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About This Publication

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Executive Summary

Public Law 99-145 (the National Defense Authorization Act for Fiscal Year 1986) and the Chemical Weapons Convention[1] required the United States to destroy its chemical weapons stockpile by April 2007, with no extensions permitted after April 2012. As public concern increased regarding the risk associated with incinerating the chemical agent, the Congress passed Public Law 104-201 (the National Defense Authorization Act for Fiscal Year 1997), which requested the Department of Defense (DoD) conduct an assessment of technologies other than incineration for destruction of assembled chemical weapons. In response to the Congress, the Deputy Secretary of Defense appointed a Program Manager (PM) for the Chemical Demilitarization – Assembled Chemical Weapons Assessment (ACWA) program in December 1996.

Public Law 107-248, approved in October 2002, assigned ACWA the responsibility for destruction of the chemical weapons stored in Pueblo, CO and Blue Grass, KY. After being enacted, the ACWA program changed its name to Assembled Chemical Weapons Alternatives to better reflect its newly expanded role: overseeing the full-scale pilot testing of neutralization technologies to destroy the chemical weapons stockpiles in Colorado and Kentucky.

Since 2003, the program has been overseen as a Major Defense Acquisition Program (MDAP), and an original Acquisition Program Baseline (APB) was established in April 2003. The program went through a critical Nunn-McCurdy breach in 2006 and a new APB was established in April 2007. In June 2010, the PM for the ACWA program notified the Under Secretary of Defense (USD) for Acquisition, Technology and Logistics (AT&L) of a significant Nunn-McCurdy breach in the Program Acquisition Unit Cost (PAUC). The PM reported that the PAUC had risen 21.67 percent from $1.726 million in the April 2007 APB to $2.1 million in Base Year 1994 dollars. Upon further refinement of the life-cycle cost estimate, the program reported a critical Nunn-McCurdy breach in their December 2010 Selected Acquisition Report (SAR) with a PAUC estimate of $2.403 million, an increase of 39.22 percent from the 2007 APB.

IDA's analysis revealed two major causes of the cost growth. First, the APB was an unrealistic cost estimate, which had insufficient allowance for risk and rested on an inadequate analogy. Second, the systems contract, with an evolving structure, allows for

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1 *National Defense Authorization Act for Fiscal Year 1986*, Public Law 99-145, was approved November 8, 1986. The Chemical Weapons Convention became law on April 29, 1997.

program flexibility, but enables undisciplined behavior by both the contractor and government personnel. A third root cause, a larger allowance for risk, includes elements of both the unrealistic cost estimate and the contract structure, but is sufficiently large to merit a separate categorization.

Contents

1. Background

Public Law 99-145 (the Department of Defense Authorization Act for Fiscal Year 1986) and the Chemical Weapons Convention required the United States to destroy its chemical weapon stockpiles by April 2007, with no extensions permitted after April 2012. Figure 1 shows the states and regions that have chemical weapon stockpiles. Yellow shading indicates states or regions without any stockpiles, brown shading indicates areas that had stockpiles that have since been destroyed, and green shading shows states that currently have chemical weapon stockpiles.

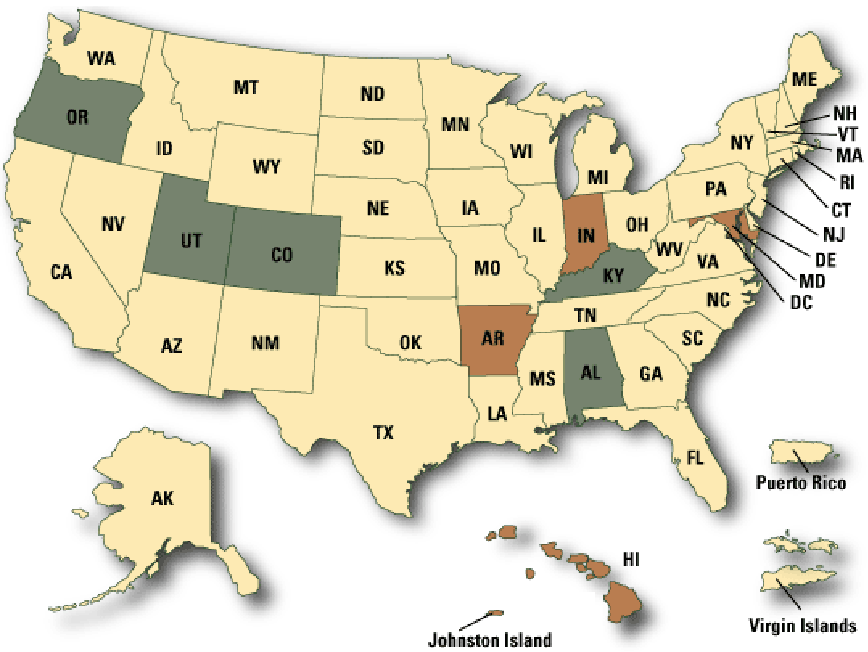

Figure 1. Map of United States indicating States/Regions with Chemical Weapon Stockpiles

Both the Department of the Army and the National Research Council (NRC) deemed incineration the most effective, economical, and safe means for disposing of the Army's aging and obsolete stockpile of chemical agents and munitions.[1] The initial NRC study, conducted in 1984, states, "when compared with disposal by incineration,

[1] Committee on Demilitarizing Chemical Munitions and Agents, "Disposal of Chemical Munitions and Agents," (Washington, DC: National Research Council, 1984).

chemical neutralization processes are slow, complicated, produce excessive quantities of wastes that cannot be certified to be free of agent, and would require higher capital and operating costs. The panel agrees with the Army's decision to abandon chemical neutralization processes in favor of incineration." A subsequent study done by the NRC in 1994 reported that the "time and money spent in search of a better technology [than incineration] are likely to result in program delays and an increase in cumulative total risk, whatever the characteristics of any new technology."[2]

Five of the nine facilities that store chemical weapons have either completed destruction or are currently in the process of destroying chemical weapons using incineration technology. These facilities include Johnston Island, in the Pacific southwest of Hawaii, Pine Bluff Arsenal in Arkansas, Anniston Army Depot in Alabama, Umatilla Chemical Depot in Oregon, and Deseret Chemical Depot in Utah. The chemical weapons in these facilities account for approximately 80 percent of the total stockpile.

The incineration process separates key components of the chemical munition (i.e., liquid agent, metal parts, and explosives) and places them into separate furnaces. The incinerators operate at high temperatures and for long periods of time to ensure complete destruction of the chemical agent and total decontamination of casings and munition pieces. Gases from incinerator furnaces pass through a pollution abatement or removal system to further cleanse emissions. As a final safeguard, operators monitor emissions to verify the agent is completely destroyed.

Despite assurances that incineration is both safe and efficient, communities surrounding these chemical depots have expressed concern about possible environmental contamination and accidental release that would be caused by incineration, and placed pressure on their representatives in the Congress to prevent chemical weapon destruction by incineration. In response to these pressures, the Congress passed Public Law 104-201 (the National Defense Authorization Act for Fiscal Year 1997), which requested the Department of Defense (DoD) conduct an assessment of technologies other than incineration for destruction of assembled chemical weapons. Subsequently, the Deputy Secretary of Defense appointed a Program Manager (PM) for the Assembled Chemical Weapons Assessment (ACWA) program in December 1996.

In October 2002, Public Law 107-248 assigned ACWA responsibility for destruction of the chemical weapons stored in Pueblo, CO and Blue Grass, KY. After being enacted, the ACWA program changed its name to Assembled Chemical Weapons Alternatives to better reflect its newly expanded role: overseeing the full-scale pilot testing of neutralization technologies to destroy the chemical weapon stockpiles in

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[2] Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program, "Recommendations for the Disposal of Chemical Agents and Munitions," (Washington, DC: National Academy of Sciences, 1994).

