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MITRETEK TECHNICAL REPORT

Analysis of Off-Site Treatment of Hydrolysates from Chemical Agent-Destruction Pilot Plants

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MTS Mitretek Systems

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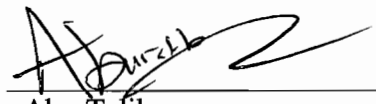
Mitretek Project Approval: 

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Abstract

Mitretek conducted an analysis of the life cycle costs for the Pueblo Chemical Agent-Destruction Pilot Plant and the Blue Grass Chemical Agent-Destruction Pilot Plant to determine the extent of cost savings if hydrolysates from these facilities were treated off-site at commercial treatment, storage, and disposal facilities. Disposal technologies were surveyed and the level of knowledge of risks posed by hydrolysate to human health and the environment was assessed. Programmatic risks in permitting, litigation, and selection of commercial treatment, storage, and disposal facilities were identified and examined. Scenarios were developed to examine various parameters; each scenario was evaluated for its process, schedule impacts, and corresponding life cycle cost estimates. Conclusions based on the cost estimates and the likelihood of the scenario are presented. An appendix contains summaries of meetings with various stakeholders that were conducted to provide information for creating and evaluating the scenarios.

KEYWORDS: Pueblo Chemical Agent-Destruction Pilot Plant, Blue Grass Chemical Agent-Destruction Pilot Plant, Off-Site Hydrolysate Treatment, Life Cycle Cost Estimate, Cost Analysis

Executive Summary

Background

The Program Manager for Assembled Chemical Weapons Alternatives (PM ACWA) is responsible for managing the design, construction, systemization, pilot testing, operation, and closure of chemical demilitarization facilities used to destroy chemical weapons stockpiles at the Blue Grass Army Depot (BGAD), Kentucky, and Pueblo Chemical Depot (PCD), Colorado. In July 2002, the Department of Defense (DOD) selected neutralization followed by biotreatment as the preferred technology for full-scale pilot testing to destroy the chemical weapons stockpile stored at PCD. On 27 September 2002, a systems contract to design, build, systemize, pilot test, operate, and close the Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP) was awarded to Bechtel National, Inc. (BNI). Later, in February 2003, DOD selected neutralization followed by supercritical water oxidation (SCWO) as the preferred technology for full-scale pilot testing to destroy the chemical weapons stockpile stored at BGAD. The systems contract to design, build, systemize, pilot test, operate, and close the Blue Grass Chemical Agent-Destruction Pilot Plant (BGCAPP) was awarded on 13 June 2003 to Bechtel Parsons Blue Grass (BPBG), a joint venture of BNI and Parsons Infrastructure and Technology Group, Inc.

Key Findings and Conclusions:

- The most likely scenarios have no cost savings, primarily due to permitting requirements that cause delays in construction.
- Cost savings from the off-site biotreatment of hydrolysates are not realized under any conditions at PCAPP, and only under very ideal conditions at BGCAPP.
- TSDF selection is limited by technology, capacity, and availability. Biotreatment and deep-well injection are commercially available technologies that are likely to have smaller programmatic risks than other available technologies.
- Many stakeholders are adamantly opposed to off-site hydrolysate treatment.
- Delays due to TSDF selection are possible because of political opposition or business reasons.
- State environmental regulators will not allow operations to start without the means for hydrolysate treatment.
- Litigation of the PCAPP Certificate of Designation appears probable if hydrolysate is treated off-site, with the potential for an injunction that would delay operations.
- Kentucky environmental regulators state that if SCWO is dropped from the BGCAPP process, BGCAPP will probably lose justification for an RD&D permit. Resulting delays for obtaining a RCRA Part B permit may be as much as three years.
- Based on Mitretek's analysis, there appears to be no significant cost advantage to off-site hydrolysate treatment at either site.

In January 2006, PM ACWA tasked Mitretek to conduct an independent analysis of whether significant cost savings could be achieved by replacing biotreatment at PCAPP and SCWO at BGCAPP with

shipment of hydrolysates for treatment off-site at commercial treatment, storage, and disposal facilities (TSDFs). Mitretek was specifically tasked to assess the impact of all potential programmatic cost and schedule risks on the estimated savings as the decision to treat the hydrolysates using on-site or off-site facilities goes through its implementation cycle.

This document presents the overall results of Mitretek's cost and schedule risk analysis. To protect the business sensitive data, the detailed life cycle costs for on-site and off-site treatment of hydrolysates are presented in a companion controlled release document, *Cost Analysis of Off-Site Treatment of Hydrolysates from Chemical Agent-Destruction Pilot Plants* (Wusterbarth et al., 2006).

Approach

Mitretek developed scenarios to assess the impact of various programmatic risk parameters to the overall life cycle cost savings anticipated as a result of off-site treatment of the hydrolysates. These parameters primarily included: (a) delays due to difficulties in contracting with a TSDF; (b) additional regulatory requirements; (c) delays due to potential litigation; and (d) time lost because of the postponement of a decision. Mitretek performed detailed technical and schedule analyses and prepared life cycle cost estimates (LCCEs) for a set of six different alternative scenarios for each site. For both PCAPP and BGCAPP, scenario 1 is the "base case," in which the currently designed facilities for on-site hydrolysate treatment are built. Scenarios 2, 3, and 4 assess the impact of difficulties in contracting with a TSDF at various stages in the life cycle. These three scenarios assume that a decision is made to treat hydrolysates off site, but that at various program milestones, the decision is reversed and the on-site hydrolysate treatment units are built. Scenario 5 is the "best case" scenario in which a decision is made to treat hydrolysate off-site, and the decision is implemented without significant delays. Scenario 6, in which a decision is also made to treat hydrolysate off-site, assesses the impact of delays due to regulatory requirements or litigation. PCAPP scenario 6 involves litigation of the Certificate of Designation (CD) with an injunction that stops construction. BGCAPP scenario 6 involves stopping construction at the site while the Research, Development, and Demonstration (RD&D) permit is replaced with a Part B Resource Conservation and Recovery Act (RCRA) permit. Finally, scenario 7 assesses the impact of postponing a decision to allow for additional stakeholder outreach and selection of a TSDF.

In order to estimate the cost and schedule impacts under these assumed scenarios, extensive field visits were conducted to collect data and information on stakeholder concerns and regulatory issues. Mitretek reviewed systems contractor and government LCCEs, as well as documentation for design data on the PCAPP and BGCAPP facilities and processes. Where required, Mitretek also used its extensive in-house experience in the optimization of process design and projected pilot plant operations. The following sections highlight major findings that will provide critical inputs to the DOD decision makers, including the Defense Acquisition Board (DAB), who will be carefully considering all cost savings and containment options to re-baseline PCAPP and BGCAPP LCCEs. The costs and schedules developed for this report are for new facilities that have not yet been constructed and have no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

Potential Delays Associated with TSDF Selection

Finding 1. TSDF selection is limited by technology, capacity, and availability. Biotreatment and deep-well injection are commercially available technologies that are likely to have smaller programmatic risks than other available technologies.

The ability to treat secondary wastes at off-site locations is limited by the availability of suitable treatment technologies with adequate capacity. In this analysis, Mitretek considered biotreatment and SCWO, the two technologies demonstrated as part of the ACWA program and certified as effective, as well as wet air oxidation (WAO), deep-well underground injection, and incineration. Although it has been certified by PM ACWA as an effective destruction technology for all hydrolysates generated from agent and energetic materials, SCWO is not currently available at any commercial TSDF, and substantial cost savings are unlikely to be realized from building a SCWO unit at a TSDF rather than at BGCAPP. WAO is available at a TSDF and will be used to destroy wastes generated by the non-stockpile chemical materiel project; however, this unit has insufficient throughput to treat in a timely fashion the volume of hydrolysates that will be generated both at PCAPP and BGCAPP. Although it is conceivable that additional WAO capacity could be installed at the current TSDF or at other TSDFs, substantial cost savings appear unlikely. Incineration is commercially available and technically acceptable, but would almost certainly cause significant stakeholder opposition; hence its application was not assessed.

Biotreatment (with chemical pretreatment as required) and deep-well injection appear to be the preferred technologies for off-site treatment of hydrolysates because they are commercially available. However, the number of TSDFs offering these technologies with sufficient capacity to treat hydrolysates from PCAPP and BGCAPP is limited. Although it is generally less expensive than biotreatment, there is also some programmatic uncertainty with using deep-well injection for hydrolysate disposal. The Organisation for the Prohibition of Chemical Weapons (OPCW) has never before been asked to accept deep-well injection as rendering the components of the hydrolysates as unrecoverable. The impact of any verification requirements imposed by OPCW on a deep-well injection facility is unknown. Therefore, hydrolysate biotreatment with chemical pretreatment (as necessary for certain wastes) is used as the off-site disposal technology in the cost analyses for this report. Alternative cost estimates have been prepared using deep-well injection as the off-site disposal technology to determine the potential for additional cost savings.

Finding 2. Many stakeholders are adamantly opposed to off-site hydrolysate treatment.

Mitretek met with a variety of stakeholders in Colorado and Kentucky. These meetings included concerned citizens, members of the Colorado Chemical Demilitarization Citizens' Advisory Commission and the Kentucky Chemical Destruction Community Advisory Board, local government officials, Congressional staff members, and officials from the Colorado Department of Public Health and Environment (CDPHE) and the Kentucky Department of Environmental Protection (KDEP). Most stakeholders are opposed to off-site hydrolysate disposal, fearing delays in implementing the demilitarization mission and increased risk from continued storage that would result from such a decision. Many stakeholders also view the off-site treatment of hydrolysates as a change to earlier technology decisions that were perceived as including on-site treatment.

A decision to treat hydrolysate off-site is likely to lead to a loss of trust with some portion of the public, potentially impacting the stakeholder cooperation that was effectively established under the ACWA program. Although its impact cannot be directly quantified in Mitretek's cost and schedule risk analyses, this stakeholder opposition has the potential to result in changes to legislation or regulation causing further delays.

Finally, it should be noted that a number of significant cost-saving processing alternatives, including off-site secondary waste disposal options, already have been or are being negotiated with stakeholders at each site. Forcing off-site hydrolysate treatment on stakeholders already opposed to it may compromise acceptance of current and future processing.

Finding 3. Delays due to TSDF selection are possible because of political opposition or business reasons.

Based on the Army's experience related to off-site disposal of hydrolysates from the Aberdeen Chemical Agent Disposal Facility (ABCDF) and the Newport Chemical Agent Disposal Facility (NECDF), as well as disposal of the U.S. stockpile of napalm that was stored at Fallbrook Naval Weapons Facility, delays in the off-site treatment and disposal of hydrolysates from PCAPP and BGCAPP appear possible. The record of ABCDF and NECDF hydrolysate disposal suggests that off-site treatment and disposal of PCAPP hydrolysate might generate less opposition than would off-site treatment and disposal of BGCAPP hydrolysates. However, because PCAPP will be operating under different circumstances (lack of urgency that was created by the 9/11 events and the proximity of the stockpile to the TSDF) than ABCDF, political opposition to off-site processing of PCAPP hydrolysate could emerge and result in delays. The Navy's experience with napalm disposal shows that a relatively successful disposal program with lower levels of perceived risk than chemical demilitarization can experience significant delays due to political opposition, even if it involves only a temporary delay to allow state or local government to review the risks involved. There is a programmatic risk that PM ACWA could encounter delays associated with selecting a TSDF for the disposal of hydrolysates from PCAPP and BGCAPP, either due to political opposition or to business reasons. Delays associated with selecting a TSDF or changing from one TSDF to another would increase costs.

Regulatory Requirements and Litigation

Finding 4. State environmental regulators will not allow operations to start without the means for hydrolysate treatment.

The NECDF precedent of operating with temporary on-site storage of hydrolysate has also resulted in limits on potential operating scenarios at PCAPP and BGCAPP. State regulators have indicated that neither PCAPP nor BGCAPP will be allowed to begin operations without the means for hydrolysate disposal. If the off-site treatment option is selected, a TSDF with the appropriate permits must be under contract. When analyzing scenarios where treatment occurs on-site, Mitretek has constrained the schedule to postpone the start of operations until the on-site treatment facilities are substantially completed.

Finding 5. **Litigation of the PCAPP CD appears probable if hydrolysate is treated off-site, with the potential for an injunction that would delay operations.**

CDPHE staff indicated that in their view, several other aspects of PCAPP besides biotreatment of hydrolysate qualified the facility for the RD&D permitting approach under RCRA. Mitretek also interviewed officials from Pueblo County, which must grant a CD to PCAPP. According to the current and former County attorneys, a CD is considered a land-use decision under Colorado law, and the issuance of a CD can be appealed to the state district court. Stakeholders have indicated that such litigation is probable. The legal process for litigating land-use decisions can take up to two years if appealed. Based on this information, litigation of the CD would result in significant delays to the PCAPP schedule.

Finding 6. **Kentucky environmental regulators state that if SCWO is dropped from the BGCAPP process, BGCAPP will probably lose justification for an RD&D permit. Resulting delays for obtaining a RCRA Part B permit may be as much as three years.**

KDEP staff indicated that if the BGCAPP RD&D permit were amended to remove the SCWO process and switch to off-site treatment of BGCAPP hydrolysates, it would reexamine whether or not the RD&D approach to permitting remained appropriate. KDEP stated that the RD&D approach would probably be deemed inappropriate without SCWO. Therefore, off-site treatment of BGCAPP hydrolysate could result in a stoppage of all work on the site until 30 days after KDEP issued a full RCRA Part B permit. For purposes of the cost analysis, Mitretek's optimistic estimate would require over 12 months for BGCAPP to complete an application and for KDEP to issue a Part B permit; the process could, however, take as long as 3 years.

Cost and Schedule Risk Analysis Results

Mitretek's cost analysis was primarily based on the estimated schedule delays caused by a combination of technical, regulatory, stakeholder opposition, and other related considerations and on the design changes appropriate for each scenario. As indicated earlier, a scenario-based analytical framework was developed to quantify the potential range of schedule delays that are likely to be encountered as the decision for off-site treatment of PCAPP and BGCAPP hydrolysates is implemented. Summary results of the cost analyses are presented in Table ES-1 for PCAPP and Table ES-2 for BGCAPP. "Likelihood of Scenario Occurring" represents the chance that the scenario, as presented in this report, will occur as described. Factors affecting this are related to permitting occurring as cited, the availability of a TSDF when needed, and the increased storage risk associated with the delays.

Finding 7. **The most likely scenarios have no cost savings, primarily due to permitting requirements that cause delays in construction.**

Table ES-1. Summary of Assessment Scenarios, Factors, and Findings for PCAPP

Scenario	Hydrolysate Processing Scenario Description	Life Cycle Phase					Design Changes	Schedule and Decision Factors[1]	Agent Ops End Delay [months]	Cost Change[2] [$M]	Likelihood of Scenario Occurring[3]
		DAB on 1 Oct 2006	Design	Construction	Systemization	Operations					
1	Base Case no change	On-site Treatment					None	No litigation or change in legislation in Colorado			
2	Off-site decision changed to on-site at start of stage III construction	Off-site Treatment		Change	On-site Treatment		None	Modify RD&D and air permits and revise EIS and EPP for off-site disposal, then repeat to resume on-site treatment. No litigation or change in legislation in Colorado	10	$50.4	Medium
3	Off-site decision changed to on-site at start of systemization	Off-site Treatment			Change	On-site Treatment	None	Same as scenario 2 above, plus BTA design, construction, and systemization and revision of CD.	18	$91.7	Medium
4	Off-site decision changed to on-site at end of systemization	Off-site Treatment				Change / On-site Treatment	Add truck loading station	Same as scenario 3 (greater impact due to longer delays)	53	$754.2	Low
5	Off-site decision, no delays	Off-site Treatment					No BTA, add truck loading station	Modify RD&D and air permits and revise EIS and EPP for off-site disposal. No litigation or change in legislation in Colorado or at TSDF site.	13	$4.4	Low
6	Off-site decision, with delays	Off-site Treatment		Extended Delays	Off-site Treatment		No BTA, add truck loading station	Same as scenario 5 but with litigation and injunction	37	$124.9	High
7	Decision to treat off-site postponed until scheduled start of agent processing building construction	Undecided		Change	Off-site Treatment		No BTA, add truck loading station	Modify RD&D and air permits and revise EIS and EPP for off-site disposal. No litigation or change in legislation in Colorado or at TSDF site.	25	$87.3	Low

(1) In all cases: Construction is delayed until permits received; off-site treatment requires TSDF permits; operations are delayed until a TSDF is contracted.

(2) Positive numbers represent increased costs relative to the base case (scenario 1). The costs and schedules in this table are for a new facility that has not been constructed and has no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

(3) "Likelihood of Scenario Occurring" represents the chance that the scenario, as presented in this report, will occur as described.

Table ES-2. Summary of Assessment Scenarios, Factors, and Findings for BGCAPP

Scenario	Hydrolysate Processing Scenario Description	Life Cycle Phase					Design Changes	Schedule and Decision Factors[1]	Agent Ops End Delay [months]	Cost Change[2] [$M]	Likelihood of Scenario Occurring[3]
		DAB on 1 Oct 2006	Design	Construction	Systemization	Operation					
1	Base Case no change	On-site Treatment					None	No litigation or change in legislation in Kentucky			
2	Off-site decision changed to on-site early in construction	Off-site Treatment		Change	On-site Treatment		None	Modify RD&D and air permits and revise EIS and EPP for off-site disposal, then repeat to resume on-site treatment. No litigation or change in legislation in Kentucky	8	$53.5	Medium
3	Off-site decision changed to on-site at start of systemization	Off-site Treatment			Change	On-site Treatment	None	Same as scenario 2 above, plus SPB design, construction, and systemization	31	$188.8	Low
4	Off-site decision changed to on-site at end of systemization	Off-site Treatment				Change / On-site Treatment	Add truck loading station	Same as scenario 3 (greater impact due to longer delays)	53	$944.9	Low
5	Off-site decision, no delays	Off-site Treatment					No SPB, add truck loading station	Modify RD&D and air permits and revise EIS and EPP for off-site disposal. No litigation or change in legislation in Kentucky or at TSDF site. Longer VX processing time.	4	-$52.1	Low
6	Off-site decision, with delays	Off-site Treatment		Extended Delays	Off-site Treatment		No SPB, add truck loading station	Same as scenario 5 but replacing RCRA RD&D permit with Part B permit.	18	$26.1	High
7	Decision to treat off-site postponed until scheduled start of agent processing building construction	Undecided		Change	Off-site Treatment		No SPB, add truck loading station	Modify RD&D and air permits and revise EIS and EPP for off-site disposal. No litigation or change in legislation in Kentucky or at TSDF site.	19	$114.7	Low

(1) In all cases: Construction is delayed until permits received; off-site treatment requires TSDF permits; operations are delayed until a TSDF is contracted.

(2) Positive numbers represent increased costs relative to the base case (scenario 1). The costs and schedules in this table are for a new facility that has not been constructed and has no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

(3) "Likelihood of Scenario Occurring" represents the chance that the scenario, as presented in this report, will occur as described.

Current permitting strategies for both PCAPP and BGCAPP involve on-site treatment of hydrolysates. Therefore, any scenario including a decision to treat hydrolysate at an off-site TSDF would require permitting changes. This causes delays in construction to varying degrees, depending on the timing of the decision, and these delays in turn result in cost increases. Given current public sentiment, the scenarios resulting in delays are considered more likely to occur than a minimal delay scenario.

Any potential cost savings realized from off-site treatment are quickly lost when permitting delays and additional munition inventory storage costs are taken into account. At PCAPP, stakeholders have indicated that litigation is likely in the event of a decision to treat hydrolysate off-site, and the Pueblo County attorney has indicated a significant potential for an injunction if the CD is the target of litigation. For this reason, scenario 6, which costs significantly more than the base case (scenario 1), is considered more likely than scenario 5, which provides the lowest cost increase relative to the base case.

At BGCAPP, KDEP has indicated that the RD&D permit would probably no longer apply following a decision to treat hydrolysate off-site. For this reason, scenario 6, which costs somewhat more than the base case (scenario 1), is considered more likely than scenario 5, which provides some savings relative to the base case.

Figure ES-1 displays cost increases for PCAPP scenarios 2-7 relative to the base case (scenario 1). The corresponding costs for BGCAPP scenarios 2-7 are presented in Figure ES-2. For both figures the cost results are ordered based on the relative likelihood of occurrence; the most likely scenarios are identified at the top of the figures, and the least likely scenarios at the bottom.

Finding 8. Cost savings from the off-site biotreatment of hydrolysates are not realized under any conditions at PCAPP, and only under very ideal conditions at BGCAPP.

Mitretek's analysis shows that even under the most favorable cases, off-site shipment of hydrolysate for biotreatment is expected to cost more than on-site hydrolysate treatment. Cost savings are possible only at BGCAPP for scenario 5 using biotreatment at an off-site TSDF; the potential cost savings in this case are about $52M. At PCAPP, scenario 5 is also the least costly off-site scenario, but there are no savings. Rather there is a slight increase of about $4M above the base case. For scenario 5 using deep-well injection as the disposal technology, savings relative to the base case are about $35M at PCAPP and $106M at BGCAPP. However, monthly expenditure rates developed for the relevant time period when these savings would accrue indicate that schedule slippage of 6 months or less could eliminate these savings. For scenario 6 using deep-well injection as the disposal technology, savings relative to the base case are about $28M at BGCAPP, but this savings could be eliminated if issuing a Part B permit required an additional 2 months. Scenario 6 was based on the minimum time required to issue a permit (about 1 year), but KDEP has indicated that permitting could require up to 3 years.

Scenarios 2, 3, and 4 for both sites indicated that costs for adding a hydrolysate treatment technology at sites that initially planned for off-site treatment are in all cases greater than the cost to include a hydrolysate treatment technology from the start of the process. Of course, the later in the process that such a change occurs, the greater the additional costs.

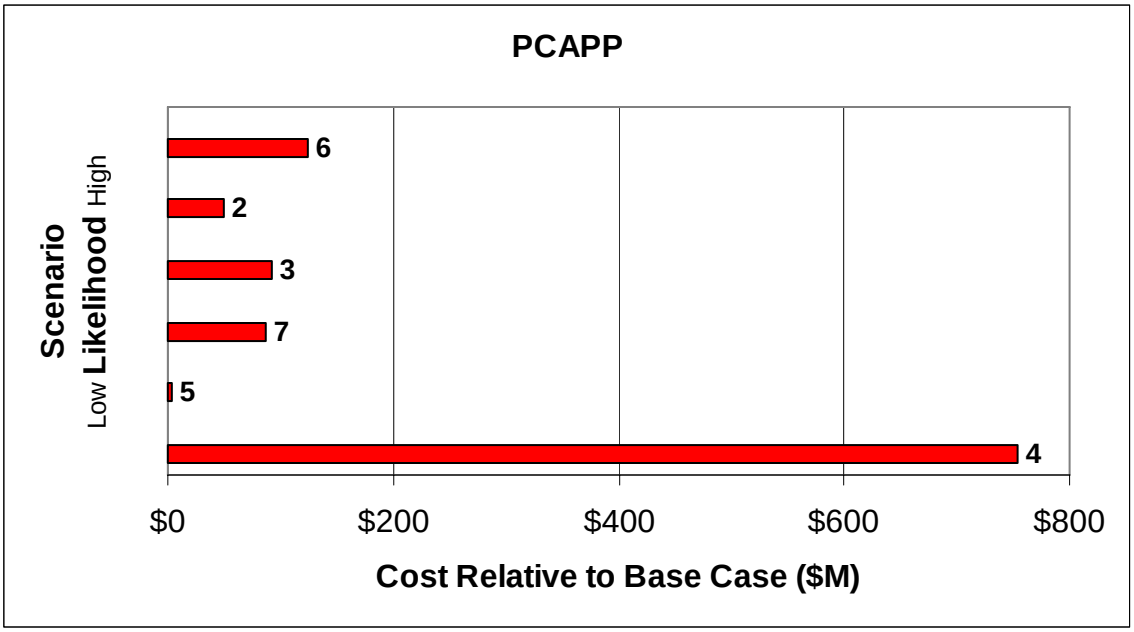

Figure ES-1. Relative Cost Changes for PCAPP Scenarios

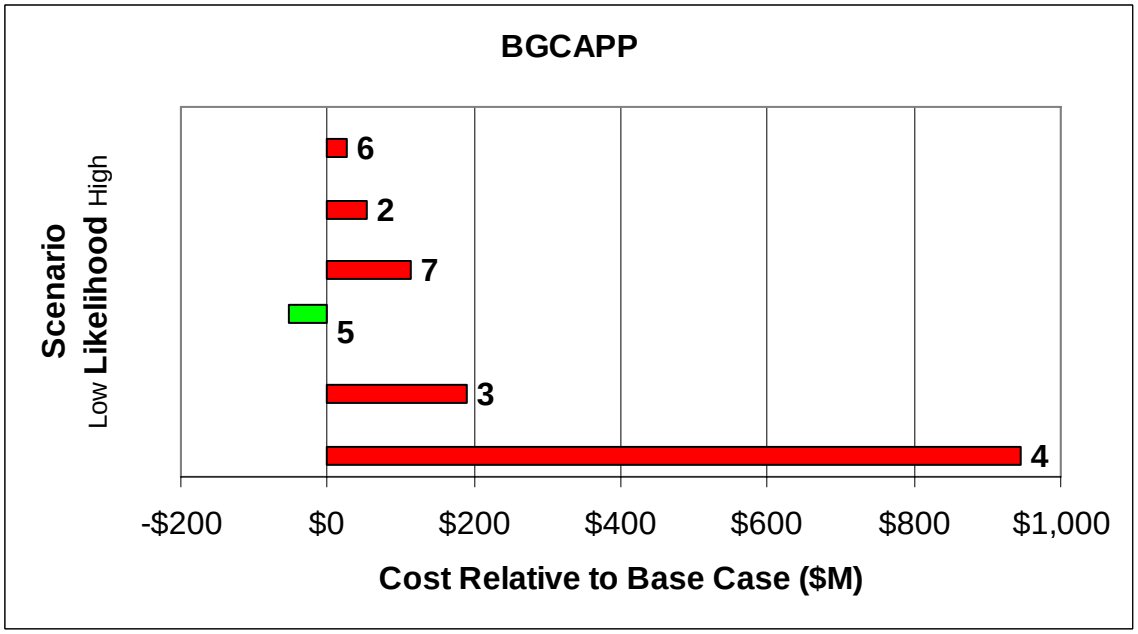

Figure ES-2. Relative Cost Changes for BGCAPP Scenarios

Scenario 7 shows that postponing the decision to treat hydrolysate off-site is likely to lead to increased costs relative to both scenarios 1 and 5, in which the decision is made earlier. This appears to result from the timing of permit changes; postponing the decision means that permit changes will occur later in the process, when they are potentially more disruptive to construction.

