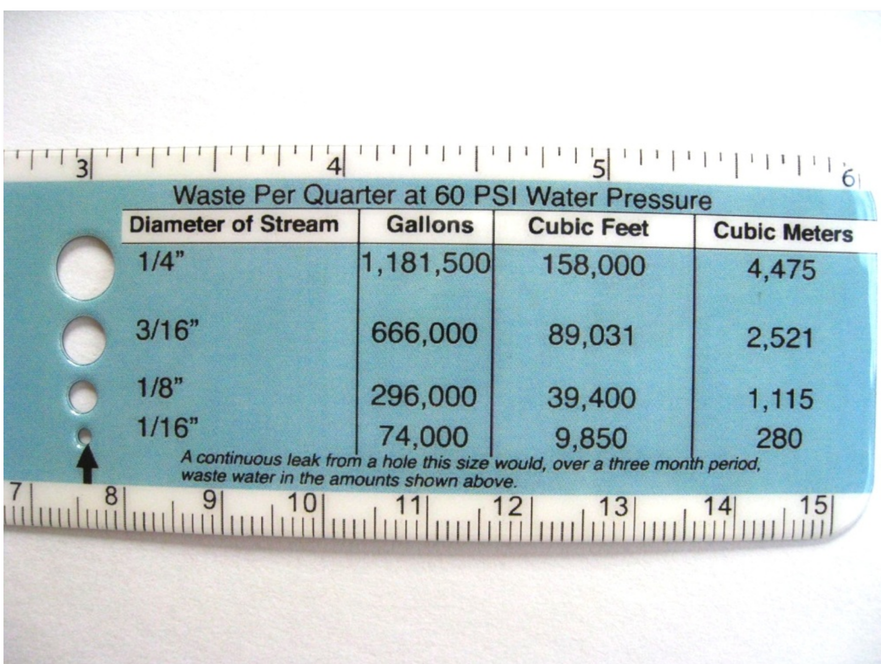

Figure 11. Leak measurement ruler.

Figure 12. Fixture inspection mirror, magnifying glass, and flashlight.

3.2.3 Hard water quality problems with fixtures in connexes

Camp Atterbury in general, and the FOBs in particular, have hard water. During the October 2011 pre-retrofit site evaluation and technology assessment phase of the project, it was found that calcium and lime buildup required the removal and cleaning of the water fixtures at all three connexes as often as once per week, sometimes more often under heavy usage. This level of regular maintenance was carried out by the staff. Significant local water quality problems caused by hard water resulted in excessive mineral buildup in the fixtures at all six connexes at FOBs 1, 2 and 3. During the technology assessment, excessive calcium/lime scale in the fixtures was found to cause poor flow volumes and distorted sprays for many of the fixtures at all three of the FOBs. As a result, the pre-retrofit (October 2011) fixture flow measurements recorded are likely *not* representative of the types of flows that would occur under normal water quality conditions.

The common types of fixture malfunctions due to hard water quality conditions observed in the six connexes were:

- significantly reduced flows in most showerheads and faucets
- very high flows in a small number of fixtures
- distorted spray patterns–tilted, overspray (outside shower stall, sink)

- fixtures that were broken or had other malfunctions (dribble only, missing fixture component, no water delivery, etc.)
- leakage.

Excessive mineral deposits of calcium and lime due to local hard water conditions were visible in many of the fixtures evaluated. Figures 13 and 14 show commonly observed calcium/lime and in some cases rust deposits on showerheads and faucet aerators.

Figure 13. Examples of excessive mineral (calcium/lime) buildup in showerheads, showerhead leaks, and malfunctions.

Figure 14. Examples of excessive mineral (calcium/lime) buildup in faucets, broken faucets, and sink overspray.

An installation site assessment by Camp Atterbury Directorate of Public Works (DPW), contractors and product vendors concluded that water softeners are needed at the connexes to correct fixture performance problems and ensure accurate water meter data collection for this project. Water softeners are used for most of the other buildings and facilities at Camp Atterbury, which explains why the problem appears to be confined to the FOBs only. As a result, water softeners were installed and became fully operational at the FOB connexes in January 2012.

Before the installation of water softeners, FOB mayors for several years have been responding to the chronic fixture clogging problem by frequently (at least monthly) inspecting and cleaning the fixtures to keep them operating at acceptable levels for soldiers and other units that use the connexes. The cleaning procedure is required every 2 to 4 weeks; this is laborious (a total of 120 labor steps at least monthly for each FOB), incurs some expense for each FOB, and includes:

- removal of all clogged showerheads and faucet aerators (total 24 showerheads and 16 faucet aerators for two connexes at each FOB)
- cleaning of 40 clogged fixtures with CLR®,* which requires several hours of soaking the fixtures to dissolve mineral buildup
- reinstallation of 40 showerheads and faucet aerators post-cleaning.

Lost productivity and additional labor and maintenance costs associated with the excessive cleaning required for the showerheads and faucets to make them usable in the connexes were incurred before the installation of the water softeners. In some instances, fixture cleaning must be done on a rushed basis when there was short notice that training units would be arriving at the FOB. Showerheads typically require cleaning to remove debris and minor mineral buildup about once per year or so under normal water quality conditions. Showerhead and aerator cleaning practices at the FOBs occurred at rates more than twelve times that of fixtures used in normal water quality conditions.

Follow-up investigation of the hard water and related fixture clogging problems resulted in plans to install water softeners by January 2012 in at least the four connexes at the two FOBs (2 and 3) to be used in the next

* CLR® (Calcium, Lime, Rust) is a common retail cleaning product used to dissolve scale and stain problems caused by hard water, typically calcium, lime, and iron oxide deposits, such as those that occur in plumbing fixtures at the connexes.

phase of this study (retrofit fixture installation and experimental and baseline sites' water use monitoring). More frequent cleaning of the water heaters in each of the connexes has also been recommended.

3.2.4 Fixture flow measurements

Fixture flow measurements and related observations were recorded for each of the 72 showerheads and 48 faucets in the six connexes evaluated at FOBs 1, 2, and 3.

3.2.4.1 Showerheads

Figure 15 shows the measured flow rates for all 72 showerheads, including the manufacturer's fixture design flow rate of a maximum of 2.5 gpm, in the six connexes at the three FOBs. Figure 16 shows the same measured flow rates, presented from lowest to the highest. The measured flow rate for all 72 showerheads averaged 1.43 gpm—about 0.57 gpm less than the showerheads' design maximum rated flow of 2.5 gpm.

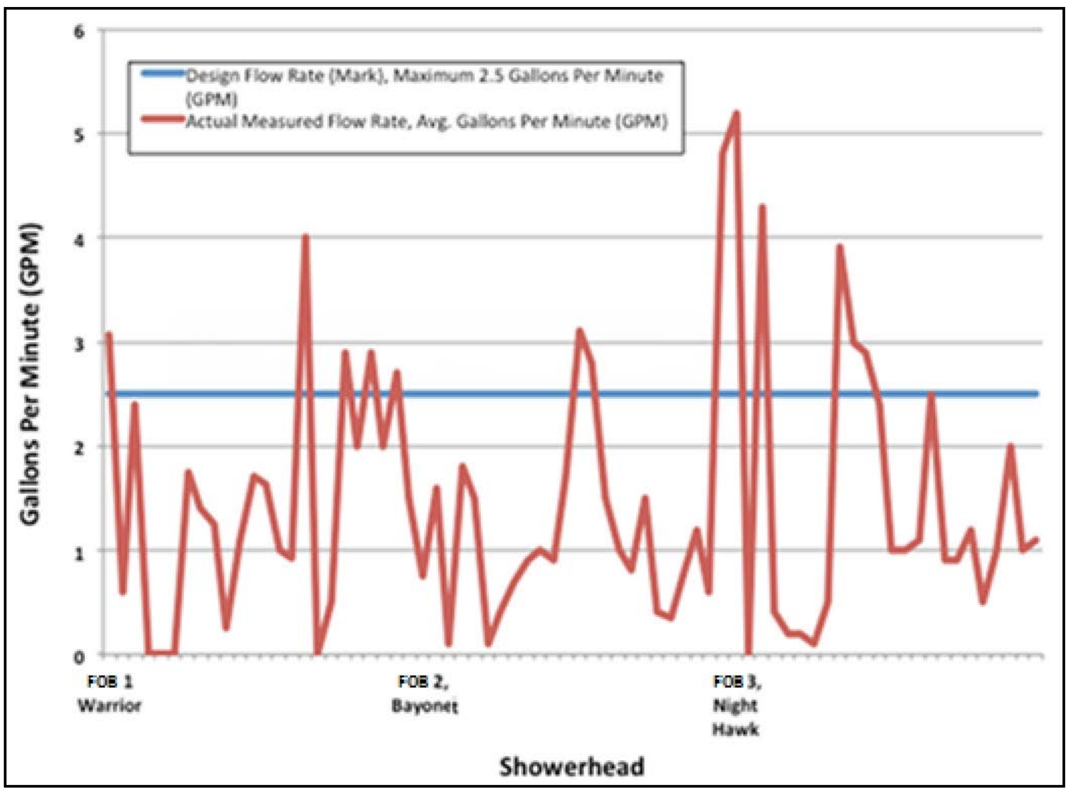

Figure 15. Design flow rate and actual measured flow rates of 72 showerheads in FOBs 1, 2, and 3 (average gpm).

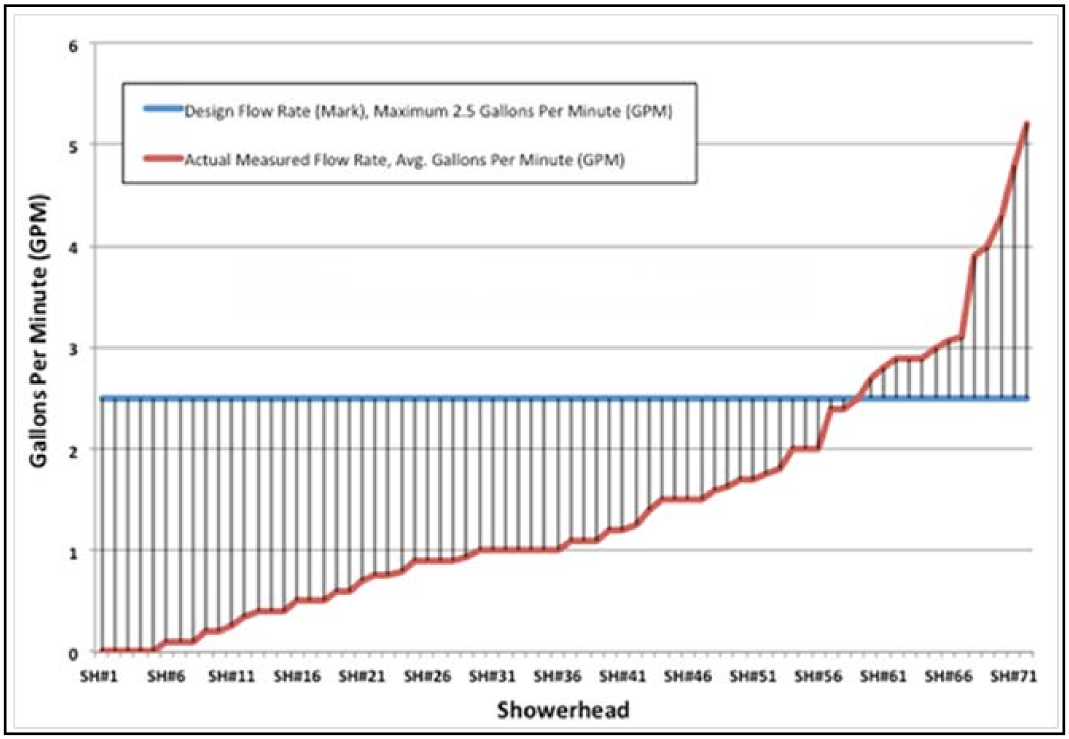

Figure 16. Design flow rate and cumulative actual measured flow rates of 72 showerheads in FOBs 1, 2, and 3 (gpm).

The measured showerhead flow rates, which average over 20% below their maximum rated flow, and their spray force and spray pattern, were generally found to be very poor. The low flow volumes measured are neither a reflection of water efficiency nor inefficiency, but rather fixture clogging and malfunction due to excessive calcium/lime buildup inside the fixture and in the metal spray pores (openings). The data in Table 1 show that only a small portion of the showerheads (15%) were found to be operating within the acceptable flow range for a conventional showerhead, i.e., from 1.70 gpm to 2.5 gpm (Vickers 2001).

Differences in showerhead flow rates among the connexes and FOBs are likely a reflection of the amount of time since the fixtures were last cleaned with CLR®, which varies by FOBs depending on the population sizes using the connexes and related fixture cleaning needs.

Actual design maximum flow rates for some showerheads installed in the connexes may be 2.0 gpm (not 2.5 gpm as originally specified). Approximately 20% of the 72 installed showerheads have a visible “2.5 gpm” flow rate mark; the rest do not. Some fixtures are very worn, possibly due to regular cleaning for calcium/lime removal, which may have removed their flow rate marks.

Table 1. Categorical flow ranges for 72 showerheads in FOBs 1, 2, and 3 (gpm).

Measured Flow Rate	Showerheads	
	Number	Percent
Flow rate above 2.5 gpm (high)	13	18%
Flow rate from 1.7 to 2.5 gpm (acceptable for design flow rate)	11	15%
Flow rate below 1.7 gpm (low)	43	60%
No flow or dribble (broken)	5	7%
Total	*72*	*100%*

Many showerheads without visible flow rate marks bear a "CHATHAM" imprint for the Chatham Brass Company, a fixture manufacturer, and a few are simply stamped "CHINA." The "CHATHAM" showerheads —22 in FOB 2 and 15 in FOB 3— appear to match two identical looking Chatham Brass showerhead products: one operates at a maximum 2.0 gpm (Model 2-ISA-2 gpm) and the other operates at a maximum 2.5 gpm (Model 3-ISA-2.5 gpm).* Thus, the flow rates, under normal water quality conditions (no calcium/lime buildup), are unknown for these particular fixtures.

Lastly, the functional condition of showerheads in the connexes was also found to be poor. Seventy-five percent of the fixtures had poor flows, were broken, or were missing part or all of the showerhead (Table 2).

3.2.4.2 Faucets

Figure 17 shows the measured flow rates for all 48 Delta Faucet Co. sink metering faucets, including the manufacturer's fixture design flow rate of a maximum of 0.5 gpm, in the six connexes at the three FOBs. The measured flow rate for all 48 faucets averaged 0.51 gpm–very close to the faucets' design maximum rated flow of 0.5 gpm.

Table 2. Functional condition of showerheads.

Condition of fixture	FOB 1		FOB 2		FOB 3	
	#	%	#	%	#	%
Good working order	13	54%	3	13%	2	18%
Poor flow, clogged, broken or missing	11	46%	21	88%	22	92%
Total	*24*	*100*	*24*	*100*	*24*	*100%*
Leaking showerheads	0	0%	0	0%	4	17%

* Chatham Brass Company. Chatham Institutional Showerheads, Model 2-ISA-2 GPM and Model 3-ISA-2.5 GPM. Chatham Brass Company, South Plainfield, NJ.

However, the average flow rate as measured in gallons per minute belies the wide range of flow rates and metering cycles that were observed among the 48 faucets. Differences in faucet flow rates among the connexes and FOBs may be a reflection of the amount of time since the fixtures were last cleaned with CLR®, which varies by FOBs depending on the population sizes using the connexes and related fixture cleaning needs.

The sink faucets installed in the connexes are *metering* faucets. Metering faucets, unlike manually operated sink faucet taps found in homes and some nonresidential facilities, deliver water for a preset length of time or cycle. When the faucet handle is activated (pressed), water flows for a preset length of time and then automatically shuts off. (Users can reactivate the handle for another cycle of water flow.) Cycle lengths for metering faucets are factory preset to run typically for less than a minute. Thus, the volume of water delivered by a metering faucet is determined by the length of time water flows after the handle is activated. Cycle lengths of metering faucets can be adjusted; over time or with fixture malfunction cycle lengths may also change.