Colorado and Kentucky. Figure 2 shows the locations for the Colorado and Kentucky facilities, lists the quantity and type of chemical agents residing there, and indicates the current status of the facility. Blister agents reference different types of mustard gas, which is abbreviated using H, HD, and HT, depending on the level of purity and mixture. In addition to blister agents, the stockpile in Kentucky contains two different types of nerve agent, abbreviated as VX or GB. GB is more commonly known as Sarin.

When the Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP) commences operations, it will be responsible for the total destruction of 2,613 tons of blister agent in 780,078 munitions. The stockpile there is composed of 20,384 4.2-inch mortars containing HT, 76,722 4.2-inch mortars containing HD, 383,418 105-mm projectiles containing HD, and 299,554 155-mm projectiles containing HD/H.

When the Blue Grass Chemical Agent-Destruction Pilot Plant (BGCAPP) commences operations, it will be responsible for the total destruction of 523 tons of nerve and blister agent in 101,764 munitions. The stockpile there is more diverse and composed of 51,740 M55 rockets containing GB, 3,977 8-inch projectiles containing GB, 15,492 155-mm projectiles containing H, 17,739 M55 rockets containing VX, and 12,816 155-mm projectiles containing VX.

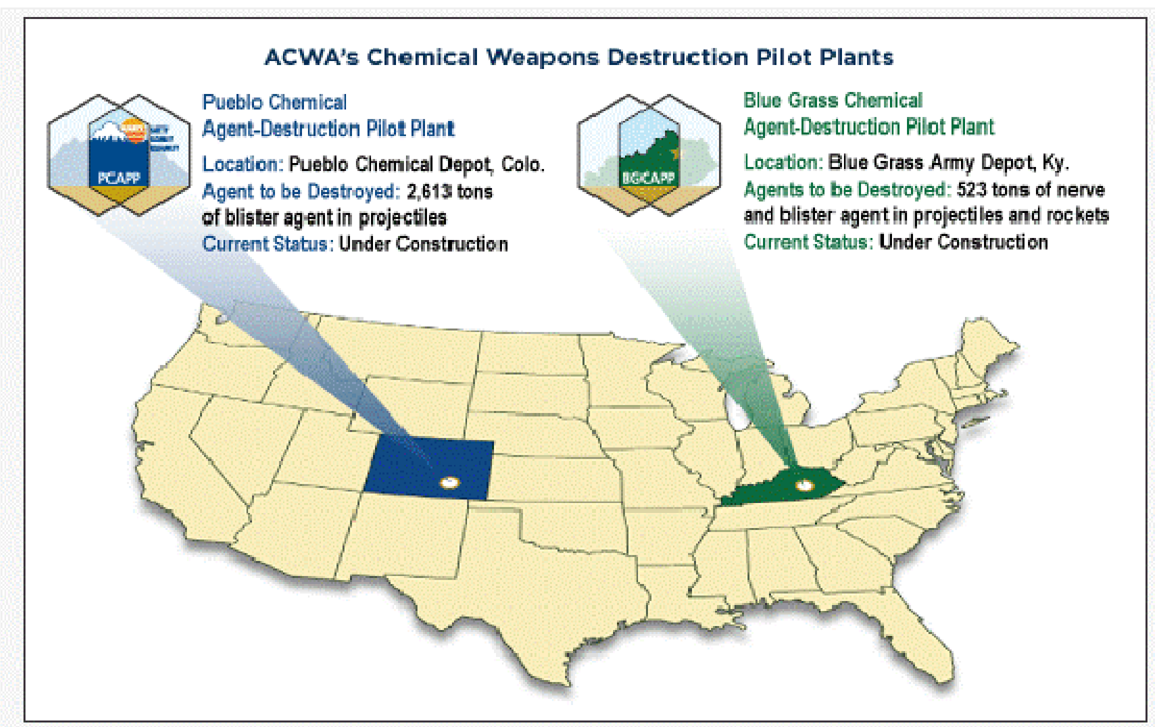

Figure 2. Stockpile Locations and Content for Colorado and Kentucky

A. Agent/Munitions Destruction Process

Although the processes for neutralizing the chemical agents at the two facilities differ, the general structure of the process, discussed in this section, is the same. Sections 1.B and 1.C discuss the unique aspects of the individual facilities' processes.

1. Remove the Energetics

Projectiles and mortars are roughly cylindrical shells with tapered noses. A hollow cylindrical tube runs the length of the shell and contains an explosive charge (a "burster") designed to disperse the chemical agent, with the fuze on the top of the mortar or the projectile. The Blue Grass site also has some M55 rockets, which are composed of a warhead with a fuze/burster arrangement analogous to projectiles and mortars.

Robotic equipment will remove the munitions' energetic components, including the fuze and the burster. Removing these parts first makes the remaining processes safer. Once removed, the energetics will be neutralized on site.

2. Remove the Chemical Agent

Once the energetic components are removed, the munitions body containing chemical agent will be robotically accessed and drained of agent A high-pressure water jet will then clean out any remaining agent as well as any gel and crystals.

3. Neutralize the Chemical Agent

The agents will be chemically decomposed and neutralized by caustic (aqueous sodium hydroxide, or NaOH),[3] for the VX and GB nerve agents, or water hydrolysis, for the mustard gas (H, HD or HT). The resultant chemical agent neutralization byproduct is termed a "hydrolysate," usually with reference to the agent type (e.g., VX hydrolysate or GB hydrolysate). Hydrolysates are classified as hazardous wastes under the Resource Conservation and Recovery Act for three reasons: (1) they are byproducts of the destruction of chemical warfare munitions, (2) they may contain heavy metals, and (3) they have corrosive properties.

4. Process the Resulting Hydrolysate

At this step, the process at the two facilities will differ. At PCAPP, a biotreatment process will use microbes in large tanks to further break down the hydrolysate. Water released from the process will be recycled, leaving various salts and biosludge. The biosludge, made up of microbial waste products and other bacterial matter, will be

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3 Committee to Assess Designs for Pueblo and Blue Grass Chemical Agent Destruction Pilot Plants, "Interim Design Assessment for the Blue Grass Chemical Agent Destruction Pilot Plant," (Washington, DC: National Research Council of the National Academies, 2005), 34.

filtered to remove water and shipped offsite to a permitted treatment, storage, and disposal facility.

At BGCAPP, supercritical water oxidation (SCWO) will subject the hydrolysate to very high temperatures and pressures, breaking it down into carbon dioxide, water, and salts. The salts will be condensed by reverse osmosis and shipped offsite to a permitted facility for disposal, while some of the water will be recycled back into the pilot plant and reused as part of the destruction process. The remaining water from the reverse osmosis process will also be shipped offsite to a permitted facility for disposal.