Summary of Findings and Conclusions:

Although off-site treatment of agent and energetics hydrolysates appears to be technically feasible and safe, it will be unacceptable to many stakeholders, subject to regulatory and legal delays, and will create additional uncertainties to a program that already has its share of challenges. The data provided in this report represent Mitretek's most-likely estimates—they could be slightly better, but they could be much worse as a result of other uncertainties that have not been previously experienced in this or other similar programs (*i.e.*, "unknown unknowns").

Mitretek's discussions with stakeholders leave little doubt that an off-site disposal decision will result in loss of the RD&D permit option at Blue Grass and litigation of the CD at Pueblo , both resulting in extensive delays. As a result, scenario 6—re-permitting at Blue Grass and litigation at Pueblo—appears to be the most realistic scenario. Although BGCAPP scenario 6 does not cost that much more than the BGCAPP base case, the situation at PCAPP is significantly more expensive and storage time extends to undesirable levels. Either way, there appears to be little tangible value added by off-site hydrolysate treatment at either site. Mitretek's analysis shows that every month of delay costs roughly $15M to 19M. Any delay over 6 months, regardless of cause, would be expected to erase all possible savings, even under the most optimistic assumptions (*i.e.*, a decision to use off-site deep-well injection at BGCAPP with no delays).

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Section 1

Introduction

1.1 Background

The office of the Program Manager for Assembled Chemical Weapons Alternatives (PM ACWA) is responsible for managing the design, construction, systemization, pilot testing, operation, and closure of chemical demilitarization facilities used to destroy chemical weapons stockpiles at the Blue Grass Army Depot (BGAD), Kentucky, and Pueblo Chemical Depot (PCD), Colorado. In July 2002, the Department of Defense (DOD) selected neutralization followed by biotreatment as the preferred technology for full-scale pilot testing to destroy the chemical weapons stockpile stored at PCD. On 27 September 2002, a systems contract to design, build, systemize, pilot test, operate, and close the Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP) was awarded to Bechtel National, Inc. (BNI). Later, in February 2003, DOD selected neutralization followed by supercritical water oxidation (SCWO) as the preferred technology for full-scale pilot testing to destroy the chemical weapons stockpile stored at BGAD. The systems contract to design, build, systemize, pilot test, operate, and close the Blue Grass Chemical Agent-Destruction Pilot Plant (BGCAPP) was awarded on 13 June 2003 to Bechtel Parsons Blue Grass (BPBG), a joint venture of BNI and Parsons Infrastructure and Technology Group, Inc.

In early 2004, the Office of the Secretary of Defense (OSD) conducted an evaluation of design alternatives for the PCAPP to ensure affordability and cost/schedule effectiveness. The results of the evaluation indicated that PCAPP was going to cost considerably more than the conceptual design that served as the basis for the January 2003 OSD certification to Congress. Similar concerns about cost growth were raised by OSD in regards to the design of BGCAPP. Mitretek Systems was tasked to perform independent evaluations of the PCAPP and BGCAPP design efforts.

In 2005, responding to the continuing need to ensure affordability and cost/schedule effectiveness, PM ACWA convened teams to examine the potential cost savings that might be achieved through off-site transportation of the hydrolysates produced at PCAPP and BGCAPP. These studies showed that potential cost savings could be achieved over the lives of the plants under some circumstances, but that the savings were not sufficient to justify the risks to timely completion of PM ACWA's mission. In January 2006, PM ACWA tasked Mitretek to conduct an independent analysis of this issue, taking into account a broad set of programmatic risks.

1.2 Approach

This report documents Mitretek's analysis of off-site treatment of hydrolysates produced at PM ACWA's PCAPP and BGCAPP. Figure 1-1 shows the general framework. As part of this effort, Mitretek developed scenarios to assess the impact of various factors contributing to programmatic risks on the overall life cycle cost savings anticipated as a result of off-site treatment of the hydrolysates. In order to estimate the cost and schedule impacts under these scenarios, extensive field visits were conducted to collect data and information on stakeholder concerns and regulatory issues.

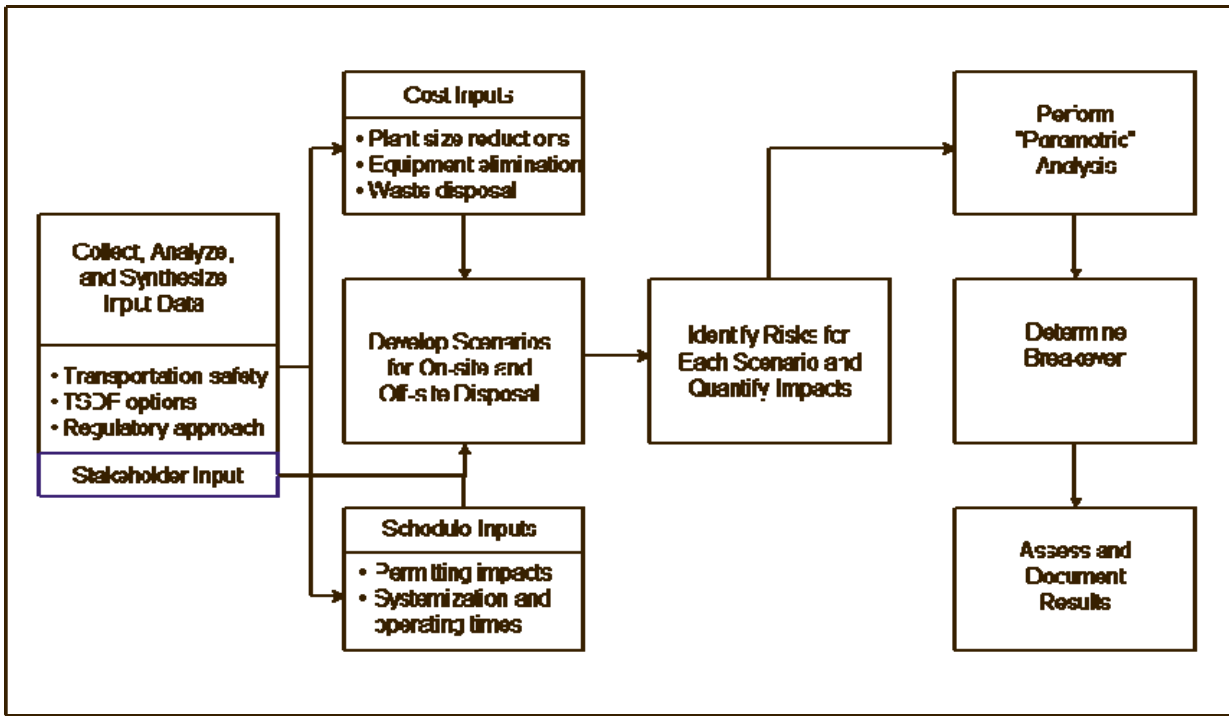

Figure 1-1. Framework for Assessing Off-Site Treatment of Hydrolysates

The cost analysis is termed *parametric* to indicate that it compares the life cycle cost estimates (LCCEs) of scenarios that were developed with the base case LCCEs and schedules for PCAPP and BGCAPP that incorporate on-site treatment of agent and energetics hydrolysates. Those base case estimates are then adjusted according to impacts from a set of conditions expected if agent and energetics hydrolysates were treated off-site. For purposes of this analysis, the hydrolysates considered are those from the mustard agents from PCAPP and those from mustard and nerve agents and rocket bursters from BGCAPP. Mitretek used systems contractor and government LCCEs for the base case. Mitretek reviewed design documentation for data on the PCAPP and BGCAPP facilities and processes, as well as the technologies available for treatment of the hydrolysates at commercial treatment, storage, and disposal facilities (TSDFs). Additionally, Mitretek determined the cost of shipping and treating agent and energetics hydrolysates off-site and reviewed the risks to human health and the environment posed by transporting the hydrolysates. Finally, Mitretek summarized the programmatic risks that could result from a decision to treat hydrolysates at off-site locations and qualitatively ranked the scenarios in terms of their likelihood of occurrence. The costs and schedules developed for this report are for new facilities that have not been constructed and have no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

1.3 Scope

Mitretek considered off-site treatment of hydrolysate independent of other potential cost saving alternatives to PCAPP and BGCAPP processes. Mitretek reviewed previous studies of off-site treatment of hydrolysate, notably the study closure package provided by the BGCAPP

Design Consideration 34 (DC 34) integrated process team (IPT) and the findings of PCAPP IPT 4, as well as the analysis of impacts of off-site treatment options for PCAPP (FOCIS, 2003). However, Mitretek conducted an independent review of off-site treatment options that was not limited by the options considered in the previous studies. Mitretek conducted field visits to collect data and information on stakeholder concerns and regulatory issues. Mitretek reviewed systems contractor and government LCCEs, as well as documentation for design data on the PCAPP and BGCAPP facilities and processes. Where required, Mitretek also used its extensive in-house expertise in the optimization of process design and projected pilot plant operations.

1.4 Report Structure

Technologies available for treatment of the hydrolysates and their availability at commercial TSDFs are reviewed in Section 2. Section 3 of this report summarizes the risks to human health and the environment posed by transporting secondary waste hydrolysates. The programmatic risks that could result from a decision to treat secondary wastes at off-site locations are discussed in Section 4. Section 5 covers the changes to the process buildings and systems resulting from off-site-treatment of hydrolysates and the schedule impacts of these changes. Cost results for on-site and off-site treatment of hydrolysate are presented in Section 6. Section 7 presents Mitretek's conclusions. The appendix summarizes stakeholder concerns in Colorado and Kentucky regarding the off-site-treatment of hydrolysates.

The detailed cost analysis for on-site and off-site treatment of hydrolysates is presented in a companion document, *Cost Analysis of Off-Site Treatment of Hydrolysates from Chemical Agent-Destruction Pilot Plants* (Wusterbarth et al., 2006). That document, which is for official use only (FOUO) because it contains business sensitive information, presents the engineering economic analysis and cost results for transporting and treating PCAPP and BGCAPP hydrolysates off-site. The relative magnitudes of the costs, however, are highlighted herein (see Section 6).

Section 2

Technologies Available For Treatment of Hydrolysates at Commercial TSDFs

The ability to treat secondary wastes at off-site locations is limited by the availability of suitable treatment technologies. This section summarizes the technologies available for treatment of hydrolysates. The first two technologies are the ACWA-certified technologies for treating agent and energetics hydrolysates; the subsequent technologies are used at commercial TSDFs.

2.1 ACWA-Certified Treatment Options

Two technologies capable of treating some or all secondary wastes that will be generated at PCAPP and BGCAPP were demonstrated as part of the ACWA program and certified as effective. They are biotreatment and supercritical water oxidation.

2.1.1 Biotreatment

Biotreatment refers to several different processes in which contaminants in waste water are broken down by the action of biological organisms. Biotreatment processes are available at multiple commercial TSDFs, although the capacities of these units vary and would need to be compared to the expected waste stream volume and composition. Commercial biotreatment has been used to treat the mustard hydrolysate generated at the Aberdeen Chemical Agent Disposal Facility (ABCDF). In addition, ACWA certified that biotreatment is an effective process for treatment of hydrolysates generated from the agent and energetic materials in mustard-containing assembled chemical weapons (ACWA, 1999).

Biotreatment processes were originally considered unacceptable for processing nerve agent hydrolysates because significant amounts of isopropyl methylphosphonic acid (IMPA), ethyl methylphosphonic acid (EMPA), diisopropyl methylphosphonate (DIMP), and methylphosphonic acid (MPA) are present in the biotreatment effluent (ACWA, 1999). IMPA, EMPA, DIMP, and MPA are all listed on Schedule 2, Part B of the *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction* (referred to as the Chemical Weapons Convention, or CWC). Different biotreatment processes have varying effectiveness at destroying diisopropylaminoethanethiol (VX thiol), which is a major constituent of VX hydrolysate. More recently, biotreatment combined with pretreatment processes have been shown in laboratory studies to effectively remove EMPA, MPA and VX thiol from the hydrolysate generated at the Newport Chemical Agent Disposal Facility (NECDF). The pretreatment process involves initial oxidation with sodium persulfate followed by precipitation of MPA with ferric chloride. The combined process destroys >99.9% of VX thiol, and removes >95% of the phosphonates (EMPA and IMPA) from Newport Caustic Hydrolysate (DuPont, 2005a; DuPont, 2005b). Although treatability studies would be required, the same treatment would be expected to be similarly effective against the IMPA, DIMP, and MPA in GB hydrolysate.

In general, the major products from hydrolysis and biotreatment of organic materials are biomass, carbon dioxide, water, nitrogen, and mineral salts including sodium chloride, sodium fluoride, sodium sulfate, and sodium phosphate.

A previous study identified five[1] commercial TSDFs that offered biotreatment, although it noted that four of the facilities were significantly smaller than the DuPont facility that processed ABCDF hydrolysate. The study indicated that it was not clear at that time whether the four smaller biotreatment facilities had enough excess capacity to process the hydrolysate from PCAPP (FOCIS, 2003, p. 65). BGCAPP is expected to generate somewhat less hydrolysate than PCAPP, and so smaller facilities may be able to process BGCAPP waste.

2.1.2 Supercritical Water Oxidation

SCWO was certified by PM ACWA as an effective destruction technology for all hydrolysates generated from agent and energetic materials (ACWA, 1999). Hydrolysates, water, and in some cases an auxiliary fuel are fed to the SCWO reactor, which is a tubular, continuous flow reactor operated at approximately 3,400 pounds per square inch (psi) and 1,200°F. In SCWO, the injected feed mixture is rapidly heated to supercritical conditions and oxidized to carbon dioxide, water, and inorganic salts. Quench water is injected at the bottom of the reactor to cool the effluent and to dissolve the salts that are insoluble above the critical point of water. The effluent is further cooled in water-cooled heat exchangers and passed through a liquid/gas separator and pressure letdown system. Gaseous effluents are scrubbed in carbon filters and released to the atmosphere. Liquid effluents containing soluble and insoluble salts and metal oxides are collected and analyzed. In general, the major products from hydrolysis and SCWO of organic materials are carbon dioxide, water, nitrogen, and mineral salts including sodium chloride, sodium fluoride, sodium sulfate, and sodium phosphate. SCWO is not operated by any commercial TSDFs in the U.S. at this time.

2.2 Other Commercially Available Treatment Options

Several other technologies are available at commercial TSDFs and could be considered for treating some or all secondary wastes that will be generated at PCAPP and BGCAPP.

2.2.1 Wet Air Oxidation

Wet air oxidation (WAO) is a liquid phase chemical reaction in water using dissolved oxygen to oxidize wastewater contaminants. The oxidation occurs at temperatures of 150°C – 350°C (300°F – 660°F) and at pressures from 150 to 5,000 psi. The process can convert organic contaminants to carbon dioxide, water, and biodegradable short-chain organic acids. Typically, WAO processes are operated at temperatures of 270°C – 300°C and 2-6% organic material in the feed. After processing in the reactor, the effluent is then cooled, depressurized, and sampled to ensure the efficacy of the treatment.

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[1] One of the five biotreatment facilities identified was Perma-Fix of Dayton, Ohio. Subsequent to the 2003 FOCIS study, Perma-Fix withdrew from a contract to treat hydrolysate from NECDF, and so should no longer be considered a candidate to treat hydrolysate.

WAO is an established technology with over 50 years of commercial history in a variety of industrial applications. WAO technology was first patented in Sweden in 1911 for destruction of spent pulping liquor and was not initially a large commercial success. The first commercially successful WAO application in the 1930s was a process to produce artificial vanilla (vanillin) from pulping liquor by partial oxidation of the lignosulfonic acids. WAO was patented as a waste treatment process in 1950 and was adopted by the pulp and paper industry in the 1950s. The waste treatment technology was introduced to the municipal sewage sludge market in the early 1960s for treatment of biosolids from the activated sludge process. A common industrial application of WAO is treatment of spent caustic wastewater streams generated by ethylene plants and refineries. Over 200 industrial or municipal WAO systems have been constructed.

WAO has been previously evaluated for applicability in the chemical demilitarization program. It has been tested as a treatment technology for liquid neutralents from several Non-Stockpile Chemical Materiel Project (NSCMP) systems, including the Rapid Response System (RRS) and the Binary Destruction Facility (BDF). In addition, the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory has completed WAO batch studies on TNT red water. Results indicate that WAO can be used for successfully treating red water. NSCMP has selected WAO as the treatment for BDF neutralents; a WAO unit is being installed at a commercial TSDF for this purpose. Bench-scale test results suggest that WAO could successfully treat hydrolysates from PCAPP and BGCAPP; 97.74% destruction of the total organic carbon in a mustard neutralent stimulant was destroyed, and 99.57% of the total organic carbon in a GB neutralent simulant was destroyed. Pilot plant testing for BDF neutralents, which contain similar constituents to GB hydrolysate and VX hydrolysate, also showed destruction to part per million (ppm) levels of total organic carbon. However, the current unit has limited throughput for containing some of the constituents of hydrolysates. This means that the current unit has insufficient capacity to treat the volume of hydrolysates that will be generated in a timely fashion unless additional capacity is added.

2.2.2 Deep-Well Injection

Deep-well injection is a technology that has been in existence since at least the 1930s. Its origin can be traced to the oil industry which used underground injection as means for disposal of oil field brines and other drilling wastes. Underground injection is currently used to dispose of more than 9 billion gallons of hazardous waste each year, and about 89% of all liquid hazardous waste that is land disposed is via injection wells. Chemical and pharmaceutical companies are the largest users of waste injection wells, and this method is often the most cost effective method for handling low concentration/high volume wastes.

The U.S. Environmental Protection Agency (EPA) promulgated Underground Injection Control (UIC) regulations in 1980. Following passage of the 1984 Hazardous and Solid Waste Amendments (HSWA), the UIC program was amended because HSWA banned the disposal of untreated liquid wastes. The UIC regulations are presented in Title 40 of the Code of Federal Regulations (CFR), Parts 124 and 144 to 148. Hydrolysates from PCAPP and BGCAPP would probably require disposal in a Class I hazardous well. There are currently five commercial hazardous waste facilities operating Class I hazardous wells: two are located in Texas, one in Oklahoma, one in Louisiana, and one in Ohio.

Class I wells are typically constructed to inject wastes several thousand feet below the ground surface. The typical injection depths are about 2,000 to 12,000 feet. High pressure is used to overcome existing lithologic and hydrostatic forces in deep aquifers, thereby forcing the aquifer to accept waste loads. Typical injection rates range from 100–400 gallons per minute. The average injection pressure is about 1,000 psi. Class I hazardous wells are comprised of multiple protective steel well casings cemented in place with acid resistant cement. The casings include a pressurized liquid filled protective casing and sensors that serve as a leak detection system.

Deep-well injection is commonly the most cost effective remedial technology. The material to be injected must be fully characterized and compared to the facility's existing permit. Deep-well injection facilities are limited to a narrow range of specific wastes. It may be difficult and costly to expand existing permits to manage unusual hazardous waste streams.

Factors that may limit the applicability and effectiveness of deep-well injection include physical and chemical characteristics of the injected material and the geologic strata receiving the waste. It may be necessary to consider the following:

- Waste compatible with the well materials and mechanical components of the well system and the natural formation water.
- High concentrations of suspended solids (typically greater than 2 ppm) can lead to plugging of the well.
- Wastes should be neutralized to minimize the potential for chemical reactions with well components, the injection zone formation, or the confining strata.
- Organic carbon may serve as an energy source for indigenous or injected bacteria resulting in bio-fouling.
- Waste streams containing organic contaminants above their solubility limits may require pretreatment before injection.

Based on these criteria, mustard and GB hydrolysates would be expected to be reasonable candidates for deep-well injection. VX hydrolysate may require pretreatment before injection because of high levels of organics close to or above the solubility limit.

The biggest uncertainty with using deep-well injection for hydrolysate disposal is whether the Organisation for the Prohibition of Chemical Weapons (OPCW) would accept deep-well injection as rendering the components of the hydrolysates as unrecoverable. Hydrolysis of chemical agents produces components, such as thiodiglycol and methylphosphonic acid and its esters, which could potentially be used to manufacture new chemical agents. For this reason, OPCW does not consider hydrolysis to constitute complete destruction of the chemical agent. Rather, for ABCDF, OPCW accepted mixing of the mustard hydrolysate with the TSDF feed to biotreatment as the endpoint of destruction, because at that point the thiodiglycol in the hydrolysate was deemed effectively unrecoverable. Similarly, VX hydrolysate from the NECDF is not considered completely destroyed because it contains methylphosphonic acid and esters. Although a strong technical case can be made that hydrolysates disposed of using deep-well injection are effectively unrecoverable due to mixing with formation water and degradation at elevated temperatures, OPCW has never been asked to rule on the question and so its position remains uncertain. In negotiating facility agreements for PCAPP and BGCAPP, OPCW could

make accepting deep-well injection as the endpoint of destruction conditional on verification requirements, but the costs of these verification requirements would not be known until the facility agreement is concluded. It has the potential to add substantially to the cost of the treatment itself.

An additional uncertainty regarding deep-well injection is how it will be regarded by stakeholders. Although most stakeholders did not discriminate between off-site treatment options, several stakeholders did indicate that they were dissatisfied with deep-well injection because it did not destroy the hydrolysate components. It is not clear whether this perception would change if OPCW accepted deep-well injection as effectively unrecoverable.

2.2.3 Incineration

Incinerators are widely used commercially for the destruction of hazardous wastes, particularly those that cannot be disposed of by other technologies due to waste disposal regulations. When performed properly, incineration destroys the organic constituents in hazardous waste and reduces the volume of the waste. Inorganic constituents in waste are converted to solid ash in an incinerator or in the associated pollution abatement system. This ash must be properly managed and disposed of in accordance with EPA requirements. Types of commercial hazardous waste incinerators include the following:

- Rotary kilns
- Fluidized bed units
- Liquid injection units
- Fixed hearth units

The Army is currently operating four liquid injection incinerators that destroy chemical agents, suggesting that the technology could be employed to dispose of hydrolysate. However, there are several factors suggesting that incineration would not be acceptable or preferable for that purpose. These include the following:

- Incineration of hydrolysate is more expensive than deep-well injection. This probably results from the relatively small energy content of hydrolysates, which are primarily composed of water. This means that incineration of hydrolysate would require extensive supplemental fuel in order to ensure proper functioning of the incinerator, at considerable expense.
- PM ACWA was originally created to test alternatives to incineration; using incineration to dispose of hydrolysate would almost certainly be considered by some stakeholders as betraying the program's founding principle. Significant diminution of public trust could result from choosing incineration for off-site treatment of hydrolysate.

2.3 Preferred Technologies for Analysis

Finding: TSDF selection is limited by technology and capacity. Biotreatment (with chemical pretreatment as required) and deep-well injection appear to be the preferred technologies for off-site treatment of hydrolysates. Incineration is technically acceptable, but would probably cause significant stakeholder opposition.

Biotreatment, deep-well injection, and incineration appear to be technically capable of treating agent hydrolysate from PCAPP. Biotreatment with chemical pretreatment, deep-well injection, and incineration appear to be technically capable of treating agent and energetics hydrolysates from BGCAPP. However, the number of TSDFs offering these technologies with sufficient capacity to treat hydrolysates from PCAPP and BGCAPP is limited: four or fewer biotreatment facilities and five or fewer deep-well injection facilities. Incineration will probably result in significant additional stakeholder opposition than the other commercially available treatment technologies, in addition to being generally more expensive than deep-well injection. Although it is generally less expensive than biotreatment, there is also some programmatic uncertainty with using deep-well injection for hydrolysate disposal; OPCW has never before been asked to accept deep-well injection as the endpoint of destruction for an agent. The cost impact of verification requirements on a deep-well injection facility is unknown. Therefore, hydrolysate biotreatment with chemical pretreatment (as necessary for certain wastes) is used as the off-site treatment technology in the cost analyses for this report. Alternative cost estimates have been prepared for selected scenarios using deep-well injection as the off-site treatment technology to determine the potential for additional cost savings if OPCW were to accept the technology without costly verification requirements.