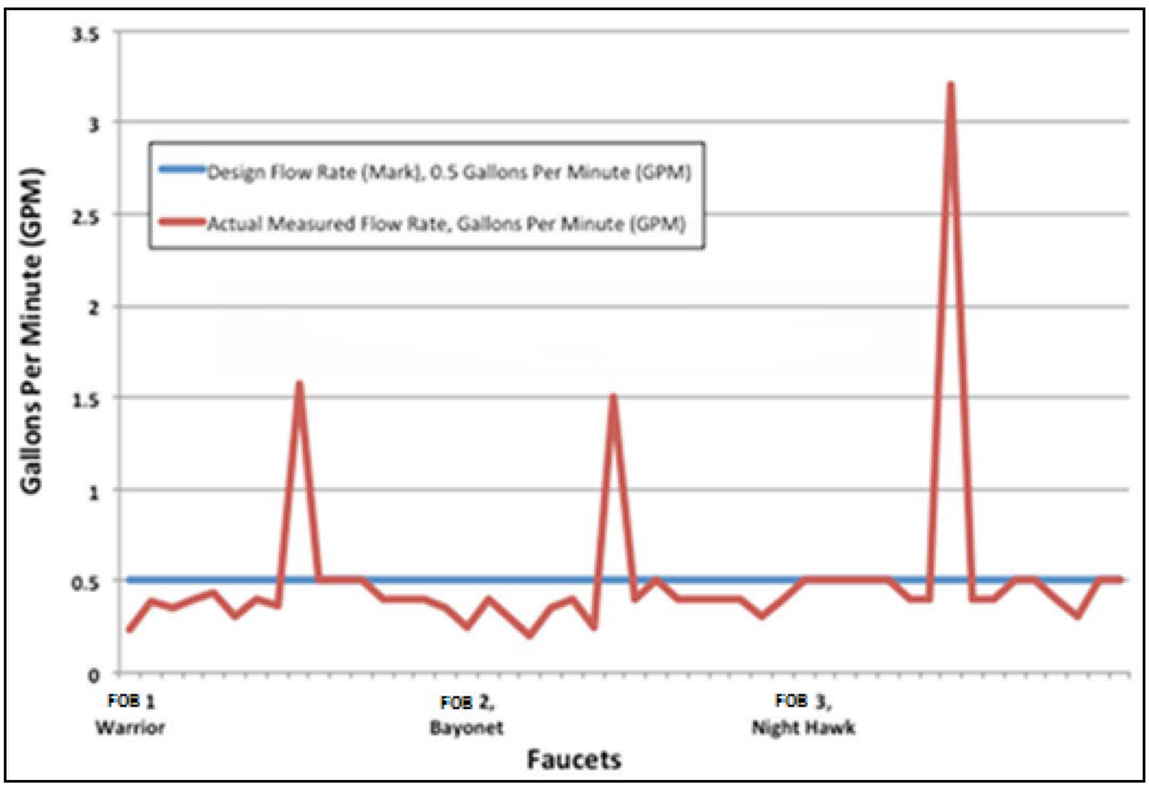

Figure 17. Design flow rate and actual measured flow rates of 48 faucets in FOBs 1, 2, and 3 (gpm).

The measured volume of water delivered for all faucets averaged 0.20 gal per handle activation, which is 0.075 gal higher than the 0.125 gal normally delivered per 15-second handle activation of a 0.5 gpm metering faucet. The average volume of water delivered per faucet varied from less than 0.1 to about 2.0 gal (Figure 18). The wide range in volume of water delivered by the faucets—which average very close to their design flow rate of 0.5 gpm—is due to the wide range in the length of preset flow cycles (seconds) found among the faucets, which range from a few seconds to over 5 minutes (Figure 19). The average length of flow per handle activation was 26.0 seconds; the factory preset for this faucet type is usually a maximum of 15 seconds (Delta Faucet Co. Undated).

The measured faucet flow rates were generally found to be poor. This condition was attributed to the calcium/lime mineralization problem, with many having very low or minimal flows and a small number with very high flows. Only 3 faucets (6%) were found to be operating within the acceptable 0.35 gpm to 0.5 gpm flow range for a metering faucet (Table 3). Too low, minimal flow, and in some cases no flow conditions were found at 42 (87%) of the faucets. Users of these faucets likely have to activate the handle multiple times to get sufficient water while using the sink.

The functional condition of faucets in the connexes was found to be poor for 27% of fixtures that had poor flows, were broken or missing part or all of the faucets (Table 4).

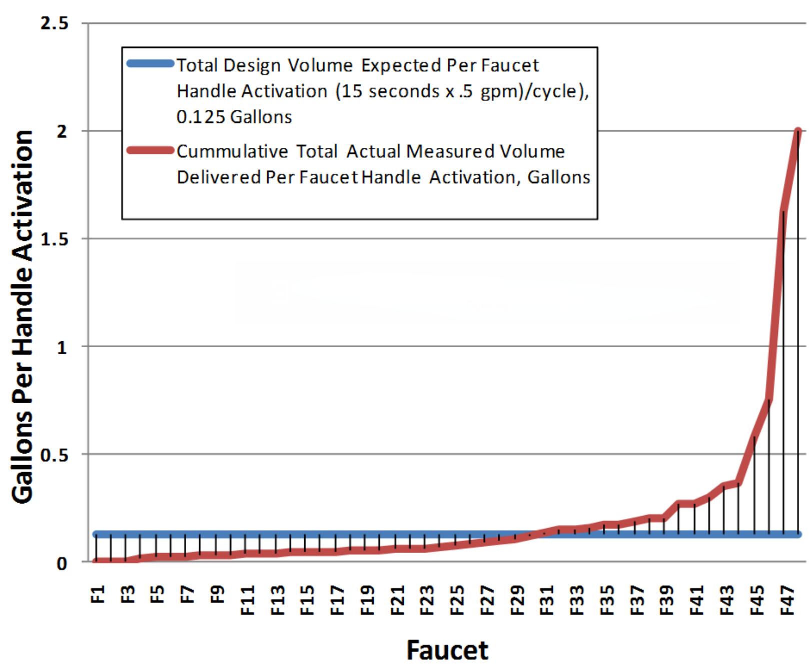

Figure 18. Design total volume and cumulative actual volume delivered per handle activation; 48 faucets in FOBs 1, 2, and 3 (gal).

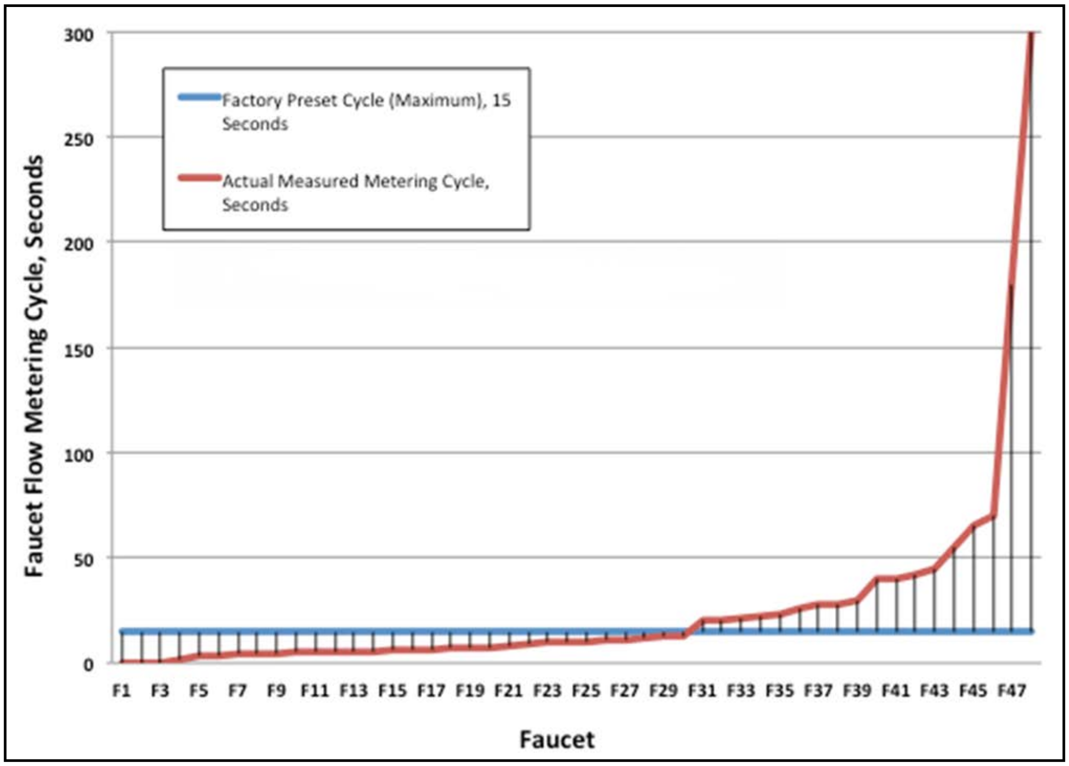

Figure 19. Design (factory preset) flow metering cycle and cumulative actual flow cycles of 48 faucets in FOBs 1, 2, and 3 (seconds).

Table 3. Categorical flow ranges for 48 faucets in FOBs 1, 2, and 3 (gpm).

Measured Flow Rate	Showerheads	
	Number	Percent
Flow rate above 0.5 gpm (high)	3	6%
Flow rate from 0.35 to 0.5 gpm (acceptable for design flow rate)	3	6%
Flow rate below 0.35 gpm (low)	25	52%
No flow or dribble (broken)	17	35%
Total	*48*	*100%*

Table 4. Functional condition of faucets.

Condition of fixture	FOB 1		FOB 2		FOB 3	
	#	%	#	%	#	%
Good working order	13	81%	10	63%	12	75%
Poor flow, clogged, broken or missing	3	19%	6	38%	4	25%
Total	*16*	*100*	*16*	*100*	*16*	*100%*
Leaking faucets	1	8%	4	33%	1	8%

3.3 Bulk water point

3.3.1 Description

Bulk Water Stations are used to supply water trucks. The water is then trucked to remote locations to support different field activities. Figures 20–22 show common operation of bulk water stations at Camp Atterbury.

Camp Atterbury has three bulk water stations. One station is located at Schoolhouse Road and it appears to be the most convenient water supply location for the training FOB's. Another is located at First Street and has a platform to reach the top of the truck. The third one is located within the borders of FOB 3 training area.

3.3.2 Field survey

The field survey revealed that access to all the water stations is unrestricted and that water consumption is not monitored at any of the stations. Consequently, there is no good understanding of how much water is used t0 support training compared to other uses throughout the installation. There is therefore not a good estimate of potential water savings through bulk water control. Discussions with Camp Atterbury personnel determined that the bulk water station on the Schoolhouse Road was the primary water point used by training units to supply water to the ranges. Thus this water point (Figures 18 and 19), was chosen for the retrofit.

Figure 20. Schoolhouse Road bulk water station at Camp Atterbury.

Figure 21. Bulk water station at Schoolhouse Road before retrofit.

Figure 22. Bulk water station at First Street.

However, the site survey also revealed that electric power is not available near the Schoolhouse bulk water station. The cost to Camp Atterbury to provide a power source to the bulk water point was prohibitive. Therefore, the bulk water point reader specifications were modified to include a solar-powered water meter and automated card reader. This increased the cost of the bulk water point significantly enough that one of the two composting toilets originally planned for installation was taken off the project.

3.4 Composting toilet

3.4.1 Description

There are currently 550 portable latrines located throughout Camp Atterbury. The average capacity of the latrines is 70 gal. This capacity can support an average of 30 visits per day. All fire ranges are provided with portable latrines to support the training activities. Figure 23 shows two of the many portable latrines at Camp Atterbury and its associated washing station. Camp Atterbury requires three portable latrines for every 100 personnel.

3.4.2 Field survey

The composting toilet retrofit field survey revealed that portable latrines are located in remote locations without nearby electric power or water connections. The portable latrines are serviced by an existing maintenance contract. Maintenance of the latrines occurs at least three times a week.

Figure 23. Portable toilets at a typical firing range.

Cleaning of the latrines alternates every other day and the location of the cleaning is based on the types of activities scheduled for the installation. Cost of the latrines includes the daily latrine and hand sanitizer rental fee, and the cleaning maintenance. Based on the rate information obtained from Camp Atterbury contracting invoices, it is estimated that the annual rental and maintenance cost per latrine is approximately $1700 per year. The total costs to service the 550 existing portable latrines at Camp Atterbury is approximately $935,000 per year. Many of the portable latrines do not receive their maximum capacity daily usage. In the more remote locations on base they likely receive one to five visits per day. Regardless, they are still serviced every other day at a cost of $1700/year. It should also be noted that the cost to maintain portable latrines varies by installation. The annual maintenance cost of Camp Atterbury's portable latrines is actually considered low compared to other locations. One extreme example was cited at Fort Bliss where it cost up to $20,000 per year per unit due to the remoteness of the locations (Mills 2012).

4 Recommended Retrofits

4.1 Recommended showerhead and faucet fixture retrofit flow rates

Table 5 lists the recommended flow rates for showerhead and faucet aerator retrofits at the two experimental connexes at Camp Atterbury. Fixtures currently installed in the two connexes at FOB 2 (Bayonet) Connex East and FOB 3 (Nighthawk) Connex North, will serve as the control or baseline sites for the study. These fixtures comply with the maximum flow rate requirements set forth in EPAct 1992. The recommended ultra high-efficiency flow rates for fixture retrofits to be installed at the two experimental connexes at FOB 2 (Bayonet) Connex West and FOB 3 (Nighthawk) Connex South meet and exceed Army requirements (American Society of Heating, Refrigerating, and Air-Conditioning Engineers [ASHRAE] 189.1-2009) for showerheads —maximum 2.0 gpm, public lavatory faucets—maximum 0.5 gpm, and public self-closing faucets— maximum 0.25 gal/cycle.

4.2 Potential water savings from fixture retrofits

Table 6 lists estimated potential water savings from the recommended fixture flow rates in the two experimental connexes compared to the two control connexes.

Table 5. Recommended showerhead and faucet retrofit fixture flow rates.

	Showerheads	Faucets Public Metering Self-closing			
FOB	Max gpm @ 80 psi	Max metering cycle, gallons	Max flow cycle, seconds	Max gpm @ 60 psi	Rqmts/ Standards
FOB 2 Connex East–Baseline	2.5	0.25	30	0.5	EPAct 1992
FOB 3 Connex North–Baseline	2.5	0.25	30	0.5	
FOB 2 Connex West–Experimental	1.5	0.25	42	0.35	Army*
FOB 3 Connex South–Experimental	1.5	0.25	42	0.35	

* ASHRAE 189.1-2009 Ultra high-efficiency recommendations meet and exceed Army requirements.

Table 6. Potential water savings from recommended fixture flow rates.

FOB	Showerheads	Faucets Public Metering Self-Closing			Rqmts/Stds
	Max gpm @ 80 psi	Max metering cycle, gallons	Max flow cycle, seconds	Max gpm @ 60 psi	
Baseline flow rates	2.5	0.25	30	0.5	EPAct 1992
Experimental flow rates	1.5	0.25	42	0.35	Army*
Potential water savings per fixture from baseline:	1.0	N/A	N/A	0.15	
	Showerheads, gallons per capita per day (gpcd)			Faucets, gallons per capita per day (gpcd)	
Potential water savings in domestic house-holds†	5.3			0.6	Mayer et al. 1999‡

* ASHRAE 189.1-2009 (ultra high-efficiency recommendations meet and exceed Army requirements).

† Estimated gpcd savings shown reflect usage patterns in domestic households. Usage characteristics for showerheads (average about 5.3 minutes per person per day) and lavatory faucets (average about 4.0 minutes per day per person) in homes are established, but use in nonresidential settings such as military showering facilities and barracks are not reliably reported and thus not shown.

‡ Residential water usage characteristics.

4.3 Recommended water softener installation

The demonstration project's water technology consultant recommended installation of water softeners in the two experimental connexes and two baseline connexes at FOBS 2 and 3 to solve the high mineral buildup and associated chronic flow restriction problems occurring with the shower-heads and faucets. Installation of water softeners should stop or minimize the lime/calcium problems and enable the fixtures to flow at or near their manufactured flow rate.

The installation of water softeners was necessary to ensure reliable fixture flow rates and accurate water meter data collection to meet the reporting objectives and goals of this demonstration project. Unchecked lime/calcium buildup in the connexes (baseline and experimental) fixtures and water meters will distort both fixture flows and water meter readings, and will produce problematic (if not unusable) data.

4.4 Recommended bulk water point retrofits

The technology options for bulk water readers at the time of this demon-stration were limited to using either a card-based system or a keypad code-based system. It was initially assumed that the coded reader would be preferable, but Camp Atterbury staff requested the card reader. Figure 24 shows the schematics of a card reader bulk water dispenser.

The retrofit contains a pulse reading meter and a card reader that is powered by a solar panel. Appendix A contains a description of the selected card reader. There was no baseline usage data for the bulk water point. For this reason, the retrofit was planned for two phases:

- Phase I was planned to install a water meter powered by the solar panel.
- Phase II was planned to install the actual card reader controlling the bulk water delivery valve.

Coordination with the contractor and installation personnel was recommended to make sure Range and Training personnel would know how to use the equipment after Phase II installation.

4.5 Recommended composting toilet retrofits

To potentially offset the costs needed to maintain multiple portable latrines, the selected retrofit was the Clivus Multrum M54 Trailhead Composting Toilet. The M54 Compost Toilet system is comprised of a composting unit with integrated bathroom structure. The composting unit serves as the “foundation” for the lightweight structure and is typically buried to a depth of approximately 4 ft. No concrete foundation is necessary. The bathroom structure meets Americans with Disabilities Act (ADA) code. No water is used for flushing. All waste matter is contained within the compost unit; there is no discharge into the surrounding environment.

