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Fort Knox, KY Containment Berm Unit Installation



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Summary Report

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Abstract:

There is interest from the range community in establishing a sustainable, closed loop small arms firing range (SAFR) bullet impact system or Containment Berm Unit (connex). Connex is a generic term used to refer to a common modified steel storage container used in a vast number of commercial storage and transport applications. The connexes constructed for the Passive Reactive Berm (PRBerm™) technology that was demonstrated at Charleston Air Force Base (CAFB) under the Environmental Security Technology Certification Program (ESTCP) project ER-0406 provide suitable containment of berm material at an active SAFR.

Bullets will be fired into berm material (sand) contained in the modified connexes and leachate water will be released from the system. The metals from the bullets will be retained, stabilized, in the berm material with the addition of proper amendments. Following sufficient firing into the Containment Berm Unit, the berm material can be excavated, the bullets and bullet fragments removed and recycled, and berm material replaced or placed back in the connex. This provides a closed loop containment system for sustainable range training purposes. The Containment Berm Unit can be made transportable and easily adapted to varied installation training requirements. Installation of a Containment Berm Unit occurred at the Fort Knox, KY Heins Qualification Test Range (QTR), a multipurpose range, at a cost of \$7000.00 (2012\$) for fabrication and delivery; the installation provided equipment and operators to assist. Data collection to demonstrate technology efficiency is on-going; however, completion of the Fort Knox connex demonstrates successful transfer of an ESTCP- and U.S. Army Environmental Command- developed technology to the installation.

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Preface

This summary report provides detailed results for the planning and installation of a 500 meter Containment Berm Unit located at the Fort Knox, KY, Heins QTR range. The U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS conducted this work. Project oversight and funding for ERDC was provided by the U.S. Army Environmental Command (USAEC), San Antonio, TX. The USAEC point of contact (POCs) for this effort are Dr. Robert Kirgan and Mr. Curtis Fey.

The report was prepared by Mr. W. Andy Martin, Ms. Deborah R. Felt, and Dr. Steven L. Larson, ERDC–Environmental Laboratory (EL); Ms. Catherine C. Nestler, Applied Research Associates, Inc. (ARA), Vicksburg, MS.

Acronyms

CAFB	Charleston Air Force Base
ESTCP	Environmental Security Technology Certification Program
ISO	International Organization for Standardization
O&M	Operation and Maintenance
PRBerm™	Passive Reactive Berm
QTR	Qualification Test Range
SAFR	Small arms firing range
SPLP	Synthetic Precipitation Leaching Procedure
USAEC	US Army Environmental Command

1 Introduction

1.1 Background

There is interest from the range community in establishing a sustainable, closed loop small arms firing range (SAFR) bullet impact system; a modified connex or Containment Berm Unit. The original connexes were constructed for the Passive Reactive Berm (PRBerm™) technology demonstration at Charleston Air Force Base (CAFB) under the Environmental Security Technology Certification Program (ESTCP) Project ER-0406 (Larson et al. 2007, Wynter et al. 2012, in press).

The PRBerm™ connexes are filled with sand (or sand + amendments) that contain bullets fired into berm material. The use of amendments will depend on the site conditions to include: weathering conditions, range use, bullet components, operation and maintenance (O&M) plan, and soil type. With the addition of proper amendments, the sand, sand/amendments can also retain and stabilize metals while releasing leachate water that meets Federal, State and local regulatory requirements.

Following sufficient firing into the containment berm, the berm material can be excavated, the bullets and bullet fragments can be removed and recycled, and then the berm material can be replaced or placed back in the containment berm. This process can provide a closed loop containment system for sustainable range operations and training purposes. An additional benefit is that the single Containment Berm Unit, if desired, can be manufactured so that it is transportable and thus easily adapted to varied installation training requirements.

1.2 Purpose

The purpose of this summary report is to document the results of the placement of a Containment Berm Unit (modified connex) at the Fort Knox, KY, Heins QTR range used for small arms training, 50 caliber or less. The document provides a step-by-step process for installation procedures. This document also provides cost estimates for the Containment Berm Unit placed at the Fort Knox, KY range and a

discussion of factors that will impact cost at other areas.

1.3 Objective

The overall objective was to support the U.S. Army Environmental Command's (USAEC) effort to provide a Containment Berm Unit that offers ease of installation, sufficient containment of bullets and bullet fragments for later removal from the berm material (i.e. sand) and recycling. The ultimate demonstration is a closed loop SAFR system where the berm material (i.e. sand, sand/amendments) can be placed back in the containment unit following removal of bullets and bullet fragments. It is also the goal to determine how the Containment Berm Units perform when challenged with newly developed ammunition in support of the US Army's training and tactical mission.