5. Dispose of the Metal Parts

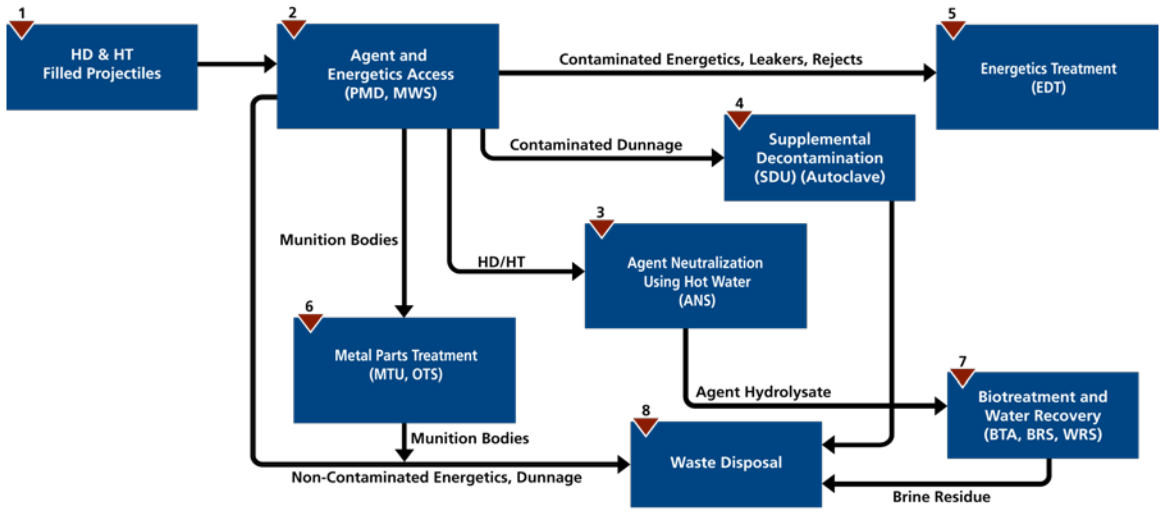
Following energetic removal and agent draining, munitions bodies and solid secondary metal waste will be subjected to an additional decontamination step. Although the metal parts were cleansed of energetics and agent in the first two steps, they still may contain some energetics and agent and need to be decontaminated to a higher level. To reach this level of decontamination, the metal parts will be heated to 1,000 degrees Fahrenheit for 15 minutes, after which the metal can then be recycled.

B. Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP)

At PCAPP, the munitions will first be accessed with the projectile mortar disassembly (PMD) machine, and the energetics will subsequently be removed with the munitions washout system (MWS). PCAPP will only destroy mustard munitions, which will be neutralized with hot water in the agent neutralization system (ANS). The resulting hydrolysate will then be sent to the biotreatment area (BTA) and the brine reduction system (BRS). Water from the biotreatment process will be recycled using the water recovery system (WRS). The munitions bodies will be sent to the munitions treatment unit (MTU) to decontaminate the metal parts.

Weapons identified during the normal process as having chemical or mechanical anomalies—often referred to as leakers and rejects—would require destruction using energetics or explosive destruction technology (EDT). EDT is commercially available and can shorten the time required for the process, due to the fact that the energetics need not be removed prior to destruction.

PCAPP's process requires the development of first-of-a-kind (FOAK) equipment. FOAK includes three systems—the PMD, MWS, and MTU. Figure 3 illustrates the basic processes of the PCAPP facility.



PMD	Projectile Mortar Disassembly
MWS	Munitions Washout System
ANS	Agent Neutralization System
EDT	Energetics Destruction Technology
SDU	Supplemental Decontamination Unit

MTU	Munitions Treatment Unit
OTS	Offgas Treatment System
BRS	Brine Reduction System
WRS	Water Recovery System

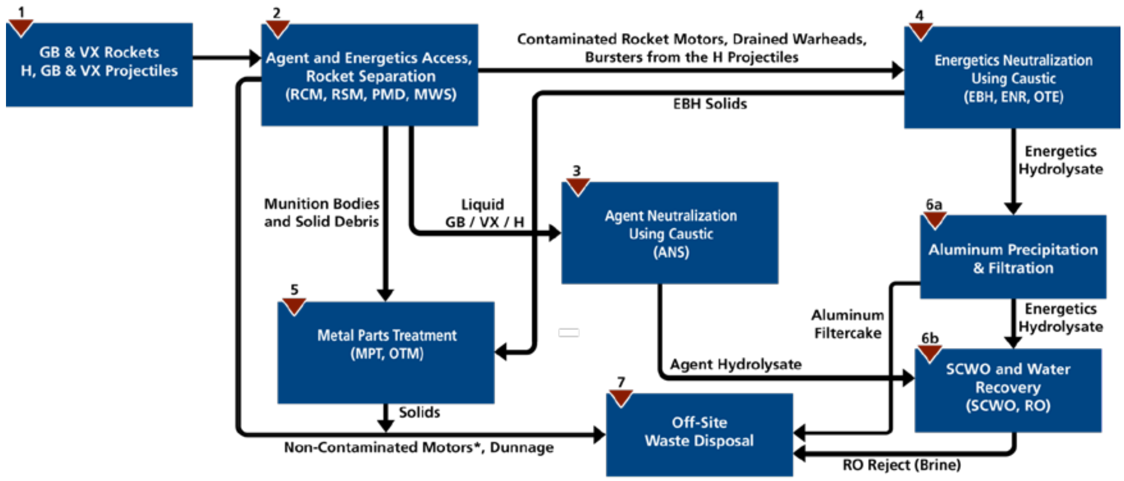
Figure 3. Schematic of the Neutralization Process at the PCAPP Facility

C. Blue Grass Chemical Agent-Destruction Pilot Plant (BGCAPP)

BGCAPP is a more complex site than PCAPP. BGCAPP will process three different agents (mustard, VX, and GB) and two types of munitions (rockets and projectiles). The rocket energetic is accessed with the rocket cutter machine (RCM) and rocket shear machine (RSM), and the projectile energetic is accessed with the PMD machine. The energetic is neutralized using caustic in the energetics batch hydrolyzer (EBH) and the energetics neutralization reactor (ENR). The agents are neutralized using either caustic or hot water with the ANS. The resulting hydrolysates from both the chemical and energetic process are then broken down into carbon dioxide, water and salts in the SCWO system. The munitions bodies and solid debris are treated in the metal parts treater (MPT) system.

The use of EDT at BGCAPP is still under development. Currently, there are no requirements for its use at BGCAPP, although there is funding allocated. Under consideration is the destruction of nearly 70,000 M55 rockets and 15,000 mustard agent projectiles with EDT, which could potentially save eight months in the overall BGCAPP schedule.

Like PCAPP, BGCAPP requires development of FOAK equipment. BGCAPP FOAK includes eight systems—the PMD, MWS, RCM, RSM, EBH, ENR, SCWO, and MPT. Figure 4 illustrates the basic processes of the BGCAPP facility.



RCM	Rocket Cutter Machine
RSM	Rocket Shear Machine
PMD	Projectile Mortar Disassembly
MWS	Munitions Washout System
EBH	Energetics Batch Hydrolyzer
ENR	Energetics Neutralization Reactor
ANS	Agent Neutralization System

MPT	Metal Parts Treater
OTM	Offgas Treatment System for MPT
OTE	Offgas Treatment System for EBH
SCWO	Supercritical Water Oxidation
RO	Reverse Osmosis
*	Non-contaminated rocket motor disposition still under review

Figure 4. Schematic of the Neutralization Process at the BGCAPP Facility

D. Timeline of Major Events

Figure 5 depicts the timeline of major events for the ACWA program. The timeline covers the period from the program's inception in 1996 through the December 2010 memo from the Under Secretary of Defense (USD) for Acquisition, Technology and Logistics (AT&L) that notified the Congress of a critical Nunn-McCurdy breach. Key dates include contracts awards, construction start, and design completion at each site.