Although it has been certified by ACWA as an effective destruction technology for all hydrolysates generated from agent and energetic materials, SCWO is not currently available at any commercial TSDF, and substantial cost savings are unlikely to be realized from building a SCWO unit at a TSDF rather than at BGCAPP. WAO is available at a TSDF and will be used to destroy wastes generated by the non-stockpile chemical materiel project; however, this unit has insufficient throughput to treat in a timely fashion the volume of hydrolysates that will be generated. Although it is conceivable that additional WAO capacity could be installed at the current TSDF or at other TSDFs, substantial cost savings are unlikely to be realized.

Section 3

Risks to Human Health and the Environment Posed By Transporting Secondary Wastes

This section contains Mitretek's review of the risks to human health and the environment posed by transporting hydrolysates. The intrinsic risks posed by the hydrolysates are discussed in Section 3.1, whereas the general risk from transportation is covered in Section 3.2. Studies that would need to be performed to allow regulatory consideration of off-site shipment of hydrolysate are also identified.

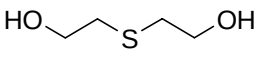
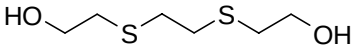
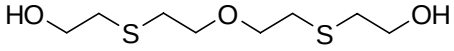
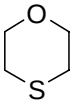
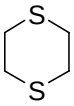
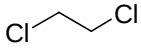
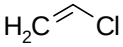
3.1 Risks to Human Health and the Environment

The intrinsic risks posed to human health and the environment by the various hydrolysates produced by PCAPP and BGCAPP are discussed in the following sections. The components of hydrolysates are addressed, along with the level of knowledge of the risks posed by the hydrolysates and major evaluations of those risks. Data gaps that may need to be filled prior to off-site shipment of hydrolysates are identified.

3.1.1 Mustard Agent Hydrolysates

Similar but not identical mustard agent hydrolysates will be generated at PCAPP (from agents HD and HT) and at BGCAPP (from agent H). The procedures are based on the ABCDF neutralization process. The target loading for both processes is 8.6% of agent by weight in water; after reaction at 90°C for 45 minutes, 2.1 equivalents of caustic (NaOH) is added to the reactor over a 15-minute period to adjust the pH to approximately 11. The major components in the mustard hydrolysates are 2,2'-thiobisethanol (thiodiglycol, TDG) and sodium chloride; levels of these and other components in mustard hydrolysates are provided in Table 3-1.

Table 3-1. Components of Mustard Hydrolysates at PCAPP and BGCAPP*

Component	Structure	HD Hydrolysate (PCAPP)	H Hydrolysate (BGCAPP)
2,2'-thiobisethanol (Thiodiglycol, TDG)		4.16%	1.54%
Chloride		2.74%	2.05%
2,2'-[1,2-ethanediylbis(thio)] bisethanol (Q-OH)		0.33%	0.22%
2,2'-[oxybis(2,1-ethanediylthio)] bisethanol (T-OH)		0.23%	0.17%
Iron		0.09%	1.3%
1,4-Oxathiane		0.03%	0.07%
1,4-Dithiane		0.03%	0.01%
1,2-Dichloroethane		0.02%	0.00002%
Vinyl chloride		0.002%	0.0002%

*Compositions taken from Usinowicz et al., 2005.

For the HD hydrolysate, nickel, copper, lead, aluminum and chrome were above 1 mg/l, and averaged 8.3, 4.57, 4.5, 4.4, and 2.16 mg/L, respectively. In the H hydrolysate, copper, chromium, aluminum, and lead were the next highest metals, with concentrations averaging 13.9, 9.6, 4.4, and 3.1 mg/L, respectively. All other metals were less than 1 mg/L. The only consistently measured semi-volatile organic compounds (SVOCs) were 2-methylnaphthalene, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, and naphthalene in HD hydrolysates, all at parts per billion (ppb) to ppm concentrations. There were no consistent SVOCs detected in the H hydrolysates. Tentatively identified compounds in hydrolysate included:

- 2-Hydroxyethyl vinyl sulfide
- 1-(2-Hydroxyethylthio)-2-(vinylthio)ethane
- 1-(2-Hydroxyethylthio)-2-(2-vinylthioethoxy)ethane
- 1,2,5-Trithiepane

Toxicology information on the hydrolysate products is limited. The available information does not suggest that biotreatment of HD hydrolysate, as was done with the ABCDF hydrolysate, poses a significant hazard to human health or the environment. TDG and sodium chloride are relatively low in toxicity, but other components have not been tested, so estimates of toxicity based on TDG and sodium chloride values will be less than complete. The Army has conducted MICROTOX®[2] testing of 15% HD hydrolysate and 3.8% HD hydrolysate. HD hydrolysate is considered toxic in the MICROTOX test. The 15% HD hydrolysate is less toxic than phenol and copper chloride by several orders of magnitude, but more toxic than acetone by a factor of roughly 4, and the 3.8% HD hydrolysate is less toxic than acetone by a factor of roughly 2. A material safety data sheet for 3.8% HD hydrolysate reports an oral median lethal dose (LD_{50}) of 6610 mg kg^{-1}, indicating that it is slightly toxic by ingestion.

There does not appear to be any direct information on the mustard hydrolysate produced at 8.6% loading planned for PCAPP and BGCAPP. The Centers for Disease Control and Prevention (CDC) has not evaluated the risks that mustard hydrolysate poses to human health, nor has the EPA evaluated the risks that mustard hydrolysate poses to the environment. The treatment of mustard hydrolysate from ABCDF started before CDC was asked by Congress to evaluate the human health impacts of off-site hydrolysate treatment (CDC, 2006a). If CDC had been asked to evaluate HD hydrolysate prior to ABCDF operations, their evaluation probably would have included caveats because of the lack of a cancer potency factor for mustard. Moreover, the PCAPP and BGCAPP mustard hydrolysates are not identical to the ABCDF mustard hydrolysate, resulting in the following data gaps:

- Effect of the matrix from H hydrolysate on mustard detection limits
- Toxicity of H and HT hydrolysates

Based on the data currently available, it appears that for CDC to evaluate the off-site shipment of mustard hydrolysate, the following toxicity tests would need to be conducted:

- Mutagenicity of mustard hydrolysate
- Acute toxicity of 8.6% H hydrolysate
- Acute toxicity of 8.6% HT hydrolysate
- Acute toxicity of 8.6% HD hydrolysate

The effect of the matrix from H hydrolysate on mustard detection limits is scheduled to be determined as part of PM ACWA's current test program prior to BGCAPP operations. If a treatment option other than biotreatment were selected, a treatability study might be required, although if such a study were required, it would be conducted as normal practice by the TSDF.

Finding: The risks to human health and the environment posed by mustard hydrolysate are not completely known. Although the available data do not suggest that significant risks exist, some toxicity testing would be required to allow a complete CDC evaluation of the risks.

[2] MICROTOX® is a registered trademark of Strategic Diagnostics, Inc., 111 Pencader Drive, Newark, Delaware 19702-3322 USA.

3.1.2 VX Hydrolysate

VX hydrolysate will be generated at BGCAPP. In this process, VX is added to a solution of 8.8% sodium hydroxide until a 16.6% loading of VX is achieved, and the reaction proceeds at nominally 90°C (194°F) for 150 minutes after completion of agent addition. The composition of VX hydrolysate using the procedure that is expected to be used at BGCAPP is given in Table 3-2. At ambient temperature, Newport hydrolysate forms two separate layers. The lower layer is an aqueous layer; it constitutes 95 to 99% by volume of the hydrolysate and contains the bulk of the water, EMPA, MPA, sodium hydroxide, and ethanol. The upper layer is an organic layer; it constitutes 3% or less of the total hydrolysate at the 16% loading to be used at BGCAPP. The upper layer contains the bulk of the 2-(diisopropylamino)ethyl disulfide, unreacted stabilizer, and stabilizer breakdown products. Thiolamine is present in both layers (Harlacker, 1998). VX hydrolysate will not be shipped if it contains detectable VX or *S*-[2-diisopropylaminoethyl] methylphosphonothioic acid (EA2192); methods have been developed to measure VX in hydrolysate with method detection limits below 20 ppb and to measure EA2192 in hydrolysate with method detection limits below 1 ppm.

Table 3-2. Composition of VX Hydrolysate at BGCAPP

Component	Concentration from 16% VX loading*
Water	75%
Thiolamine	11%
EMPA	7%
MPA	2%
Other components (including ethanol and diisopropylamine)	0.5%
Sodium hydroxide	4%
2-(diisopropylamino)ethyl disulfide	0-4%
Stabilizer and stabilizer breakdown products	0-1%
EA2192	ND (< 1 mg/L)
VX	ND (< 20 μg/L)

*All percentages reported as weight-to-weight unless otherwise specified.

CDC found that the potential human health hazards of the untreated VX hydrolysate are associated predominantly with its corrosive and caustic properties and not nerve agent effects, although trace levels of VX and EA 2192 (a degradation product with nerve agent properties) may be present below detection limits. CDC concluded that the toxicity of VX hydrolysate does not preclude handling and transportation provided that proper precautions are in place (CDC, 2005). The primary risk arises from dermal contact. VX hydrolysate is classified as corrosive according to U.S. Department of Transportation (DOT) regulations. The neutralization uses excess caustic, with the 16% VX hydrolysate containing approximately 4% unreacted sodium

hydroxide. Experiments on rats and rabbits indicated that VX hydrolysate is corrosive to skin and, if swallowed, damaging to the gastrointestinal tract, as expected of a sodium hydroxide solution. However, the effects seen were not indicative of nerve agent activity nor were they sufficiently severe to qualify VX hydrolysate as a DOT poison or toxic material (Manthei, et al., 1999).

In addition, the first 24 batches of VX hydrolysate generated using the original NECDF procedure were classified as flammable, with a flashpoint below 140 ºF (Kimmell and Brubaker, 2005). Subsequent batches (25-102) at NECDF indicate that longer processing times are required to give a nonflammable hydrolysate with no detectable VX or EA2192 (Parsons, 2006). If the hydrolysate were shipped off-site for treatment and disposal, a modified procedure with longer processing times (as is currently being done at NECDF) would be required to generate a nonflammable hydrolysate with no detectable VX or EA2192. Finally, VX hydrolysate also has a strong odor. It results from extremely small concentrations of thiolamine in air, which are unlikely to present a significant toxicological risk, but are highly objectionable.

No additional toxicity testing would be required for VX hydrolysate. If a treatment option other than chemical oxidation/biotreatment were selected, a treatability study might be required. If such a study were required, it would be conducted as normal practice by the TSDF.

Finding: VX hydrolysate poses hazards associated predominately with its corrosive and caustic properties. The hazard does not preclude handling, transportation, and treatment provided that proper precautions are in place.

3.1.3 GB Hydrolysate

GB-unique hydrolysate will be generated at BGCAPP. In the neutralization process, GB is added to a solution of 5% sodium hydroxide until a 7.5% loading of GB is achieved, and the reaction proceeds at nominally 160°F (71°C) for 50 minutes after completion of agent addition. The components of GB hydrolysate are given in Table 3-3; the hydrolysate has a pH of 14.23 (Weibel et al., 2005). GB hydrolysate will not be shipped if it contains detectable GB; methods have been developed to measure GB in hydrolysate with a method detection limit of 20 ppb.

Table 3-3. Components of GB Hydrolysate at BGCAPP

Compound	Measured Concentration	Expected Concentration
IMPA	6.9%	6.8%
Sodium	2.7%	2.7%
Methylphosphonic Acid	0.26%	0.25%
Fluoride	0.89%	0.99%
Hydroxide	Not determined	1.01%
Isopropyl alcohol	Not determined	0.08%

It should be noted that the GB hydrolysate described in Table 3-3 was generated from unstabilized GB; the BGCAPP process will include stabilizer and stabilizer breakdown products, including tributylamine and dialkylcarbodiimides, at levels between 0 and 1%.

There is little data available concerning the toxicity of GB hydrolysate. MICROTOX results for 2% loading of GB indicate a toxic hydrolysate, although one that is less toxic than VX hydrolysate (Haley, Kumas, & Ware, 1997). CDC indicated its preference that the limit for residual GB in hydrolysate has a rational basis in safety and human health rather than being based on method detection limits (CDC, 2006a). It appears that for CDC to evaluate the off-site shipment of GB hydrolysate, PM ACWA would need to conduct the following toxicity tests:

- Acute toxicity of GB hydrolysate
- Ecotoxicity of GB hydrolysate
- Risk assessment for residual GB in hydrolysate

A treatability study might be required for certain treatment technologies. If such a study were required, it would be conducted as normal practice by the TSDF.

Finding: The risks to human health and the environment posed by GB hydrolysate are not completely known. The available data do not suggest that significant risks exist. Multiple data gaps would need to be resolved prior to off-site shipment of hydrolysate to allow a complete CDC evaluation.

3.1.4 Energetic Hydrolysate

Hydrolysate generated from energetic materials are not as well characterized as the agent hydrolysates. Energetics hydrolysate is much more complex; there are many more components, not all of which have been identified by chemical analysis. In addition, BGCAPP currently plans to treat shipping and firing tubes from leaking rockets in the Energetics Batch Hydrolyzer, which will introduce polychlorinated biphenyls (PCBs) into the hydrolysate. Therefore, determination of health risks posed by energetics hydrolysate would almost certainly require testing. If it is necessary for CDC to evaluate the off-site shipment of energetics hydrolysate, PM ACWA would probably need to conduct the following toxicity tests:

- Acute toxicity of energetics hydrolysate
- Combustibility of energetics hydrolysate

A treatability study might be required for certain treatment technologies. If such a study were required, it would be conducted as normal practice by the TSDF. If off-site treatment options were selected, it might be possible that these data gaps could be filled by seeking information from explosives manufacturers and the operators of government ammunition facilities.

Finding: The risk posed by energetics hydrolysate is not completely known. Available data do not suggest that the risk is significant. Major data gaps would need to be resolved prior to off-site shipment of energetics hydrolysate.

3.2 Transportation Risk

A transportation risk assessment has been prepared for PCAPP (Argonne National Laboratory, 2003). Option C of that risk assessment includes an assessment of mustard

hydrolysate shipment, but it assumes that the risk from shipping this cargo is essentially identical to the risk of shipping any cargo that is not considered "dangerous goods." However, mustard hydrolysate is considered a hazardous waste under Colorado law, and thus appears to be subject to standards applicable to transporters of hazardous waste in 40 CFR Part 263 and to the regulations implementing the Hazardous Materials Transportation Act in 49 CFR 171-179. If off-site treatment of mustard hydrolysate were selected for PCAPP, the Pueblo County Certificate of Designation (CD) requires a transportation risk assessment to be performed. That assessment would probably need to include a specific assessment of the risk to human health and the environment posed by mustard hydrolysate.

No transportation risk assessment has been performed for the off-site shipment of hydrolysates from BGCAPP. Although not a regulatory requirement *per se*, a transportation risk assessment for BGCAPP wastes evaluating the risk arising both from the hazardous cargo and the carrier would be useful to local officials determining how shipments of hydrolysate from the site complied with local hazardous material transportation ordinances.

Finding: Additional transportation risk assessments would need to be conducted prior to off-site shipment of hydrolysate.

Section 4

Programmatic Risks

Based on Mitretek's discussions with various stakeholders, it appears that in the current environment, programmatic risks can arise from regulatory delays as well as difficulties in identifying a TSDF to accept the hydrolysates. In addition, stakeholder opposition has the potential to result in changes to legislation or regulation. These risks are discussed in the sections that follow.

4.1 Regulatory Delays

Mitretek interviewed officials from state and local governments as part of its analysis to determine the potential for regulatory actions that would delay the program schedule. Based on those discussions, Mitretek identified two plausible mechanisms for delay in the ACWA program schedule, one for each site.

4.1.1 PCAPP: Appeal of the Pueblo County Decision on the PCAPP Certificate of Designation

Mitretek interviewed officials from the Colorado Department of Public Health and Environment (CDPHE); a summary of the meeting is included in Appendix A. CDPHE indicated that in their view, several other aspects of PCAPP besides biotreatment of hydrolysate qualified the facility for the Research, Development, and Demonstration (RD&D) permitting approach under the Resource Conservation and Recovery Act (RCRA). Based on this, off-site treatment of PCAPP hydrolysate should not result in a change of the RD&D permitting approach. CDPHE also indicated that parties can appeal the issuance of the full RCRA Part B permit, but the appealing party must present a technical basis for the appeal and to prevail it must show that at least some part of the permit reflects arbitrary or capricious decision making by CDPHE. In the absence of a strong technical case, permit appeals are unlikely to result in an injunction by the state district court. Although a successful appeal can be time-consuming, it appears unlikely that state permitting issues would result in significant delays to PCAPP.

Mitretek also interviewed officials from Pueblo County, which must grant a CD to PCAPP; a summary of the meeting is included in Appendix A. The current and former County attorneys explained that a CD is considered a land-use decision under Colorado law, and that the issuance of a CD can be appealed to the state district court. The attorneys indicated that a preliminary injunction could be granted against the CD, which would effectively stop all activity on the PCAPP site. The appeal would probably require a year at the district court level, with another year at the state Court of Appeals required if the district court decision is appealed. Based on this information, litigation of the CD has a chance of resulting in significant delays to the PCAPP schedule.

Finding: There is a significant programmatic risk of an appeal of the Pueblo County decision on the PCAPP Certificate of Designation, which could result in an injunction halting work at PCAPP for 1-2 years.

The potential for an appeal of the Pueblo County CD to cause significant delays is analyzed in PCAPP scenario 6.

4.1.2 Kentucky Department of Environmental Protection Decision that Research, Development, and Demonstration Permitting is Inappropriate for BGCAPP

Mitretek interviewed officials from the Kentucky Department of Environmental Protection (KDEP); a summary of the meeting is included in Appendix A. KDEP indicated that if the BGCAPP RD&D permit were amended to remove the SCWO process and switch to off-site treatment of BGCAPP hydrolysate, it would reexamine whether or not the RD&D approach to permitting remained appropriate. The current BGCAPP design has removed the integrated dunnage shredding and handling process and the heated discharge conveyor from the original process, both of which were used to support the RD&D approach. KDEP would reevaluate the permitting approach in light of all the changes. KDEP stated that although the outcome is not certain, it is probable that the RD&D approach would be deemed inappropriate without SCWO. Therefore, off-site treatment of BGCAPP hydrolysate could result in a change from the RD&D permit to a full RCRA Part B permit. If the permitting approach were to change, regulations require that all work on the site stop until 30 days after KDEP issued the Part B permit. For purposes of this analysis, Mitretek assumed that KDEP could issue a Part B permit within no less than 7 months of receiving a permit application, which included a complete BGCAPP design. Based on information provided by KDEP, this short turnaround is very optimistic, and would require close coordination between the systems contractor, the Depot, PM ACWA, and KDEP, as well as continued PM ACWA funding of dedicated staff at KDEP for permit review. Without such coordination and support, KDEP has indicated that the time required to issue a permit could extend to 3 or more years.

Kentucky requires that the Madison County Judge-Executive certify that the infrastructure improvements identified in the Emergency Response Plan be complete and that the Community Liaison position is filled before BGCAPP can begin operations. All critical shortcomings in the Emergency Response Plan must be resolved before operations begin. Although these local issues have the potential to cause schedule delays, that potential is judged less significant and the delays shorter than those associated with the RD&D permitting approach.

Finding: There is a significant programmatic risk that KDEP may determine that an RD&D permit is no longer appropriate for BGCAPP if hydrolysate is processed off-site. This results in delays as the permit is converted to a RCRA Part B permit.

The minimum delay possible due to the loss of the RD&D permit is analyzed in BGCAPP scenario 6.

4.2 Delay Associated with Finding a Treatment, Storage, and Disposal Facility to Process Hydrolysate

In this section, Mitretek examines the potential for delay to the program schedule associated with finding a TSDF able and willing to process hydrolysates from PCAPP and BGCAPP. Mitretek's findings are based on the historical record of roughly similar disposal projects, recent regulatory and Congressional actions, and discussions with stakeholders.

4.2.1 Experience with Waste Treatment from ABCDF

Since beginning agent operations in April 2003, all of the mustard hydrolysate generated at ABCDF has been destroyed at the DuPont Secure Environmental Treatment at Chambers Works, located in Deepwater, N.J. The hydrolysate was treated using two-stage enhanced biodegradation process. This TSDF is the largest commercial and industrial wastewater treatment facility in the United States. The neutralization of the ABCDF stockpile and the decontamination of the containers produced roughly 7 million gallons of hydrolysate, shipped in over 1,300 truckloads. In addition, as ABCDF is being closed, mustard agent-contaminated parts are being shipped to the Veolia Environmental Service's[3] Port Arthur facility in Texas for thermal treatment. Spent decontamination solution and rinsate are being shipped for biotreatment at DuPont.

ABCDF presents a relatively successful example of a shipment of agent-derived wastes to TSDFs. However, the example of ABCDF may not apply to PCAPP and BGCAPP for the following reasons:

- Mustard hydrolysate shipments were not assessed by CDC, and were little-noticed by nationally-based activists, even though the activist community near the DuPont facility was included in outreach activities. Although the mustard hydrolysate shipments were completed without significant harm to human health or the environment, there are some data gaps that would prevent CDC from reaching a definitive conclusion were it to evaluate mustard hydrolysate shipments from PCAPP and BGCAPP at the level it evaluated VX hydrolysate shipments from NECDF. In today's environment, it appears much more probable that activists would notice and would protest shipments of mustard hydrolysate to DuPont. For this reason, Mitretek does not assume that PCAPP hydrolysate could be shipped to DuPont for treatment with the same lack of opposition to the ABCDF shipments.
- Shipments of agent-contaminated waste to Port Arthur also appear to be little-noticed by the nationally-based activist community. With the concentration of petrochemical industry in the area, the lack of opposition could mean that the local population has been better educated about the nature of chemical risks. Nevertheless, it appears risky to assume that shipments of other agent-derived materials would not be opposed simply based on the level of opposition to ABCDF waste shipments in the Port Arthur area.

4.2.2 Experience with Hydrolysate Treatment from NECDF

Destruction of VX at NECDF began on 5 May 2005; to date, approximately 15% of the stockpile at the Newport depot had been neutralized. NECDF currently intends to ship the hydrolysate to DuPont for treatment, but DuPont will not be able to accept the hydrolysate for treatment until it submits a permit modification. The hydrolysate being generated at NECDF is stored temporarily in intermodal shipping containers at Newport Chemical Depot.

The treatment of NECDF hydrolysate has been a controversial issue. The controversy began in early 2004. The initial TSDF subcontractor for NECDF hydrolysate was forced to withdraw

[3] Veolia Environmental Services was formerly known as Onyx North America.

from the project. The TSDF was a biotreatment facility that discharged its effluent to a publicly owned treatment facility. The county government that owned the public facility threatened to stop accepting effluent from the TSDF if NECDF hydrolysate were treated at the TSDF. This forced the TSDF to decline to accept NECDF hydrolysate, and the subcontract was terminated.

After the first TSDF withdrew in early 2004, NECDF announced its intention to ship the hydrolysate from NECDF to DuPont. Activist groups and local politicians of both Delaware and New Jersey protested the decision. DuPont decided to modify the treatment process to reduce levels of hydrolysate constituents of concern in the plant discharge and conducted an additional treatability study on the modified biotreatment process. DuPont's discharge permit had expired in 2004, and it had submitted a renewal application before the old permit expired. During the summer of 2005, public hearings were conducted and the permit renewal was reviewed. In October 2005, the permit was extended, with the condition that acceptance of VX hydrolysate is prohibited at this time. In order to accept hydrolysate from NECDF, CDC and EPA must complete their reviews of the proposal, and DuPont must submit a permit modification to the NJ Department of Environmental Protection (NJDEP). NJDEP will consider the CDC and EPA reviews and make a determination on whether to allow future acceptance of the hydrolysate.

The proposed treatment of NECDF hydrolysate at DuPont has also drawn criticism from politicians at the state level. In May 2005, Acting Governor Richard J. Codey issued a letter informing the Army that New Jersey was opposed to the discharge of VX nerve agent waste from DuPont's treatment plant. Then gubernatorial candidate Jon Corzine turned neutralized VX nerve agent into a campaign promise in 2005, saying he would never "let the Army dump the stuff into a New Jersey river" if he were elected governor. More recently, Governor Corzine indicated through a spokesperson that he remained concerned about the proposal and was "still very interested in seeing the result of the CDC's study of the human impact."

U.S. Representatives Robert Andrews (D-NJ 1st), Frank LoBiondo (R-NJ 2nd), and Jim Saxton (R-NJ 3rd) have sponsored language in the version of the Defense Authorization Act for Fiscal Year 2007 (Sec 922, H.R. 5122) passed by the House requiring the Comptroller General to submit a review of the Army's cost-benefit analysis of off-site versus on-site treatment and disposal of NECDF hydrolysate to Congress by 1 December 2006. If this provision is contained in the final law, hydrolysate could not be transported from NECDF until February 2007. Rep. Andrews was recently quoted as stating "I don't believe the VX will ever come to New Jersey, and the same would apply to any chemical weapon byproduct from Kentucky or Colorado. I think the DuPont project will never happen, nor do I think it should" (Montgomery, 2006).