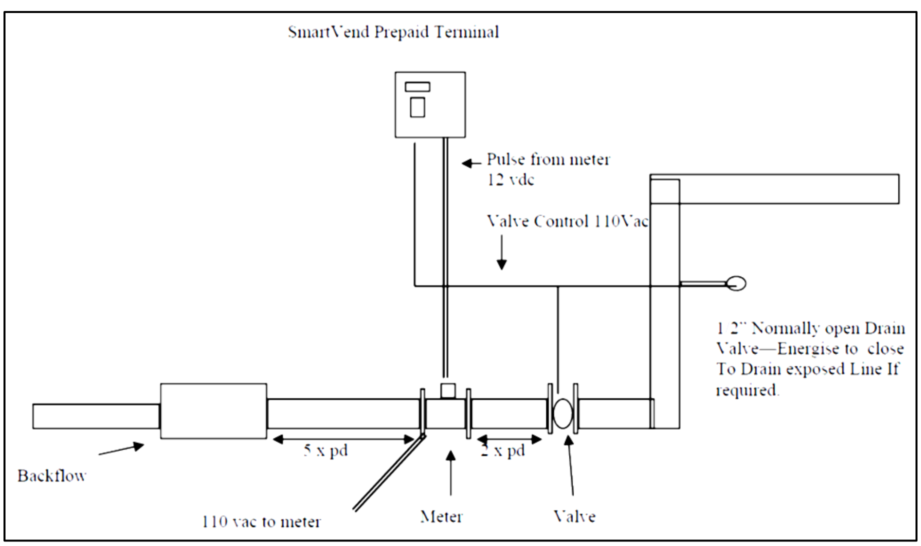

Figure 24. Schematics of smart bulk water delivery system.

The bathroom is kept continuously odorless by the action of a fan that pulls air down the waterless toilet chute. The unit's fan is powered by a photovoltaic system. The M54 Compost Toilet system has a rated capacity of 60 uses per day at conditions of 65 °F. At the rated daily capacity for the site selected, the unit requires maintenance once every 3 months with an estimated $1800 average annual maintenance cost. Cost of maintenance is typical deferred to the units that use the facilities during training; it may be at the discretion of the commanding officer to include this service in the training contract. (During a recent site visit, it was observed that routine maintenance had not occurred on several portable latrines.)

The compost process is aerobic decomposition. The primary vent-gas is carbon dioxide, which is removed by the solar-powered fan. Both urine and feces are converted into fertilizers that can be used to enhance soil fertility and plant growth. The M54 can be installed in less than 3 days. Appendix B contains manufacturer's product information for the Clivus Multrum composting toilet.

Site selection for the installation of the composting toiled was subject to two constraints: (1) the maximum number of daily visit could not be more than 60, and (2) the toilet should not be located in a low point where storm water would tend to accumulate. Moreover, the toilet should be located in an area where the maximum number of people would be able to take advantage of it. Using available historical and forecasted training data, geological data for water table levels, and Environmental Protection Agency (EPA) guidance, the site selected for installation was located between Ranges 18 and 19 because this location met the three stated requirements.

The exact location for the installation was chosen to be between the ranges rather than immediately next to the ranges. This offsets the composting toilet about 25 yards away from the road and about 50 yards away from the immediate ranges. Camp Atterbury selected this location to encourage Soldiers to use the unit while they are transitioning between Ranges 18 and 19, which is in the path of their typical training rotation. Since the existing portable latrines were left in place (due to contractual limitations), it was thought that more soldiers would choose to use the composting unit over the present portable latrines.

After choosing the site, verification for compliance was confirmed with the Indiana Department of Health. The Camp Atterbury's Cultural Resource Manager also verified that a submission to the State Historic Preservation Office for placement of the composting toilet was unnecessary (Cunningham April 2012). Figures 25 and 26 show site location and pre-installation survey.

Figure 25. Site of composting toilet installation.

Figure 26. Personnel in photo show location of selected site.

5 Retrofit Installations

Connex units at FOBs 2 (Bayonet) and 3 (Nighthawk) were selected as the study sites for evaluation of water use and savings associated with the recommended fixture retrofits. Both FOBs have similar activity patterns that make them good sites for comparison. At each FOB, one baseline or control connex will keep its existing (conventional flow) fixtures and one experimental connex will have the recommended retrofit (experimental ultra high-efficiency) fixtures installed. Before the installation of retrofit devices, water meters were installed at all four connexes at FOBs 2 and 3 to collect before and after water use data that will be analyzed to measure water savings associated with the fixture retrofits. Water softeners were also installed in the connexes to correct water quality and fixture flow problems.

5.1 Connex water meter installation

Water meters were installed at the incoming water supply lines in the four connexes at FOBs 2 and 3 on 4 January 2012. All meters were the same type, Badger meter–Recordall® Cold Water Bronze Disc Model 70, 1-in. size (Figure 27). The meter register records in gallon units and includes a small leak indicator dial. The meters installed have a typical operating range of 1¼ –70 gpm.

Figure 27. Badger meter installed in the FOBs.

5.2 Water softener installation

Water softeners were installed in all four connexes at FOBs 2 and 3 on 9 January 2012. Each connex was equipped with two WaterBoss Model 900 units (one for each side). These were installed in the ReMS utility rooms (Figures 28 and 29).

The water softeners were not all immediately operational due to delays in acquiring salt supplies for the softeners, and some softener units fell into disuse when supplies ran out. By early April 2012 the FOBs were understood to have a steady supply of conditioning salt so that the softeners could operate continuously.

Figure 28. Water softener as seen in ReMS utility room.

Figure 29. WaterBoss softener display.

5.3 Showerhead retrofits

The recommended Delta 1.5 gpm pressure compensating showerhead retrofit was installed in the experimental FOB 2 West and FOB 3 South connexes on 2 May 2012 (Figures 30–32). (Installation was originally planned for 3 April 2012, but was delayed 1 month due to a sizing problem with the showerhead adapter.) For each shower stall, the showerhead installation process involved two steps:

1. The old 2.5 gpm showerheads were removed. Most of the showerheads could be unscrewed with a wrench, or in some cases, by hand. The reduction in the mineralization on the existing showerheads (to little or none, as shown in Figure 30) evidences the improvement to water quality in the connexes since installation of the water softeners.
2. The new 1.5 gpm showerhead and adaptor were installed. Adaptors are required to install most types of after-market showerheads to the existing Zurn wall-mounted shower panels in the connexes. During the 3 April installation, it was found that the adaptors that had been used on some of the existing 2.5 gpm showerheads did not fit the new 1.5 gpm showerheads. Installation of the new showerheads was delayed 1 month while correctly sized adaptors were produced and installed on 2 May.

Appendix C to this report contains the Delta Faucet Company specification sheet for the 1.5 gpm showerhead retrofit.

Figure 30. Showerhead after installation of water softener.

Figure 31. New showerheads showing adapter.

Figure 32. New showerhead installed at FOB 3.

5.4 Faucet retrofits

The recommended Delta pressure-compensating, 0.35 gpm faucet aerator retrofit was installed in the experimental FOB 2 West and FOB 3 South connexes on 3 April 2012. For each metering faucet, the aerator installation process involved three steps:

1. The old 0.5 gpm faucet aerators were removed. The tamper-resistant aerators require a key for removal and installation (Figure 33). High mineral buildup and/or debris were evident in most of the old aerators that were removed (Figure 34). The old rubber seal valve was warped compared to those in the new aerators (Figure 35).
2. New 0.35 gpm aerators (Figure 34) were installed into the metering faucets (Figure 35)
3. The faucet metering valve (cartridge) was adjusted to allow a maximum cycle of approximately 30 seconds, and not to exceed 0.25 gal per metering cycle (Figures 36–39). Wear in the flow valve cartridges of the metering faucets makes it difficult to set (and maintain) the same number of seconds per cycle for all the faucets, but most were close to 30 seconds.

Appendix C to this report contains the Delta Faucet Company specification sheet for the 0.35 gpm faucet aerator retrofit.

Figure 33. Installation of new aerator.

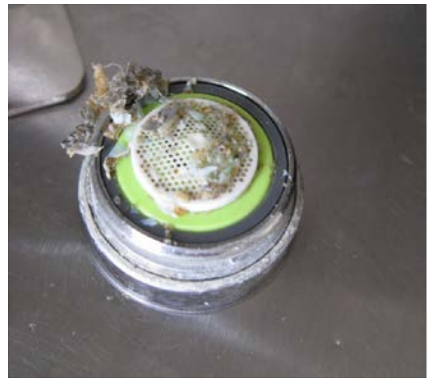

Figure 34. Corroded 0.5 gpm faucet aerator.

Figure 35. New 0.35 gpm and old 0.5 gpm faucet aerators.

Figure 36. New 0.35 gpm aerator installed.

Figure 37. Retrofitted metering faucet.

Figure 38. Checking the flow cycle.

Figure 39. Making timing adjustments.

5.1 Bulk water retrofit

The installation of the smart card reader at the Schoolhouse Road bulk water station was done in two phases as described in Section 4.4. In the first phase, the water meter and the valves were installed and water consumption was monitored for a period of 2 months (Figure 40). In the second phase, the card reader dispenser and the solar panel will be installed and cards will be issued to the different users so water use may be monitored by activity and by user. (This installation was planned for August 2012, after this report had been sent to editing. Results will be included in the addendum.)

Installation of the new water valve took place on 6 June 2012. During the installation a special reducer (from 6- to 4-in. diameter piping) had to be manufactured to adapt the 6-in. diameter of the existing pipes to the diameter of the valves and actuators. Additionally, adjacent piping required replacement due to its deteriorating condition (Figure 41).

At the time of this writing, the Phase II retrofit, including the installation of the actual card reader, was not yet complete. A water flow recorder set at 1-minute intervals was installed during valve installation, but no data have yet been downloaded for analysis.

5.2 Composting toilet installation

Installation of the M54 Composting Toilet system took 2 days during April 2012. The unit order was finalized after site selection was confirmed and the color of the above ground housing was chosen by Camp Atterbury staff (Figure 42). Since the installation, Clivus Multrum has received additional training data to schedule their maintenance. Camp Atterbury has taken the responsibility of maintaining the toilet paper stock. Current feedback from installation staff regarding the composting toilet has been positive and no smell has been noted during use. However, the usage is lower than was expected (Mills 2012). The unit's housing is so different from the typical portable latrines that it is possible that soldiers may not know that it is for their use. Additionally it must compete with more convenient portable latrines that are located directly adjacent to the road connecting the ranges at the Camp. The composting toilet's exact location is in the grassy area between fire ranges and not next to the fire ranges so soldiers are required to walk further to use it than to use the portable latrines adjacent to the ranges.

Figure 40. Bulk water station after first phase retrofit.

Figure 41. Six-inch pipe replaced due to poor condition at bulk water station.

Figure 42. Composting toilet installation.

6 Water Survey and Awareness Program

Improvements to the water infrastructure at FOBs 2 and 3 (i.e., water meter and softener installation) had to take place before reliable baseline usage data could be collected. Figure 43 shows the project timetable. During this time, the first set of the Water Attitudes and Practices Survey was administered in-person on-site. Appendices E and F explain the survey and its results in detail. Following approximately 2 months of usage data collection, the water awareness campaign, described in Appendices G and H, was initiated. A second set of follow-up surveys began after the start of the campaign to measure its effectiveness. Collection of water meter data continued after the fixture upgrade alongside the secondary surveys.

6.1 Water attitudes and awareness survey

Surveys were administered in-person to groups staying overnight during training at any of the three FOBs. A brief verbal explanation of the study's purpose was given as an introduction. A total of 243 paper surveys were collected this way before the completion of the hardware retrofits. Forty-nine percent of respondents were Army Reservists, 49% were Marine Reservists, and the remaining 2% were made up of Army and National Guard service members.

6.1.1 Survey design

The survey tool was developed to gauge soldiers' attitudes toward water use. The questions focused on basic habits, past education about conservation, observations about water usage and waste, conceptualization about resources and their effect on everyday tasks, and general demographic information. Questions were worded to be easily understood by the average soldier with no special subject-matter knowledge. Completing the entire hard copy survey was meant to take from 10 to 15 minutes. Appendix E contains the complete survey.

6.1.2 Water meter data

Once installed, connex water meters were read once per month (Table 7). The number of personnel staying overnight at FOBs 2 and 3 was also recorded every day and summed over the same periods as the meter readings.

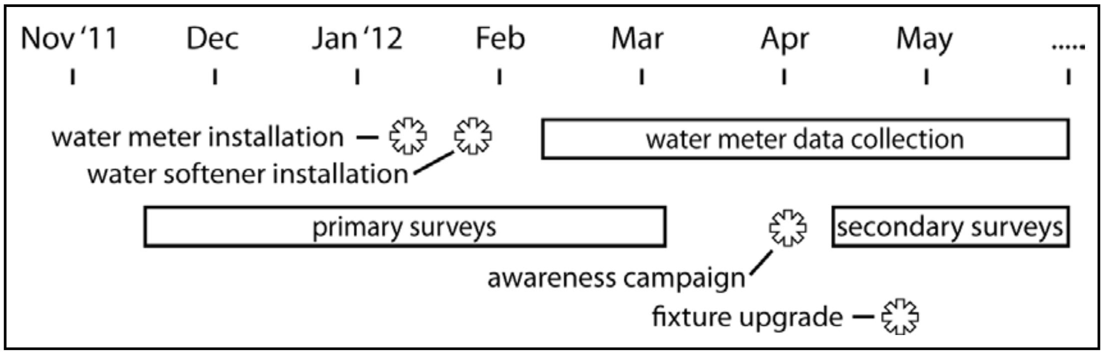

Figure 43. Project timetable.

Table 7. Water meter and strength data.

Period End Date	FOB2 Bayonet			FOB3 Nighthawk		
	West Connex	East Connex	Overnight Strength	South Connex	North Connex	Overnight Strength
	water used (gal)	water used (gal)	(personnel)	water used (gal)	water used (gal)	(personnel)
19-Dec-11	meter installation					
4-Jan-12	0	110	–	10	–	–
1-Feb	75	25	–	50	–	–
10-Feb	0	0	0	0	–	0
24-Feb	85	75	0	7,260	2,310	2,526
5-Mar	580	200	847	5,820	2,090	2,526
1-Apr	4,690	7,920	4,150	1,650	9,060	1,955
3- Apr	awareness campaign installation					
3-May	2,780	4,160	2,075	10,140	9,200	2,004

The average water usage before the awareness campaign was 2.7 gal/person/day at FOB 2, and 4.0 gal/person/day at FOB 3. After the awareness campaign, the rates were 3.3 gal/person/day at FOB 2, and 9.7 gal/person/day at FOB 3. By comparison, the average American household uses 11.6 gal/person/day for showers (Mayer et al. 1999).

A number of caveats accompany this data. First, the strength reported at a FOB does not guarantee that these soldiers used the shower facilities during their stay. Second, unreported use, leaks, or malfunctions may have inflated the usage rates; one or more of these is most certainly the cause of the usage recorded at FOB 2 when no soldiers were present. Third, FOB 3 has a second set of shower units in addition to the ReMS that are available to soldiers, potentially deflating the gal/person calculations. Fourth, the WaterBoss® Model 900 water softeners installed at the connexes, which became fully operational in January 2012, are a new and additional water demand at the connexes. The softeners use approximately 27 gal of water per regeneration cycle. The frequency of softener regeneration—and related water use—at each connex is unknown, but can be expected to vary based on the number of soldiers served. Finally, as the weather turns warmer during the spring and the terrain becomes muddier, an increase in showering is expected. The above rates are therefore rough indicators of use per person; the true rates may be higher or lower.

6.1.3 Survey results

Soldiers were asked how frequently they practiced particular habits of water and energy usage (Figure 44). Certain behaviors were meant to indicate responsible uses of resources, such as turning off lights and water faucets when not being used. Others were meant to indicate wasteful actions, such as using showers and toilets for unintended purposes. The frequency of practicing positive habits was mixed, although the behaviors with the lowest costs of time, effort, and comfort were more likely to be performed. Negative habits, on the other hand, were much more likely to be avoided.