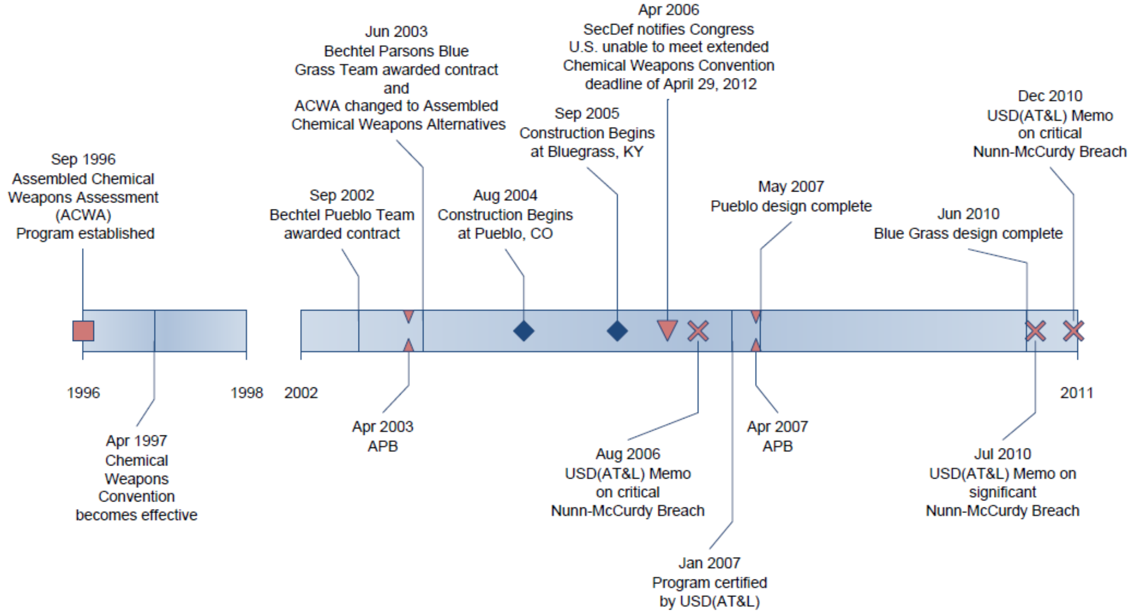


Figure 5. Timeline of Major Events in ACWA Program

2. Cost Growth and Nunn-McCurdy Breach

Since 2003, the program has been overseen as a Major Defense Acquisition Program (MDAP), and an original Acquisition Program Baseline (APB) was established in April 2003. The program went through a critical Nunn-McCurdy breach in 2006, and a new APB was established in April 2007. The September 2006 Selected Acquisition Report (SAR) listed design immaturity, incorporation of lessons learned from other facilities, and funding instability as significant cost drivers for the Nunn-McCurdy breach. The current baseline estimate was derived from an Office of the Secretary of Defense Cost Analysis Improvement Group (CAIG) analysis presented to the Defense Acquisition Board on August 22, 2006. The CAIG estimate included the entire life-cycle cost of both sites through closure. The Weapon Systems Acquisition Reform Act of 2009 transferred the functions of the CAIG to the Office of the Director of Cost Assessment and Program Evaluation (CAPE). Throughout this document, CAIG and CAPE will be considered interchangeable.

In June 2010, the PM for the ACWA program notified the USD(AT&L) of a significant Nunn-McCurdy breach in the Program Acquisition Unit Cost (PAUC).[5] The PM reported that the PAUC had risen 21.67 percent, from $1.726 million in the April 2007 APB to $2.1 million in Base Year 1994 dollars. Upon further refinement of the life-cycle cost estimate, the program reported a critical Nunn-McCurdy breach in their December 2010 SAR, with a PAUC estimate of $2.403 million, an increase of 39.22 percent from the 2007 APB.

In addition to the total program cost growth, Table 1 details the relative cost growth in research, development, test and evaluation (RDT&E) and military construction (MILCON) from the 2007 APB. The table also details the 2011 program office estimate (POE), upon which most of this analysis is based. Although the SAR and POE do not match, the overall assessment of root cause does not vary between them. Figure 6 illustrates the evolution of the PAUC from the original 2003 APB though the December 2010 SAR. The figure also includes the August 2010 Defense Acquisition Executive Summary (DAES), which reported the significant Nunn-McCurdy breach.

If one were to treat the two sites separately, PCAPP and BGCAPP would each have experienced a critical Nunn-McCurdy breach. According to the 2011 POE, the PAUC at PCAPP and BGCAPP grew 37.96 percent and 45.26 percent, respectively.

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5 A copy of the memo is included as Appendix A.

Table 1. Cost Growth

BY 1994 $M	April 2007 Baseline	December 2010 SAR	% Change	2011 POE	% Change
RDT&E	4,728.0	6,537.3	+38.3	6,697	+41.6
MILCON	685.0	998.5	+45.8	1,027	+49.9
TOTAL	**5,413.0**	**7,535.8**	**+39.2**	**7,724**	**+42.7**
Quantity[a]	3,136	3,136		3,136	
PAUC	1.726	2.403	+39.22	2.463	+42.70

[a] Quantity reflects tons of chemical agent to be disposed by ACWA. This number is 3,136 U.S. tons (881,842 munitions) and is composed of 2,613 U.S. tons (780,078 munitions) in the Pueblo stockpile and 523 U.S. tons (101,764 munitions) in the Blue Grass stockpile.

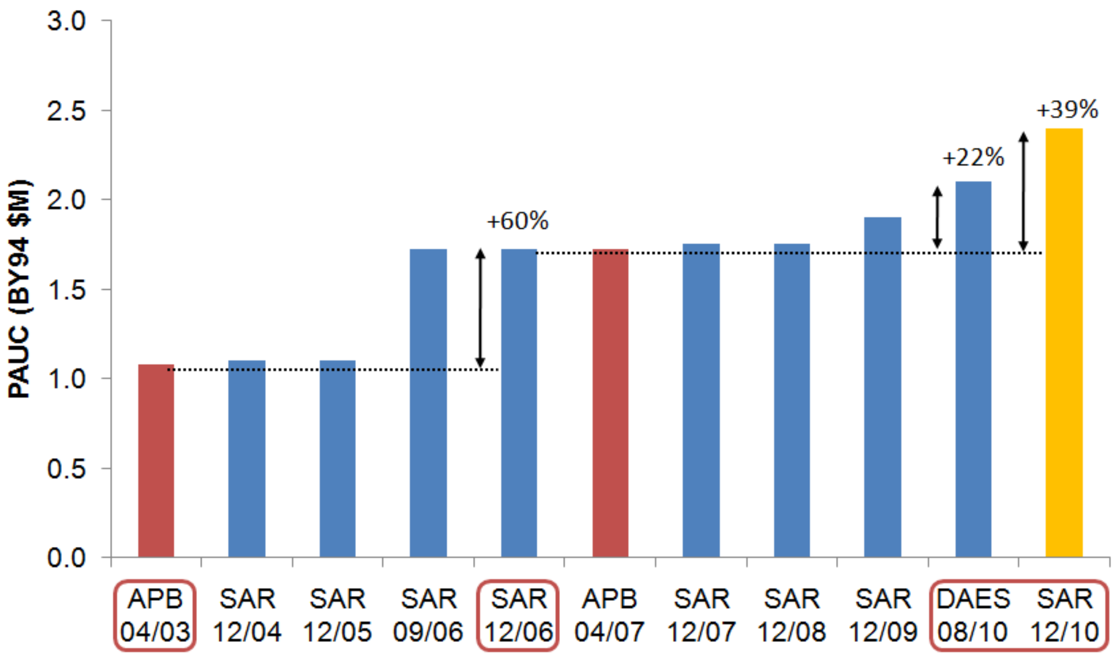

Figure 6. PAUC Cost Growth Over Time (BY94$)

3. Areas of Cost Growth

The SAR only reports the total program cost growth; however, the POE itemizes the program cost by phase—design, construction, systemization, operations, and closure—for each of the two sites. Although the 2007 APB based on the CAIG estimate covered the entire life-cycle cost through closure at both sites, the baseline only reported total annual funding and did not further refine the funding by phase. That refinement by phase was done by the program office, given the baseline's annual funding.