NECDF represents an example of some of the difficulties that can be encountered with shipment of agent-derived wastes to TSDFs. Political opposition prevented one TSDF from accepting NECDF hydrolysate, and has at a minimum delayed the acceptance of hydrolysate at a second TSDF by several years. It is notable that political opposition in New Jersey did not emerge until the Army's announcement of its intent to send NECDF hydrolysate to DuPont; lack of opposition in the absence of a specific proposal does not indicate acceptance.

The NECDF controversy has resulted in limits on potential operating scenarios at PCAPP and BGCAPP. Based on discussions with state regulators, neither PCAPP nor BGCAPP will be allowed to begin operations in the fashion that NECDF is currently operating, with temporary on-site storage of hydrolysate pending finalization of an arrangement with a TSDF. KDEP has

indicated that it will not issue the letter that is required to begin processing munitions at BGCAPP unless BGCAPP has a contract with a TSDF to receive secondary hazardous wastes to be processed off-site, including hydrolysate. KDEP will also require reasonable assurance that the TSDF(s) will not be subject to interruption due to potential public opposition.

CDPHE has taken a similar position; it will not allow PCAPP to begin operations without a means of disposing of hydrolysate. In addition, under Colorado regulations, PCAPP would be restricted to a year of storage of hydrolysate prior to final disposal. Violations of the land disposal restrictions storage prohibition could result in fines of up to $25,000 per violation per day. It does not appear that such fines would be waived if violations resulted from interruptions in the ability to transport or treat hydrolysate off-site.

Finding: Based on discussions with state regulators, neither PCAPP nor BGCAPP will be allowed by state regulatory authorities to begin operations unless a contract with a TSDF for the treatment of hydrolysates is in place, and the contracted facility has all required permits to accept hydrolysates.

4.2.3 U.S. Navy Disposal of Napalm

The U.S. stockpile of napalm[4] was stored at Fallbrook Naval Weapons Facility in California. A plant was built during the 1990s to drain the napalm from the bombs in the stockpile. On 11 April 1998, two 6,000-gallon containers of napalm were shipped for treatment at Pollution Control Industries (PCI), an industrial recycling plant in East Chicago, Indiana. However, with the shipment en route, PCI withdrew from its contract due to pressure from concerned politicians and local citizens. The shipment was halted in a Kansas rail yard and then sent back to California.

Subsequently, the GNI Group was awarded a subcontract to recycle the napalm for use as an industrial fuel. The first shipment to GNI was made in July 1998; public reaction was much milder than was the case in Indiana. In December 1998, a Louisiana chemical plant agreed to burn the recycled napalm as a fuel in furnaces that regenerate sulfuric acid used by petrochemical companies. Permits allowed the plant to begin burning the fuel in January 1999, but at the request of the Louisiana governor, the start was delayed until June 1999 to address community concerns. On 4 April 2001, the Navy recycled its final two napalm canisters.

Initially projected to take just two years to complete and cost no more than $28 million, the project required 4 years and cost about $50 million to complete. At a minimum, nine months of the delay were a result of public opposition to the recycling or use of the recycled napalm at the destination sites.

4.2.4 Outlook for Hydrolysate Treatment for PCAPP and BGCAPP

Based on the historical record of treatment projects of similar controversy, recent regulatory and Congressional actions, and discussions with stakeholders, delays in the off-site treatment and treatment of hydrolysates from PCAPP and BGCAPP appears possible. The treatment of

[4] Napalm was a mixture of gasoline, polystyrene, and benzene that formed a gelatinized substance for use in napalm bombs or flame throwers.

hydrolysate from ABCDF suggests that off-site treatment and disposal of PCAPP hydrolysate has a higher potential for success. However, under different circumstances, political opposition to acceptance of PCAPP hydrolysate could emerge and result in delays. The treatment of hydrolysate from NECDF suggests that off-site treatment and disposal of BGCAPP hydrolysates could be more difficult. The Navy's experience with napalm disposal shows how a relatively successful disposal program with lower levels of perceived risk than typically associated with chemical demilitarization can experience significant delays due to political opposition, even if it involves only a temporary delay to allow state or local government to review the risks involved.

Another source of uncertainty is simply the dynamic nature of the waste treatment business. At this point, the projected off-site shipment of hydrolysates from PCAPP and BGCAPP would begin in 2011 and 2012. It may be instructive to examine records from 2000 and 2001 to see how the waste treatment business can change in 5-6 years. Many of the TSDF facilities with the capabilities required for hydrolysate treatment have changed owners within that time. The number of Class 1 hazardous disposal wells accepting off-site waste for injection has decreased from 11 facilities (EPA, 2001) to 5 (EHSO, 2006) over the past 7 years. The availability of TSDFs also changes for business reasons. One example of this is Vopak Industrial Services in Deer Park, Texas, one of five TSDFs identified in a previous analysis (FOCIS, 2003) as technically viable for treating PCAPP hydrolysate. Vopak did not use its injection well for disposal of third party wastes between 1996 and 2002. After resuming the acceptance of third party-wastes for deep well injection, it recently stopped accepting such wastes again. This uncertainty is particularly significant because, as previously mentioned, only a limited number of TSDFs offer the preferred technologies with sufficient capacities.

Finding: There is a programmatic risk that PM ACWA could encounter delays in the off-site treatment and disposal of hydrolysates from PCAPP and BGCAPP, either due to political opposition or to business reasons.

4.3 Changes in Legislation or Regulations

Discussions with stakeholders in Colorado and Kentucky suggest that many view the off-site treatment of hydrolysates as a change in the rules following what they viewed (whether correctly or not) as technology decisions that included on-site hydrolysate treatment as part of PCAPP and BGCAPP. A decision to treat hydrolysate off-site would probably lead to a loss of trust with some portion of the public. It is extremely difficult to factor loss of trust into an economic analysis, so Mitretek is not explicitly including loss of trust in its analysis. Nevertheless, there is a notable programmatic risk that disappointed stakeholders could make the political process a more prominent feature than it is currently. For example, prior to the ACWA program, Kentucky stakeholders played a part in passing state legislation that made construction of an incineration facility difficult by forcing a much lengthier permitting process on incineration facilities than is being used for BGCAPP. Similar stakeholder involvement in either Kentucky or Colorado could lead to legislation making hydrolysate shipment from the facility much more difficult than it is currently. In addition, some of the local government approvals necessary for operation of PCAPP and BGCAPP are currently in the hands of officials who have expressed opposition to off-site treatment of hydrolysate. Although those officials have not suggested that they would delay operations, an adversarial relationship has the potential to cause delays. These uncertainties

increase the programmatic risk and may require new and possibly more costly approaches to manage.

It should also be noted that a number of significant cost-saving processing alternatives have been or are being discussed with stakeholders at each site. Examples of these alternatives at PCAPP include shipment of explosives for off-site destruction and the processing of leaking munitions using a contained detonation technology. Examples of these alternatives at BGCAPP include separation of uncontaminated rocket motors for processing outside of BGCAPP and off-site shipment of uncontaminated shipping and firing tubes. At both PCAPP and BGCAPP, only contaminated secondary wastes will be processed on-site, allowing substantial quantities of carbon and demilitarization protective ensembles to be shipped off-site for treatment. The continued acceptance of these cost-saving alternatives by stakeholders could be jeopardized by the spillover from opposition to off-site treatment of hydrolysate.

Finding: There is a programmatic risk that PM ACWA could find itself in a more adversarial operating environment than at present due to political opposition to off-site shipment of hydrolysate. Such changes have the potential to increase program costs.

Section 5

Process and Schedule Impacts of Off-Site Treatment of Hydrolysates

Mitretek modified the PCAPP and BGCAPP schedules and LCCEs from April 2006 to reflect seven potential scenarios for treating hydrolysates off-site. This section describes the scenarios, the process changes, and the schedule impacts for each scenario at both sites. These scenarios were designed to evaluate certain parameters for analytical purposes, but were not intended to represent all possible scenarios. Indeed, some of the scenarios are rather unlikely to occur as stated. If a decision is made to treat hydrolysates off-site, PM ACWA will probably explore additional contingencies that were not explicitly analyzed in this report. A general diagram depicting the seven scenarios is shown in Figure 5-1; note, however, that the dates for specific milestones vary from scenario to scenario and between PCAPP and BGCAPP. Because the cost information is procurement sensitive, the cost analysis and supporting documentation are provided in another report (Wusterbarth et al., 2006). The specific descriptions of each scenario are given in the individual sections that follow.

Scenario No.	Life Cycle Phase			
	DAB	Construction	Systemization	Operations
1 (base)	On-site Treatment			
2	Off-site Treatment	On-site Treatment		
3	Off-site Treatment		On-site Treatment	
4	Off-site Treatment			On-site Treatment
5	Off-site Treatment			
6	Off-site Treatment	Extended Delays	Off-site Treatment	
7	Undecided	Off-site Treatment		

Figure 5-1. General Scenarios Considered in the Analysis

5.1 PCAPP Scenarios

This section describes the changes in the process buildings and systems and the impacts on the project schedule for the seven different scenarios used to generate LCCEs for PCAPP. For scenarios 1 through 4, in which systems for on-site hydrolysate treatment would be constructed, the process buildings and systems were based on the "LCCE revised design" as reflected in the systems contractor's LCCE (BNI, 2006a, pp. ES-8 – ES-10). For scenarios 5 through 7, in which

systems for off-site hydrolysate treatment would be constructed, the process buildings and systems were based on the modifications for off-site shipment of hydrolysate described in the systems contractor's LCCE (BNI, 2006a pp. VIII-1 – VIII-4.). For scenarios 2 through 7, Mitretek used its professional judgment to determine how the events in the scenario under consideration impact which of the process buildings and systems would be constructed. The schedules for scenarios 1 through 7 were based on the summary execution schedule in the LCCE, which also is used as the schedule for the base case (BNI, 2006b). To determine the schedule impacts for scenarios 2 through 7, Mitretek applied the experience of other demilitarization facilities, information gathered from Colorado and Pueblo County officials (see Appendix A), and professional judgment to determine the impacts of the events in the scenario under consideration on the schedule. The specific results of Mitretek's analysis of changes in the process buildings and systems and the impacts on the project schedule for each scenario are detailed below.

Much of the schedule impact on the scenarios being analyzed resulted from permitting issues. RD&D permits for PCAPP construction are being issued in stages. Stage IA construction began in late 2005; it includes the Northwest Passage Road to the PCAPP site, security fencing, and an access control point to screen personnel and vehicles entering the site. Stage IB construction began in March 2006 and includes site clearing and underground utilities. Stage II construction consists of all non-processing facilities and is scheduled to begin this summer. Permits for Stages I and II have already been issued, and are unaffected by the scenarios being analyzed. Stage III permitting and construction covers the main process buildings and equipment; the current permit application, based on treating hydrolysate on-site, is being prepared. Changing from on-site treatment of hydrolysate to off-site treatment of hydrolysate or vice-versa would require changing the Stage III permit application or modifying the Stage III permit. Stage III construction activities at the PCAPP site cannot start until after the Stage III permit is issued. The schedule provided with the LCCE shows that construction of Stage III facilities starts 4 months after the permit is issued. Furthermore, systemization of Stage III facilities starts 1 year after the start of construction. These intervals were used for all PCAPP scenarios. Specific timing of the changes and the impact on Stage III construction are discussed in the scenario details below.

5.1.1 Scenario 1

Scenario 1 is the base case, assuming that the 2006 Defense Acquisition Board (DAB) would direct PM ACWA to treat all hydrolysate from the facility on-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to continue with the current PCAPP design and to finalize the facility design based on on-site biotreatment of hydrolysate. All facility construction and equipment purchases would be made as described in the systems contractor's LCCE for on-site biotreatment of hydrolysate, and all facility staffing would be based on the systems contractor's LCCE for on-site biotreatment. The process used for the base case was the design used to generate the April 2006 LCCE (BNI, 2006a, pp ES-8 – ES-10). The summary execution schedule in the LCCE was used as the schedule for the base case (BNI, 2006b). A diagram of the base case process used at PCAPP is shown in Figure 5-2, and the base schedule for the major life cycle phases from the LCCE is shown in Figure 5-3.

5.1.2 Scenario 2

In scenario 2, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility designs based on off-site treatment. The systems contractor would revise permit applications to include off-site treatment. This scenario assumed that on 1 October 2007, the systems contractor would inform PM ACWA that no TSDF with the required permits and appropriate treatment technology had indicated interest in bidding on the waste disposal subcontract. PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the biotreatment area (BTA) designs as they existed on 1 October 2006, completing the design to integrate biotreatment and proceeding with construction, systemization, operations, and closure for that design. On 1 October 2007, the revisions to the permit applications would be withdrawn, and another set of modified permit applications would be submitted.

5.1.2.1 Process Systems Changed for Scenario 2

In scenario 2, the process buildings and systems that would be constructed are the same as those constructed for the base case in scenario 1. There would be no change from the base case.

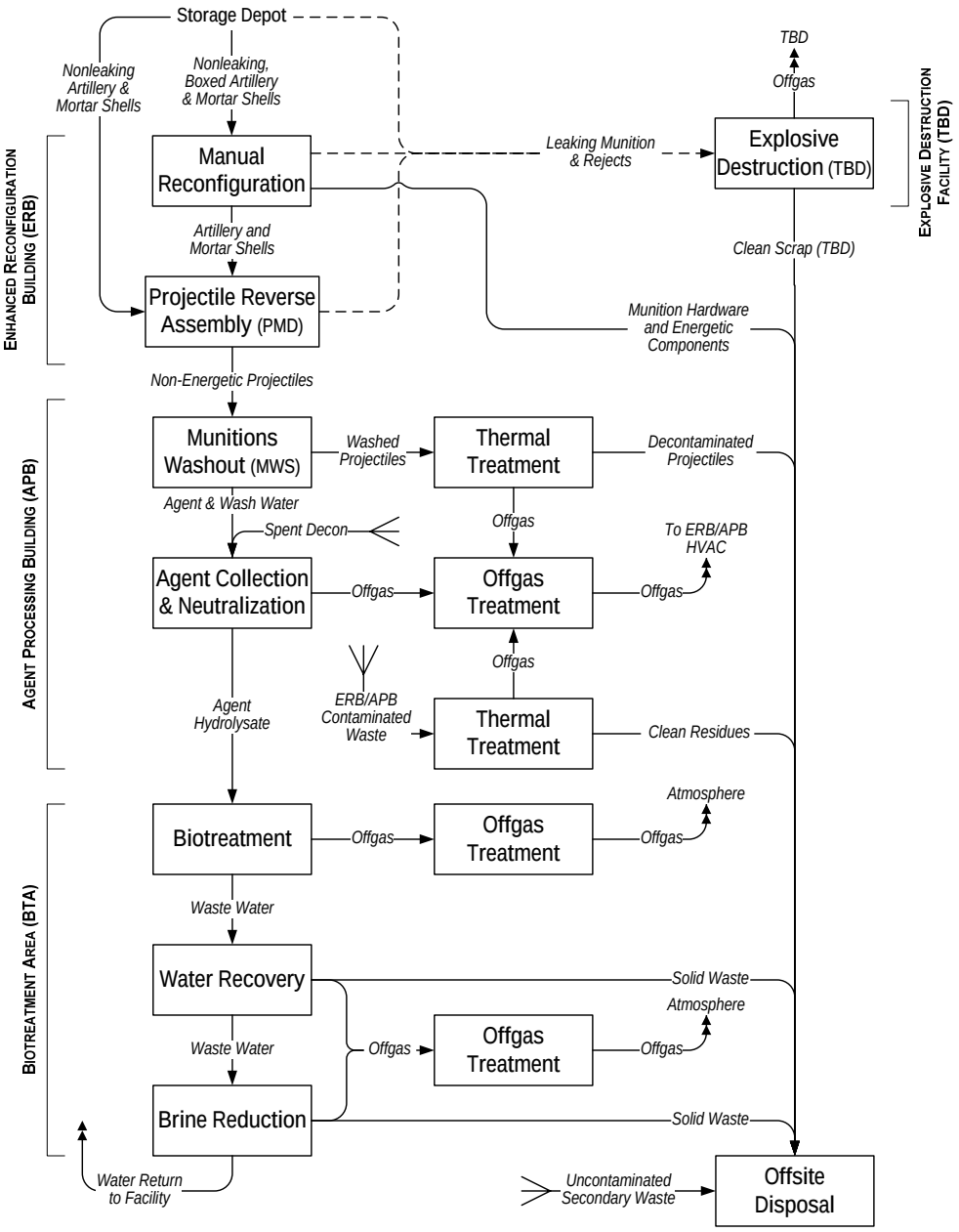


Figure 5-2. Diagram of the Base Case PCAPP Process

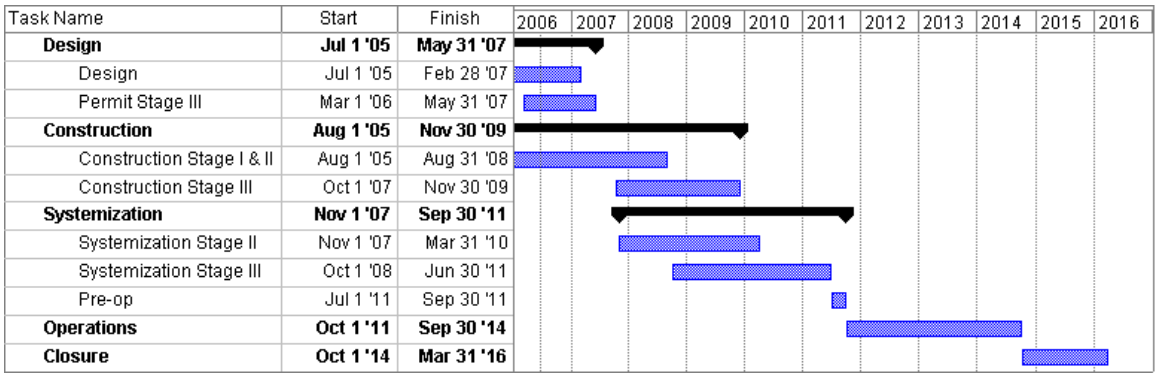


Figure 5-3. Major Phases of PCAPP Scenario 1 (Base Case) Schedule

5.1.2.2 Schedule Impacts of Scenario 2

To determine the schedule impacts for scenario 2, Mitretek assumed that beginning on 1 October 2006, the systems contractor would prepare a modification of the Stage III RD&D and air permit applications and that PM ACWA would revise the Environmental Impact Statement (EIS) and the Emergency Preparedness Plan (EPP) to reflect off-site treatment. Mitretek assumed that with the permit modifications pending, CDPHE would allow the Stage I and II construction and systemization activities to continue, but that all Stage III construction would be delayed until the new permit was issued. Although it is possible that some of the schedule impact could be mitigated by continuation of off-site fabrication and shifting of resources between planned Stage III construction and continuing work on Stage II non-processing facilities, Mitretek took a conservative approach and did not assume any mitigation. The decision to resume on-site hydrolysate treatment would occur while the modified "off-site" Stage III permit application is pending, requiring a second modification to the permit application. Mitretek allowed 3 months from the 1 October 2007 decision for the revised design to be developed[5] and the application to be submitted and 3 months for CDPHE to process and issue the Stage III permit, which would occur on 31 March 2008. Consequently, the start of construction of the Agent Processing Building (APB) and Enhanced Reconfiguration Building (ERB) would be delayed until 1 August 2008, 4 months after permit issuance (the same interval as in the base case). The 10 month overall delay to the start of Stage III construction would also delay the start of systemization of the main process buildings and equipment ("Stage III systemization"), operations, and closure by 10 months. Durations of Stage III construction, Stage III systemization, operations, and closure were unchanged from the base case (scenario 1). The resulting schedule for the major phases of the project for scenario 2 is shown in Figure 5-4.

[5] Based on the PCAPP schedule, the BTA design is expected to be finalized in November 2007.

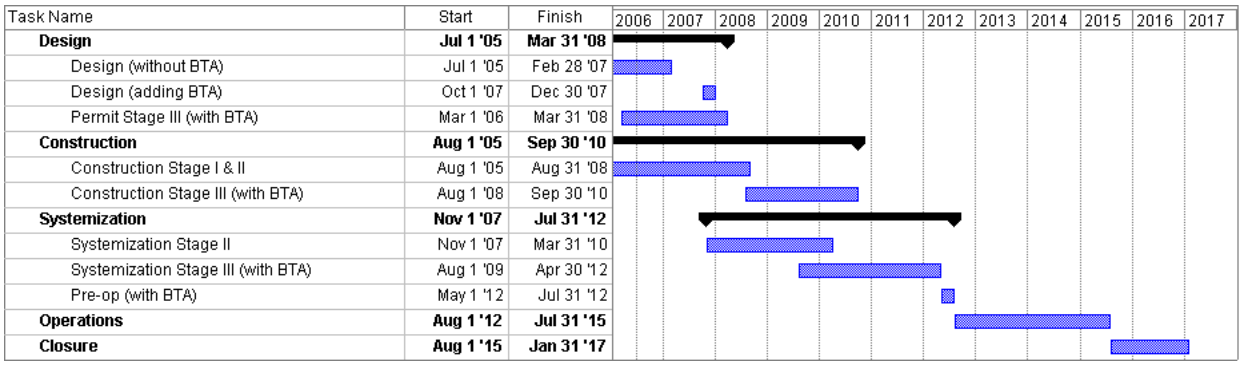


Figure 5-4. Major Phases of PCAPP Scenario 2 Schedule

5.1.3 Scenario 3

In scenario 3, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility design based on off-site treatment. The systems contractor would also revise permit applications for off-site treatment. A construction permit would be issued and Stage III construction would proceed; all facility construction and equipment purchases would be made based on off-site treatment of hydrolysate. This scenario assumed that on 1 November 2009, as Stage III systemization commenced, the systems contractor would inform PM ACWA that the selected TSDF subcontractor was backing out and it had been unable to contract with another TSDF with the permits and technologies required to accept the hydrolysate. PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the BTA designs as they existed on 1 October 2006, completing the design to integrate biotreatment and proceeding with construction, systemization, operations, and closure for that design.

5.1.3.1 Process Systems Changed for Scenario 3

In scenario 3, the process buildings and systems that would be constructed are the same as would be constructed for the base case in scenario 1. Mitretek assumed that equipment purchases for and construction of a pad for loading hydrolysate into tanker trucks, which would be required for shipment of hydrolysate from PCAPP to an off-site TSDF, would not have begun until after 1 November 2009. This assumption was based on the relatively short time required for construction of the loading station.

5.1.3.2 Schedule Impacts of Scenario 3

To determine the schedule impacts for scenario 3, Mitretek assumed that beginning on 1 October 2006, the systems contractor would prepare a modification of the Stage III RD&D and air permit applications and that PM ACWA would revise the EIS and the EPP to reflect off-site treatment. Mitretek assumed that with the permit modifications pending, CDPHE would allow the Stage I and II construction and systemization activities to continue, but that Stage III construction would be delayed until the new permit was issued. Mitretek allowed 3 months from the 1 October 2007 decision for the revised design to be developed and the application to be submitted and 6 months for CDPHE to process and issue the Stage III permit, which would occur

on 30 June 2008. The 6 months for CDPHE processing included a public comment period and allowed for conducting supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD. In this scenario, it was assumed that there will be no lawsuits filed against the issuance of the Stage III permit. Consequently, the start of construction of the APB and ERB was delayed until 1 November 2008, 4 months after permit issuance (the same interval as in the base case, scenario 1).

Mitretek assumed that starting on 1 November 2009, the systems contractor would require 3 months to review and to complete the design of the biotreatment area. The permit modification process to include the BTA would take 4 months, although there would be a one month overlap between this period and the schedule for finalizing the BTA design. During this time, there would be other ongoing activities, primarily the construction of the ERB and APB. Hence the Project Services and Plant staff levels during this period (*i.e.*, during BTA design) would be the same as in scenario 1. Procurement of equipment for and construction of the biotreatment area would require 22 months, based on information provided by BNI (Lacey, 2006). Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting HD and HT hydrolysate (including studies to fill data gaps), and permit modifications to allow the TSDF to accept the hydrolysate could be completed within the time required for Stage III construction and systemization. The duration of Stage III systemization and pre-operations for the facility exclusive of the biotreatment area was assumed to remain at 36 months. Systemization and pre-operations of the BTA was assumed to require 13 months. Durations of operations and closure were unchanged from the base case. The resulting schedule for the major phases of the project for scenario 3 is shown in Figure 5-5.