The tasks documented in the scope of work are:

Task 1. Design and construction of the Containment Berm Unit.

Task 2. Installation of the Containment Berm Unit.

Task 3. Analysis of the Containment Berm Unit while in use.

Task 4. Technology transfer via report / presentation following the project.

Long term performance objectives provide valuable insight into the ability of the Containment Berm Unit to function as designed and engineered. There are several long term objectives that could be addressed: post-installation site visit, investigate leachate metals concentrations, investigate alternative munition performance, remove the Containment Berm Unit and investigate its long term performance in regards to structural integrity. These tasks will provide additional performance evaluation critical to the connex design and use.

2 Installation of the Containment Berm Unit (Modified Connex)

2.1 Site Visit

2.1.1 Initial Site Visit

The first site visit was conducted in the fall of 2011 to determine the applicability of the Containment Berm Unit installation at the Fort Knox, KY, Heins QTR range. It was determined that the 500 meter target, Figure 1, would provide the best evaluation of the Containment Berm Unit at the Fort Knox Heins QTR range, since it is regularly used as a familiarization target. The unit placement was determined to be best located where the round impacts were visible in the berm, Figure 2.



Figure 1. The 500 meter target, proposed location of the Containment Berm Unit.



Figure 2. The 500 meter target impact pocket for majority of rounds.

2.1.2 Coordination Site Visit

A second site visit was conducted in April 2012 in order to coordinate equipment and placement of the Containment Berm Unit. A final site inspection determined connex placement, connex design specifications, and overall general lay of the land prior to installation. Equipment coordinated for berm installation included: a fork lift, bobcat, backhoe, and dump trucks.

2.2 Containment Berm Unit Installation

2.2.1 Installation Preparation

The Containment Berm Unit preparation included site visits to the Fort Knox Heins Range and coordination meetings regarding the connex installation. Procurement of materials and supplies, and connex (Figure 3) design and construction were also coordinated.

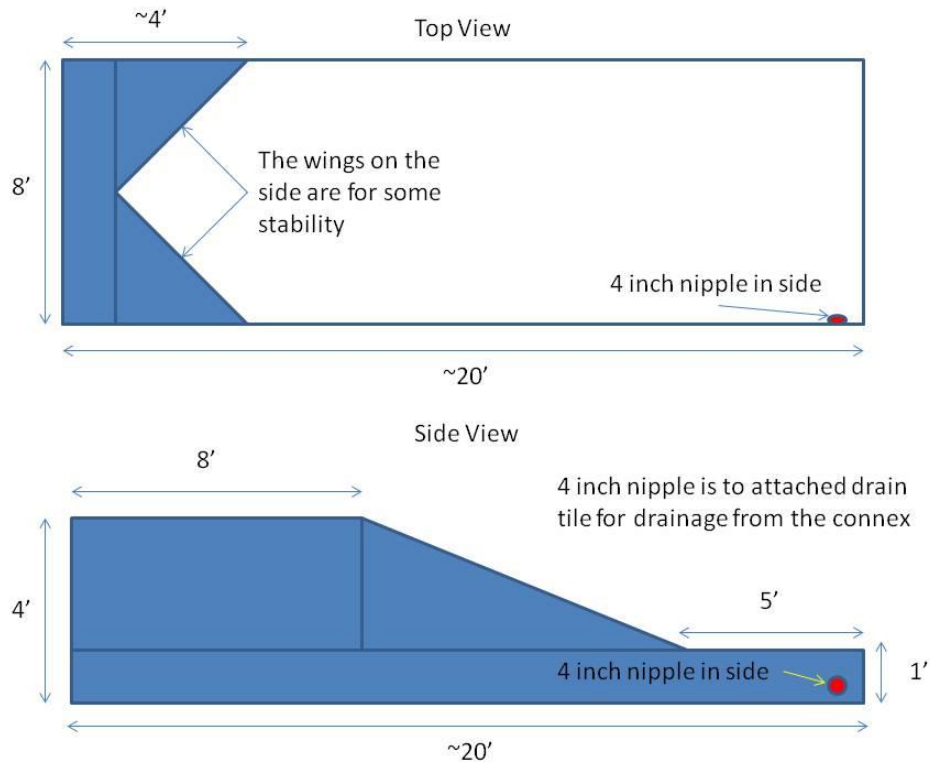


Figure 3. Containment Berm Schematic Drawing.