Both sites have completed their design phase and are in the midst of the construction phase. As of April 2011, 76 percent of the construction was complete at PCAPP and 31 percent of the construction was complete at BGCAPP. Systemization is a phase that will occur concurrently with construction at the sites and involves integration, testing, and check-out of the processing and support equipment, inclusive of control systems, prior to plant start-up. The systemization contract was awarded at PCAPP in the first quarter of Fiscal Year 2011 and the BGCAPP systemization contract proposal is currently being prepared.

The revised program cost estimate is informed by nearly complete facility designs at both PCAPP and BGCAPP. When the APB was established in 2007, both facility designs were incomplete—PCAPP with 60 percent of its design complete and BGCAPP with only 13 percent of its design complete. In addition to the design immaturity, the program office attributes some of the cost growth in the construction phase due to longer schedules, increase in quantity of construction material, increased costs associated with the FOAK equipment, and escalation of material costs. Additional growth was attributed to increased cost of the systemization phase due to higher staffing levels needed to support 24/7 operations at both sites.

Although the program office estimate allocates cost growth by phase, the cost growth can also be apportioned into a few key areas that can span across phases. Our analysis found the following to be key cost drivers: content and scope changes since the baseline was established, increased construction costs, changes in programmatic assumptions, and a larger allowance for risk. Appendix C details the quantifiable cost growth with the data made available. The exogenous factors associated with scope growth account for about one-fifth of the cost growth and the change in programmatic assumptions account for another fifth; however, the POE is not sufficiently detailed to quantitatively apportion the remaining cost growth further.

A. Content and Scope Changes

First, the program content and scope has evolved. The most recent program estimate includes increased funding for expanded use of EDT at both sites of almost $273 million. The 2007 baseline only assumed the use of EDT at PCAPP at the end of operations. Since the use was limited, the funding for EDT covered only equipment rental. In October 2009, the Assistant Secretary of Defense for Nuclear and Biological Defense Programs directed ACWA to formulate a plan to minimize/eliminate the destruction gaps at PCAPP and address accelerating BGCAPP destruction effort using EDT.[6] Although the plan's implementation has not been directed, the program office funds procurement of EDT equipment for both sites as well as associated costs, such as installation, systemization (as needed), and start-up tests (as needed).

Approximately $86 million in increased funding has been allocated to PCAPP for a proposed modification to the Research, Development, and Demonstration permit for monitoring of 1,2-dichloroethane and vinyl chloride. The proposed modification would increase the destruction removal efficiency to 99.99 percent, which is beyond the capabilities of the current off-gas treatment system. Finally, an additional $30 million was allocated for the Department of Defense Information Assurance Certification and Accreditation Process (DIACAP).

B. Increased Construction Quantities and/or Prices

As previously discussed, both designs for PCAPP and BGCAPP were incomplete when the baseline was established. One consequence of this design immaturity is additional construction costs associated with building these complex facilities when compared to the 2007 estimate. This includes requirements for additional labor, more material, higher costs for the development of FOAK equipment, and associated contractor award and incentive fees.

C. Changes in Programmatic Assumptions

The most recent POE also includes some changes in programmatic assumptions since the 2007 APB. For example, the program office has allocated additional costs for closure based on data from the closure process at the Umatilla and Anniston Chemical Agent Disposal Facilities. This cost growth accounts for almost $211 million.

In a more complex arrangement, the 2011 POE also allocates additional funding for labor in the amount of $170 million for 24/7 operations during systemization and operations. Although the original CAIG estimate in 2007 assumed 24/7 operations, the program felt there was insufficient funding to support that staffing requirement and

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[6] The memo is included as Appendix B.

assumed only 24/4 operations for their planning purposes. In 2008, Public Law 110-116 directed DoD to complete work on the destruction of the United States stockpile of lethal chemical agents and munitions by the deadline established by the Chemical Weapons Convention (April 2012), and, under no circumstances, later than December 31, 2017. In order to complete operations as close as possible to the 2017 deadline, the facilities must operate 24/7. The program now includes funding for 24/7 staffing for both the systemization and operation phases at both facilities. Between the 2007 APB and the latest estimate, CAPE adopted the program office's burn rate for labor costs. Previously, the CAIG estimate for labor was independently calculated based on analogous sites and regional costs of living.

D. Larger Allowance for Risk

Finally, the program has allotted a larger allowance for risk to increase coverage of contingencies. Much of this additional allocation for risk manifests itself in additional schedule for construction, systemization, and operations at both sites. For the most recent POE, the program modeled schedule risk using Primavera Pertmaster and cost risk using ACE. Both Pertmaster and ACE are commercially available risk software programs. These new risk modeling tools assume more significant consequences, in terms of schedule delay, for realized risk than had been previously modeled in the 2007 APB.

4. Root Causes for Cost Growth

IDA's analysis revealed two major causes of the cost growth. First, the 2007 APB was an unrealistic cost estimate that had insufficient allowance for risk and rested on an inadequate analogy. Second, the systems contract, with an evolving structure, allows for program flexibility, but enables undisciplined behavior by both contractor and government personnel. A third root cause, a larger allowance for risk, includes elements of both the unrealistic cost estimate and the contract structure, but is sufficiently large to merit a separate categorization.

A. Unrealistic Cost Estimate

The facility designs for both PCAPP and BGCAPP were insufficiently mature in 2007 to establish a meaningful baseline. PCAPP was the more developed design between the two, with 60 percent of its design completed. BGCAPP was relatively immature, with only 13 percent of its design completed. Given their immaturity, the cost estimate should have accounted for the inherent design risk and provided additional funding. Common practice in construction is to allot an additional 20 to 30 percent of the direct construction costs for allowance for indeterminates (AFI) prior to design completion. For more complex facilities, AFI can be as high as 50 percent. As the design stabilizes, AFI usually settles at around 10 percent. The APB from 2007 assumed an AFI of only 10 percent against direct construction costs, which was insufficient considering the incomplete nature of both designs and the complexity associated with chemical demilitarization facilities.

In addition to insufficient allowance for risk, the APB rested on an inadequate analogy to incineration sites for chemical demilitarization. Based on experience from non-ACWA sites such as Newport Chemical Agent Disposal Facility (NECDF), neutralization facilities have proven to be far more complex than incineration facilities; therefore, the APB significantly underestimated the sites' construction requirements in terms of both material and labor. According to experts associated with the systems contractor, PCAPP is approximately five times as complex than the Anniston incineration facility and BGCAPP is roughly ten times as complex.[7] As an example, the original estimate from 2007 assumed BGCAPP needed 1.7 million linear feet of electrical cables. A more recent estimate indicates that the number is closer to 7.5 million linear feet, more

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[7] Bechtel Systems & Infrastructure Inc., Meeting, Frederick, MD, 29 March 2011.

than four times larger than the original estimate. Not only does that result in more material but also more craft labor required to install the cable. The criticism of an inadequate analogy is limited to only the construction phase of the ACWA sites and possibly the systemization phase.

B. Contract Structure

Both facilities have a cost-plus-incentive-fee (CPIF) systems contract, in which the contractor is responsible for the life cycle of the project from design through closure. The systems contractors are Bechtel National, Inc. (at PCAPP) and a joint venture between Bechtel and Parsons (at BGCAPP). Upon commencing a new phase, the contract is amended and the phase is negotiated as a separate task order. Consequently, the systems contract evolves as the project progresses. Because of this contract structure, the contract section in the SAR only reflects the cost of negotiated work, not the total life-cycle cost for the project. The Chemical Demilitarization program, which oversees the other chemical stockpile sites, uses a similar contract structure for each of their sites.