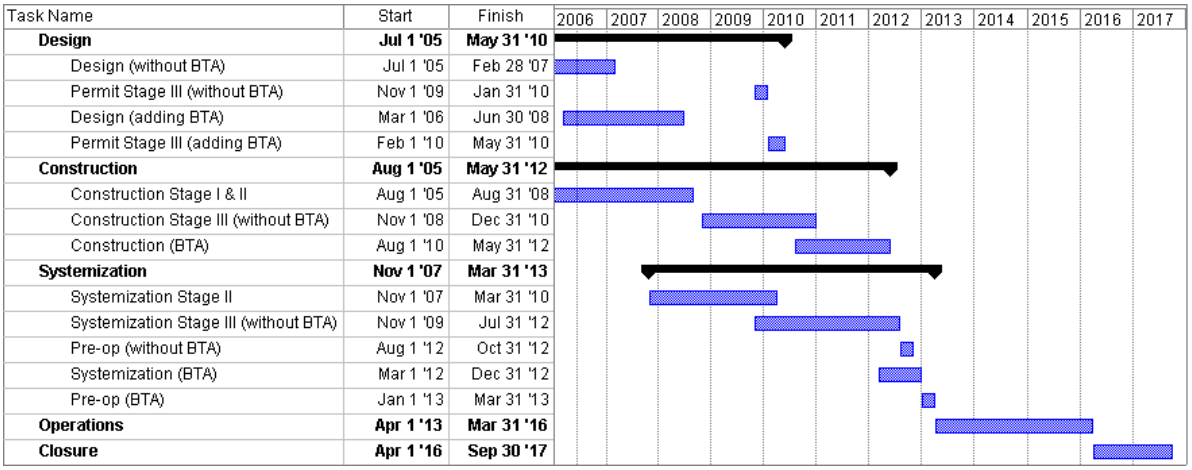


Figure 5-5. Major Phases of PCAPP Scenario 3 Schedule

5.1.4 Scenario 4

In scenario 4, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility designs based on

off-site treatment. The systems contractor would revise permit applications for off-site treatment. A construction permit would be issued, and Stage III construction would proceed; all facility construction and equipment purchases would be made based on off-site treatment of hydrolysate. This scenario assumed that on 1 November 2012, as Stage III systemization would be nearly complete, the systems contractor would inform PM ACWA that the selected TSDF subcontractor was backing out, and the systems contractor had been unable to contract with another TSDF with the permits and technologies required to accept the hydrolysate. PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the BTA designs as they existed on 1 October 2006, completing the design to integrate biotreatment and proceeding with construction, systemization, operations, and closure for that design.

5.1.4.1 Process Systems Changed for Scenario 4

In scenario 4, the process buildings and systems that would be constructed are the same as would be constructed for the base case (scenario 1). In addition, Mitretek assumed that equipment purchases for and construction of a pad for loading hydrolysate into tanker trucks would have been completed before 1 November 2012. The canopy covered loading station was assumed to have two truck loading bays with filling equipment rising from a center island located between the two bays. The filling equipment would consist of pivoting booms mounted with flexible hose and with camlock fittings installed at a level two to three feet higher than the top of the truck tank. A local control panel with pump start/stop controls and readout for total volume discharged to truck would be located on the center island. Each bay would have at its center a pit with sump discharge back to the hydrolysate holding tank.

5.1.4.2 Schedule Impacts of Scenario 4

To determine the schedule impacts for scenario 4, Mitretek assumed that beginning on 1 October 2006, the systems contractor would prepare a modification of the Stage III RD&D and air permit applications, and that PM ACWA would revise the EIS and the EPP to reflect off-site treatment. Mitretek assumed that with the permit modifications pending, CDPHE would allow the Stage I and II construction activities to continue, but that Stage III construction would be delayed until the new permit was issued. Mitretek allowed 3 months from the 1 October 2007 decision for the revised design to be developed and the application to be submitted and 6 months for CDPHE to process and issue the Stage III permit, which would occur on 30 June 2008. The 6 months for CDPHE processing would include a public comment period and allow for conducting supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD. In this scenario, it was assumed that there would be no lawsuits filed against the issuance of the Stage III permit. Consequently, the start of construction of the APB and ERB would be delayed until 1 November 2008, 4 months after permit issuance (the same interval as in the base case).

Mitretek assumed that starting on 1 November 2012, the systems contractor would require 3 months to review and complete the design of the BTA and that procurement of equipment for and construction of the biotreatment area would require 22 months. Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting HD and HT hydrolysate (including studies to fill data gaps), and permit modifications to allow the TSDF to accept the hydrolysates could be completed within the time required for Stage III construction and systemization. The duration of Stage III systemization and pre-operations for the facility exclusive of the biotreatment area was assumed to remain at 36 months, and systemization and

pre-operations of the BTA are assumed to require 13 months. Durations of operations and closure would be unchanged from the base case (scenario 1). The resulting schedule for the major phases of the project for scenario 4 is shown in Figure 5-6.

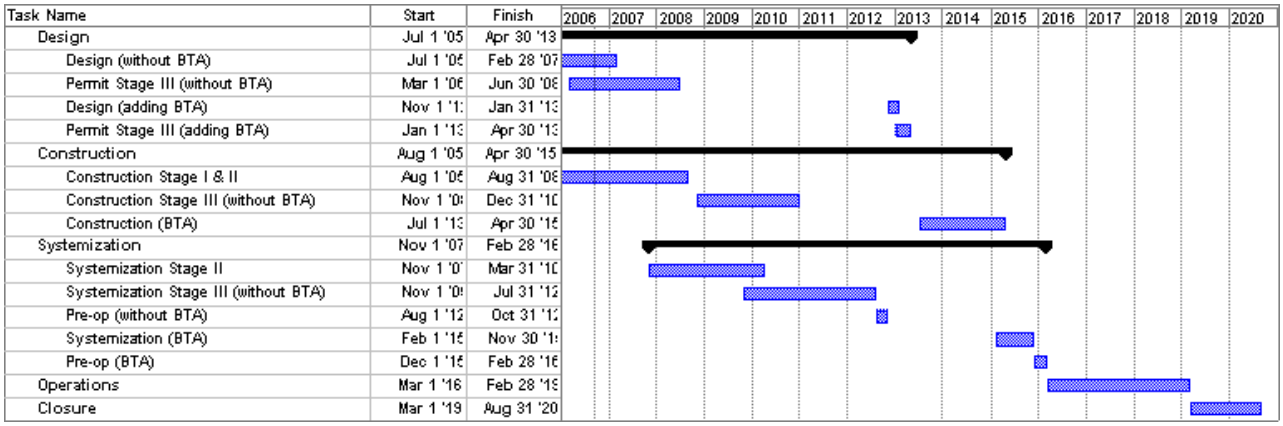


Figure 5-6. Major Phases of PCAPP Scenario 4 Schedule

5.1.5 Scenario 5

In scenario 5, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility designs based on off-site treatment.

5.1.5.1 Process Systems Changed for Scenario 5

As part of the LCCE supplied by the systems contractor (BNI, 2006a), a savings estimate was provided for this scenario. This estimate of savings was based on the removal of the four systems needed for on-site processing of agent hydrolysates: the Immobilized Cell Bioreactors (ICBs, System B09), the Offgas Treatment System (OTS, System B11), the Brine Reduction System (BRS, System B12), and the Water Recovery System (WRS, System B14). Mitretek performed its own independent evaluation based on the equipment list provided in the LCCE revised design. The systems contractor‘s estimate removed a portion of the Agent Collection and Neutralization System, which Mitretek’s estimate retained, but did not remove any of the Residue Handling System and some utilities, which were removed in the Mitretek estimate. Other differences arose from estimates of the amounts of pipe, manual valves, control valves, pipe hangers, and piping insulation that could have been removed. Although these differences were considered minor, Mitretek used its estimate for elimination of BTA systems from the LCCE for this scenario instead of what was provided by the systems contractor.

In addition, Mitretek included the cost for a pad for loading hydrolysate into tanker trucks (described in Section 5.1.4.1) to the processes required for this scenario. The cost of this loading station was provided in the systems contractor’s PCAPP LCCE. A diagram of the process used at PCAPP if off-site treatment is selected is shown in Figure 5-7.

5.1.5.2 Schedule Impacts of Scenario 5

To determine the schedule impacts for scenario 5, Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the Stage III RD&D and air permit applications and that PM ACWA would have to revise the EIS and the EPP to reflect off-site treatment. Mitretek assumed that with the permit modifications pending, CDPHE would allow the Stage I and II construction activities to continue, but that Stage III construction would be delayed until the new permit was issued. Mitretek allowed 3 months from the 1 October 2006 decision for the revised design to be developed and the application to be submitted and 6 months for CDPHE to process and issue the Stage III permit, which would occur on 30 June 2008. The 6 months for CDPHE processing would include a public comment period and allow for conducting supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD. In this scenario, it was assumed that there would be no lawsuits filed against the issuance of the Stage III permit. Consequently, the start of construction of the APB and ERB would be delayed until 1 November 2008, 4 months after permit issuance (same as the base case). Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting HD and HT hydrolysate (including studies to fill data gaps), and permit modifications to allow the TSDF to accept the hydrolysate could be completed within the time required for Stage III construction and systemization. Durations of Stage III construction, Stage III systemization, operations, and closure would be unchanged from the base case (scenario 1). Mitretek assumed that the duration of operations for mustard agent neutralization would not change if the hydrolysate were destined to be shipped off-site. The planned mustard operations at PCAPP are based on procedures developed for ABCDF; the hydrolysate from ABCDF was shipped from that facility to DuPont's TSDF in Deepwater, NJ. The resulting schedule for the major phases of the project for scenario 5 is shown in Figure 5-8.

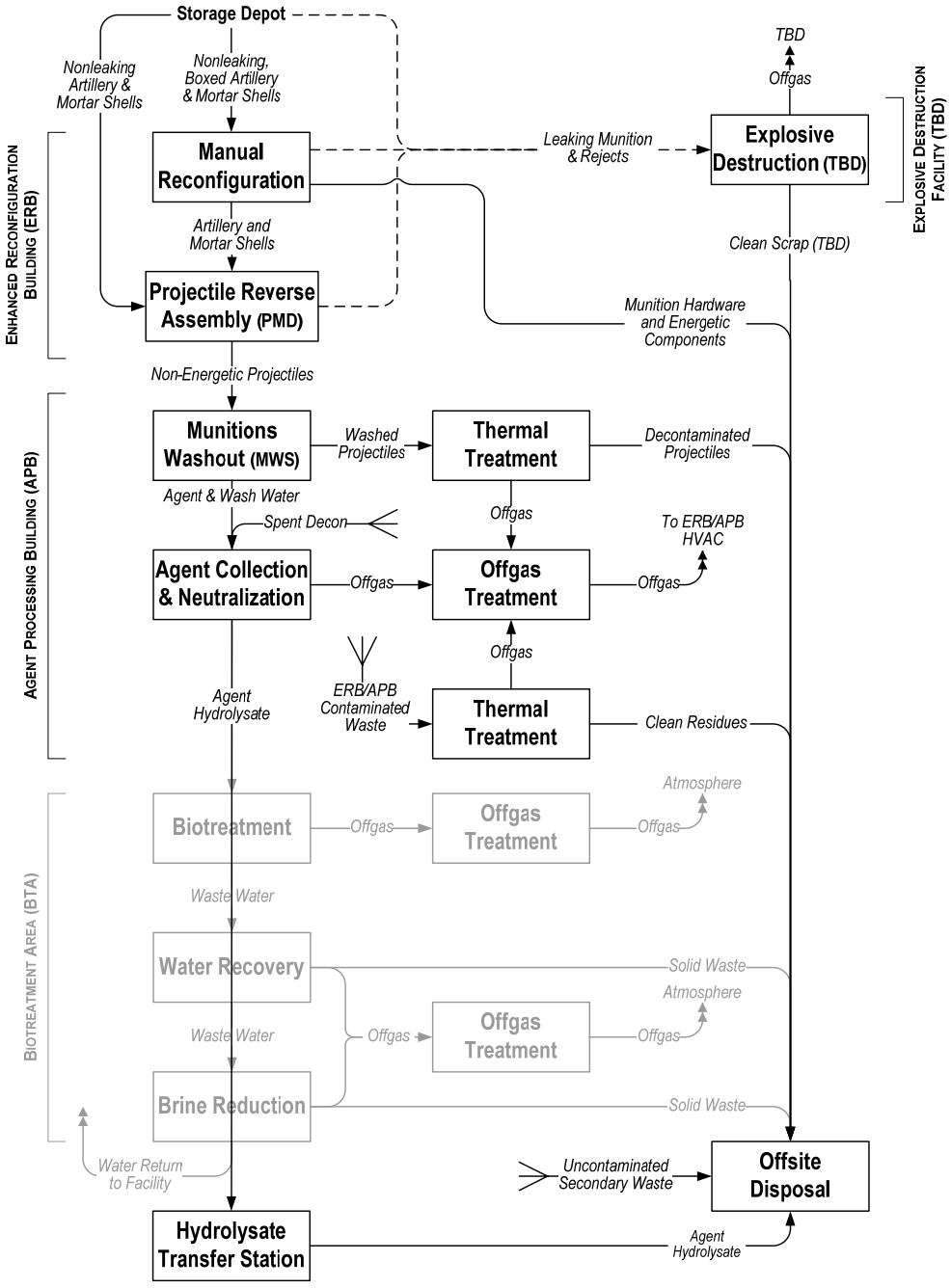


Figure 5-7. Diagram of the PCAPP Process with Off-Site Hydrolysate Treatment

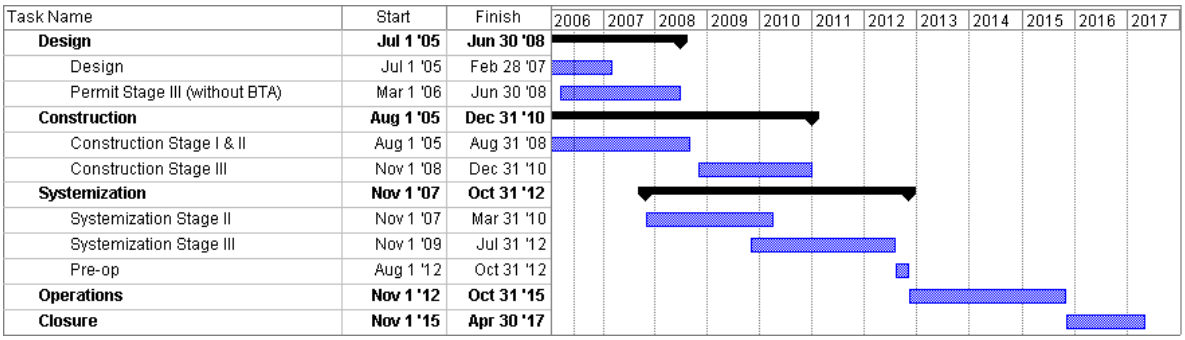


Figure 5-8. Major Phases of PCAPP Scenario 5 Schedule

5.1.6 Scenario 6

In scenario 6, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility design based on off-site treatment. After Pueblo County issues the CD, a group of local residents would appeal the issuance to the State District Court, which would grant an injunction on 1 November 2008 to stop construction while the issue is decided. PM ACWA would direct the systems contractor to stop work on construction and to reduce the work force to the minimum possible required to manage the project and continue Stage II systemization (including continuing procurement of long lead items) while the issue is decided. After one year, the State District Court would make a decision, which would subsequently be appealed to the State Court of Appeals, which would reinstate the injunction. After a second year, the appeal would be decided in favor of issuing the Certificate, and PM ACWA would direct the systems contractor to restart work with the APB and ERB construction, and the project would proceed through construction, systemization, and operations phases with the off-site treatment of hydrolysate.

5.1.6.1 Process Systems Changed for Scenario 6

In scenario 6, the process buildings and systems that would be constructed are the same as those that would be constructed for scenario 5.

5.1.6.2 Schedule Impacts of Scenario 6

To determine the schedule impacts for scenario 6, Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the Stage III RD&D and air permit applications and that PM ACWA would have to revise the EIS and the EPP to reflect off-site treatment. Mitretek assumed that with the permit modifications pending, CDPHE would allow the Stage I and II construction activities to continue, but that Stage III construction would be delayed until the new permit was issued. Mitretek allowed 3 months from the 1 October 2006 decision for the revised design to be developed and the application to be submitted and 6 months for CDPHE to process and issue the Stage III permit, which would occur on 30 June 2008. The 6 months for CDPHE processing would include a public comment period and allows for conducting supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD.

In this scenario, the litigation related to the CD would cause a further delay of 24 months. As a result, there would be a 35-month delay in the start of construction of the APB and ERB. Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting HD and HT hydrolysate (including studies to fill data gaps), and permit modifications to allow receiving TSDF to accept the hydrolysate could be completed within the time required for Stage III construction and systemization. Durations of Stage III construction, Stage III systemization, operations, and closure would be unchanged from the base case (scenario 1). The resulting schedule for the major phases of the project for scenario 6 is shown in Figure 5-9.

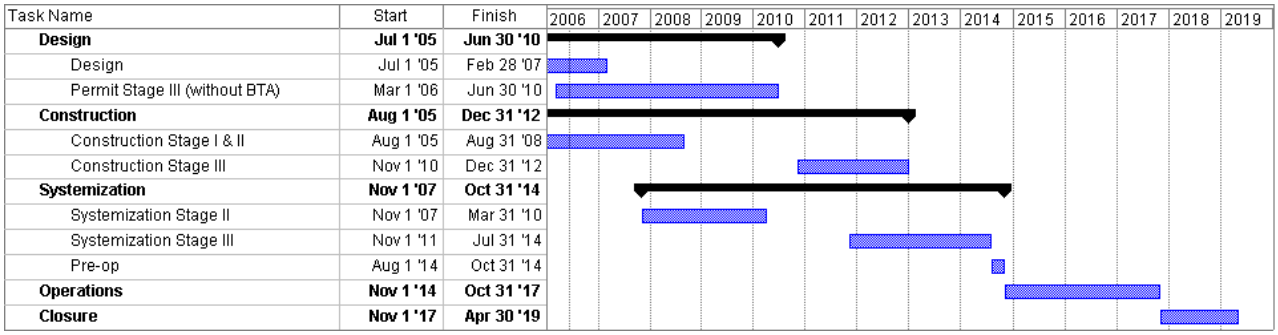


Figure 5-9. Major Phases of PCAPP Scenario 6 Schedule

5.1.7 Scenario 7

In scenario 7, the 2006 DAB would direct PM ACWA to continue to plan for both on-site and off-site options. PM ACWA would direct the systems contractor to complete the design of the units and facilities that would treat hydrolysate on-site, and would assume the risk of investing in any required long-lead item procurement. APB and ERB construction would begin as scheduled. On 1 October 2007, the day that construction of APB would begin, the systems contractor would inform PM ACWA that it had a contract with a TSDF to treat all hydrolysate from the facility off-site and that the TSDF had completed all required permit modifications. The local community neighboring the TSDF would have agreed for the TSDF to accept the hydrolysate. At that point, PM ACWA would direct the systems contractor to remove on-site treatment systems from the design. From that point on, all facility construction and equipment purchases, as well as all facility staffing, would be made based on off-site treatment of hydrolysate.

5.1.7.1 Process Systems Changed for Scenario 7

In scenario 7, the process buildings and systems that would be constructed are the same as those that would be constructed for scenario 5.

5.1.7.2 Schedule Impacts of Scenario 7

To determine the schedule impacts for scenario 7, Mitretek assumed that, beginning on 1 October 2007, the systems contractor would have to prepare a modification of the Stage III RD&D and air permit applications and that PM ACWA would have to revise the EIS and the EPP to reflect off-site treatment. Mitretek assumed that with the permit modifications pending,

CDPHE would allow the Stage I and II construction activities to continue, but that Stage III construction would be delayed until the new permit was issued. Mitretek allowed 3 months from the 1 October 2007 decision for the revised design to be developed and the application to be submitted and 6 months for CDPHE to process and issue the Stage III permit, which would occur on 30 June 2009. The 6 months for CDPHE processing would include a public comment period and allow for conducting supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD. Consequently, the start of construction of the APB and ERB would be delayed until 1 November 2009, 4 months after permit issuance (same as the base case), and the start of Stage III systemization, operations, and closure would also be delayed. Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting HD and HT hydrolysate (including studies to fill data gaps), and permit modifications to allow the TSDF to accept the hydrolysate could be completed within the time required for Stage III construction and systemization. Durations of Stage III construction, Stage III systemization, operations, and closure would be unchanged. The resulting schedule for the major phases of the project for scenario 7 is shown in Figure 5-10.

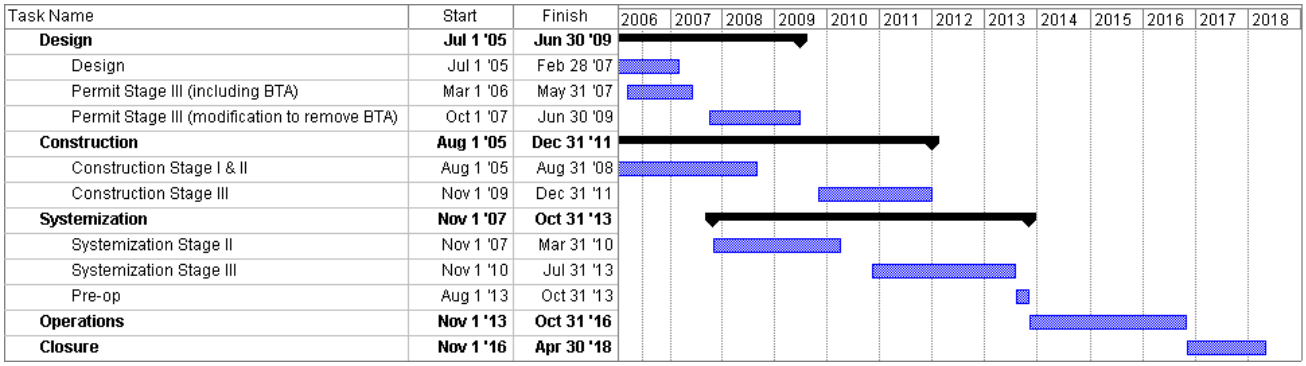


Figure 5-10. Major Phases of PCAPP Scenario 7 Schedule

5.2 BGCAPP Scenarios

This section describes the changes in the process buildings and systems and the impacts on the project schedule for the seven different scenarios used to generate LCCEs for BGCAPP. For scenarios 1 through 4, in which systems for on-site hydrolysate treatment would be constructed, the process was based on the design described in the systems contractor's LCCE (BPBG, 2006a, pp. 11-44). For scenarios 2 through 7, Mitretek used its professional judgment to determine how the events in the scenario under consideration would impact which of the process buildings and systems would be constructed. To determine the schedule impact for scenarios 2 through 7, Mitretek used a detailed project schedule provided in electronic form by the systems contractor (BPBG, 2006e) as the basis. Mitretek then applied the experience of other demilitarization facilities, information gathered from Kentucky state officials (see Appendix A), and professional judgment to determine the impacts of this scenario on the schedule. Impacts resulting from potential shifting of resources (which were not specified in the electronic project schedule) were not considered in this analysis. For each of these scenarios, the schedule model was re-run using Primavera Systems, Inc. Project Manager software to reflect the constraints imposed by the

scenario. The specific results of Mitretek's analysis of changes in the process buildings and systems and the impacts on the project schedule for each scenario are detailed below.

Again, much of the schedule impact of the scenarios came from permitting issues. At BGCAPP, a single RD&D permit has been issued, but the permit includes a compliance schedule for submission of design information as it is developed. Changing from on-site treatment of hydrolysate to off-site treatment of hydrolysate or vice-versa would require modification of the compliance schedule. The compliance schedule currently includes submission of the design for the on-site SCWO facility, so a change to remove SCWO from the process would require a modification to the RD&D permit. Mitretek assumed that construction activities at BGCAPP could not start or continue until such a modification had been submitted and approved. Specific timing of the changes and the impact on the schedules are discussed in the scenario details below.

5.2.1 Scenario 1

Scenario 1, the base case, assumed that the 2006 DAB would direct PM ACWA to treat all hydrolysate from the facility on-site. Based on that decision, on 1 October 2006, the systems contractor would be directed to continue with the current BGCAPP design and to finalize the facility design using SCWO for treating hydrolysate. All facility construction and equipment purchases would be made as described in the systems contractor's LCCE for on-site treatment of hydrolysate using SCWO, and all facility staffing was based on the systems contractor's LCCE for on-site SCWO treatment. The process for scenario 1 was based on the design described in the systems contractor's LCCE (BPBG, 2006a, pp. 11-44). The schedule for scenario 1 was derived from a detailed project schedule provided in electronic form by the systems contractor (BPBG, 2006e). A diagram of the BGCAPP process for the current design is shown in Figure 5-11. The major phases of the schedule for scenario 1 are shown in Figure 5-12.