The PRBerm™ from the ER-0406 project was constructed out of a 20 foot refrigerated container and some modifications to that design were incorporated in the connex used at Fort Knox. These modifications include reduced height profile (4 feet vs 8 feet), use of the starting connex type, and some slight finishing modifications. The Containment Berm Unit was fabricated by inverting a 20 foot International Organization for Standardization (ISO) shipping container, or connex, and modifying the connex as specified in Figure 23. The edges of the connex were finished with angle iron, so no sharp edges were exposed. The connex was painted with an epoxy paint to retard corrosion and the floor was finished with a skid free paint to avoid potential slips (Figure 4).



Figure 4. Painted containment berm prior to installation.

2.2.2 Containment Berm Unit Costs

The cost is reported as the fabrication and installation of one Containment Berm Unit. While this provides a good estimate of what it may cost to install multiple Containment Berm Units, the user should be aware that cost offsets could also be incorporated due to various factors such as:

- Reduced rate for fabrication and purchase of multiple connexes,
- Reduced costs associated with an experienced crew placing several units and reduced mobilization time,
- Using garrison available equipment over renting equipment,
- Using borrowed labor, such as on-station military engineers, to place Containment Berm Units,
- Disposal and / or stabilization of berm spoil material.

The initial assumptions are listed below and are based on previous work as well as results from the PRBerm™ study (Larson et al. 2004; Larson et al. 2005; Larson et al. 2007, Wynter et al. 2012, in press). The use of a containment berm may be indicated when the native soils of the bullet impact area:

- are characterized by high acidity (low pH),
- are characterized by high alkalinity (high pH),
- have high permeability,
- and have low soil/water K_d values for a particular metal (such as lead)

The majority costs associated with the Containment Berm Units are material and labor. Construction and installation of a single unit can run from \$7,000.00 to \$18,500.00 depending on the available assets and resources (Table 1). Generally, material costs will scale linearly with increasing numbers of Containment Berm Units, unless cost breaks are given by the manufacturer for a large number of connexes, since the cost of sand and amendments is relatively small. However, the cost can be offset, as mentioned above, by the installation of multiple Containment Berm Units at the same time which reduces equipment mobilization fees.

Table 1. Cost Breakdown for Installation of One Containment Berm Unit.

Element	Quantity	Fort Knox		Potential	
		Cost	Total	Cost	Total
20 Foot Connex	1			\$ 1,500.00	\$ 1,500.00
Fabrication / Handling	1	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00
Painting	1	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00
Drainage Port (10 foot sections)	2	\$ 6.00	\$ 12.00	\$ 6.00	\$ 12.00
Equipment Operator Labor (man hours)	12			\$ 50.00	\$ 600.00
Supervisor	6			\$ 75.00	\$ 450.00
Bobcat	1			\$ 2,000.00	\$ 2,000.00
Backhoe	1			\$ 2,000.00	\$ 2,000.00
Fork Lift	1			\$ 1,500.00	\$ 1,500.00
Dump Truck	1			\$ 2,000.00	\$ 2,000.00
Grass Seed	1			\$ 25.00	\$ 25.00
Straw	12			\$ 20.00	\$ 240.00
Sand (per 10 ton)	3			\$ 400.00	\$ 1,200.00
TOTAL		\$ 7,012.00		\$ 18,527.00	

The cost of a traditional small arms earthen berm compared to the cost of a fixed Containment Berm Unit / PRBerm™, and a steel bullet trap is shown in Table 2 (updated, ESTCP ER-0406 Cost and Performance Report). The estimated construction cost for a 100 foot containment berm is approximately \$55K more than a traditional earthen berm and for the construction of a steel bullet trap is estimated at \$210K more than a traditional earthen berm.

Table 2. Comparative Cost and Maintenance of SAFR Impact Technologies (\$) (updated, ESTCP ER-0406 Cost and Performance Report).