This type of contract structure allows for program flexibility. As stated in their March 2010 Acquisition Strategy document, "a flexible contractual instrument was required to allow the Government broad execution latitude in dealing with the complexity of the requirements, compressed schedule, and high probability for change." For example, neither PCAPP nor BGCAPP has negotiated their closure costs, so long-term decisions as to the level of demolition at each site can be delayed until after operations have begun. To further illustrate the contract flexibility, the PCAPP contract has been modified over 221 times as of August 5, 2010. Of the 221 modifications, 62 of them changed the contract value. Of those 62 modifications, 11 of them were greater than $10 million in Base Year 1994 dollars. Of those 11, the average duration between subsequent modifications was approximately seven months.

Although a systems contract with an evolving structure allows for program flexibility, it enables undisciplined behavior by both the contractor and government, such as delayed decision-making and constantly evolving requirements. The combination of the contract structure and schedule pressures to meet treaty requirements results in a lack of incentive to control costs.

Much of the program flexibility since the 2007 baseline has been directed at accelerating the program's schedule to safely complete operations as close as possible to the 2017 deadline set forth in Public Law 110-116. This includes the expanded use of EDT at both sites, the program office's staffing level assumptions to achieve 24/7 operations, and the incentive programs intended to retain craft labor and employees and prevent schedule delay due to training new hires. The latest POE also includes additional testing for the FOAK equipment at PCAPP to reduce risk and increase the probability of meeting the 2017 deadline.

Despite the overall mission remaining constant, program execution continues to evolve, and the contract structure allows for those changes. Aside from destroying the stockpile safely, the program does not have a constant and clear set of requirements. Consequently, the program is sensitive to programmatic whims that require additional resources, such as the use of EDT or implementing 24/7 operations. As a result, there is concern that the program may overlook long-term planning of resource allocation in favor of a near-term accurate cost estimate based on current direction. Neither the contract structure nor the Department incentivizes an accurate cost estimate for the full life-cycle of the facility. To illustrate this point, the latest POE shows most of the cost growth to be in the current construction phase and the next phase, systemization, as shown in Figure 7. PCAPP construction is almost 80 percent complete and the POE shows similar growth in both construction and systemization, whereas, BGCAPP construction is only about 30 percent complete and the POE shows the majority of that site's cost growth is in construction and less is in systemization.

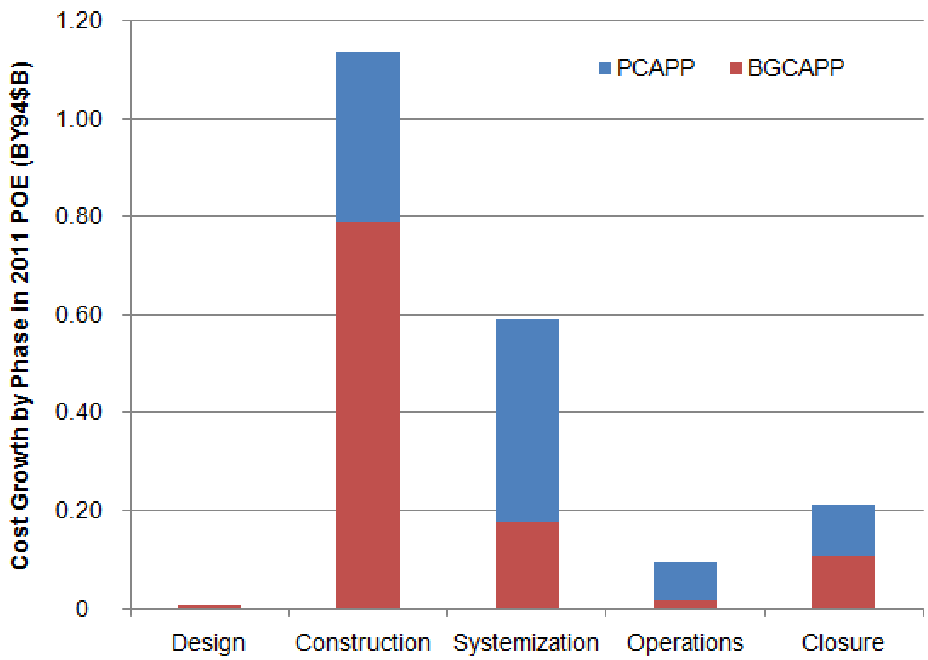

Figure 7. Cost Growth by Phase by Site According to the 2011 POE (BY94$)

The intent of our analysis is not to address the content of the changes, but rather to show that the content continues to evolve and the contract structure enables those changes. As a result, the program office is not incentivized to control costs and engage in long-term planning.

In addition to discussing the incentives of the program office, one needs to also address the incentives of the contractor as well. The program office asserts that the current negotiated contract structure establishes incentives that: "(1) do not compromise high standards for safety, surety, security, and environmental compliance; (2) recognize and reward successful performance against schedule milestones and cost targets; (3) provide an integrated plan that ties cost and schedule performance to the successful achievement of programmatic objectives; (4) balance cost, schedule, and performance objectives within funding constraints; (5) provide multiple-incentive arrangements to motivate the contractor to strive for outstanding results and to compel trade-off decisions among the incentive areas to enhance the overall performance execution."[8] Currently, the contracting officer utilizes cost, schedule, and safety incentive fees to support these five goals.

As a general rule, maximum and minimum fee levels and the sharing formula established under a CPIF contract should be negotiated such that the incentive will remain in effect over a relatively wide range of possible cost outcomes that made CPIF contracting necessary in the first place.[9] A reasonable range of cost outcomes in this scenario is commonly greater than ±20 percent. Due to the nature of the PCAPP contract, each contract modification has a target fee and, when appropriate, an associated cost incentive fee and share line for overruns and underruns. Looking at the largest modifications of the PCAPP contract, the range of incentive effectiveness is less than ±4 percent of the total modification. The relatively narrow range of possible cost outcomes indicates that the current cost incentive fee strategy is not optimized and possibly not effective.

C. Larger Allowance for Risk

Two types of risk are identified: (1) known risk that can be reasonably quantified and (2) unknown risk that must be covered in contingency. Some examples of quantifiable risk include productivity assumptions, commodity availability, and difficulty in fabricating the FOAK equipment, whereas unknown risk includes externally-directed studies, role of explosive destruction technology, and potential schedule delays.

For risk that is identified and can be reasonably quantified, the program office has used two separate models. For the 2007 APB, the program allocated risk dollars using an Excel model called @Risk. The @Risk model is a commercially available Monte Carlo simulation and funding was set to achieve a 50 percent confidence level from the Monte Carlo simulation. For the most recent POE, the program modeled schedule risk using Primavera Pertmaster and modeled cost risk using ACE. Both Pertmaster and ACE are commercially available risk software programs. As previously discussed, much of the

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8 "Acquisition Strategy for the Assembled Chemical Weapons Alternatives Program," March 2010, C-10.

9 "DOD and NASA Guide: Incentive Training Guide," 1969.

allocation for risk manifests itself in additional schedule for construction, systemization, and operations at both sites.

To account for unanticipated risk, the program office estimate sets aside funding for AFI during construction and “cost risk” during systemization and operations. The funding to cover unknown risk in construction increased substantially since 2007. The baseline estimate set aside funding for unknown risk during the construction phase; it did not address unknown risk during systemization and operations. As previously discussed, AFI is intended to account for the unanticipated risk associated with the immaturity of design and the percentage is usually calculated against direct construction costs. AFI expenditure at PCAPP is currently about 10 percent of the total construction costs and has been spent to cover not only design issues, but also cost overruns and material price escalation. Effectively, AFI dollars at PCAPP have been spent on contingency.