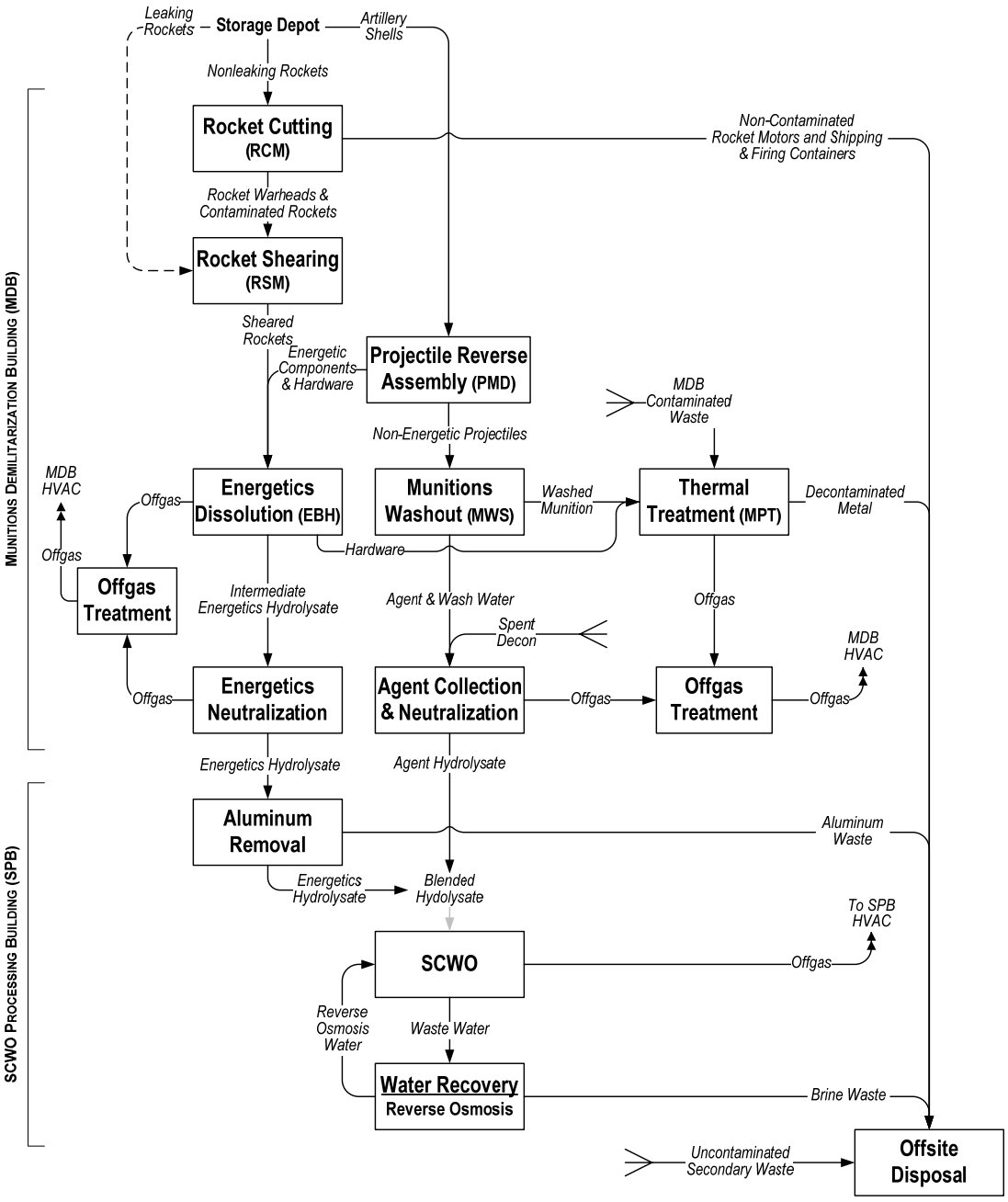


Figure 5-11. Diagram of the Base Case BGCAPP Process

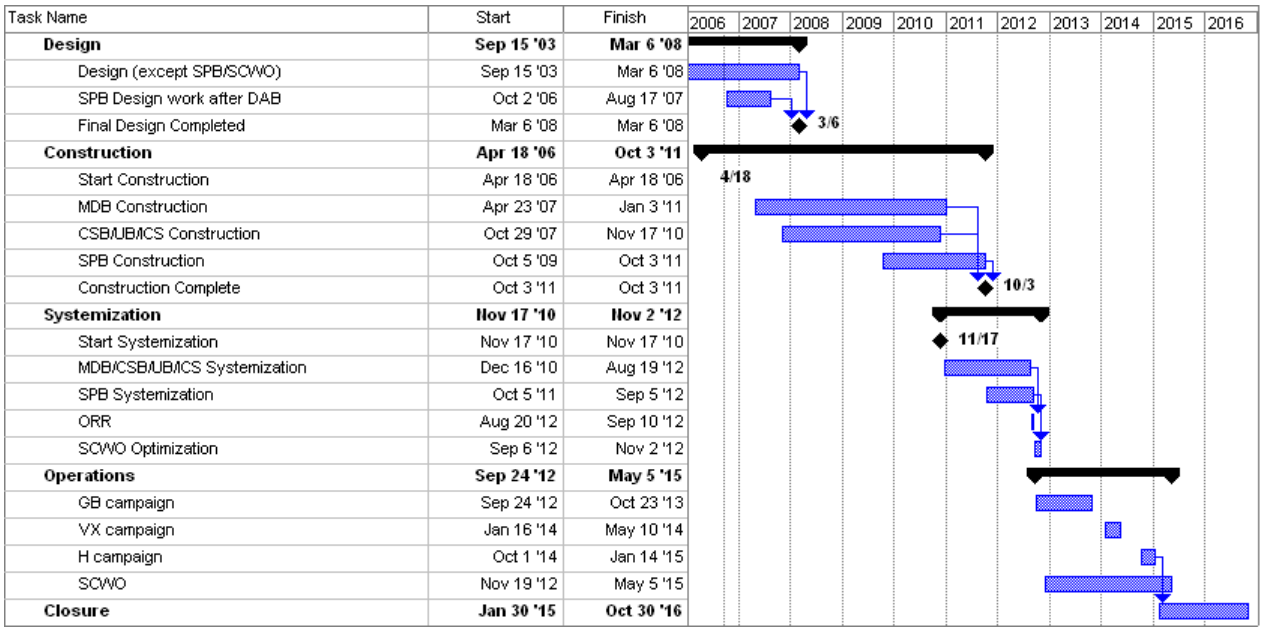


Figure 5-12. Major Phases of BGCAPP Scenario 1 (Base Case) Schedule

5.2.2 Scenario 2

In scenario 2, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, the scenario assumed that on 1 October 2006 the systems contractor would be directed to finalize the facility design based on off-site treatment. The project schedule would be adjusted to allow for the consequences of this decision, including additional time for modification of facility construction and granting of operational permits, CDC and EPA assessments of human health and ecological risks presented by transporting H, GB, VX, and energetics hydrolysates (including studies to fill data gaps), and permit modifications to allow the receiving TSDF to accept the hydrolysates. The systems contractor would revise permit applications for off-site treatment. One year after this decision, the systems contractor would inform PM ACWA that no TSDF with the required permits and appropriate treatment technology had indicated interest in bidding on the waste disposal subcontract. PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the SCWO processing building (SPB) designs as they existed on 1 October 2006, completing the design to integrate SCWO and proceeding with construction, systemization, operations, and closure for that design.

5.2.2.1 Process Systems Changed for Scenario 2

The process buildings and systems constructed at BGCAPP in scenario 2 would be unchanged from scenario 1.

5.2.2.2 Schedule Impacts of Scenario 2

To determine the schedule impacts for scenario 2, Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the RCRA and air permit applications, and that PM ACWA would have to revise the EIS for BGCAPP and the

EPP to reflect off-site treatment of hydrolysate. Mitretek assumed that with the permit modifications pending and a new compliance schedule under consideration, KDEP would allow the general site preparation construction activities already in progress to be completed, but that construction of specific demilitarization facilities would be delayed until the modified permit was issued. These modifications and revisions would be withdrawn shortly after 1 October 2007, with the permits, EIS, and EPP reverting to the previously effective versions, which would allow construction activities to start. Mitretek therefore constrained the Munitions Demilitarization Building (MDB) on-site construction activities in the project schedule to start no sooner than 15 October 2007. Mitretek also determined that when the systems contractor was directed to stop work on the off-site option on 1 October 2006, 320 calendar days of design work remained for the SPB and SCWO. The remaining design work was constrained to start on 13 November 2007, which would be shortly after a decision to restart work for on-site treatment. The schedule was also constrained so that GB rocket processing in pilot testing could not start until SCWO optimization begins. The resulting schedule for the major phases of the project for scenario 2 is shown in Figure 5-13.

5.2.3 Scenario 3

In scenario 3, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysates from the facility off-site. Based on that decision, the scenario assumed that on 1 October 2006, the systems contractor would be directed to finalize the facility design based on off-site treatment. The systems contractor would revise permit applications, including the RD&D permit, for off-site treatment and the construction of the MDB would proceed; all facility construction and equipment purchases would be made based on off-site treatment of hydrolysates. MDB construction would be completed, but before systemization could start, the systems contractor would inform PM ACWA that the selected TSDF subcontractor was backing out, and the systems contractor had been unable to contract with another TSDF with the required permits and appropriate technology. On 17 November 2010, PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the SPB designs as they existed on 1 October 2006, completing the design to integrate SCWO and proceeding with construction, systemization, operations, and closure for that design.

Task Name	Start	Finish
Design	**Sep 15 '03**	**Sep 29 '08**
Design (without SPB/SCWO)	Sep 15 '03	Mar 6 '08
SPB Design work after DAB	Nov 13 '07	Sep 29 '08
Final Design Completed	Sep 29 '08	Sep 29 '08
Construction	**Apr 18 '06**	**Jan 13 '12**
Start Construction	Apr 18 '06	Apr 18 '06
MDB Construction	Oct 15 '07	Dec 21 '10
CSB/UB/CS Construction	Apr 21 '08	Jan 13 '12
SPB Construction	Oct 5 '09	Sep 29 '11
Construction Complete	Jan 13 '12	Jan 13 '12
Systemization	**Nov 12 '10**	**May 7 '13**
Start Systemization	Nov 12 '10	Nov 12 '10
MDB/CSB/UB/CS Systemization	Dec 21 '10	Nov 27 '12
SPB Systemization	Sep 29 '11	Feb 5 '13
ORR	Apr 17 '13	May 7 '13
SCWO Optimization	Feb 6 '13	Apr 6 '13
Operations	**May 22 '13**	**Dec 31 '15**
GB campaign	May 22 '13	Jun 19 '14
VX campaign	Sep 13 '14	Jan 5 '15
H campaign	May 29 '15	Sep 9 '15
SCWO	Jul 17 '13	Dec 31 '15
Closure	**Sep 23 '15**	**Jun 26 '17**

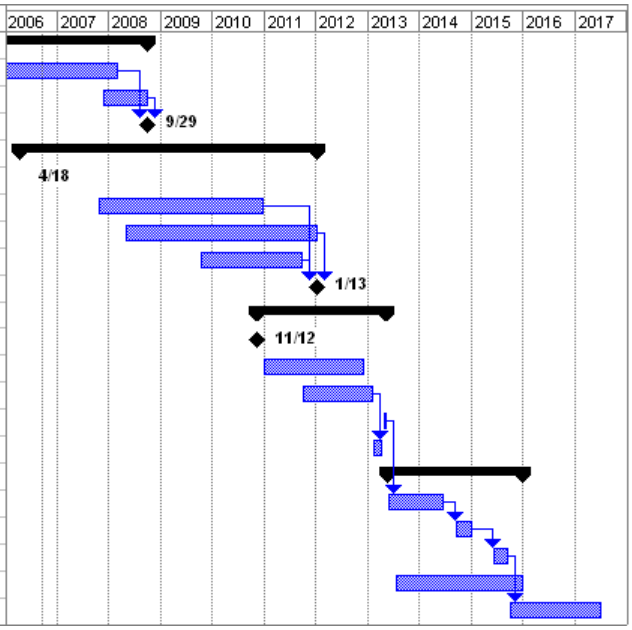


Figure 5-13. Major Phases of BGCAPP Scenario 2 Schedule

5.2.3.1 Process Systems Changed for Scenario 3

The process buildings and systems constructed at BGCAPP in scenario 3 would be the same as those constructed in scenario 1. Mitretek assumed that equipment purchases for and construction of a pad for loading hydrolysate into tanker trucks, which would be required for shipment of hydrolysate from BGCAPP to an off-site TSDF, would not have begun until after 17 November 2010. This assumption was based on the relatively short time required for construction of the loading station.

5.2.3.2 Schedule Impacts of Scenario 3

To determine the schedule impact for scenario 3, Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the RCRA and air permit applications, and that PM ACWA would have to revise the EIS for BGCAPP and the EPP to reflect off-site treatment of hydrolysate. Mitretek assumed that with the permit modifications pending and a new compliance schedule under consideration, KDEP would allow the general site preparation construction activities already in progress to be completed, but that construction of specific demilitarization facilities would be delayed until the modified permit was issued on 1 September 2007. Mitretek therefore constrained the MDB on-site construction activities in the project schedule to start no sooner than 1 October 2007. Mitretek determined that when the systems contractor was directed to stop work on the off-site option, 320 calendar days of design work remained for the SPB and SCWO. Mitretek constrained the SPB design task to finish 320 days after 17 November 2010, when the decision to resume using the on-site treatment designs would be made. Mitretek assumed that the systems contractor would prepare a revision to the RCRA Part B and air permit applications beginning on 17 November 2010, and that KDEP would issue the permit modification to incorporate SCWO 60 days after receiving the SPB design package. Permits become valid 30 days after they are issued, allowing SPB construction to start 90 days after the design package is issued. The schedule was also constrained so that GB

rocket processing in pilot testing could not start until SCWO optimization begins, because KDEP would not allow large-scale accumulation of hydrolysate. The resulting schedule for the major phases of the project for scenario 3 is shown in Figure 5-14.

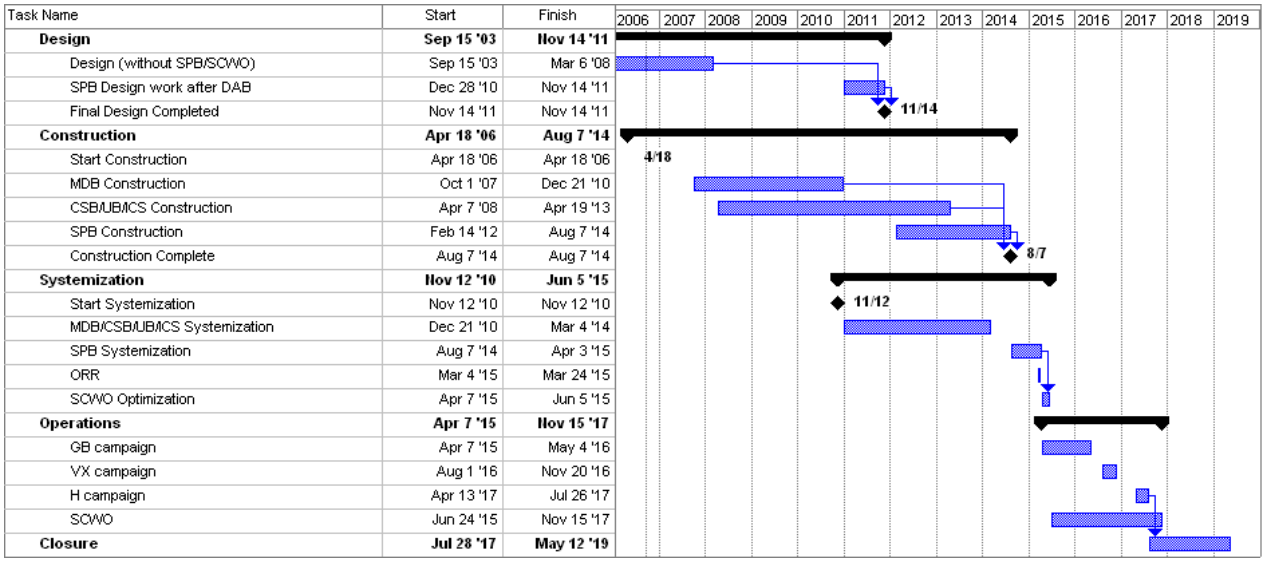


Figure 5-14. Major Phases of BGCAPP Scenario 3 Schedule

5.2.4 Scenario 4

In scenario 4, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysates off-site. Based on that decision, on 1 October 2006, the systems contractor would be directed to finalize the facility design based on off-site treatment. The schedule would be adjusted to allow for the consequences of this decision, including additional activities for CDC and EPA assessments of human health and ecological risks presented by transporting H, GB, VX, and energetics hydrolysates (including studies to fill data gaps), and permit modifications to allow the TSDF to accept the hydrolysates. The systems contractor would revise permit applications (including the RD&D permit application) for off-site treatment, and the construction of the MDB would proceed with some delays; all facility construction and equipment purchases would be made based on off-site treatment of hydrolysates. Construction would be completed and systemization would proceed. However, at the end of systemization, the systems contractor would inform PM ACWA that the selected TSDF subcontractor was backing out, and the systems contractor had been unable to contract with another TSDF with the required permits. As a result, the State would inform PM ACWA that it would not allow operations to begin until a TSDF contract was in place or an on-site treatment facility was completed. On 24 September 2012, PM ACWA would then direct the systems contractor to stop work on the off-site option and to resume work using the SPB design as they existed on 1 October 2006, completing the design to integrate SCWO and proceeding with construction, systemization, operations, and closure for that design.

5.2.4.1 Process Systems Changed for Scenario 4

The process buildings and systems constructed at BGCAPP in scenario 4 would be those specified for scenario 1 plus the off-site shipment loading facility. Mitretek assumed that equipment purchases for and construction of a pad for loading hydrolysate into tanker trucks would have been completed before 24 September 2012. The design of the loading facility was based on a scaled version of the design included in the PCAPP LCCE and described in Section 5.1.4.1.[6]

5.2.4.2 Schedule Impacts of Scenario 4

To determine the schedule impact for scenario 4, Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the RCRA and air permit applications, and that PM ACWA would have to revise the EIS for BGCAPP and the EPP to reflect off-site treatment of hydrolysate. Mitretek assumed that with the permit modifications pending and a new compliance schedule under consideration, KDEP would allow the general site preparation construction activities already in progress to be completed, but that construction of specific demilitarization facilities would be delayed until the modified permit was issued on 1 September 2007. Mitretek therefore constrained the MDB on-site construction activities in the project schedule to start no sooner than 1 October 2007. Mitretek determined that when the systems contractor would be directed to stop work on the off-site option, 320 calendar days of design work remained for the SPB and SCWO. Mitretek constrained the SPB design task to finish 320 days after 24 September 2012, when the decision to resume using the on-site treatment designs would be made. Mitretek assumed that the systems contractor would prepare a revision to the RCRA Part B and air permit applications beginning on 24 September 2012, and that KDEP would issue the permit modification to incorporate SCWO 60 days after receiving the SPB design package. Permits become valid 30 days after they are issued, allowing SPB construction to start 90 days after the design package is issued. The schedule was also constrained so that GB rocket processing in pilot testing could not start until SCWO optimization begins, because KDEP would not allow large-scale accumulation of hydrolysate. The resulting schedule for the major phases of the project for scenario 4 is shown in Figure 5-15.

[6] This is the same type of analysis that was performed for PCAPP scenario 4; the BGCAPP LCCE did not include a cost estimate for off-site hydrolysate treatment, so Mitretek used PCAPP's equipment list to generate cost estimates for a loading station for BGCAPP scenarios 4, 5, 6, and 7.

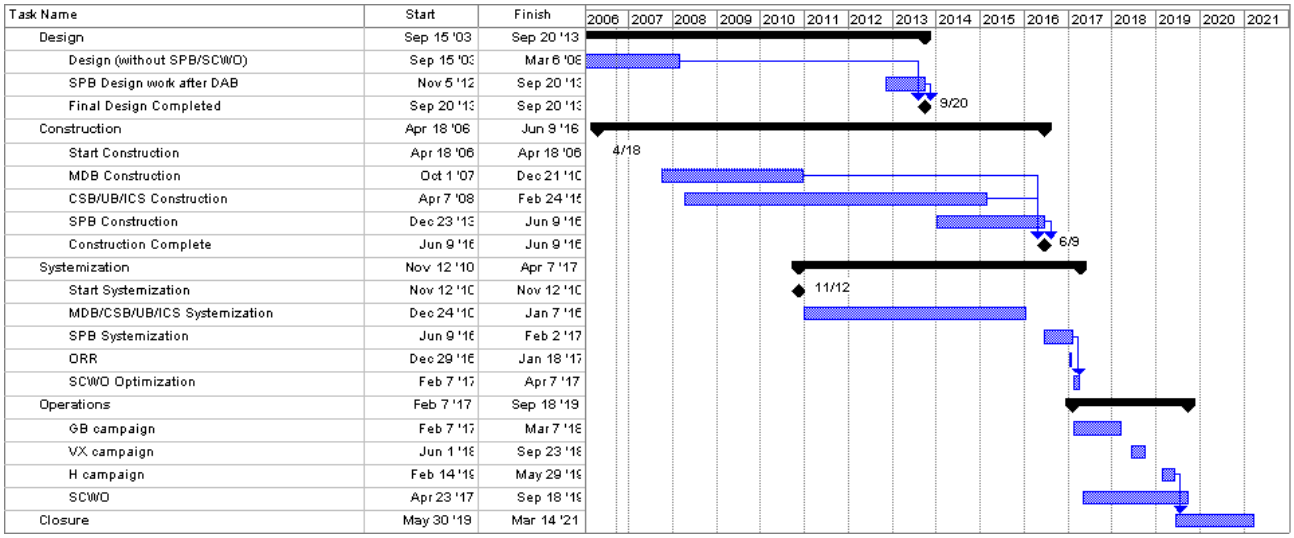


Figure 5-15. Major Phases of BGCAPP Scenario 4 Schedule

5.2.5 Scenario 5

In scenario 5, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006 the systems contractor would be directed to finalize the facility design based on off-site treatment.

5.2.5.1 Process Systems Changed for Scenario 5

Mitretek examined the list of equipment provided in the spreadsheet "Construction Cost Estimate.xls" supplied with the systems contractor's LCCE (BPBG, 2006a). Equipment was grouped by system and then each system was adjusted based on the expected reduction in equipment from on-site treatment to off-site treatment. Adjustment factors were developed from existing design data such as total square feet of the SPB, the electrical load list, and other user load lists for cooling water, nitrogen, and plant air, as well as available material and energy balance calculations.

For scenario 5, the SPB, associated equipment, and the Hydrochloric/Sulfuric/Phosphoric Acid Systems would be eliminated entirely. In addition, equipment requirements would be reduced for the following systems:

- The Reverse Osmosis System would be eliminated because this system provides quench water solely to the SCWO.
- The Chilled Water Process would be reduced in size by 8% because the chilled water supply to the Aluminum Precipitation System (APS) would no longer be needed if the SCWO system and consequently the APS were removed.
- The Standby Diesel Generator (SDG) System would be reduced in size by 15%. The basis for this reduction was the proportion of the essential electrical load of the SPB (1,131 kW) compared to the electrical power supplied by the two operating SDGs

(6.6 MW) included in the base case design. This proportion yielded an estimated reduction of roughly 17%, rounded conservatively to 15%.

- The Chilled Water System, Electrical Substation, Fire Water, Nitrogen, Communication Systems, and also Non-System Related Items would each be reduced in size by 5% or less. The Chilled Water System, Fire Water System, and Non-System Related Items would be reduced 5% in size based on total square feet of the SPB compared to the total square feet of all BGCAPP buildings. The Electrical Substation equipment would be reduced 5% by assuming only half as much reduction compared to the SDGs, due to simpler changes in equipment. The Nitrogen System would be reduced 2% in size by considering the amount of nitrogen used by the agent and energetic hydrolysate storage tanks compared to total plant usage of nitrogen. The Communication System would be reduced 5% based on the Communication System components specifically earmarked for the SPB in the data supplied by the systems contractor.

Equipment lead time data was obtained from the initial construction budgetary cost estimate data contained in the spreadsheet "Construction Cost Estimate.xls" supplied with the systems contractor's LCCE addendum (BPBG, 2006b). In addition, a pad for loading hydrolysate into tanker trucks (described in Section 5.1.4.1) would be required for this scenario.

A diagram of the BGCAPP process modified for off-site treatment of hydrolysate is shown in Figure 5-16.

5.2.5.2 Schedule Impacts of Scenario 5

To determine the schedule impacts of scenario 5, Mitretek adjusted the project schedule provided by the systems contractor by eliminating all activities related to the SPB and SCWO, and extending the period for VX operations by 51 calendar days. Mitretek assumed that beginning on 1 October 2006, the systems contractor would have to prepare a modification of the RCRA and air permit applications, and that PM ACWA would have to revise the EIS for BGCAPP and the EPP to reflect off-site treatment of hydrolysate. Mitretek assumed that with the permit modifications pending and a new compliance schedule under consideration, KDEP would allow the general site preparation construction activities already in progress to be completed, but that construction of specific demilitarization facilities would be delayed until the modified permit was issued. These permit modifications would be issued effective 1 September 2007. Mitretek therefore constrained the MDB on-site construction activities in the project schedule to start no sooner than 1 October 2007. The schedule for the major phases of the project for scenario 5 is shown in Figure 5-17.

Mitretek assumed that CDC and EPA assessments of human health and ecological risks presented by transporting H, GB, VX, and energetics hydrolysates (including studies to fill data gaps) could be completed within the period allowed for construction and systemization in scenario 5.