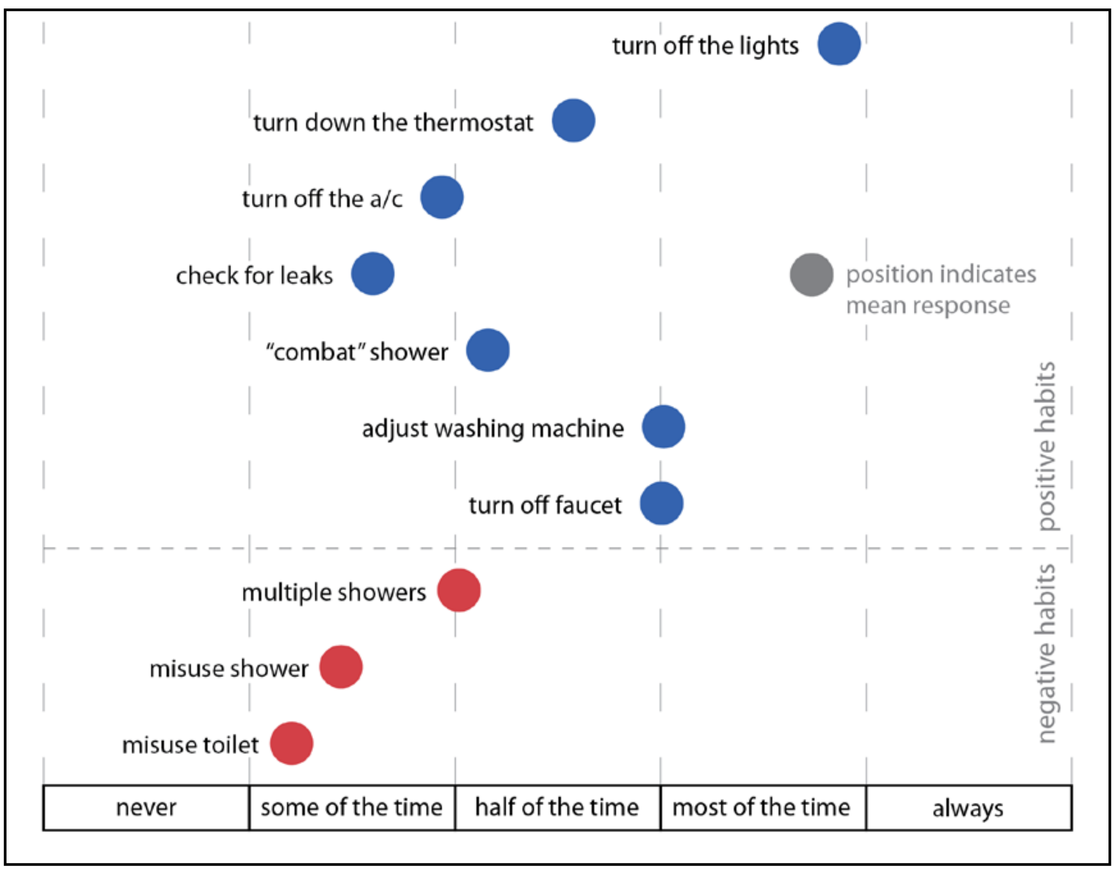

Figure 44. Survey question 1 – "How often do you ... ?"

When asked whether they had heard about the importance of water conservation, the overwhelming majority of respondents, 84%, said "yes" (Figure 45). When asked how often they thought about water use during daily tasks, however, more than half responded "never" (Figure 46). Clearly, familiarity with resource conservation does not necessarily indicate actual conservation.

Similarly, out of a list of factors influencing task execution, resource conservation was ranked lowest in importance by a wide margin, even though other factors were ranked of similar importance (see Table F6, p 81 in Appendix F).

When asked how they have learned about the importance of water conservation in the past, soldiers listed "television" most frequently. "Army training" was the fifth most common answer, following "school," "family" or "parents," and "as a kid" (word size in Figure 47 represents relative popularity among answers).

Most respondents were also unaware of the Army's and Camp Atterbury's efforts to reduce water use (Figure 43). Of those that were aware (they were instructed to answer Question 14 only if they had known about Army conservation efforts), most reported not altering their habits in an effort to conserve water. This was despite the fact that over 40% of respondents were given restrictions on water use in some way while deployed or training.

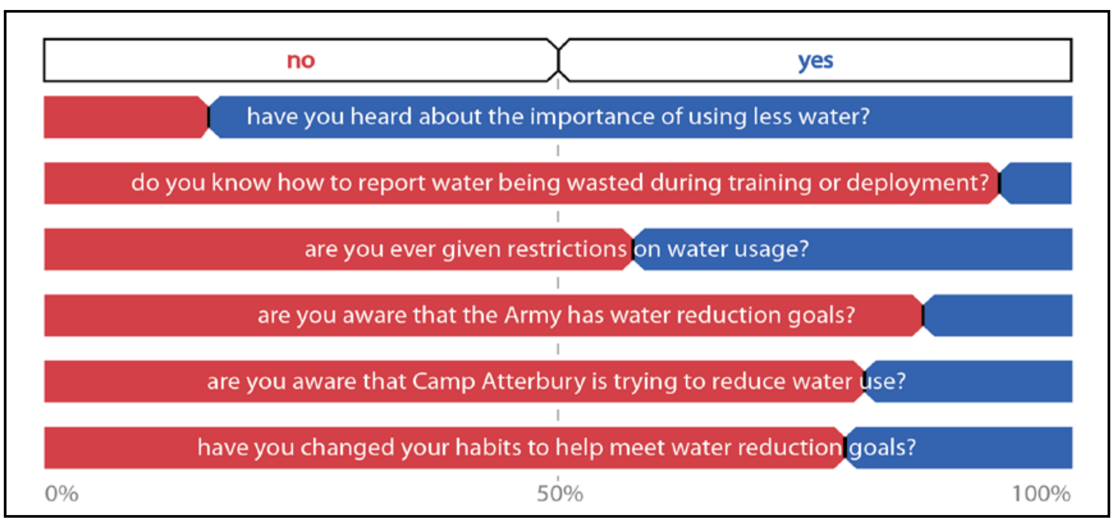

Figure 45. Survey questions 3, 6–7, 12–14.

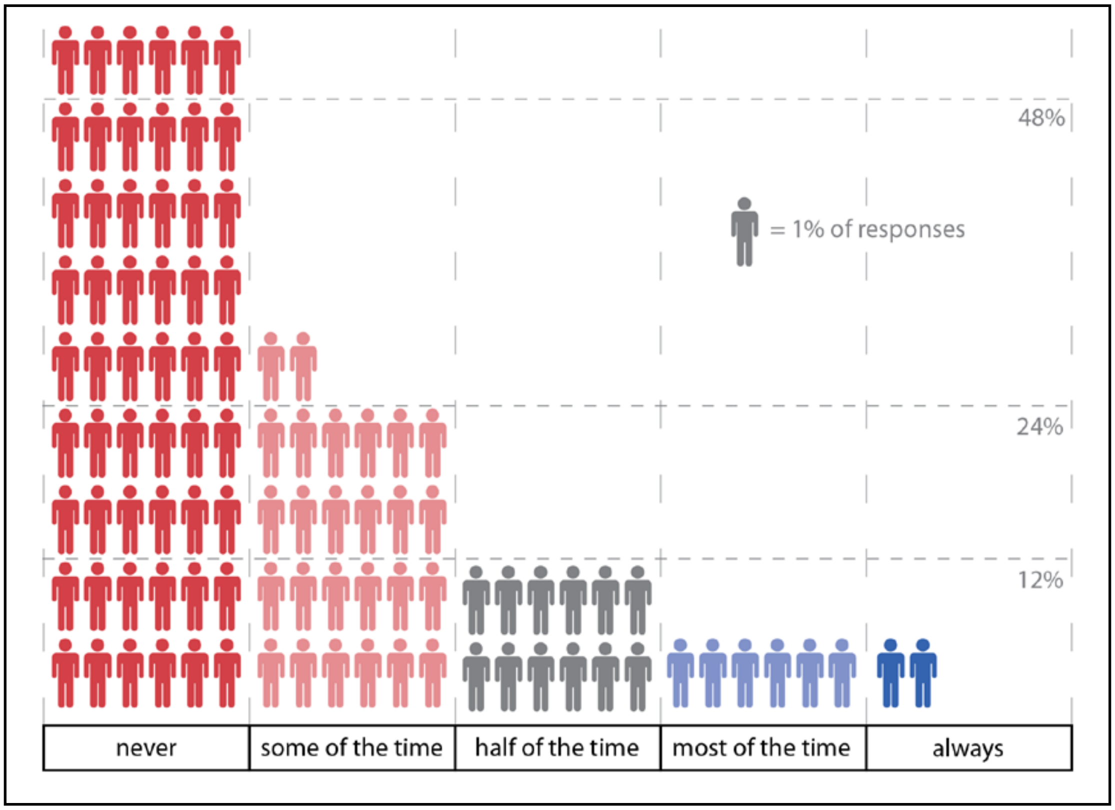

Figure 46. Survey question 10, “How often do you think about how much water is used during daily training tasks?”

Figure 47. Survey question 3, “Have you ever heard about the importance of using less water? If so, how?”

Respondents who were aware of Army conservation goals, either in general or specifically at Camp Atterbury, responded that they thought about how much water is used during daily training tasks more often than those who were unaware of conservation goals (see Table F6, p 81 in Appendix F: Survey Analysis). Respondents who changed their habits to help meet those goals were more likely to consider water usage. These aware respondents also put more importance on resource conservation than those who were unaware.

The corresponding quantitative analysis for Figures 44 through 47 can be found in Appendix F: Survey Analysis, p80.

6.1.4 Survey conclusions

Given that respondents expressed familiarity with both general resource conservation and recommended habits for conserving, and also reported not practicing wasteful habits, education and training in these areas would probably be ineffective. Likewise, promoting conserving habits, such as checking for leaks for their own sake would be unlikely to improve the frequency of these actions. Soldiers are already aware of water conservation and how to do it.

The opportunities for increasing conserving behavior are in promoting usage reductions as an Army priority and training soldiers to be cognizant of water use during daily routines. The problem to address is not a lack of knowledge, but a disconnect between conservation knowledge and actions. As such, any education and awareness materials should be designed to bridge that gap and connect water conservation to other service-related directives and activities.

The Army is also not effectively communicating its conservation goals or its expectations regarding soldiers' responsibilities. Mere awareness of goals is positively correlated to changes in behavior, but soldiers hear more about conservation from other sources than from official training.

6.2 Training and awareness campaign

6.2.1 Campaign design

An analysis of the Water Attitudes and Practices Survey led to the creation of an awareness campaign focused on addressing shortcomings in the Army's approach to water conservation. The multi-part campaign included a briefing to unit commanders, posters relating conservation to Army issues, and signage with instructions for reporting observations of waste. The form and function of all the elements were deliberately chosen based on the lessons learned from the results of the survey. Appendices G and H, pp 84 and 85, respectively, describe the complete campaign.

6.2.2 Environmental briefing addendum

As part of orientation at Camp Atterbury, unit points-of-contact are briefed on environmental, safety, and other local procedures. An explanation of the Energy Technology Assessment was added as a component of the awareness campaign. The purposes of this element were to clarify at the command level both the Army's and Camp Atterbury's mission to improve conservation as well as to establish procedures to report observations of waste.

6.2.3 Large format posters

The primary message of the awareness campaign did not involve the detailed specific of conservation, as does Fort Huachuca's campaign, but rather focuses on how conservation relates to the average soldier's daily concerns. The cornerstone component of the campaign was 11 x 17-in. graphic posters. Safety was a major focus, as was effectiveness, efficiency, and equating the activities of training to those downrange. Text was kept to a minimum and imagery was bold and eye-catching. Clichéd design elements typically used in material about water (shades of blue, "watery" fonts, pictures of lakes, etc.) were consciously avoided.

Posters were hung in commonly used areas around the FOBs, two in each connex and four in each DFAC. Materials in the DFACs were placed in the most conspicuous locations possible – on food storage equipment, by entrances and exits, and near the check-in tables (Figure 48).

6.2.4 Small format stickers

In addition to posters, two types of stickers were hung in the connexes and DFACs. The yellow mailing label-sized version, an abbreviated message about safety and supply convoys, were placed in abundance. The narrow blue version, instructions to report waste to the FOB staff, were used more sparingly and only in the connexes (Figure 49).

Figure 48. A poster and stickers on a DFAC ice machine.

Figure 49. Stickers above the sinks in a connex.

6.3 Secondary surveys

6.3.1 Methods

A second round of surveys was administered after initiation of the resultant awareness campaign. Because these changes only affected FOBs 2 and 3, units training at FOB 1 were not eligible to be surveyed during this stage. The purpose of this second dataset was to measure the campaign's effectiveness on influencing attitudes toward water use. Only 93 surveys were completed by Reserve Officers' Training Corps (ROTC) cadets before this writing, limiting statistical significance and comparability. More surveys should be collected at FOBs 2 and 3 to strengthen this secondary dataset.

6.3.2 Results

Because the respondents were only exposed to the campaign once, differences in past behavior from the initial set of respondents cannot be attributed to it. Since there may be changes in awareness levels, this analysis focused on awareness-related questions.

Before the initiation of the campaign, 14.5 and 20.2% of respondents were aware of Army and Camp Atterbury resource conservation goals, respectively (see Appendix F: Survey Analysis, p 80). After the campaign, those rates increased to 41.3 and 43.5% (see Table F9, p 83). Respondents that claimed to have changed their habits to meet these goals increased from 21.1 to 50.8%.

The awareness campaign was mentioned directly by four respondents in answers to various open-ended questions.

6.3.3 Conclusions

There was a very clear increase in awareness of official goals and of conservation after the implementation of the campaign. Since multiple respondents wrote about the campaign, its presence and message was absorbed by at least a portion of the unit. These are promising indicators and support the leading assumptions of the campaign's potential to influence attitudes and behaviors. The success of the campaign, whether improvements are possible, and whether or not increases in awareness do indeed lead to increases in conservation remains to be seen. Further monitoring is required.

7 Data Collection

Water use and related data collection practices were established for various types of water meters, population (soldier/personnel) reports, and preliminary analysis of fixture water use data.

7.1 Meters/data loggers

There are two main meters at Camp Atterbury, located on each of the two main water supply points entering the installation. Each main meter site contains two meters. Figure 50 below shows one of the main meter sets. The two meters are read and logged daily by installation personnel. In addition, a water meter is located in FOB 3. Figure 51 shows the water meter located at FOB 3.

7.1.1 Connex meters

Each of the four Badger water meters installed at the connexes in FOBs 2 and 3 are read at least monthly. A minimum of 3 months of pre-retrofit water usage data was collected at all four connexes to establish “normal” water use patterns and correlations to soldier/personnel occupancy figures at the FOBs. This pre-retrofit data set will be compared to post-retrofit water and population data at the FOBs on an ongoing basis throughout the duration of the project.

7.1.2 Flow recorders

Four Meter Master 100EL Flow Recorders were installed to monitor the four Badger water meters installed at the connexes (Figure 52). The flow recorders can hold up to 30 days of data, and were set to record every 10 seconds. Data was downloaded using Master-Meter Model 100 Software. A fifth recorder was installed at the Schoolhouse Road bulk water station to monitor water consumption between Phase I and Phase II of the retrofit (Figure 53). Finally, a sixth flow recorder was installed at a water meter located in FOB 3 (Figure 54).

Figure 50. Main meter set composed of two meters.

Figure 51. FOB 3 meter.

Figure 52. Flow recorder attached at badger meter in FOB.

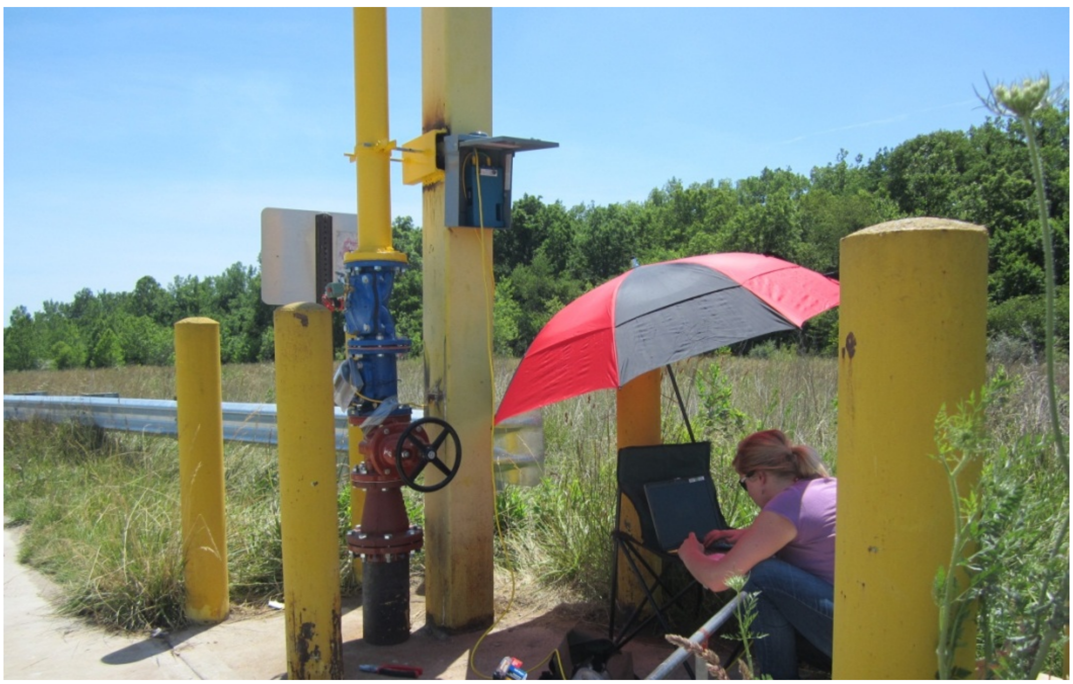
Figure 53. Flow recorder installed at bulk water station.