In the most recent cost estimate, the program office also protects against contingency during the systemization and operations phases. The baseline estimate did not have this allowance, but the program office now allocates almost $100 million for this purpose. The funding was determined as a best guess of the program office, based on prior experience with other Chemical Material Agency destruction sites.

5. Conclusions

In July 2010, the USD(AT&L) notified the Congress of a significant Nunn-McCurdy breach in the PAUC threshold of the ACWA program. Based on a program office estimate, the ACWA PM reported in a memo sent to USD(AT&L), dated June 2010, that the PAUC had risen more than 21 percent. Upon further refinement of the life-cycle cost estimate, the program reported a critical Nunn-McCurdy breach in their December 2010 SAR, with a PAUC estimate of $2.403 million, an increase of 39.22 percent from the 2007 APB.

IDA's analysis traced this cost growth to three root causes—unrealistic cost estimate, contract structure, and a larger allowance for risk. The risk categorization contains elements of both the unrealistic cost estimate and the contract structure. Due to the interconnectedness of the major causes for cost growth, the cost growth cannot be easily apportioned into the three categories.

There are also unquantifiable factors that contribute to the cost growth, which are not captured in either the program cost estimate or IDA's analysis, that should be mentioned. In particular, there is a fundamental misalignment of incentives throughout the program. First, the Chemical Weapons Convention treaty requires destruction of our chemical weapons within a certain time period. Consequently, there is little possibility that the ACWA program will be cancelled because of cost overruns, due to the political implications of falling short of the treaty deadline. This fundamental lack of incentive, already present from the contract structure and schedule pressures to meet treaty requirements, prevents the contractor and the government from controlling costs.

An additional unquantifiable factor in cost is due to the interplay between DoD, the Congress, and the local communities. From the Department's perspective, the chemical stockpiles at Pueblo and Blue Grass should be destroyed as quickly, safely, and inexpensively as possible. From a community perspective and, indirectly, those that represent them in the Congress, PCAPP and BGCAPP create employment and boost the local economies. PCAPP provides opportunities to retain local graduates in Pueblo, a city faced with a declining economy, which in turn incentivizes longer schedules and additional funds.[10] Similarly, the representatives for the community surrounding Blue Grass applauded the Department's decision to dispose of the hydrolysate on-site (the

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10 John Norton, "Jobs at depot help plug brain drain," *The Pueblo Chieftain*, October 6, 2008, http://www.chieftain.com/news/local/article_22c68429-4d77-5ee3-a8d5-3ab01aa81503.html.

more expensive option). They cited both environmental reasons and a desire to preserve jobs locally.[11]

These unquantifiable factors have been an issue since the inception of the ACWA program and, although they are not explicit causes in the most recent Nunn-McCurdy breach, they are relevant to the overall issue of incentivizing cost controls.

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11 Sen. Mitch McConnell, R-Ky and Congressman Ben Chandler, D-Ky, "Making progress at the depot," *The Richmond Register*, May 27, 2009, http://richmondregister.com/viewpoints/x155225619/Making-progress-at-the-depot/print.

Appendix A.
ACWA Program Deviation Report

DEPARTMENT OF THE ARMY
US ARMY ELEMENT, ASSEMBLED CHEMICAL WEAPONS ALTERNATIVES
5183 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5424

REPLY TO
ATTENTION OF:

AMSAW-PM 7 June 2010

MEMORANDUM FOR Under Secretary of Defense for Acquisition, Technology and Logistics, Dr. Ashton B. Carter, 3010 Defense Pentagon, Washington, DC 20301-3010

SUBJECT: Assembled Chemical Weapons Alternatives (ACWA) Program Deviation Report

1. References:

a. Memorandum, USAE ACWA, 3 Apr 2007, subject: Chem Demil- ACWA Acquisition Program Baseline (APB).

b. Memorandum, USAE ACWA, 7 July 2008, subject: ACWA Program Deviation Report.

c. Memorandum, USAE ACWA, 21 October 2009, subject: ACWA Program Deviation Report.

2. In accordance with 10 USC 2433 (Nunn McCurdy) and Section 10.9.1.3 of the Defense Acquisition Guidebook, and based on my recently completed Program Office Estimate (POE), I am notifying you that I have reasonable cause to believe the Program Acquisition Unit Cost (PAUC) for the Assembled Chemical Weapons Alternatives Program has exceeded 15% of the approved APB estimate (reference 1a).

3. I previously reported an APB objective cost breach of 10.9% in October 2009 (reference 1c), and indicated a revised program office estimate (POE) was under development. Based on the revised POE, the current estimate for the PAUC is $2.100M base-year 1994 dollars (BY94$), which exceeds the approved APB PAUC objective of $1.726M BY94$ by 21.67%.

4. The revised POE is based on nearly complete facility designs, whereas, the April 2007 CWE reflected only a 10% design for the Blue Grass facility. Increased costs since April 2007 are attributed primarily to construction and systemization, whereas, operations costs decreased. Construction cost estimates increased $947M (BY94$), and systemization cost estimates increased $332M (BY94$), while operations cost estimates decreased $191M (BY94$). Primary causes for construction increases are construction schedules, quantity increases based on design evolution, and escalation of construction material costs. Primary cause for systemization increases is increased staffing levels required to support 24/7 operations at both sites.

5. I will be providing the updated POE to the Cost Assessment and Program Evaluation (CAPE) Office in June 2010 for their review and analysis. I expect to receive the CAPE analysis and submit a revised APB for your approval by September 2010.

6. My point of contact for this action is Mr. Stephen Worton, (410) 436-7689.

KEVIN J. FLAMM
Program Manager

CF:
Assistant to the Secretary of Defense for Nuclear and Chemical and Biological Defense Programs, Mr. Andrew Weber, 3050 Defense Pentagon, Washington, DC 20301-3050
Deputy Assistant to the Secretary of Defense for Treaties and Threat Reduction, Dr. A. Tom Hopkins, 3050 Defense Pentagon, Washington, DC 20301-3050

Appendix B.
ACWA Destruction Acceleration Plan

ASSISTANT TO THE SECRETARY OF DEFENSE
3050 DEFENSE PENTAGON
WASHINGTON, DC 20301-3050

NUCLEAR AND CHEMICAL AND BIOLOGICAL DEFENSE PROGRAMS

OCT - 1 2009

MEMORANDUM FOR PROGRAM MANAGER, ASSEMBLED CHEMICAL WEAPONS ALTERNATIVES

SUBJECT: Assembled Chemical Weapons Alternatives (ACWA) Destruction Acceleration Plan

Thank you for providing the ACWA Program status update on September 22, 2009. The briefing was informative and insightful, providing a good perspective on the Program's acquisition history and path forward including opportunities for further acceleration. Please extend my thanks and appreciation to Mr. Brad Pierce and Ms. Carolyn Young of the Army Contracting Command for their participation.

On August 5, 2009, I requested you and the Deputy Assistant Secretary of the Army for Elimination of Chemical Weapons (DASA(ECW)) determine how best to eliminate the gap between completion of destruction operations at the U.S. Army Chemical Materials Agency sites and the start of destruction operations at the Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP). Based on your destruction technology concept discussed at the update, I request you develop a plan to destroy over-packed and other selected munitions using the Explosive Destruction System (EDS) and commercial explosive destruction technology (EDT) to minimize/eliminate the destruction gaps at the Pueblo site. In addition, the plan will address accelerating the Blue Grass destruction effort using EDT that would permit initiation of destruction operations at Blue Grass as soon as possible.