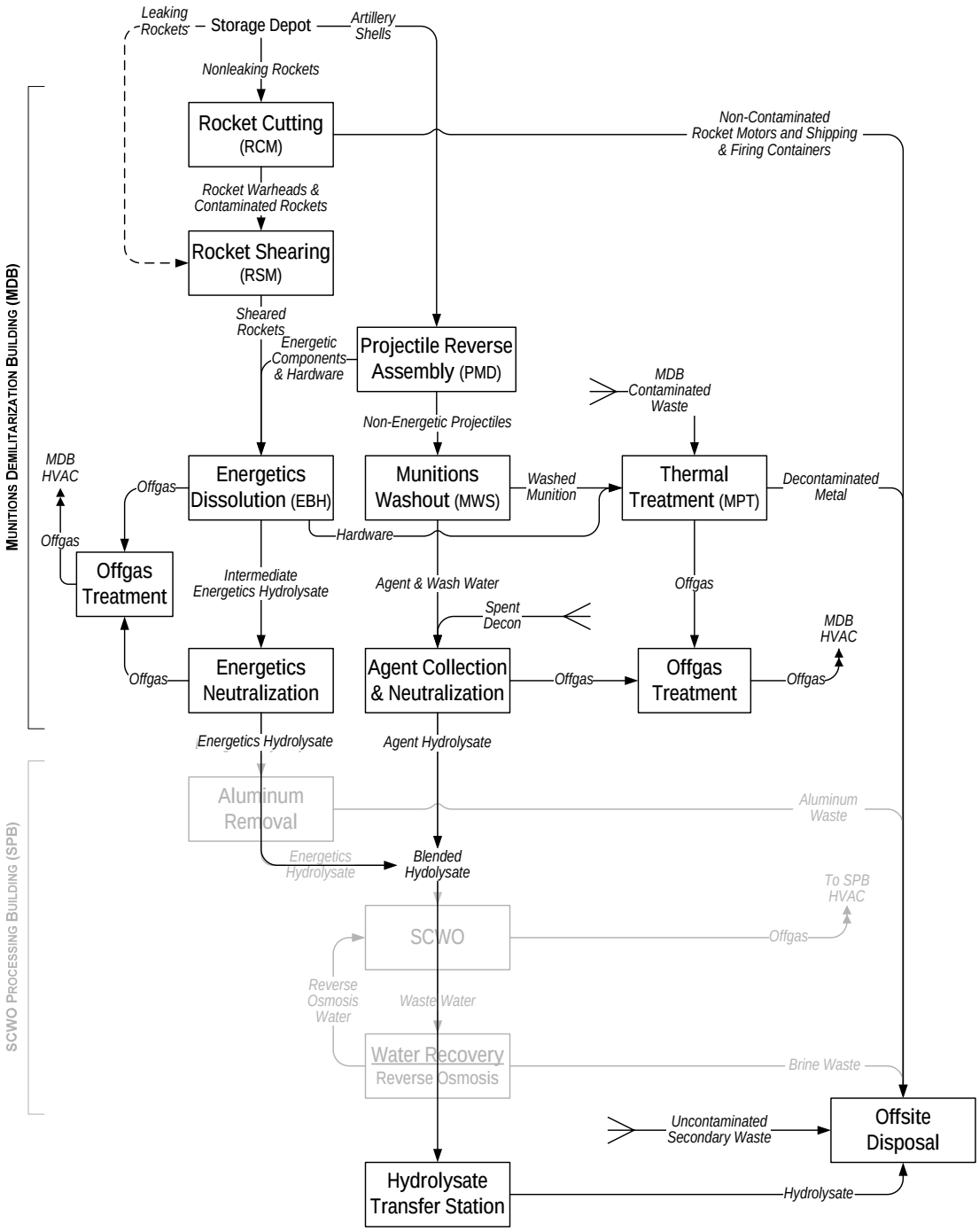


Figure 5-16. Diagram of the BGCAPP Process with Off-Site Hydrolysate Treatment

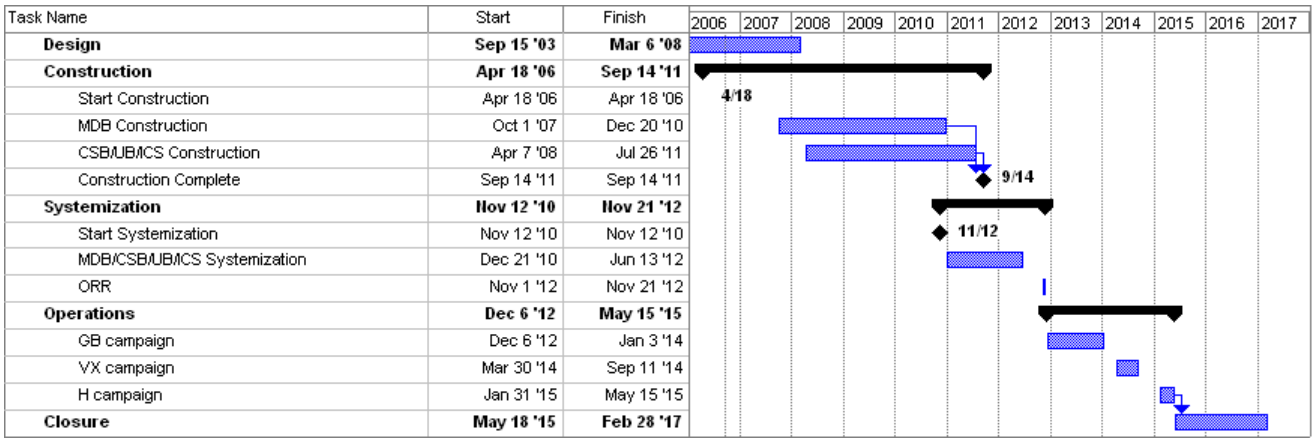


Figure 5-17. Major Phases of BGCAPP Scenario 5 Schedule

Mitretek assumed that the duration of operations for GB neutralization would not change if the hydrolysate were destined to be shipped off-site. The planned GB operations at BGCAPP appear to be based on the procedures developed during demilitarization operations at Rocky Mountain Arsenal several decades ago as well as those developed to generate hydrolysate during ACWA demonstration testing in 1999. Mitretek's assumption was based on the following factors:

- GB is water-soluble whereas VX is not. Although some GB hydrolysate can form a second organic phase from tributylamine stabilizer, GB can partition between the aqueous and the organic phase, so the rate of GB hydrolysis appears less limited by phase-transfer phenomena than is VX hydrolysis.
- GB hydrolysate should not exhibit significant flammability. A significant portion of the VX processing time is required to vent flammable reaction products; such extra time would not be required for GB processing.

Based on reaction rate considerations alone, GB would be expected to be destroyed to below detectable levels within the planned GB procedure. With the high water solubility of GB and smaller need to vent flammable byproducts, there is little reason to assume that GB hydrolysate as produced using the planned GB procedure would not be suitable for shipment to an off-site TSDF.

Mitretek assumed that the duration of operations for energetics neutralization would not change if the hydrolysate is destined to be shipped off-site. The primary hazard from energetics is removed once the bulk energetics have dissolved, which should occur within the duration of the planned procedure.

Mitretek determined that the duration of operations for VX neutralization at BGCAPP would be longer if the hydrolysate has to be shipped to an off-site TSDF. The planned VX operations at BGCAPP are based on the original procedures developed for the NECDF; this procedure has been shown to meet the original design criteria of 99.9999% agent destruction prior to treatment of the hydrolysate in the SCWO. However, NECDF has determined that the procedure must be lengthened to generate VX hydrolysate that meets residual agent and flammability criteria for

shipment off-site to a commercial TSDF. Based on preliminary information from NECDF (Parsons, 2006), Mitretek assumed that the time that each batch is held and recirculated at 194 ºF would be lengthened from 2.5 hours to 12 hours. It was also assumed that all other agent hydrolyzer process activities such as adding caustic, feeding agent, cool down, sampling in the hydrolyzer, and waiting for the analysis results would take the same time as is currently planned for subsequent hydrolysate treatment with SCWO at BGCAPP. Therefore, based on times in the BGCAPP Agent Collection and Neutralization System design documentation (BPBG, 2006c), the batch sequence duration would increase from 740 minutes to 1,310 minutes.

This increase in batch processing time would cause a reduction in Agent Neutralization System (ANS) peak processing capability from about 8,800 lb/day agent to about 5,000 lb/day agent. Mitretek obtained information on peak processing rates and equipment availabilities for rocket and projectile processing systems from the BGCAPP Throughput and Availability Analysis (BPBG, 2006d). This information was used to calculate expected average throughput of the ANS during the VX coprocessing of rockets and projectiles. The average throughput for the current design is about 5,600 lb agent per day, which assumes that the rocket disassembly and energetics processing equipment train or path is rate limiting for rocket processing, and the projectile disassembly and metal parts treatment processing path is rate limiting for projectile processing. During planned operations, the ANS would have 5 to 10% idle time because it is sized to match the peak production rates of agent from rockets and projectiles, and it has a higher availability than the rocket energetics destruction and metal parts treatment systems.

A new expected average rate of about 3,600 lb/day agent was calculated using the new peak processing rate through the new rate limiting system (the ANS) and the ANS availability. Thus, the system capability would be about 64% of the original value. Note that in the current design, the occasional batch that needs to be reprocessed in the agent hydrolyzer (because it did not meet the agent destruction specification) can be reprocessed during the ANS idle time with no effect on operations time. However, for this scenario, where the ANS is rate limiting and because agent hydrolysate is sampled directly in the hydrolyzer instead of in a sampling tank, reprocessed batches would directly reduce the effective throughput. To account for reprocessed batches and other unknowns with this new processing scheme, Mitretek assumed that the processing capability for this scenario would be 60% of the original value.

Mitretek adjusted the duration of the VX rocket and projectile processing activities within the Primavera schedule using this 60% factor. The six week ramp-up periods and two week Performance Test period were not increased, rather the amount of agent (and thus rockets and projectiles) able to be processed during each period was reduced and added to the requirements for the full-rate operations period. Existing full-rate operations durations were divided by 0.60 to reflect the new reduced plant capacity. Results showed that the original duration of 115 days for the VX campaign would increase by 51 days to 166 days.

Mitretek assumed that the duration of operations for mustard agent neutralization would not change if the hydrolysate is destined to be shipped off-site. The planned mustard operations at BGCAPP are based on procedures developed for ABCDF, and the hydrolysate from ABCDF was suitable for shipment from that facility to DuPont's TSDF in Deepwater, NJ.

5.2.6 Scenario 6

In scenario 6, the 2006 DAB would direct PM ACWA to abandon on-site hydrolysate treatment and to treat all hydrolysate from the facility off-site. Based on that decision, on 1 October 2006, the systems contractor would be directed to finalize the facility design based on off-site treatment. The systems contractor would revise permit applications for off-site treatment. After receiving the proposed modifications, the scenario assumed that KDEP would determine that an RD&D permit is no longer appropriate for BGCAPP. Mitretek assumed that KDEP notifies BGAD on 1 October 2007 that construction of activities cannot proceed. PM ACWA would then direct the systems contractor to reduce the work force to the minimum possible required to manage the project (including continuing procurement of long lead items) while the design would be completed and a RCRA Part B permit modification would be prepared. The State would issue the modification to the Depot's Part B permit, at which point the systems contractor could resume on-site construction activities, and the project would proceed through construction, systemization, and operations phases with the off-site treatment of hydrolysate.

5.2.6.1 Process Systems Changed for Scenario 6

The process buildings and systems constructed at BGCAPP in scenario 6 would be unchanged from those in scenario 5.

5.2.6.2 Schedule Impacts of Scenario 6

To determine the schedule impacts of scenario 6, Mitretek assumed that the final design package would be completed on 6 March 2008, and the BGAD commander would submit the RCRA permit modification on 22 April 2008; these dates are the same as those determined for scenario 5. Based on discussions with KDEP, Mitretek has assumed that the public comment period for the permit application would occur between 23 April and 21 June 2008, and that KDEP could issue a notice of decision as early as 15 October 2008, issuing the Part B permit on that date.[7] Construction could then proceed when the permit becomes valid, 30 days after it the date of issue. The schedule was adjusted by constraining all on-site construction activities not substantially completed by 1 October 2007 to start no earlier than 17 November 2008. The schedule for the major phases of the project for scenario 6 is shown in Figure 5-18.

[7] Scenario 6 is based on the minimum time required to issue a permit; KDEP has indicated that the process typically requires 2 years, but could require more than 3 years.

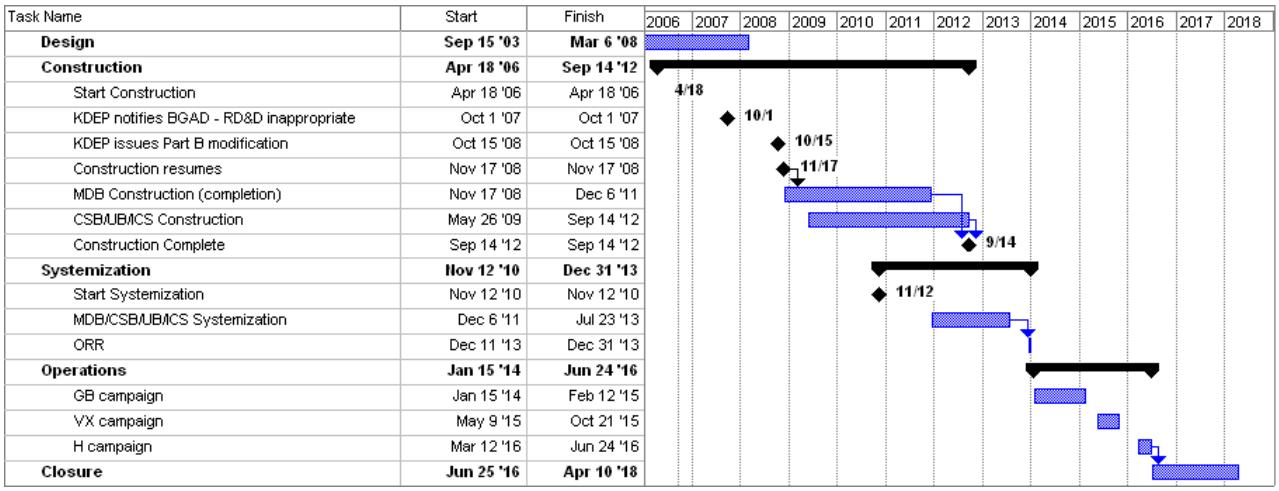


Figure 5-18. Major Phases of BGCAPP Scenario 6 Schedule

5.2.7 Scenario 7

In scenario 7, the 2006 DAB would direct PM ACWA to continue to plan for both on-site and off-site options. PM ACWA would direct the systems contractor to complete the design of the units and facilities that would treat hydrolysates on-site, and assume the risk of investing in any required long-lead item procurement. MDB construction would begin as scheduled. Shortly before construction of the SPB beginning on 1 October 2009, the systems contractor would inform PM ACWA that it had a contract with a TSDF to treat all hydrolysate from the facility off-site and that the TSDF had completed all required permit modifications. The local community near the TSDF would have agreed for the TSDF to accept the hydrolysate. At that point, PM ACWA would direct the systems contractor to remove the SCWO facility from design and to make appropriate changes to the support systems.

5.2.7.1 Process Systems Changed for Scenario 7

The process buildings and systems constructed at BGCAPP in scenario 7 would be unchanged from those in scenario 5.

5.2.7.2 Schedule Impacts of Scenario 7

To determine the schedule impacts of scenario 7, Mitretek assumed that beginning on 1 October 2009, the systems contractor would have to prepare a modification of the RCRA and air permit applications, and that PM ACWA would have to revise the EIS for BGCAPP and the EPP to reflect off-site treatment of hydrolysate. Mitretek assumed that with the permit modifications pending and a new compliance schedule under consideration (after 1 October 2009), KDEP would allow the construction activities already in progress to be completed, but that new construction activities would be delayed until the modified permit could be issued on 1 September 2010. Mitretek therefore constrained on-site construction activities scheduled to start after 1 October 2009 to start no sooner than 1 October 2010, and recalculated the schedule using Primavera Systems, Inc. Project Manager software. The schedule for the major phases of the project for scenario 7 is shown in Figure 5-19.

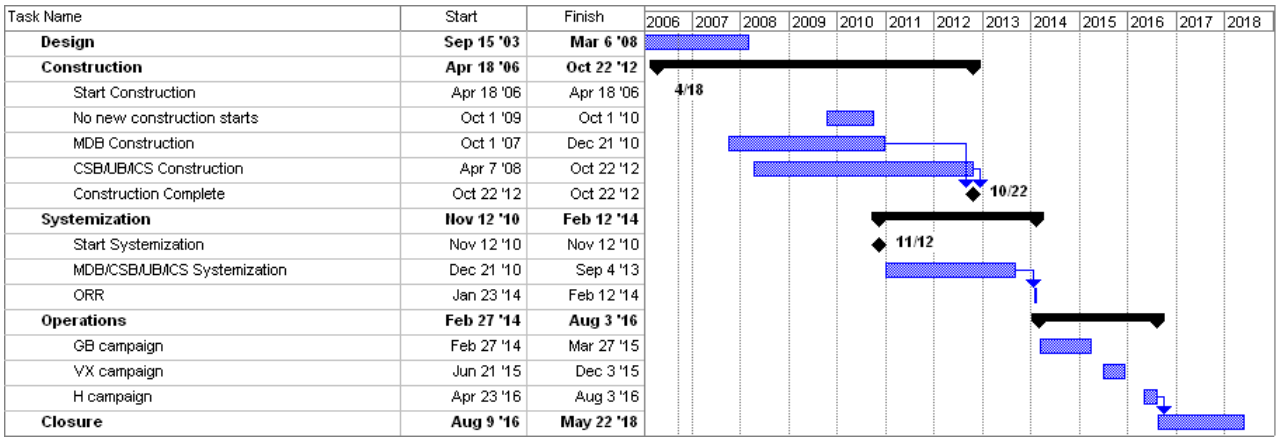


Figure 5-19. Major Phases of BGCAPP Scenario 7 Schedule

5.3 Relative Likelihoods of Scenarios

As part of its technical analysis, Mitretek assigned to each of the alternative scenarios 2-7 a likelihood of occurrence of high, medium, or low. Mitretek considered several criteria for assessing the relative likelihood of occurrence for the various scenarios developed for PCAPP and BGCAPP. These factors include technical, economic, safety, environmental, and programmatic. While technical factors were initially considered, they were not used to assess the relative likelihood of occurrence because all scenarios evaluated were technically feasible. There are no strong technical reasons suggesting that any scenario is more likely to occur than another. Discriminating factors used to ultimately rank the scenarios are programmatic risks and munitions storage risks.

No relative likelihood of occurrence was developed for scenario 1 for two reasons:

- Determining the likelihood for scenario 1 relative to scenarios 2-7 requires a judgment of the likelihood of the DAB decision; this judgment is outside the scope of Mitretek's analysis.
- The key results of Mitretek's analysis are based on the cost differentials between scenario 1 and scenarios 2-7. Determining the likelihood for scenario 1 relative to scenarios 2-7 is not necessary for analyzing the cost differentials.

5.3.1 PCAPP Scenario Likelihoods

Mitretek assessed the relative likelihood of occurrence for scenarios 2 through 7 for PCAPP based on programmatic factors outside the control of PM ACWA and safety factors that PM ACWA could address. The primary programmatic factors outside the control of PM ACWA were the risk of litigation delays and the risk of difficulties in finding a TSDF willing to process hydrolysate. Based on discussions with stakeholders, it appears that a decision to remove biotreatment from the PCAPP process would probably result in litigation. Based on discussions with the Pueblo County attorney, such litigation could result in an injunction. For this reason, Mitretek determined that scenario 6 has a high likelihood of occurrence, whereas scenarios 5 and 7 have low likelihoods. Based on the programmatic risk that PM ACWA could encounter

political opposition to its initial selection of a TSDF, Mitretek determined that scenarios 2 and 3 have a medium likelihood of occurrence.

The primary safety factor is the increased risk from continued storage of aging chemical munitions. Although there are risks from transportation of hydrolysate, these risks tend to be smaller than the storage risk. For this reason, scenario 4, which completes agent operations 53 months later than the base case (scenario 1), is considered to have a low likelihood of occurrence because decision makers are unlikely to tolerate the increased storage risk.

5.3.2 BGCAPP Scenario Likelihoods

Mitretek assessed the relative likelihood of occurrence for scenarios 2-7 for BGCAPP based on programmatic factors outside the control of PM ACWA and safety factors that PM ACWA could address. The primary programmatic factors outside the control of PM ACWA are the risk of permitting delays and the risk of difficulties in finding a TSDF willing to process hydrolysate. Based on discussions with KDEP, it appears that a decision to remove SCWO from the BGCAPP process would probably result in a KDEP decision that an RD&D permit could no longer be justified. For this reason, Mitretek determined that scenario 6 has a high likelihood of occurrence, whereas scenarios 5 and 7 have low likelihoods. Based on the programmatic risk that PM ACWA could encounter political opposition to its initial selection of a TSDF, Mitretek determined that scenario 2 had a medium likelihood of occurrence.

The primary safety factor is the increased risk from continued storage of aging chemical munitions. Although there are risks from transportation of hydrolysate, these risks tend to be smaller than the storage risk. For this reason, scenario 4, which completes agent operations 53 months later than the base case and scenario 3, which completes agent operations 31 months later than the base case, are considered to have low likelihoods of occurrence because decision makers are unlikely to tolerate the increased storage risk.

Section 6

Cost Analysis

This section summarizes results from the cost analysis of the PCAPP and BGCAPP scenarios described in Section 5. The cost estimates are presented in general terms because certain aspects of the cost estimates are business sensitive information. Another report (Wusterbarth et al., 2006) provides a more detailed breakdown of the costs, which contain the business sensitive data.

6.1 Methodology

Scenario 1 for PCAPP and BGCAPP represents the base case. Mitretek used the LCCEs provided by the systems contractor in April 2006 (BNI, 2006a; BNI, 2006b; BPBG, 2006a; BPBG 2006b) for this scenario. The costs were broken down by life cycle phase and were provided in constant 2006 dollars. In addition to the systems contractor's cost estimates, Mitretek also obtained the government's programmatic costs and munitions stockpile storage costs. These costs are factored into the LCCEs developed for each scenario.

Stockpile storage costs include depot stockpile maintenance and security costs, as well as Chemical Stockpile Emergency Preparedness Program (CSEPP) costs. Note that only the CSEPP costs are funded through the Chemical Demilitarization Program; the rest come from other Army funds. However, to reflect the effects of schedule delays associated with the scenarios analyzed in this study, the entire storage cost is included in the LCCEs.

In estimating the costs associated with scenarios 2 through 7, Mitretek determined the cost increase or decrease resulting from major activities specific to a scenario as compared to the base case (scenario 1). Cost items in the LCCE that are impacted by on-site or off-site treatment of hydrolysate include design, permit modifications, construction of hydrolysate treatment systems, and plant systemization, operations, and closure. No additional costs to revise the EIS and the EPP were included. These documents are expected to require updating anyway because there are significant changes to the PCAPP and BGCAPP processes even for the base case, *e.g.*, off-site shipment of uncontaminated energetics from PCAPP and the changes to rocket motor processing at BGCAPP. The cost of including off-site hydrolysate shipment in these documents is unlikely to be significant.

The PCAPP LCCE (BNI, 2006a; BNI, 2006b) included an estimate of the cost to ship and biotreat agent hydrolysate at a commercial TSDF off-site. As indicated in section 5.1.5, Mitretek performed its own independent evaluation based on the equipment list provided in the LCCE revised design. The cost analysis of scenarios 5, 6, and 7 used the Mitretek estimated savings for elimination of the BTA. The BGCAPP LCCE (BPBG, 2006a; BPBG 2006b) did not contain an estimate for the cost to ship and treat hydrolysate at a commercial TSDF off-site. Mitretek also developed estimates of those costs and applied them to scenarios 5, 6, and 7, which involve off-site treatment of hydrolysates.

Finally, there is one cost to the taxpayer for off-site hydrolysate treatment that has not been included in this analysis. As discussed in Section 2.2.2, OPCW does not consider hydrolysis to constitute complete destruction of the chemical agent. For ABCDF, OPCW inspectors required

office space at the TSDF, and equipment such as closed circuit cameras was installed to allow the inspectors to verify that mustard hydrolysate was mixed with the TSDF feed to the biotreatment unit. The inspectors also traveled periodically to the TSDF with U.S. government escorts. It is virtually impossible to predict the additional expenses for OPCW to verify the endpoint of agent destruction at an off-site TSDF until a facility agreement is concluded. Nevertheless, they represent real costs that should be considered at least qualitatively in any decision.

6.2 PCAPP Life Cycle Cost Estimates

Table 6-1 summarizes the results of Mitretek's analysis. It shows the cost increase or decrease associated with scenarios 2 through 7 relative to scenario 1. Details on cost drivers are discussed in the following sections.

Table 6-1. Summary of PCAPP Schedule and Cost Differentials by Scenario

Scenario	Description	Change Relative to Scenario 1 (Base Case)	
		Schedule (Months)*	Cost ($M)†
2	Off-site decision changed to on-site at start of Stage III construction	10	$50.4
3	Off-site decision changed to on-site at start of systemization	18	$91.7
4	Off-site decision changed to on-site at end of systemization	53	$754.2
5	Off-site decision, no delays	13	$4.4
6	Off-site decision, with delays	37	$124.9
7	Decision to treat off-site postponed until scheduled start of agent processing building construction	25	$87.3

* delay in end of agent operations

† the costs and schedules in this table are for a new facility that has not been constructed and has no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

6.2.1 Scenario 1

In this base case scenario, the agent hydrolysate would be processed on-site using biotreatment technology. The LCCE developed for scenario 1 includes the costs for the systems contractor, PM ACWA management (including site office, Corps of Engineers, and other demilitarization program costs), and munitions stockpile storage.

6.2.2 Scenario 2

The primary distinction between scenario 2 and scenario 1 is the fact that an off-site treatment of hydrolysate would be pursued initially, but in October 2007, PM ACWA would revert back to on-site treatment. From the schedule analysis, the decision to first eliminate the BTA and associated systems (*e.g.*, BTA offgas treatment system, brine reduction system) from the design and then to add these back one year later would delay issuance of the Stage III permit by 10 months, relative to scenario 1.