Figure 54. Flow recorder installed at the FOB 3 water meter.

7.1.3 Utility monitoring and control system (UMCS) system

There is a Supervisory and Control and Data Acquisition (SCADA) system installed by the installation and managed by Prince's Lake Water Utility. The system is used for controlling and monitoring water pumps. Although both main supply meters are connected to the SCADA, the meters are read manually.

7.2 Data analysis

7.2.1 Fixtures

Figure 55 shows fixture retrofit installation dates and connex water demands at FOBS 2 and 3.

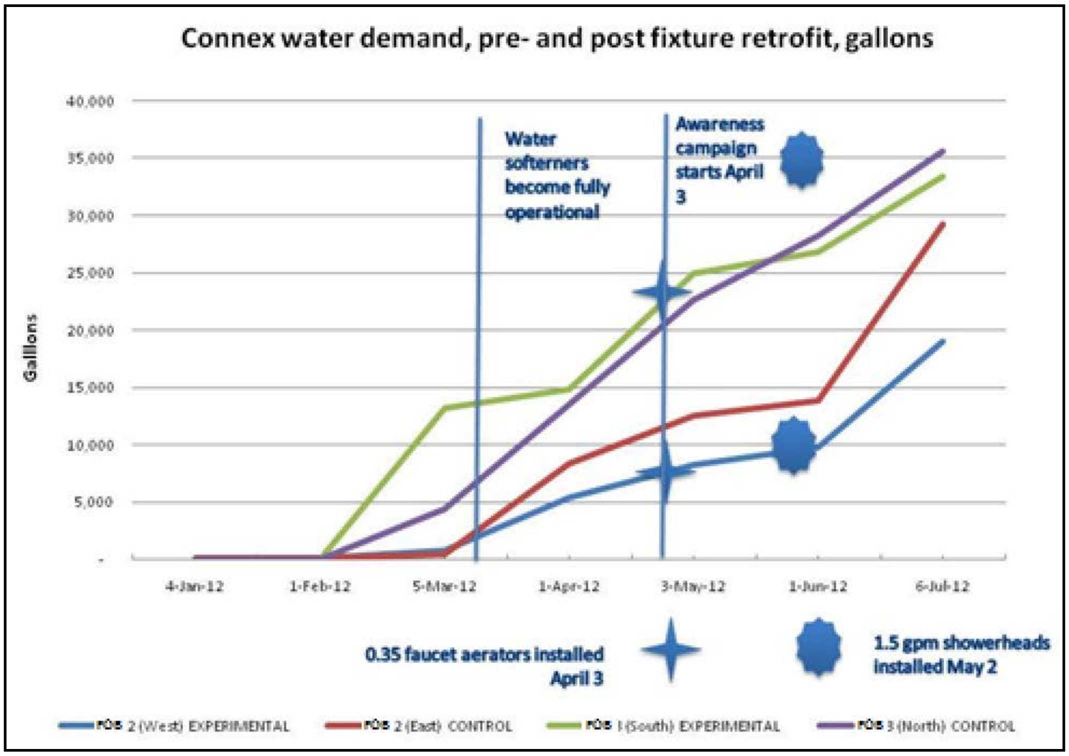

Figure 55. Connex water demand, before and after fixture-retrofit (gal).

Analysis of connex water use data at FOBs 2 and 3 based on monthly meter readings from January through 6 July 2012, on a pre-retrofit and post-retrofit basis (Tables 8 and 9), yield these preliminary findings:

- Pre-retrofit combined total volume and percentage water demands (4 January to 3 May 2012) at the Experimental and Control connexes at FOBs 2 and 3 were similar (Table 8), despite the fact that FOB 3 reported higher strength figures than did FOB 2. This is an unexpected finding. Higher overnight personnel numbers reported at FOB 3 during those months would be expected to correlate to higher total water usage, but that did not occur. This anomaly is likely explained by the fact that, in addition to the South and North demonstration connexes at FOB 3, there are two additional (unmetered) shower connexes used by soldiers. Hence, the strength figures reported for FOB 3 likely do not correlate reliably with the metered usage data for the Control and Experimental connexes. Future strength data collection at FOB 3 needs to record only figures for personnel using the two study connexes. Otherwise, per person water use data findings and related metrics for FOB 3 may be unreliable and also not comparative to FOB 2.
- Post-retrofit combined total volume and percentage water demands (3 May to 6 July 2012) at the two Experimental connexes were lower

than the combined total usage at the Control connexes (Table 9), which represents a contrast to the pre-retrofit months (Table 8). The Experimental connexes dropped from 49 to 45% of water demand at the two FOBs after the fixture retrofits were installed. This 4% drop in demand over the 2-month post-retrofit period is an early indicator that water savings are being achieved as a result of the fixture retrofits. Continued monitoring of post-retrofit usage as well as its correlation to strength data in the coming years will enable more definite measurements of changes in water use attributable to the water-saving fixtures.
- Uneven usage of the connexes by soldiers at the FOBs is apparent in the pre-and post-retrofit water usage data. This is an unexpected finding; FOB staff had indicated previously that approximately equal numbers of soldiers used the connexes.
- The installation of water softeners at the connexes in FOBs 2 and 3 adds another complicating factor in accurately measuring potential water savings related to fixture retrofits from changes in metered water demands, on top of inconsistent correlative strength data. The water softeners use water as part of the water regeneration process, at the rate of approximately 27 gal per conditioning cycle. As a result, connex water meter and flow recorder data reflect higher usage than that caused by the demands of showerheads, metering faucets, and relatively small utility sinks. Hence, estimates for softener water use will have to be created and factored out of total water meter usage at each connex to evaluate water use efficiencies by the baseline and experimental fixtures.

These preliminary findings indicate the need for more accurate overnight strength data collection reports from the FOBs as well as potential changes to the connex locations for the fixture retrofit installations. Chapter 8 discusses these issues in more detail.

Additional post-retrofit flow measurements were obtained when the showerheads were retrofit during the 7 June 2012 site visit. Figures 56 and 57 show these results for both faucet aerators and showerheads.

7.2.2 Bulk water point

At the time of publication metered tracking had just begun. Thus no conclusive data is ready to present.

Table 8. Cumulative water demand (gal).

Data of Meter Reading	FOB 2 (West) EXPERIMENTAL	FOB 2 (East) CONTROL	FOB 3 (South) EXPERIMENTAL	FOB 3 (North) CONTROL	Total Use, gallons	Total Use, %
4-Jan-12	—	110	10	—	120	
1-Feb-12	75	135	60	30	300	
5-Mar-12	740	410	13,140	4,430	18,720	
1-Apr-12	5,430	8,330	14,790	13,490	42,040	
3-May-12	8,210	12,490	24,930	22,690	68,320	
Total use, Experimental connexes compared to Control connexes, gallons:	(4,280)	—	2,240	—	—	
Total use, Experimental connexes compared to Control connexes, percent:	40%	60%	52%	48%		
Total use Experimental connexes, FOBs 2 & 3:					33,140	49%
Total use Baseline connexes, FOBs 2 & 3:					35,180	51%

Table 9. Cumulative water demand (%).

Data of Meter Reading	FOB 2 (West) EXPERIMENTAL	FOB 2 (East) CONTROL	FOB 3 (South) EXPERIMENTAL	FOB 3 (North) CONTROL	Total Use, gallons	Total Use, %
1-Jun-12	9,840	13,810	26,860	28,260	78,770	
6-Jul-12	19,020	29,250	33,360	35,640	117,270	
Total use, Experimental connexes compared to Control connexes, gallons:	(10,230)	—	(2,280)	—	—	
Total use, Experimental connexes compared to Control connexes, percent:	39%	61%	48%	52%		
Total use Experimental connexes, FOBs 2 & 3:					52,380	45%
Total use Baseline connexes, FOBs 2 & 3:					64,890	55%

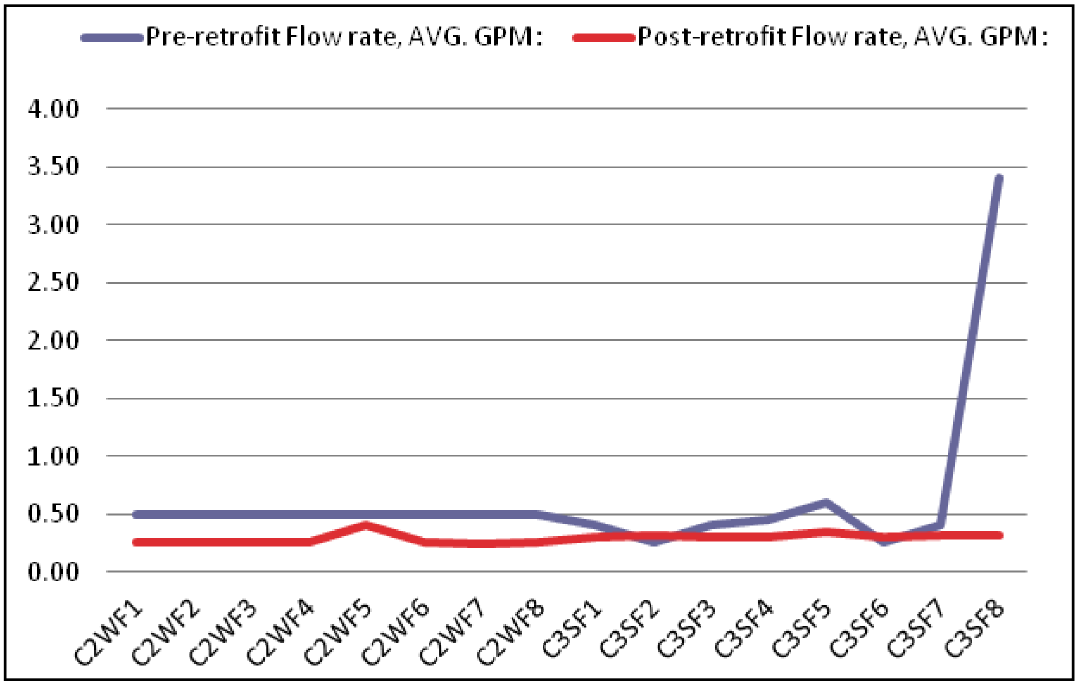

Figure 56. Pre-and post-retrofit flow rates for faucet aerators (gpm).

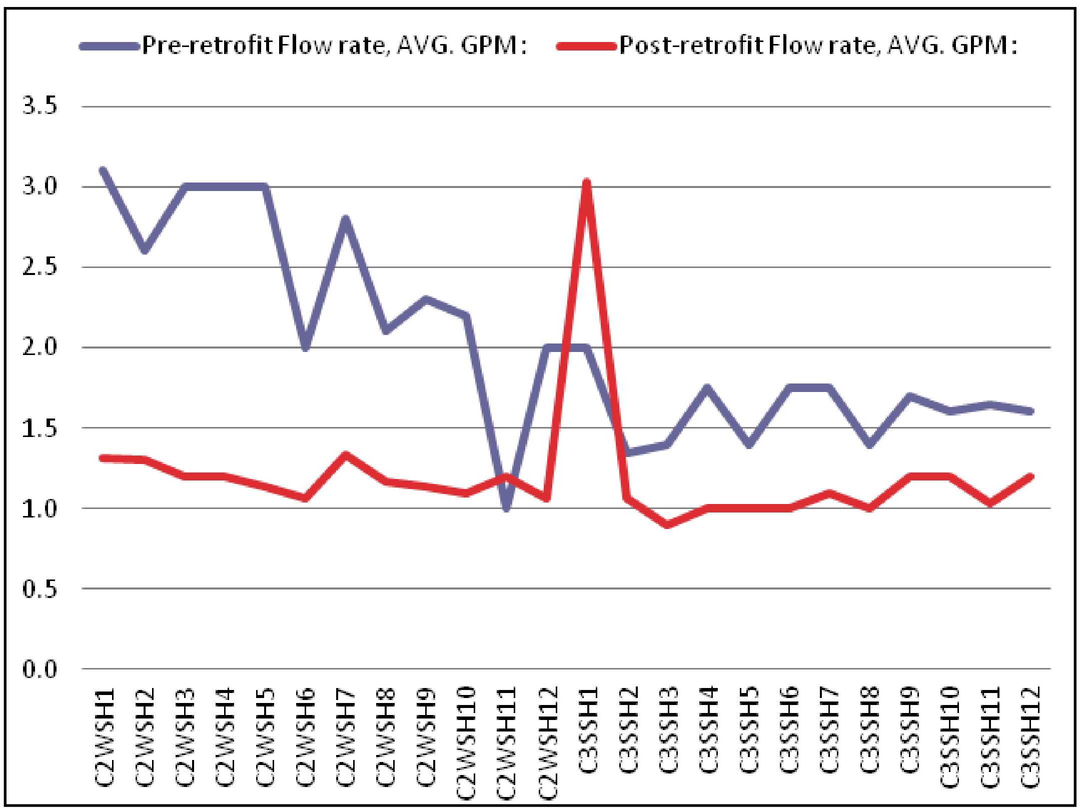

Figure 57. Pre- and post-retrofit showerhead flow rates (gpm).

7.2.3 Composting toilet

The cost effectiveness of replacing either flush toilets or porta-potties with composting toilets depends on the operations and maintenance cost of the existing units. Training sites are ideal locations for this retrofit due to the long distances that maintenance personnel must travel to service sanitation facilities. Whether that service involves hauling tankers of water to supply trailer-based flush toilets, or the requirement to pump porta-potties on a regular maintenance schedule, maintaining toilets in the training environment is expensive.

Currently Camp Atterbury pays approximately $935,000 per year for maintenance of 550 porta-potties, independent of the level of training or usage of the units. This amounts to a per-unit maintenance cost of $1700/year. It is unlikely that most porta-potties are used at their maximum capacity (30 uses per day).

Monthly maintenance for a single composting toilet is $3000/year, based on the maximum 60 uses per day (Clivus Multrum 2011). Assuming that a number of porta -potties are used 15 times per day, then one composting toilet serviced monthly could replace four under-utilized porta-potties. The installed cost per unit (for one composting toilet) is $25,000, and the life cycle of the unit is 20 years. In this scenario, the simple payback, including monthly maintenance, is 6.57 years.

On the surface, composting toilet technology may seem costly. However, as the number of composting toilets at a particular site increases, the maintenance cost per unit decreases. The most expensive part of maintaining a composting toilet is the maintenance contractor's drive to the installation. Once on site, the cost to maintain each additional composting toilet is low. At locations where use is variable or low, the potential cost-effectiveness of replacing porta-potties with composting toilets increases. Table 3 lists the economics underlying several scenarios that use composting toilets. This data assumes that:

- Maintenance for Porta-Potties remains at a constant $1700/each for the cantonment and $2200/each for remote sites.
- One composting toilet replaces four porta-potties.
- Maintenance for the first composting toilet costs $250/month for the cantonment and $350/month for the remote site, and that each additional composting toilet adds $50/month to the maintenance cost.

Table 10. Costs and payback of composting toilets at Camp Atterbury, IN.

Location of Composting Toilets	No. of Units	Unit Cost	Installation Cost	Maintenance Cost (Old/New)	Simple Payback
Cantonment	2	40,000	8,000	13,600/3600	4.8 years
Cantonment	4	80,000	16,000	27,200/4800	4.2 years
Cantonment	8	160,000	28,000	54,400/7200	3.9 years
Remote Site	2	40,000	9,000	17,600/5400	4 years
Remote Site	4	80,000	18,000	35,200/6600	3.4 years

Also, installations can realize economies of scale when installing greater numbers of composting toilets. The data in Table 3 can serve as a guide for those considering whether this technology might offer water and/or cost savings.

Site selection is a key factor that affects the performance and economics of composting toilets. Installation staff should strategically locate composting toilets to achieve the maximum usage rating of 60 uses per day.

The location of the composting toilet between Ranges 18 and 19 was intended to control usage of the units and to not overload them as has occurred elsewhere in the Army. It is likely that the units are underutilized. As such, they are receiving quarterly maintenance from the manufacturer (Mills 2012). Feedback from Camp Atterbury FOB Mayors is that the troops like the composting toilet and that the unit smells better than the porta-potties. Additional feedback from multiple units is needed to determine the overall satisfaction with the composting toilets.

The cost of maintenance for the training areas at Camp Atterbury is typically deferred to the units utilizing the facilities during training, and may be at the discretion of the commanding officer to incorporate necessary maintenance services. During a project site visit, it was observed that routine maintenance had not occurred causing an unsanitary situation to training personnel. If maintenance costs can be reduced, then perhaps the responsibility could be assumed by Camp Atterbury staff rather than multiple training units. This would ensure safe and sanitary conditions for training personnel.