At a minimum, the plans for implementing the EDS and EDT at Blue Grass and Pueblo should provide the following:

- A Fiscal Year (FY) 2011-2015 funding profile with the cost-to-complete, breaking out the cost requirements for implementing each destruction system separately. Compare the current working estimate (CWE) to the proposed funding profile.
- A revised ACWA Program office schedule estimate compared to the CWE.
- The pros and cons of this destruction concept to eliminate the destruction gap at each site.
- The risks associated with implementing this concept.
- Impacts to cost, schedule, and performance of the PCAPP and BGCAPP projects.
- The PM ACWA recommendation regarding implementation of the plans.

In order to support the Department of Defense's review and decision-making processes, including those associated with the FY 2011 President's Budget Request, request you provide the execution plan no later than November 6, 2009. In addition, the DASA(ECW) will be asked to continue support of these efforts.

If you need additional information, please do not hesitate to call me at 703-697-1771. The point of contact for this issue is COL Joseph Marquart, Office of Assistant to the Secretary of Defense for Nuclear and Chemical and Biological Defense Programs, 703-588-1983, extension 114.

Andrew Weber

cc:
Deputy Assistant Secretary of the Army for Elimination of Chemical Weapons
Director, U.S. Army Chemical Materials Agency

Appendix C.
Detailed Cost Growth

Table C-1 attempts to tabulate the quantifiable cost growth by area. Cost growth is defined as the difference between the most recent 2011 POE and the 2007 APB. It is important to note that after the CAIG established the top-level funding, the program office apportioned the funding to each site by phase. Funding that was not specified for either site is referred to as "programmatic" and covers overall government program management.

As previously discussed, the larger allowance for risk touches on multiple aspects of the program; as a result, we are unable to fully identify its components.

Table C-1. Quantifiable Cost Drivers (BY 1994 $M)

Quantified Cost Drivers	BGCAPP Growth	PCAPP Growth	Total Growth	% of total	% of growth	Areas of Cost Growth
Explosive Destruction Technology	155	117	273	12%	5.0%	Content and Scope Changes
Permit Modification		86	86	4%	1.6%	Content and Scope Changes
DIACAP	15	15	29	1%	0.5%	Content and Scope Changes
Increased Construction Costs *(includes PCAPP AFI[a])*	644	331	975	42%	18.0%	Increased Construction Costs/Larger Allowance for Risk
Increased Closure Costs	108	103	211	9%	3.9%	Changes in Programmatic Assumptions
Labor for 24/7 Systemization + Operations	0	170	170	7%	3.1%	Changes in Programmatic Assumptions
BGCAPP AFI	53		53	2%	1.0%	Larger Allowance for Risk
FOAK Testing	90	12	102	4%	1.9%	Larger Allowance for Risk
Systemization + Operations Cost Risk	57	38	95	4%	1.8%	Larger Allowance for Risk
Programmatic			259	11%	4.8%	Combination of all
Total	**1,122**	**871**	**2,252**	**97%**	**41.6%**	
Total Growth from APB to 2011 POE:			**2,311**	**100%**	**42.7%**	

[a] In the most recent program cost estimate, the PCAPP site construction costs did not separately report AFI, unlike the BGCAPP site construction costs.

Illustrations

Figures

Table

References

ACWA Program Office. "Acquisition Strategy for the Assembled Chemical Weapons Alternatives Program." March 2010.

Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program, National Academy of Sciences. "Recommendations for the Disposal of Chemical Agents and Munitions." Washington, DC: National Academy Press, 1994.

Committee to Assess Designs for Pueblo and Blue Grass Chemical Agent Destruction Pilot Plants, National Academy of Sciences. "Interim Design Assessment for the Blue Grass Chemical Agent Destruction Pilot Plant." Washington, DC: National Academies Press, 2005.

Department of Defense, and National Aeronautics and Space Administration. "DOD and NASA Guide: Incentive Contracting Guide." Washington, DC: 1969.

McConnell, Sen. Mitch, R-Ky and Congressman Ben Chandler, D-Ky. "Making progress at the depot." *The Richmond Register*. May 27, 2009. http://richmondregister.com/viewpoints/x155225619/Making-progress-at-the-depot/print.

National Research Council. "Disposal of Chemical Munitions and Agents." Washington, DC: National Academy Press, 1984.

Norton, John. "Jobs at depot help plug brain drain." *The Pueblo Chieftain*. October 6, 2008. http://www.chieftain.com/news/local/article_22c68429-4d77-5ee3-a8d5-3ab01aa81503.html.

Abbreviations

ACWA	Chemical Demilitarization – Assembled Chemical Weapons Assessment/Alternatives
AFI	Allowance for Indeterminates
ANS	Agent Neutralization System
APB	Acquisition Program Baseline
AT&L	Acquisition, Technology and Logistics
BGCAPP	Blue Grass Chemical Agent-Destruction Pilot Plant
BRS	Brine Reduction System
BTA	Biotreatment Area
BY	Base Year
CAIG	Cost Analysis Improvement Group
CAPE	Cost Assessment and Program Evaluation
CPIF	Cost-Plus-Incentive-Fee
DAES	Defense Acquisition Executive Summary
DIACAP	Department of Defense Information Assurance Certification and Accreditation Process
DoD	Department of Defense
EBH	Energetic Batch Hydrolyzer
EDT	Explosive Destruction Technology
ENR	Energetics Neutralization Reactor
FOAK	First-Of-A-Kind
IDA	Institute for Defense Analyses
M	Million
MDAP	Major Defense Acquisition Program
MILCON	Military Construction
MPT	Metal Parts Treater
MTU	Munitions Treatment Unit
MWS	Munitions Washout System

NECDF	Newport Chemical Agent Disposal Facility
NRC	National Research Council
OSD	Office of the Secretary of Defense
PAUC	Program Acquisition Unit Cost
PCAPP	Pueblo Chemical Agent-Destruction Pilot Plant
PM	Program Manager
PMD	Projectile Mortar Disassembly
POE	Program Office Estimate
RCM	Rocket Cutter Machine
RDT&E	Research, Development, Test and Evaluation
RSM	Rocket Shear Machine
SAR	Selected Acquisition Report
SCWO	Supercritical Water Oxidation
U.S.	United States
USD	Under Secretary of Defense
WRS	Water Recovery System

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14. ABSTRACT

The Chemical Demilitarization – Assembled Chemical Weapons Alternatives (ACWA) program is responsible for the destruction of the chemical weapons stored in Pueblo, CO and Blue Grass, KY. In June 2010, the Program Manager (PM) for the ACWA program notified the Under Secretary of Defense (USD) for Acquisition, Technology and Logistics (AT&L) of a significant Nunn-McCurdy breach in the Program Acquisition Unit Cost (PAUC). The PM reported that the PAUC had risen 21.67 percent, from $1.726 million in the April 2007 acquisition program baseline (APB) to $2.1 million in Base Year 1994 dollars. Upon further refinement of the life-cycle cost estimate, the program reported a critical Nunn-McCurdy breach in their December 2010 Selected Acquisition Report (SAR) with a PAUC estimate of $2.403 million, an increase of 39.22 percent from the 2007 APB.
IDA's analysis revealed two major causes of the cost growth and a third root cause that is intrinsically tied to the other two. First, the APB was an unrealistic cost estimate, which had insufficient allowance for risk and rested on an inadequate analogy. Second, the systems contract, with an evolving structure, allows for program flexibility, but enables undisciplined behavior by both the contractor and government personnel. A third root cause, a larger allowance for risk, includes elements of both the unrealistic cost estimate and the contract structure, but is sufficiently large to merit a separate categorization.

15. SUBJECT TERMS
Chemical Demilitarization – Assembled Chemical Weapons Alternatives (Chem Demil - ACWA), Neutralization, Nunn-McCurdy Breach, Program Acquisition Unit Cost (PAUC), Root Cause Analysis, Cost Analysis, Cost Growth, Contract Structure, Risk, Allowance for Indeterminates (AFI)

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