Technology	Construction Cost ^a \$	Yearly O&M ^b \$	Years in Operation	30 Year O&M Cost \$	Overhaul at 10 years \$	Number of Overhauls	Cost for Overhauls \$	30 year Total Cost ^c \$
Earthen berm(2003\$)	108,672	5000	30	150,000.00	54,336	2	108,672	367,343.90
Containment Berm Unit / PRBerm(2011 \$)	162,284	3750	30	112,500.00	81,142	2	162,284	437,068.90
Steel bullet trap(2011\$)	322,850	12,000	30	360,000.00	176,425	2	352,850	1,035,699.65
^a Assumes for 100 ft berm; does not include range floor or surrounding area								
^b 5,000 Estimated cost for sand addition, less sand addition required for containment berm								
^c Adjusted for inflation to 2012\$								

A stabilization material commercially identified as TRAPPS™ was used to stabilize a small volume of berm spoil removed to place the containment berm. The TRAPPS™ was selected for use to stabilize the metals in the soil based on its synthetic precipitation leaching procedure (SPLP) results so that the berm spoils could be treated and used elsewhere on the range. Amendments were not used in the actual containment berm sand as per the project scope, but could be added. The cost for the TRAPPS™ stabilization material was \$3,000.00 to include shipping and is provided to give the reader a general cost estimate for this material or suitable material. An amendment cost is based on several factors such as quantity needed, availability, ease of use and shipping, etc.

The cost estimates in Table 2 does not include ejecta material (i.e. ejected during impact or berm O&M, etc.) that would have to be remediated / cleaned up due to final closure. The volume of soil would substantially increase and may or may not be pertinent to the containment berm or steel trap technologies.

In general, the cost of a Containment Berm Unit or PRBerm™ is slightly more than a traditional earthen berm due to the additional contrainment connex and amendment (if needed), while much less than the cost of a steel bullet trap system. Maintenance of the Containment Berm Unit is minimal, little more than what is required for an earthen berm. Life cycle cost analysis should note that the Containment Berm Unit reduces metal migration, therefore the potential of permit problems and regulatory fines, range shutdown issues and a reduced training capability. In addition, metal recycling from the Containment Berm Unit could offset yearly maintenance costs.

2.2.3 Containment Berm Unit Installation

The Containment Berm Unit installation was planned to occur over a three day time period to accommodate potential rain delays. Fabrication of the connex, as well as equipment and operators, were coordinated prior to installation. Sand was ordered to be delivered on the second day of installation with the option of early delivery if requested.

The berm area to be excavated was marked off with flags and marking paint (Figure 5). The excavation continued until the hole was large enough to place the Containment Berm Unit (modified connex) with approximately 12 to 18 inches of cover material (Figure 6). The floor was sloped to allow drainage from the unit.



Figure 5. Initial excavation using a backhoe, showing marking flags.



Figure 6. Final excavation at a depth ranging from 2 to 5 feet.

Following excavation, the fabricated connex was lowered into place using a forklift, ensuring proper alignment with the point of aim (Figure 7). The unit was fitted with a four inch diameter drain port to ensure proper drainage (Figure 8).



Figure 7. Fabricated connex unit after being lowered into the excavated berm.



Figure 8. Placement of drainage port for the Containment Berm Unit.

The area around the fabricated connex was backfilled (Figure 9) prior to placement of sand into the unit to avoid the bowing of the containment berm walls.



Figure 9. Backfill of the fabricated connex prior to filling the unit with sand and amendments.

The Containment Berm Unit was filled with 22.5 cubic yards of sand (Figure 10) compacted into the containment berm using the backhoe and bobcat to ensure that air pockets were removed. Following compaction, the berm was regraded to conform to the contours of the range and make it ready for use (Figure 11).



Figure 10. Filling Containment Berm Unit with sand and metal stabilizing soil amendment.



Figure 11. Completed Containment Berm Unit after re-grading.

3 Conclusions

Based on our experiences at Fort Knox, after the preparation work, the installation of one Containment Berm Unit can be accomplished in under six (6) hours with experienced equipment operators and prior coordination to ensure equipment, fabricated connex, and fill material (e.g. sand) are on site and ready for installation. Sufficient site visits are necessary to ensure proper coordination with garrison staff, and others, for installation. The fabricated containment berm design was based on the PRBerm™ connex design, but was slightly modified to account for onsite conditions and connex availability.

The cost to install one Containment Berm Unit will vary depending on installation equipment, operator experience and material costs; the cost to install one Containment Berm Unit at Fort Knox was \$7,000.00 (not including cost of \$3,000 for soil amendment as necessary).

4 Future Work

Future work that could move this technology towards large-scale use at SAFRs:

- Three and nine (if needed) month post-installation inspections.
- Evaluate the leachate water generated from the berm.
- Investigate the containment of alternative munitions (primarily small arms munitions) in the berm unit.
- Remove the Containment Berm Unit to evaluate long term, three to five year, performance.
- Evaluate the use of a filter or filter media to capture any metals that may be leaching from the Containment Berm Unit.
- Amendment selection at specific site.

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