8 Conclusions and Recommendations

8.1 Conclusions

This work has demonstrated and documented the effectiveness of using a holistic approach to identifying water inefficiencies and water waste, and to improving water conservation at training sites and downrange practices at Camp Atterbury, IN by retrofitting existing facilities with technologies that support reduced potable water consumption through conservation and building greywater reuse.

8.1.1 Fixtures

Estimates of water savings achieved at FOBs 2 and 3 by the fixture retrofits installed in the two experimental connexes compared to the control connexes suggest that water conservation is being achieved at Camp Atterbury. However, there is inconclusive evidence based on actual (metered) water demands reported thus far to document the actual volumes of water that are being saved by this ongoing demonstration project.

Several factors limit the project's ability to accurately identify and measure actual water savings being achieved by the fixture retrofits. These include:

- Unforeseen non-fixture-related water use at the FOBs (i.e., water softeners as well as possible leaks, malfunctions, and other unreported use at the connexes)
- Inconsistent strength data (i.e., figures for FOB 3 likely include those for soldiers and personnel who use unmetered shower connexes not included in this study)
- Inconsistent strength use of Experimental and Control connexes at the FOBs that cannot be correlated to connex metered water use in gallons per person and similar metrics. (Total strength data is reported for each FOB, but the numbers using each connex are different but unknown.)

Changes in data collection practices and also possibly reconfiguration of the control and experimental connexes are needed in the next phase of this project so that fixture water use and related changes from installed retrofits can be reliably identified, measured, and reported.

8.1.2 Bulk water point

Recommendations for the bulk water point will be made in an addendum, following publication of this report.

8.1.3 Composting toilet

This work has shown that the use of composting toilets at remote training locations is feasible and should be considered. The use of composting toilets potentially offers cost savings over the use of porta-potties. The Army has become dependent on porta-potties as a convenient way to deal with human waste on training ranges and contingency bases. However, the cost for such convenience is high, both in terms of economic costs, and in the potential to damage local environments if the collected waste from porta-potties is not deposited at treatment facilities, which is the case at some contingency bases. Moreover, even the proper disposal of large accumulated amounts of human waste can overload sewage treatment facilities, particularly those located on Army installations.

Composting toilets are an alternative to flush toilets and porta-potties that requires some initial planning. This demonstration has shown that the simple payback of 6.57 years can justify the relatively high up-front investment in composting toilets. Site selection and geography are instrumental in correctly locating the units and in determining their maximum cost effectiveness. Once located, it is necessary to document daily usage rates to coordinate maintenance, i.e., to keep the composting toilets in working order and to hold costs down. Even assuming a monthly maintenance schedule, the overall cost of installing and maintaining the M54 composting toilets system is more cost effective than equivalent capacities of porta-potties.

While this demonstration site did not use flush toilets—and therefore did not realize water savings with this retrofit—other sites do truck water into remote areas to service flush toilet trailers. Composting toilets should be explored at those sites where pumping maintenance is likely to be a high cost item. In regions where water scarcity is a concern, this technology will help preserve water for other required uses.

8.2 Recommendations

It is recommended that Camp Atterbury:

- Change the setup for experimental and control connexes at FOBs 2 and 3 to better identify and measure fixture retrofit water use and savings compared to control fixtures. Consolidate experimental connexes to one FOB at a time while the other FOB connexes are controls only. This will result in three distinct data sets for the study that could yield more accurate and reliable findings on changes in water use from fixture retrofit installations:
    - Maintain the current arrangement of one control and one experimental connex at each FOB for at least another month (through July 2012) so that a quarter-year (3 months) data set can be collected for the current setup. This data set can be used to evaluate and compare differences in water use per person from one FOB to another, which may reflect differences in FOB *activity* type (Water/user Data set 1: May, June, and July 2012).
    - In the next phase of the project, exchange showerhead and faucet aerator retrofits from the FOB 3 (South) Experimental connex with the FOB 2 (West) Control connex so that the fixtures in both connexes at FOB 2 are all experimental (retrofits) and the connexes at FOB 3 have control fixtures only. This second dataset will enable better evaluation of fixture water use per person for the retrofit fixtures as well as for the control fixtures, so that differences in *fixture flow type* can be identified. Currently, the combination of control and experimental connexes at the FOBs coincident with lack of correlative user data (number of users per connex) is making it difficult to decipher and compare water use between the control and experimental connexes (Water/user Data set 2: August, September, and October 2012).
    - In the last phase of the project, reverse the fixture installations in the FOBs to measure and evaluate retrofit-related water use and savings at FOB 3. Exchange showerhead and faucet aerator retrofits from both experimental connexes at FOB 2 with the control connexes at FOB 3 (Water/user Data set 3: November and December 2012 and January 2013).
- Clarify the overnight strength data collection procedures with the FOB mayors and their staff to ensure accurate connex user data:
    - Overnight personnel should only be reported for those who are using the experimental and control connexes.

- Report the number of males and females in the strength reports, if possible. There may be differences in the length of time and water used by each gender, e.g., for shaving and shampoo removal from hair.
- Report or estimate the breakdown of total users among the two study connexes at each FOB so that differences in water use per person can be determined at both the experimental and control connexes. This may be difficult if not impossible for FOBs to report, which is why the approach involving a restructured experimental-only FOB and a control only FOB is recommended above.
- Further adjust campaign materials based on long-term tracking of future survey results.

Acronyms and Abbreviations

<u>Term</u>	<u>Definition</u>
ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BMP	Best Management Practice
CAJMTC	Camp Atterbury Joint Maneuver Training Center
CERL	Construction Engineering Research Laboratory
DFAC	Dining facility
DPW	Directorate of Public Works
ECB	Engineering and Construction Bulletin
ECIP	Energy Conservation Investment Program
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
ERDC	Engineer Research and Development Center
ETL	Engineer Technical Letter
FOB	forward operating base
gpm	gallons per minute
IDIQ	Indefinite Delivery/Indefinite Quantity
ITTP	Information Technology Training Program
NSN	National Supply Number
NZW	Net Zero Water
OMB	Office of Management and Budget
PX	Post eXchange
ReMS	Remote Mobile showers
ROI	Return on Investment
ROTC	Reserve Officers Training Corps
SAR	Same as Report
SCADA	Supervisory Control And Data Acquisition
SF	Standard Form
TR	Technical Report
TRADOC	US Army Training and Doctrine Command
TV	television
UMCS	Utility Monitoring and Control System
URL	Universal Resource Locator
US	United States
USACE	US Army Corps of Engineers

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Appendix A: Card Reader Brochure

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SMARTVEND BULK WATER STATION OVERVIEW

The SmartVend Bulk Water Fill System is designed for a utility that wants a simple to operate and maintain system without the added expense of a communication network or does not want to incorporate the added customers into their utility accounting package.

The SmartVend System consists of the following components – Smart Console Programmer, Transaction Terminal, Smart Cards, Meter, Solenoid Valve and Back Flow Prevention.

SMART CONSOLE

The Smart Console Card programmer is located in the office. It is a small counter device that requires AC 120 power. The Smart Console programs the SmartCard with a dollar value. When a customer requests water, they are issued a card (Deposit or No Deposit)). The card is inserted in the Programmer and the dollar amount of water purchased is added to the card. This is a reusable card that can be programmed after the dollar amount has been spent. Optionally, an automatic reload station is available.

SMARTVEND TERMINAL

The SmartVend terminal is located at the Bulk Water Station Site. It is mounted on the exterior of the building in weatherproof housing It is suitable for winter operation. The utility programs the SmartVend Terminal with a dollar value per pulse from the meter. For example, one pulse is equal $.002 per gallon or liter. SmartVend will work with a variety of pulses and meter manufacturers.

METER

The meter can be any size depending on the flow rate and volume of water the utility required. The meter will have a dry contact pulse value that is suitable for the Transaction Terminal and the flow rate of the meter. Most manufactures meters are acceptable. Magnetic Flow Meters may also be incorporated.

SOLENOID VALVES

The Solenoid Valve will be sized for the flow rate required for the system. The solenoid will be a normally closed, energize to open, 110 Ac powered. If freezing is an issue in the standpipe a ½" drain solenoid valve can be added that is normally open, energize to close. This will drain the line when not in use.

BACK FLOW PREVENTION

The Back Flow Prevention is sized for the flow rate. Optional air brake on overhead discharge is available.

OPERATION

The customer inserts the card into the SmartVend Terminal. The display shows the dollar balance on the card. SmartVend request the "Volume" and the customer keys in the volume requested in liters or gallons and confirms the purchase. SmartVend ensures the volume keyed in does not exceed the balance on the Smart Card and opens the solenoid valve and water flows. As the water is flowing, the meter is pulsing back to the Terminal. The display on the SmartVend terminal counts up the volume. Once the requested volume is reached or the customer stops the flow, the terminal will deduct the amount of water taken from the card and instructs the customer to take the card. The ending balance is also displayed on the display prior to removing.

Continued

If the customer chooses to terminate the transaction prior to the keyed in volume being reached, the SmartVend will refund the remaining value onto the card. THE CUSTOMER IS NOT CHARGED FOR WATER NOT TAKEN.

Once the value on the card is low the customer can take the card to the office and purchase more water on it. The Smart Card can be reused multiple times.

SPECIAL FEATURES

TRANSACTION MEMORY STORAGE

All transactions are stored in memory. Transactions may be copied to a standard SD Card and inserted in a SD reader. Transaction open in excel format. Data includes SmartCard number, time and date of transaction, terminal id, dollar amount taken and SmartCard balance.

SHUTOFF VOLUME

SmartVend allow the utility to adjust the relay to close the solenoid valve prior to the volume keyed in. This allow the utility to account for slow closing valves. For example if a valve takes 10 seconds to close and 50 liters of water goes through prior to fully closing, the Smart Vend will begin to close 50 liters before the volume is reached.

SOLAR OPTIONS

SmartVend is a very low power 12 vdc unit which can be configured for Solar powered stations. Stations may be either stationary, or portable.

OPTIONAL ACCESSORIES

- Curbside Standalone Fill Station
- Overhead Discharge Towers
- Coin Integrated systems
- Stainless Steel Piping
- Air Brake on Overhead Discharge
- Multiple Size hose Outlet
- Custom Design
- Installation
- Sewage Dumping Stations

For additional information or quote

JOHLIN MEASUREMENT LTD.
1-888-933-8979 FAX 1-403-933-4740

walshjb@telus.net

Appendix B: Composting Toilet Brochure

clivus multrum incorporated

Model M54W
Specification Sheet

NSF Certification

The Clivus Model M54W is certified by the National Sanitation Foundation under Standard 41 (day-use, park).

Capacity

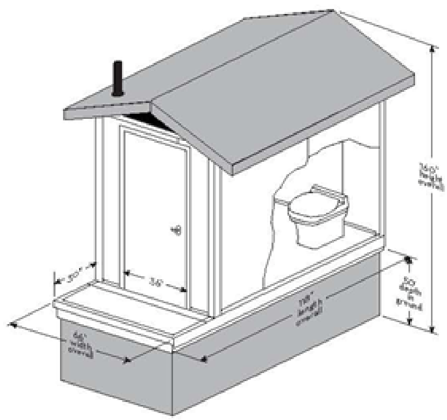
M54W VOLUME

Solids storage capacity: 81 cubic feet; 604 US gallons

Liquid storage capacity: 40 cubic feet; 300 US gallons

Daily capacity at average temp. >65°F: 60 visits

Annual capacity at average temp. >65°F: 22,000 visits



Specifications and Materials

DIMENSIONS

Shipping Dimensions: Length: 118"; Width: 84"; Height: 92"

Shipping Weight: 2,400 lbs

Assembled Building Dimensions:

Outside Length: 118"; Width: 66"; Height: 110"

Building Enclosure (inside)

Inside Length: 84"; Inside Width: 61.5"

Composter Base

Length: 118"; Width: 65"; Height: 48"

MATERIALS

Composter Base

Composter Base is rotationally molded high-density linear polyethylene resin that conforms with the following specifications:

- Density (ASTM TEST 4883): 0.942 g/cm3
- Tensile Strength at Yield (ASTM D638): 2,950 psi
- Dart Impact (-40°C, 250 mils thickness): 108 ft-lbs
- Envt. Stress Crack Resistance, 100% Igepal (D1693): 550 hrs

Building

Building is 2" thick sandwich panels of virgin expanded polystyrene faced with T1-11 plywood outside and white fiberglass reinforced panels inside. The sandwich panels connect to each other with dark bronze anodized aluminum extruded molding and screws. Door is .060 aluminum, both sides, with expanded polystyrene core. Standard exterior is custom painted.

Roof is aluminum frame construction with 1/2" plywood for field application of asphalt shingles or other finish. Gable ends have pebble-finish lexan windows.

Floor panel has .060 aluminum with expanded polystyrene core. Finish surface is continuous non-skid NORA flooring, grey color.

Standard package ships in kit form. Prefabrication is an option.

VENTILATION

DC: 12V fan. Maximum free air is 100 cfm. Power input is 5 watts. CSA & UL approved. DC fan is powered by an optional photo- voltaic system customized for location and site requirements. Call for quotation. AC fan also available.

TOILETS

Waterless toilets constructed of impact resistant fiberglass with sanitary white finish. Seat and lid are made of plastic; the liner is rotationally molded polyethylene. Grab bars and toilet paper holder included.

Toilet Height: 18"; Width: 18.5"; Length: 24.25"

ADA COMPLIANT

The M54w Trailhead conforms to the requirements for universal access of the Americans with Disabilities Act .

Clivus Multrum, Inc., 15 Union Street, Lawrence, MA 01840 | 800.425.4887 | clivusmultrum.com Rev. 11/09

Appendix C: Delta Faucet Company Specification Sheet for the 1.5 gpm Showerhead Retrofit

RP46384

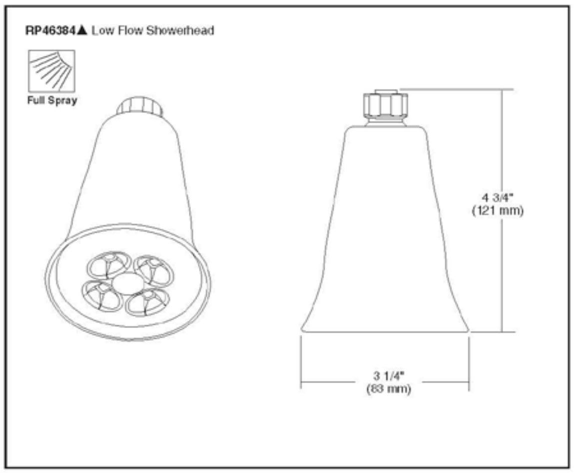
DELTA

LOWFLOW SHOWERHEAD

- Full spray function
- 1.5 GPM @ 80 PSI
- H_2O Kinetic Technology

Submitted Model No.: ____________________

Specific Features: ____________________



▲ Designate proper finish suffix

STANDARD SPECIFICATIONS:

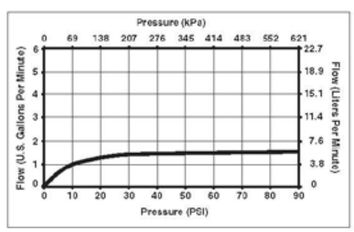
- Full spray function.
- 1.4 GPM, 5.3 L/Min. @ 45 PSI (310kPa)
- 1.5 GPM, 5.7 L/Min. @ 80 PSI (550kPa)
- H_2O Kinetic technology.

WARRANTY

- Lifetime Faucet and Finish Limited Warranty to the original consumer purchaser to be free from defects in material and workmanship.
- 5 Year Limited Warranty for usage in all industrial, commercial and business applications.

COMPLIES WITH:

- ASME A112.18.1 / CSA B125.1
- EPA WaterSense



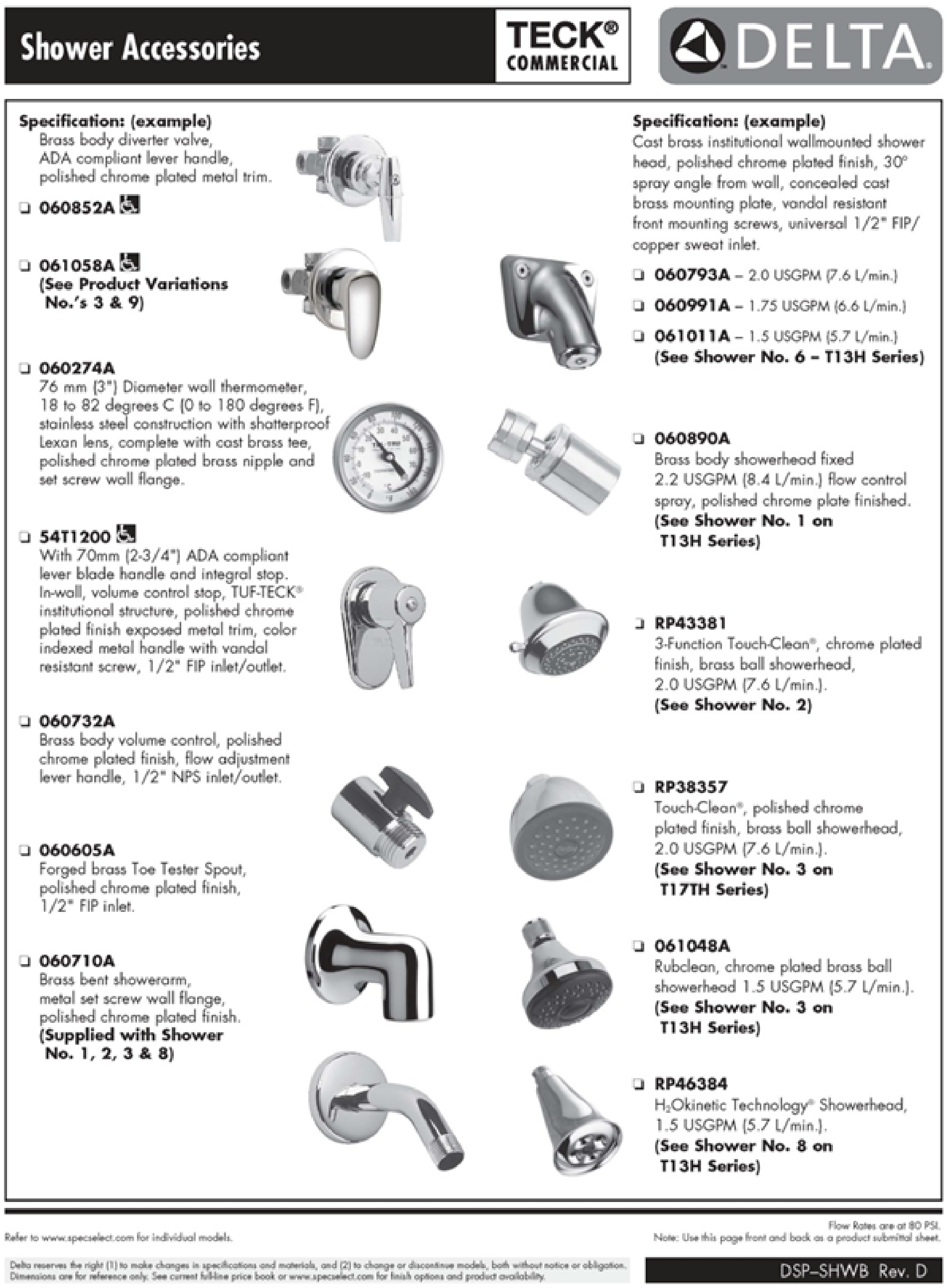
DELTA FAUCET COMPANY

55 E. 111th Street, Indianapolis, Indiana 46280
395 Matheson Blvd. E., Mississauga, ON L4Z 2H2

Delta reserves the right (1) to make changes in specifications and materials, and (2) to change or discontinue models, both without notice or obligation. Dimensions are for reference only. See current full line price book or www.specselect.com for finish options and product availability.

DSP-E-RP46384 Rev. C

Appendix D: Shower Head and Faucet Information



Shower Accessories

TECK® COMMERCIAL

DELTA

Specification: (example)
Brass body diverter valve,
ADA compliant lever handle,
polished chrome plated metal trim.

- ❑ **060852A**
- ❑ **061058A** **(See Product Variations No.'s 3 & 9)**
- ❑ **060274A**
  76 mm (3") Diameter wall thermometer, 18 to 82 degrees C (0 to 180 degrees F), stainless steel construction with shatterproof Lexan lens, complete with cast brass tee, polished chrome plated brass nipple and set screw wall flange.
- ❑ **54T1200**
  With 70mm (2-3/4") ADA compliant lever blade handle and integral stop. In-wall, volume control stop, TUF-TECK® institutional structure, polished chrome plated finish exposed metal trim, color indexed metal handle with vandal resistant screw, 1/2" FIP inlet/outlet.
- ❑ **060732A**
  Brass body volume control, polished chrome plated finish, flow adjustment lever handle, 1/2" NPS inlet/outlet.
- ❑ **060605A**
  Forged brass Toe Tester Spout, polished chrome plated finish, 1/2" FIP inlet.
- ❑ **060710A**
  Brass bent showerarm, metal set screw wall flange, polished chrome plated finish.
  (Supplied with Shower No. 1, 2, 3 & 8)

Specification: (example)
Cast brass institutional wallmounted shower head, polished chrome plated finish, 30° spray angle from wall, concealed cast brass mounting plate, vandal resistant front mounting screws, universal 1/2" FIP/ copper sweat inlet.

- ❑ **060793A** – 2.0 USGPM (7.6 L/min.)
- ❑ **060991A** – 1.75 USGPM (6.6 L/min.)
- ❑ **061011A** – 1.5 USGPM (5.7 L/min.)
  (See Shower No. 6 – T13H Series)
- ❑ **060890A**
  Brass body showerhead fixed 2.2 USGPM (8.4 L/min.) flow control spray, polished chrome plate finished.
  (See Shower No. 1 on T13H Series)
- ❑ **RP43381**
  3-Function Touch-Clean®, chrome plated finish, brass ball showerhead, 2.0 USGPM (7.6 L/min.).
  (See Shower No. 2)
- ❑ **RP38357**
  Touch-Clean®, polished chrome plated finish, brass ball showerhead, 2.0 USGPM (7.6 L/min.).
  (See Shower No. 3 on T17TH Series)
- ❑ **061048A**
  Rubclean, chrome plated brass ball showerhead 1.5 USGPM (5.7 L/min.).
  (See Shower No. 3 on T13H Series)
- ❑ **RP46384**
  H_2Okinetic Technology® Showerhead, 1.5 USGPM (5.7 L/min.).
  (See Shower No. 8 on T13H Series)

Refer to www.specselect.com for individual models.

Flow Rates are at 80 PSI.
Note: Use this page front and back as a product submittal sheet.

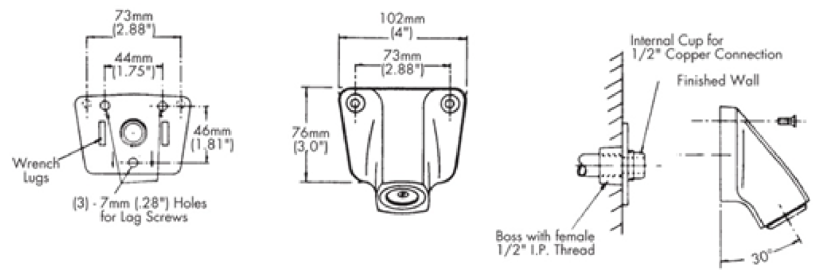
Delta reserves the right (1) to make changes in specifications and materials, and (2) to change or discontinue models, both without notice or obligation. Dimensions are for reference only. See current full-line price book or www.specselect.com for finish options and product availability.

DSP–SHWB Rev. D

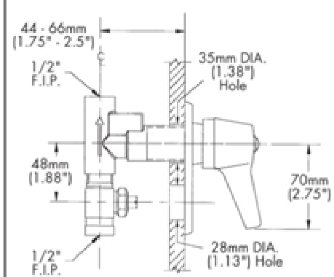
DELTA | TECK® COMMERCIAL | **Shower Accessories**

060793A, 060991A & 061011A SHOWERHEAD

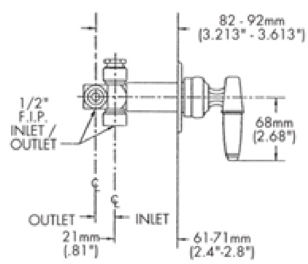
ANCHOR PLATE



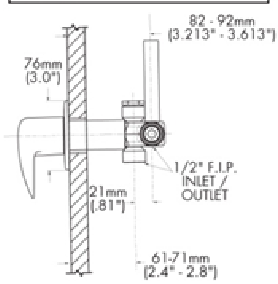
54T1200 CONTROL VALVE



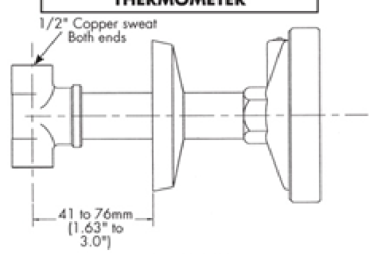
060852A DIVERTER VALVE



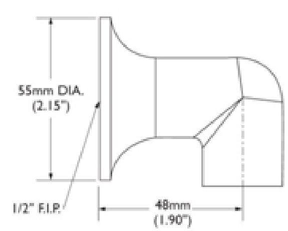
061058A DIVERTER VALVE



060274A WALL THERMOMETER



060605A TOE TESTER SPOUT



Note: Measurements may vary ± 6mm (0.25")

Refer to www.specselect.com for individual models.

Note: Use this page as a product submittal sheet.

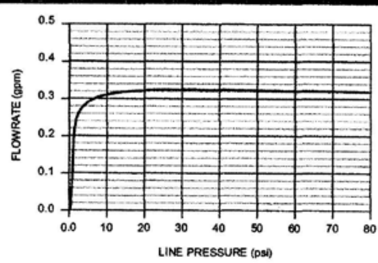
DSP–SHWB Rev. D

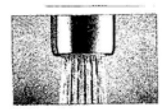
DELTA

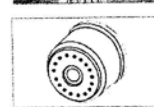
PCA® Spray
Faucet Attachment - 0.35 gpm max
Pressure Compensating **Regular Size**

Part Number	Description	
061104A	Vandal Proof Male	15/16"-27
061105A	Vandal Proof Female	55/64"-27
061106A	Regular Male	15/16"-27
061107A	Regular Female	55/64"-27

Flow Rate Curve







Delta reserves the right (1) to make changes to specifications and materials, and (2) to change or discontinue models, both without notice or obligation. Dimensions are for reference. Measurement may vary plus or minus 6mm(0.25"). Mounting locations are suggested only. Check with local codes for requirements in your area.

Delta Faucet Company - 55 East 111th St. - Indianapolis, Indiana, USA 46280 - (317) 848-1812
Delta Faucet Canada - 395 Matheson Blvd E - Mississauga, Ontario, Canada L4Z 2H2 - (905) 712-3030

- 1.0.1911

Appendix E: Survey

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory

WATER ATTITUDES AND PRACTICES SURVEY 2011

USACE RCS 2011-CERL-001

Statement of Purpose

Executive Order 13514, Federal Leadership in Environmental, Energy and Economic Performance, has directed the establishment of an integrated strategy towards sustainability in the Federal Government and made improving water efficiency and management a priority for Federal agencies. Goals for agencies include reducing potable water consumption intensity 26% by the end of fiscal year 2020, relative to a fiscal year 2007 baseline.

The Construction Engineering Research Laboratory (CERL) is conducting a Water Attitudes and Practices Survey to collect information related to Army employee water use perceptions and habits. The purpose of this survey is to inform the design of a future water use reduction training program and collect data on the efficacy of water reduction technologies. This survey is for participating training classes at Camp Atterbury Joint Maneuver Training Center (CAJMTC).

Participation is completely voluntary and your response is anonymous. Failure to provide all or any part of the information will not affect you or your employment status. The survey should take no more than 15 minutes to complete.

Survey results will be presented in aggregate form in conference presentations, articles and publications, and other outlets such as Public Works Technical Bulletins (PWTB) and will not be attributed to any individual. The information collected will be stored on a secure USACE server and managed in accordance with AR 25-400-2 records retention requirements.

If you have questions about the purpose or content of the survey, the points of contact are Ira Mabel, USAERDC-CERL, 217-352-6511x7439 and Laura Curvey, USAERDC-CERL, 217-352-6511x7338.

Pre-assessment: _______

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory

Using Resources

For question 1, circle one of the following answers that best fits each question

1 - never   2 - some of the time   3 - half of the time   4 - most of the time   5 - always

1. How often do you:

turn off the lights when you leave a room	1	2	3	4	5	N/A
turn down the thermostat at night or when leaving for the day	1	2	3	4	5	N/A
check for water leaks around the barracks	1	2	3	4	5	N/A
shower more than once a day	1	2	3	4	5	N/A
take “combat showers”	1	2	3	4	5	N/A
use the shower to wash clothes/boots or do other tasks	1	2	3	4	5	N/A
lower the water level of the washing machine for smaller loads	1	2	3	4	5	N/A
turn off the faucet while brushing teeth/shaving	1	2	3	4	5	N/A
turn off air conditioning when leaving a room	1	2	3	4	5	N/A
use the toilet to dispose of garbage	1	2	3	4	5	N/A

2. Have you ever heard about the importance of using less energy? ☐ Yes ☐ No

   If so, how? (Army training, as a kid, school, family, TV, etc.) ____________________

   ____

   ____

3. Have you ever heard about the importance of using less water? ☐ Yes ☐ No

   If so, how? (Army training, as a kid, school, family, TV, etc.) ____________________

   ____

   ____

4. Have you ever noticed water being wasted during field training? ☐ Yes ☐ No

   If so, how? ____________________________________

   ____

   ____

   ____

5. Have you ever noticed water being wasted during deployment?

☐ Yes ☐ No ☐ Never deployed

If so, how? ____________________

6. Do you know how to report water waste during training or deployment? ☐ Yes ☐ No

If so, please describe ____________________

7. Are you ever given restrictions on water usage? (length of showers, amount of drinking water, etc.)

☐ Yes ☐ No

If so, please describe ____________________

Resource Perception

For question 8, circle one of the following answers that best fits each question

1 - will not drink 2 - low quality 3 - acceptable 4 - high quality 5 - preferred

8. What is your opinion of drinking water from:

water buffaloes	1	2	3	4	5	N/A
dining facility	1	2	3	4	5	N/A
bathroom taps/other faucets/spigots	1	2	3	4	5	N/A
bottles	1	2	3	4	5	N/A

For questions 9-10, circle one of the following answers that best fits each question

1 - never 2 - some of the time 3 - half of the time 4 - most of the time 5 - always

9. How often do you think about how much energy is used during daily training tasks?

1 2 3 4 5 N/A

10. How often do you think about how much water is used during daily training tasks?

1 2 3 4 5 N/A

For question 11, use the following scale to circle one answer that best fits each question

1 - not important 3 - somewhat important 5 - very important

11. Rate the importance of the following on the way you perform daily tasks:

effectiveness (getting the best results)	1	2	3	4	5	N/A
efficiency (saving time)	1	2	3	4	5	N/A
standing operating procedures (requirements)	1	2	3	4	5	N/A
resource conservation (saving energy, water, etc.)	1	2	3	4	5	N/A
safety (reducing risk)	1	2	3	4	5	N/A

12. Are you aware that the Army has water reduction goals? ☐ Yes ☐ No

13. Are you aware that Camp Atterbury is trying to reduce water use? ☐ Yes ☐ No

14. If you answered "Yes" to question 12 or 13, have you changed your habits to help meet water reduction goals? ☐ Yes ☐ No

If so, how? ______________________________

____

____

General Information

15. How often do you have field training? ______________________________

16. How long is your typical field training course? ______________________________

17. How would you like to learn more about reducing water use? (check all that apply):

☐ posters and signs ☐ classroom lectures

☐ online tutorials ☐ hands-on demonstrations

☐ handbooks and pamphlets ☐ other: ______________

18. What is your branch of service? ______________________________

Active or reserve? ______________________________

19. Where did you grow up (U.S. state, foreign country)? ______________________________

20. Where do you live now (U.S. state)? ______________________________

21. Gender: ☐ Male ☐ Female

22. Do you have other suggestions about reducing water usage? ______________________________

____

____

page 4

Appendix F: Survey Analysis

Primary Surveys

Table F1. Survey Question 1, “How often do you … ?”.

How often do you:	Mean response	Standard deviation
turn off the lights when you leave a room	3.87	1.075
turn down the thermostat at night or when leaving for the day	2.58	1.416
turn off air conditioner when leaving a room	1.94	1.142
check for water leaks around the barracks	1.60	0.959
take “combat showers”	2.16	1.017
lower the water level of the washing machine for smaller loads	3.02	1.567
turn off the faucet while brushing teeth/shaving	3.01	1.527
shower more than once a day	2.02	0.989
use the shower to wash clothes/boots or do other tasks	1.45	0.849
use the toilet to dispose of garbage	1.21	0.658
1 = never, 2 = some of the time, 3 = half of the time, 4 = most of the time, 5 = always		

Table F2. Survey Questions 2-3.

	Have you heard about the importance of using less energy?	Have you heard about the importance of using less water?
yes	87.7%	84.0%
no	12.3%	16.0%

Table F3. Survey Questions 4-7.

	Have you ever noticed water being wasted during field training?	Have you ever noticed water being wasted during deployment?
yes	24.3%	16.9%
no	75.7%	35.0%
never deployed		48.1%
	Do you know how to report water being wasted during training or deployment?	**Are you ever given restrictions on water usage?**
yes	7.0%	42.7%
no	93.0%	57.3%

Table F4. Survey Questions 12–14.

	Are you aware that the Army has water reduction goals?	Are you aware that Camp Atterbury is trying to reduce water use?	Have you changed your habits to help meet water reduction goals?
yes	14.5%	20.2%	21.1%
no	85.5%	79.8%	77.9%

Table F5. Survey Questions 9–10.

	Mean response	Standard deviation
How often do you think about how much energy is used during daily training tasks?	1.86	1.113
How often do you think about how much water is used during daily training tasks?	1.77	1.028
1 = never, 2 = some of the time, 3 = half of the time, 4 = most of the time, 5 = always		

Table F6. Survey Question 11.

Rate the importance of the following on the way you perform daily tasks:	Mean response	Standard deviation
effectiveness	4.56	0.715
efficiency	4.48	.0794
standing operating procedures	4.29	0.872
resource conservation	3.31	1.269
safety	4.56	0.835
1 = not important, 3 = somewhat important, 5 = very important		

Table F7. Survey Question 3A.

Response	Number of occurrences
TV	87
school	63
family	31
as a kid	26
Army training	21
water bill	7
parents	6
work	5
everywhere	5
radio	4
Al Gore	3
commercials	3
news	3
internet	3
reading	3
newspaper	2
general knowledge	2
media	1
environmental activists	1
word of mouth	1

Table F8. The effect of awareness on attitudes and practices.

	Q12. Are you aware that the Army has water reduction goals?		Q13. Are you aware that Camp Atterbury is trying to reduce water use?		Q14. Have you changed your habits to help meet water reduction goals?	
	No (N=207)	Yes (N=35)	No (N=194)	Yes (N=49)	No (N=74)	Yes (N=20)
Q10. How often do you think about how much water is used during daily training tasks?	1.74	1.89	1.70	2.00	1.84	2.00
Q11. How important is resource conservation on the way you perform daily tasks?	3.24	3.66	3.18	3.81	3.14	4.32
1 = never, 5 = always; 1 = not important, 5 = very important						

Secondary Surveys

Table F9. Survey Questions 12–14.

	Are you aware that the Army has water reduction goals?	Are you aware that Camp Atterbury is trying to reduce water use?	Have you changed your habits to help meet water reduction goals?
yes	41.3%	43.5%	50.8%
no	58.7%	56.5%	49.2%

Table F10. Survey Questions 9–10.

	Mean response	Standard deviation
How often do you think about how much energy is used during daily training tasks?	2.03	0.931
How often do you think about how much water is used during daily training tasks?	2.10	1.094
1 = never, 2 = some of the time, 3 = half of the time, 4 = most of the time, 5 = always		

Appendix G: Awareness Campaign

Briefing Module

"Camp Atterbury is participating in an Army Corps of Engineers initiative to improve water efficiency and quality. Lessons learned at Camp Atterbury will contribute to decisions made Army-wide. Please inform your unit to be responsible when using water for both training activities and personal use. Report any problems with water utilities to the FOB Mayor's Cell."

Figure 58. Awareness sticker.

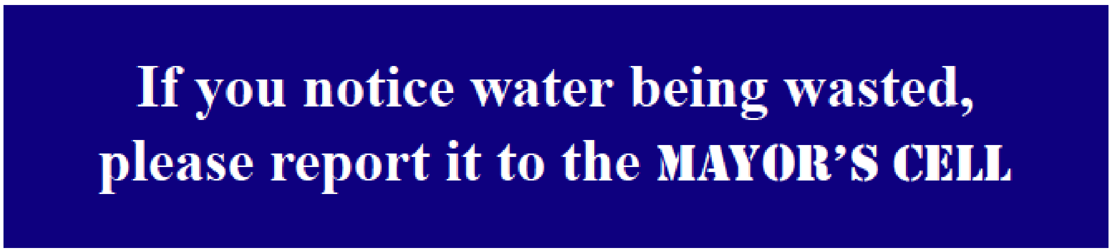
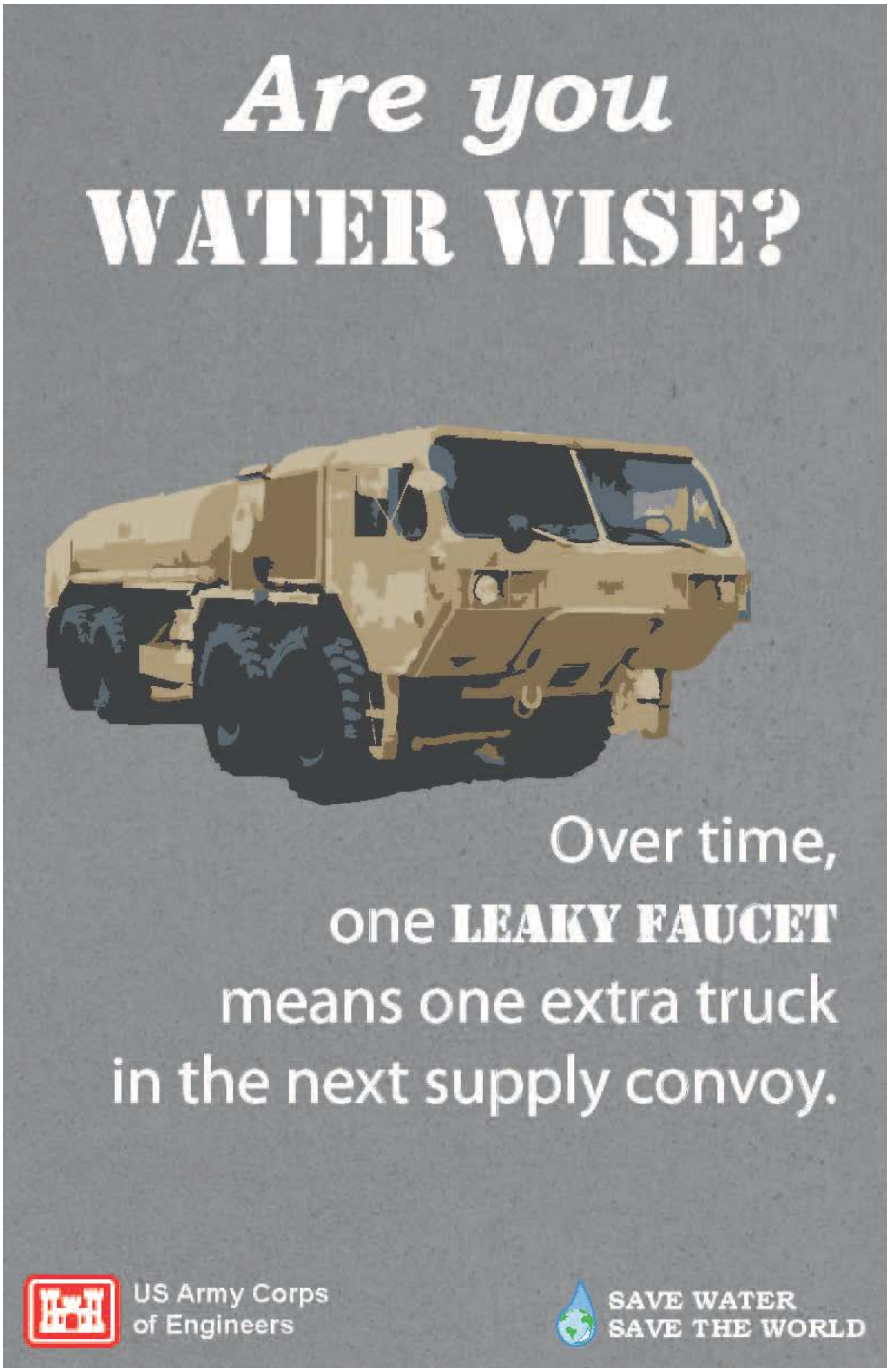
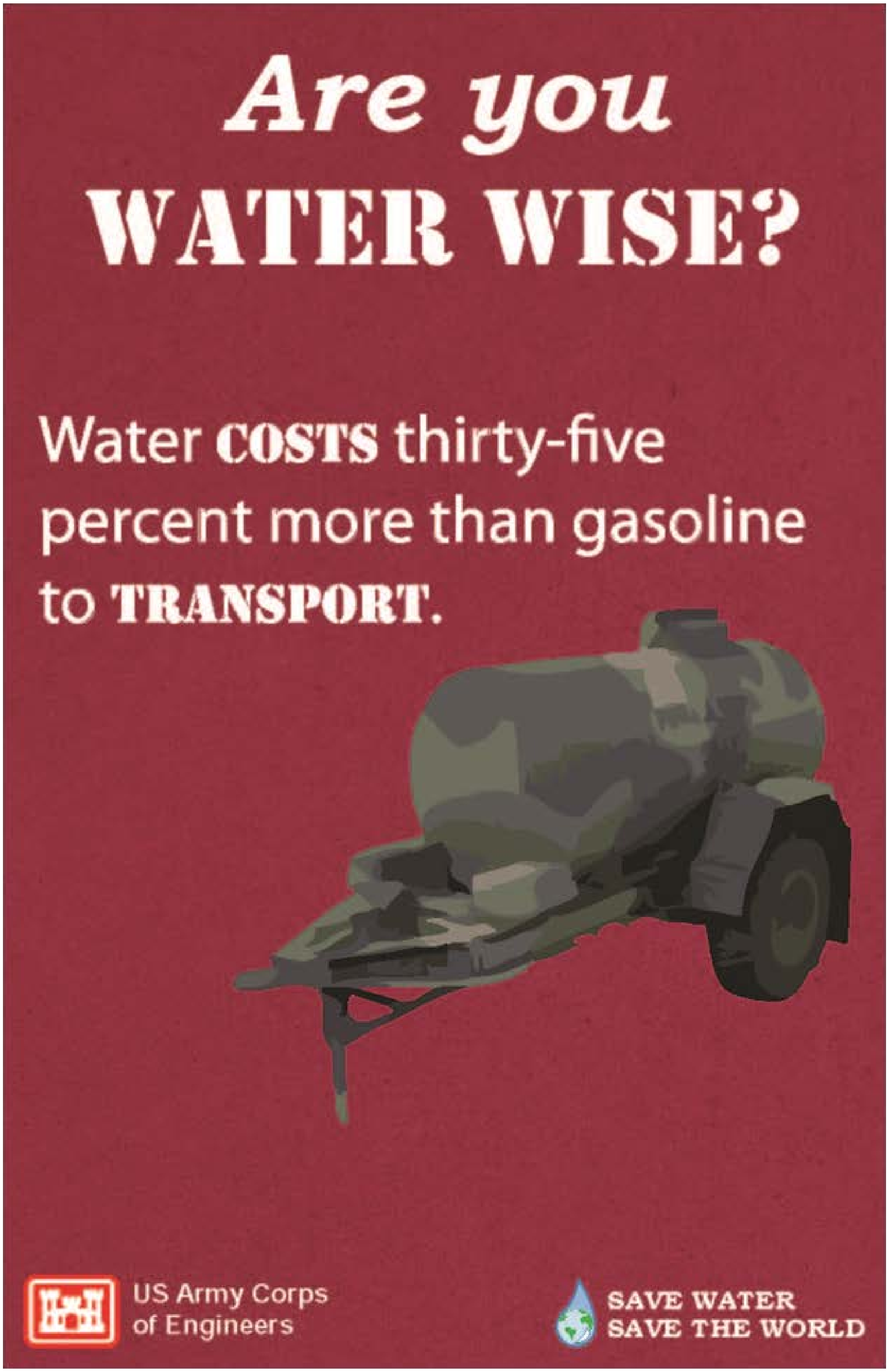
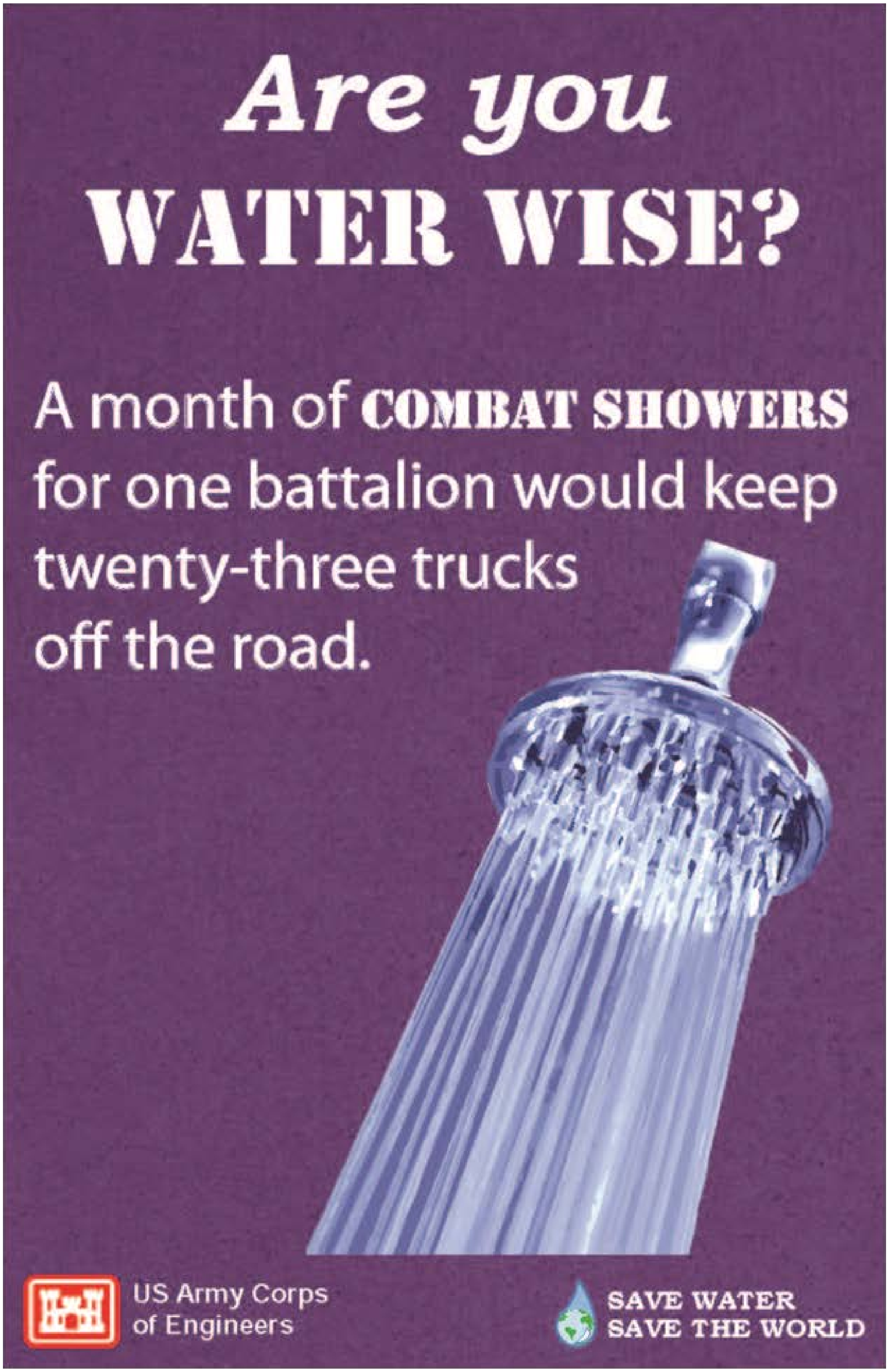


Figure 59. Instructions to report waste.

Appendix H: Posters




Are you
WATER WISE?
Water COSTS thirty-five percent more than gasoline to TRANSPORT.
US Army Corps of Engineers
SAVE WATER
SAVE THE WORLD


Are you
WATER WISE?
A month of COMBAT SHOWERS for one battalion would keep twenty-three trucks off the road.
US Army Corps of Engineers
SAVE WATER
SAVE THE WORLD

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14. ABSTRACT
Many Army installations within the United States are located within watersheds that are highly vulnerable to issues of water supply or demand stress. Army testing and training ranges are at particular risk to issues of water scarcity due to the fluctuations in population and the transient nature of residents. Additionally, testing and training areas offer the opportunity to expose soldiers to the importance of water efficiency and conservation because 500,000 soldiers pass through these facilities in any given year. Commercially available water conservation technologies can be implemented to realize water savings in Army testing and training 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 demonstration/validation of the shower trailer plumbing fixtures, bulk water point, and composting toilet at training sites and water systems at the Camp Atterbury Joint Maneuver Training Center (CAJMTC), IN. Surveys were employed to determine general attitudes about water conservation and how these were affected by the conservation retrofits.

15. SUBJECT TERMS
water conservation, training lands, net zero water (NZW), Camp Atterbury, IN

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