In scenario 1, the final design of the BTA is expected to be completed by November 2007. For the cost analysis of scenario 2, it was assumed that PM ACWA would allow BNI to complete the final design package for the BTA as scheduled, even though it would make a decision in October 2007 not to pursue on-site treatment of hydrolysate for PCAPP. The final BTA design package would not be reviewed by the government, but would be put on file. When the final design package would be recovered a year later, additional resources would be needed to ensure that the design specifications meet codes and standards. These additional design costs were included in the analysis of scenario 2.

Labor and storage costs were impacted during the 10-month delay in scenario 2. For the systems contractor, an increase in labor costs would result from keeping Project Services staffing at a certain level for 10 more months. There would be sustained programmatic and stockpile storage costs incurred during this time period, as well.

There were no cost changes related to systemization, operations, and closure for this scenario, relative to scenario 1. However, it was anticipated that there would be additional public outreach costs because of the rapid reversal of the decision. It was assumed that public outreach to explain the government's decision to ship the hydrolysate off-site and then the reversal to process the hydrolysate on-site would require one additional year of effort.

The cost factors discussed above led to an overall cost increase of $50.4M for scenario 2 relative to scenario 1 (base case).

6.2.3 Scenario 3

In scenario 3, the Stage III permit would be modified first to eliminate the BTA and associated systems from the plant design; however, before ERB and APB systemization could start, PM ACWA would decide to revert to on-site treatment of the hydrolysate. It was assumed that supporting studies for the off-site shipment of hydrolysate (*e.g.*, transportation risk assessment and toxicity studies), updating the EPP, and issuance of a revised CD would be completed before the decision to revert to on-site hydrolysate treatment. The schedule analysis indicated that the overall delay in getting the Stage III permit (for a plant with no on-site

treatment features) was about 13 months relative to scenario 1. It was assumed that there would be no lawsuits filed against the issuance of the Stage III permit.

In this scenario, the decision to switch to on-site treatment would be made on 1 November 2009. It was assumed that it would take a total of 3 months for the systems contractor to review the BTA final design to make sure it meets current codes and standards and for the government to review the final design package. The additional resources required for the design review would be 20% more than that estimated for scenario 2 because more time would have elapsed since the design was placed on hold.

The permit modification process (to include the BTA) would take 4 months, although there would be a one month overlap between this period and the schedule for finalizing the BTA design. During this time, there would be other ongoing activities, primarily the construction of the ERB and APB. Hence the Project Services and Plant staff levels during this period (*i.e.*, during BTA design) would be the same as those in scenario 1.

The start of BTA systemization overlaps with the systemization of other Stage III facilities. Hence, the total systemization period would be extended by 5 months. During this 5-month extended systemization period, Mitretek assumed that there would be no net increase in plant staffing cost. The systems contractor would adjust the staffing level appropriately so that the total resources (in staff months) during systemization remain the same over a slightly longer systemization period.

The overall delay in the end of agent operations for scenario 3 relative to scenario 1 would be 18 months, of which 13 months would be incurred before construction. Cost increases during this 18-month period (13 months prior to construction and 5 months before operations start) would be primarily attributed to the costs of Project Services staffing and government Program Management, as well as munitions stockpile storage.

Public outreach to explain the government decision to ship the hydrolysate off-site and then the change to treat it on-site was assumed to require 2 additional years of effort. It was also assumed that toxicity studies in support of the off-site treatment would have been completed by the time a decision was made to switch back to the on-site treatment option. Toxicity studies would include the following:

- Mutagenicity of mustard hydrolysate
- Acute toxicity of HT hydrolysate
- Acute toxicity of HD hydrolysate

A transportation risk assessment, required for the CD, would also have been completed prior to the decision to proceed with on-site treatment.

The cost factors discussed above led to an overall cost increase of $91.7M for this scenario relative to scenario 1 (base case).

6.2.4 Scenario 4

Similar to scenario 3, the Stage III permit would be modified initially to eliminate the BTA and associated systems from the plant design. The analysis assumed that the overall delay in

getting the modified Stage III permit would be about 13 months relative to scenario 1. In this scenario, it was assumed that there would be no lawsuits filed against the issuance of the Stage III permit.

The decision to revert to the on-site treatment of the hydrolysate would occur on 1 November 2012 after systemization of the APB and ERB was completed. The systems contractor would have to review the BTA final design to make sure it meets current codes and standards. The total time required for contractor and subsequent government review of the final design package was assumed to be 3 months. However, more resources would be allocated for this review because yet more time would have elapsed since the design was placed on hold. The resources required would be 20% more than scenario 2. While the BTA design was being finalized, there would be other ongoing activities, primarily the construction of the ERB and APB. Hence the Project Services and Plant staff levels during this period would be the same as in scenario 1.

The completion of ERB, APB, and BTA systemization would extend the schedule by 40 months relative to scenario 1. During this additional 40 month period, the Plant staff level was assumed to be the same as the FY 2011 level (peak of systemization period) for scenario 1. The Project Services staff level during FY 2011 would also be extended for 40 months. This reflects the assumption that while the plant is ready to operate, CDPHE would not allow operations to start until the BTA had been constructed and systemized. The systems contractor would not be expected to reduce its plant staffing level at this point. During this 40-month delay, the systems contractor would conduct more training to ensure the staff was fully trained by the time operations could start and more systems tests to ensure the standing and maintenance operating procedures would have been fully exercised.

The overall delay in the end of agent operations for scenario 4 relative to scenario 1 would be 53 months. Cost increases during the entire 53-month period would be attributed to the costs of Project Services staffing and government Program Management costs, as well as munitions stockpile storage. There would be an additional Plant staffing cost (at the systemization staffing level) over 40 months (systemization phase). The costs of the pad for loading hydrolysate into tanker trucks, the loading/unloading and other mechanical equipment, piping and electrical materials, and associated labor were added to the construction cost for this scenario.

Public outreach to explain the government decision to ship the hydrolysate off-site and then treat it on-site was assumed to require 2 additional years of effort. As in scenario 3, it was assumed that the toxicity studies and transportation risk assessment would have been completed prior to the decision to switch back to the on-site treatment option.

The cost factors discussed above led to an overall cost increase of $754.2M for this scenario relative to scenario 1 (base case).

6.2.5 Scenario 5

Scenario 5 evaluated a situation where off-site shipment and treatment of agent hydrolysate would be successfully pursued without any delay due to litigation. The modification of the Stage III permit, as well as updates to the EPP, EIS, and the CD would delay the start of construction (and therefore, the end of agent operations) by 13 months, consistent with the assumptions for

scenarios 2, 3, and 4. For labor hours, adjustments were made to Project Services and Plant staff (for systemization, operations, and closure) due to the elimination of the BTA and ancillary systems. However, because of the delay in the start of construction of Stage III facilities (13 months), Project Services support (at the level expected in FY07) would be extended for 13 more months. Government Program Management and munitions stockpile storage costs would also be extended for 13 months.

Capital (equipment and material) and labor costs associated with the construction and installation of the ICBs, BTA OTS, BRS, and WRS were deducted from the total construction costs. The costs of the pad for loading hydrolysate into tanker trucks, the loading/unloading and other mechanical equipment, piping and electrical materials, and associated labor were added to the construction cost for this scenario. The costs for biotreatment of the hydrolysate were also added for this scenario.

Other costs for this scenario would include public outreach, toxicity studies, risk assessment, and water use costs. Public outreach to explain the government decision and activities up to the time construction of Stage III facilities begin was assumed to require 2 additional years of effort. Costs of toxicity studies and the transportation risk assessment (as discussed in scenario 3) were also included in this scenario. Note that the additional cost incurred by purchasing water to replace that lost in the hydrolysate was small when compared to the other costs incurred by shipping and treating the hydrolysate off-site.

The cost factors discussed above led to an overall cost increase of $4.4M for this scenario relative to scenario 1 (base case).

6.2.6 Scenario 6

Scenario 6 evaluated a situation where CDPHE would approve PM ACWA's plan to ship and treat the hydrolysate off-site, but the CD granted by the City of Pueblo would be litigated and work would be stopped by an injunction. Although the off-site option would eventually prevail, the injunction would cause a 24-month delay in the start of construction from the time the permit would be issued. The rest of the schedule durations for systemization, operations, and closure in scenario 1 would apply to scenario 6, as well.

The total delay in the start of construction of Stage III facilities relative to scenario 1 would be 37 months (13 months for permit modification and 24 months for the CD litigation). The corresponding delay in the end of agent operations, relative to scenario 1, is also 37 months. Project Services support (at the level expected in FY 2007) would be extended for 37 more months. Government program support and stockpile storage costs would also be extended for 37 months.

Other costs for this scenario included hydrolysate biotreatment, legal services, toxicity studies, transportation risk assessment, public outreach, and water use costs. Public outreach to explain the government decision and activities up to the time construction of Stage III facilities finishes (after the injunction is lifted) was estimated to require 3 additional years of effort.

The cost factors discussed above led to an overall cost increase of $124.9M for this scenario relative to scenario 1 (base case).

6.2.7 Scenario 7

In scenario 7, PM ACWA would be directed by the DAB to keep the on-site treatment of hydrolysate option open. The scenario also assumed that the permit and the CD would not be litigated. The rest of the schedule durations for systemization, operations, and closure in scenario 1 would apply to scenario 7, as well.

The decision to pursue the off-site treatment option before APB construction starts would mean that money spent to procure materials and equipment for the BTA, WRS, and BRS would not be recovered. Long-lead items considered in the analysis of scenario 7 included the ICB, BRS, WRS, and ICB Off-gas Treatment System. Based on the April 2006 schedule for PCAPP, the BTA construction would start about 8 months after APB construction started. For scenario 7, Mitretek assumed that the decision to treat the hydrolysate off-site would be made before the APB was originally scheduled to start (1 October 2007). Hence, if the time for ordering the long-lead items were 12 months before installation, they would have been ordered 4 months before APB construction began. This meant that the equipment may only be partially fabricated. For this reason, only 40% of equipment cost was considered irrecoverable whereas 100% of materials cost and subcontractor fees were considered sunk. For details, please see Wusterbarth et al. (2006).

Project Services support (at the level expected in FY 2007) would be extended for 25 more months. Government Program Management and munitions stockpile storage costs would also be extended for 25 months.

Other costs for this scenario included hydrolysate biotreatment, toxicity studies, transportation risk assessment, public outreach, and water use costs. Public outreach to explain the government decision and activities up to the time Stage III construction began was assumed to require 2 additional years of effort.

The cost factors discussed above led to an overall cost increase of $87.3M for this scenario relative to the base case.

6.3 BGCAPP Life Cycle Cost Estimates

Table 6-2 summarizes the results of Mitretek's analysis for BGCAPP. It shows the cost increase or decrease associated with scenarios 2 through 7 relative to scenario 1. Details on cost drivers are discussed below.

Table 6-2. Summary of BGCAPP Schedule and Cost Differentials by Scenario

Scenario	Description	Change Relative to Scenario 1 (Base Case)	
		Schedule (Months)*	Cost ($M)†
2	Off-site decision changed to on-site at start of SPB construction	8	$53.5
3	Off-site decision changed to on-site at start of systemization	31	$188.8
4	Off-site decision changed to on-site at end of systemization	53	$944.9
5	Off-site decision, no delays	4	-$52.1
6	Off-site decision, with delays	18	$26.1
7	Decision to treat off-site postponed until scheduled start of agent processing building construction	19	$114.7

* delay in end of agent operations

† the costs and schedules in this table are for a new facility that has not been constructed and has no operating permits. These values should not be compared to an existing operational Chemical Agent Disposal facility.

6.3.1 Scenario 1

In this base case scenario, the agent hydrolysate would be processed on-site using biotreatment technology. The LCCE developed for scenario 1 included the systems contractor, PM ACWA management (including site office, Corps of Engineers, and other demilitarization program costs), and munitions stockpile storage costs.

6.3.2 Scenario 2

The primary distinction between scenario 2 and scenario 1 is the fact that an off-site treatment of hydrolysate would be pursued initially, but on October 2007, PM ACWA would revert back to the on-site treatment option. From the schedule analysis, the decision to first eliminate the SPB and associated systems from the design and then to add these back one year later would delay the start of major construction relative to scenario 1. The estimated schedule shows that the start of operations would be delayed by 8 months relative to scenario 1. For the systems contractor, the increase in labor costs would result from keeping Project Services staffing at a certain level for 8 more months. There would be corresponding programmatic and munitions stockpile storage costs, as well. It was also anticipated that there would be additional

public outreach costs because of the rapid reversal of the decision. It was assumed that public outreach to explain the Government's decision to ship the hydrolysate off-site and then the reversal to process the hydrolysate on-site would require one additional year of effort.

The cost factors discussed above led to an overall cost increase of $53.5M for this scenario relative to scenario 1 (base case).

6.3.3 Scenario 3

In scenario 3, the design would be modified first to eliminate the SPB and associated systems from the plant; however, at the completion of MDB construction, PM ACWA would revert to on-site treatment of the hydrolysates. It was assumed that supporting studies for the off-site shipment of hydrolysates (*e.g.*, transportation risk assessment and toxicity studies) and updating the EPP would be completed before the decision to revert to on-site hydrolysate treatment. The schedule analysis indicated that construction and systemization would be delayed, and the duration of construction and systemization would be extended due to permitting changes and the late addition of the SPB.

The delay in the end of agent operations for scenario 3 relative to scenario 1 was 31 months. Cost increases during this 31-month period would be attributed primarily to the costs of Project Services staffing and Government Program Management, as well as munitions stockpile storage. Public outreach to explain the Government's decision to ship the hydrolysate off-site and then the change to treat it on-site was assumed to require 3 additional years of effort. It was also assumed that toxicity studies in support of the off-site treatment would have been completed by the time a decision is made to switch back to the on-site treatment option. Toxicity studies would include the following:

- Acute toxicity of H hydrolysate
- Acute toxicity of GB hydrolysate
- Ecotoxicity of GB hydrolysate
- Acute toxicity of energetics hydrolysate
- Combustibility of energetics hydrolysate

A transportation risk assessment and a risk assessment for residual GB in hydrolysate would also have been completed prior to the decision to proceed with on-site treatment.

The cost factors discussed above led to an overall cost increase of $188.8M for this scenario relative to scenario 1 (base case).

6.3.4 Scenario 4

Similar to scenario 3, the design would be modified initially to eliminate the SPB and associated systems from the plant. The decision to revert to the on-site treatment of the hydrolysate would occur on 24 September 2012 after systemization of the MDB would be completed. The systems contractor would have completed the SPB design at this point.

The total delay in the end of agent operations for scenario 4 relative to scenario 1 would be 53 months. Cost increases during the entire 53-month period would be attributed to the costs of

Project Services staffing and Government Program Management, as well as munitions stockpile storage. There would be an additional Plant staffing cost (at the systemization staffing level) over 40 months (systemization phase). The costs of the pad for loading hydrolysate into tanker trucks, the loading/unloading and other mechanical equipment, piping and electrical materials, and associated labor were added to the construction cost for this scenario.

Public outreach to explain the Government's decision to ship the hydrolysate off-site and then treat it on-site was assumed to require 3 additional years of effort. As in scenario 3, it was assumed that the toxicity studies and transportation risk assessment would have been completed prior to the decision to switch back to the on-site treatment option.

The cost factors discussed above led to an overall cost increase of $944.9M for this scenario relative to scenario 1 (base case).

6.3.5 Scenario 5

Scenario 5 evaluated a situation where off-site shipment and treatment of agent hydrolysate would be pursued successfully without any delay due to permitting issues. The modification of the RD&D permit would delay the start of construction by 5 months from the base case (scenario 1). However, there is sufficient slack in the schedule to allow for approximately half of this delay to be made up during MDB construction and systemization; the beginning of agent operations is delayed by 2 months. Agent operations would be extended by about 2 months because of the longer time required to process VX hydrolysate. The total delay in the end of agent operations is therefore 4 months for scenario 5 relative to scenario 1. Costs would increase during the 4-month period due to the costs of Project Services staffing and Government Program Management, as well as munitions stockpile storage.

Capital (equipment and material) and labor costs associated with the construction of the SPB and installation of the SCWOs and the Hydrochloric/Sulfuric/Phosphoric Acid Systems were deducted from the total construction costs. Costs for other utility systems were adjusted based on the reductions described in Section 5.2.5.1. The costs of the pad for loading hydrolysate into tanker trucks, the loading/unloading and other mechanical equipment, piping and electrical materials, and associated labor were added to the construction cost for this scenario.

Other costs for this scenario would include hydrolysate biotreatment, public outreach, toxicity studies, and transportation risk assessment. Public outreach to explain the Government's decision and activities up to the time construction begins was assumed to require one additional year of effort.

The cost factors discussed above led to an overall cost decrease of $52.1M for this scenario relative to scenario 1 (base case).

6.3.6 Scenario 6

Scenario 6 evaluated a situation where KDEP would determine that the BGCAPP RD&D permit would be no longer applicable, and work would be stopped until a RCRA Part B permit could be issued. This would cause an 18-month delay in the end of agent operations relative to scenario 1. Project Services support (at the level expected in FY 2007) was extended for 18 more months. Government Program Management and munitions stockpile storage costs also would be

extended for 18months. Other costs for this scenario included hydrolysate biotreatment, toxicity studies, transportation risk assessment, and public outreach costs; these would be expected to be almost the same as in scenario 5. Public outreach efforts were assumed necessary for 2 additional years.

The cost factors discussed above led to an overall cost increase of $26.1M for this scenario relative to scenario 1 (base case).

6.3.7 Scenario 7

In scenario 7, PM ACWA would be directed by the DAB to keep the on-site treatment of hydrolysate option open. The scenario also assumed that the RD&D permit would be modified, which would lead to a delay in construction and systemization. The schedule duration for operations and closure in scenario 5 would apply to scenario 7, as well.

The decision to pursue the off-site treatment option before SPB construction starts would be made in this scenario before any procurement of equipment for the SPB. Costs of long-lead items were imposed, but the contract would allow PM ACWA not to incur labor installation costs. Project Services support (at the level expected in FY 2007) was extended for 19 more months. Government Program Management and munitions stockpile storage costs were also extended for 19 months.

Other costs for this scenario included hydrolysate biotreatment, toxicity studies, transportation risk assessment, and public outreach. Public outreach to explain the Government's decision and activities up to the time construction begins was assumed to require 2 additional years of effort.

The cost factors discussed above led to an overall cost increase of $114.7M for this scenario relative to scenario 1 (base case).

6.4 Summary of Cost Findings

Finding: Cost savings from the off-site biotreatment of hydrolysate are not realized under any conditions at PCAPP.

Finding: The off-site shipment and treatment of agent and energetics hydrolysates from BGCAPP provide some cost savings when compared to the current plan to treat the hydrolysates at BGCAPP using the SCWO technology, but only if no significant permitting delays are incurred.

Three scenarios (scenarios 5, 6, and 7) involving off-site shipment and biotreatment of agent hydrolysates were analyzed and the total LCCEs determined for each site. At PCAPP, the delays in the end of agent operations range from 13 months to 37 months. At BGCAPP, the delays in the end of agent operations range from 4 months to 19 months. For both sites, scenario 5 represents the most optimistic case, in which the delay in the schedule that leads to increased costs for munitions stockpile storage, Project Services labor, and government Program Management, and the additional construction and operations costs are incurred by the addition of the truck loading pad and supporting mechanical and electrical equipment for shipment of hydrolysate, are offset by the cost savings (capital and labor) resulting from the elimination of the hydrolysate treatment systems. There is only a net cost saving of about $52M for BGCAPP.

At PCAPP, any potential cost savings that could have been realized from off-site biotreatment are quickly lost when permitting delays and additional munition inventory storage costs are taken into account.

Alternatives for scenario 5 using deep-well injection as the off-site disposal technology rather than biotreatment were also analyzed. For the deep-well injection alternatives, net savings relative to the base case are about $35M at PCAPP and $106M at BGCAPP. However, monthly expenditure rates developed for the relevant time period when these savings would accrue indicate that schedule slippages of 6 months or less could eliminate these savings.

An alternative to scenario 6 at BGCAPP was analyzed and found to result in cost savings of $28M relative to the base case. However, scenario 6 assumes that a RCRA Part B permit could be issued approximately 1 year after loss of the RD&D permit. This is the absolute minimum required for the process; KDEP indicated it could take up to 3 years. Based on the expenditure rate during FY07 for BGCAPP, scenario 6 cost savings would be eliminated if issuing the permit required as little as an additional 2 months over the minimum period. For this reason, cost savings in the event of loss of the RD&D permit for BGCAPP appear to be extremely unlikely, even if the less expensive deep-well injection technology were selected.

Other scenarios involving off-site treatment of the hydrolysate result in no cost savings for either PCAPP or BGCAPP. This is primarily due to additional labor and stockpile storage costs resulting from the delays in the end of agent operations, which range from 25 months (scenario 7) to 37 months (scenario 6) at PCAPP and are in the 4 to 19-month range at BGCAPP.

Finding: Any delay in implementing the option to treat hydrolysates on-site would lead to a cost increase.

There is some uncertainty in getting a commercial TSDF that has appropriate permits and interest in treating hydrolysate from PCAPP. Hydrolysates from BGCAPP are potentially more controversial than PCAPP hydrolysate. Potential problems that could be encountered with a TSDF—causing PM ACWA to revert back to on-site treatment—are reflected in the analysis of scenarios 2, 3, and 4. The cost increase is particularly significant if the decision to treat the hydrolysate on-site is made after the pilot plant is almost fully staffed. CDPHE would not allow PCAPP to operate before the on-site biotreatment systems are operational, and KDEP would not allow BGCAPP to operate before the on-site SCWO systems are operational. Thus, scenario 4 has the potential to increase costs by $750M-$945M and delay the complete destruction of the munitions stockpile by more than 50 months.

Although an alternative TSDF could probably be identified, the small number of TSDFs with acceptable technologies and adequate capacity could translate into delays from a change, particularly close to the start of operations. Changing TSDFs is not explicitly addressed in any of the analyzed scenarios, but the results clearly indicate that delays, especially those incurred close to the start of operations, are particularly costly.

In general, Mitretek's analysis shows that every month of delay costs roughly $15M to 19M. Any delay over 6 months, regardless of cause, would be expected to eliminate all possible savings, even under the most optimistic assumptions (*i.e.*, a decision to use off-site deep-well injection at BGCAPP with no delays).

Finding: Additional delays in the destruction of the munitions stockpile at either site increase stockpile storage costs. Any cost savings attributed to lower capital investments are quickly eroded by increased munitions storage costs from schedule delays associated with off-site treatment of hydrolysates.

Previous estimates of the savings achievable through off-site treatment of hydrolysates did not take into account the added cost of storing the munitions arising from delay because of design and permit changes. They also did not take into account labor expenses to keep the project running while awaiting approval of modified permits. In general, the expense of continuing to store munitions at the depots because of schedule delays associated with the off-site treatment of hydrolysates cancels out any potential cost savings for almost all scenarios analyzed in this study.

Section 7

Conclusions

In this study, Mitretek analyzed life cycle costs for PCAPP and BGCAPP for a variety of scenarios. Current permitting strategies for both facilities are based on on-site treatment of hydrolysates and, given discussions with state regulators, a decision to treat hydrolysate at an off-site TSDF would require permitting changes that cause delays in all scenarios. At PCAPP, construction of the main processes cannot start until a Stage III construction permit would be issued; changes would delay issuing the permit and thus construction by at least 13 months. As a result, even under the most optimistic scenario, the off-site shipment and biotreatment of agent hydrolysate from PCAPP provides no cost savings, when compared to the current plan to process the hydrolysate at PCAPP using the biotreatment technology. At BGCAPP, the construction permit has already been issued and would require modification, also delaying construction by at least 4 months. The off-site shipment and biotreatment of hydrolysates from BGCAPP provides some cost saving when compared to the current plan to process the hydrolysates at BGCAPP using the SCWO technology, but only if no significant permitting delays are incurred.

Mitretek's most significant findings are that virtually any delay in implementing the option to treat the hydrolysates on-site would lead to a cost increase, and that scenarios resulting in delays should be considered more likely to occur than a minimal delay scenario. Cost savings from the off-site biotreatment of hydrolysate are not realized under any conditions at PCAPP, and only under very ideal conditions at BGCAPP. The relative cost changes for PCAPP scenarios 2-7 are presented in Figure 7-1, and the relative cost changes for BGCAPP scenarios 2-7 are presented in Figure 7-2. In each case, the scenarios are ordered based on the likelihoods of occurrence discussed in Section 5.3, with the most likely scenarios at the top of the figure and the least likely scenarios at the bottom.

At PCAPP, stakeholders have indicated that litigation is probable in the event of a decision to treat hydrolysate off-site, and the Pueblo County attorney has indicated a significant potential for an injunction if the CD is the target of litigation. For this reason, scenario 6, which costs significantly more than the base case, is considered more likely than scenario 5, which costs slightly more than the base case. At BGCAPP, KDEP has indicated that the RD&D permit would probably no longer be applicable following a decision to treat hydrolysates off-site. For this reason, scenario 6, which costs more than the base case, is considered more likely than scenario 5, which provides savings relative to the base case.

Scenarios 2, 3, and 4 for both sites may not be very likely, but they show that costs for adding a hydrolysate treatment technology at sites that initially planned for off-site treatment are in all cases greater than the cost to include a hydrolysate treatment technology from the start of the process. The later in the process that such a change occurs, the greater the cost increase. If circumstances force the addition of an on-site hydrolysate treatment technology when the site is otherwise ready to operate, the costs are staggering, because the regulators for both sites have indicated that they would not allow operations until a treatment technology is available.

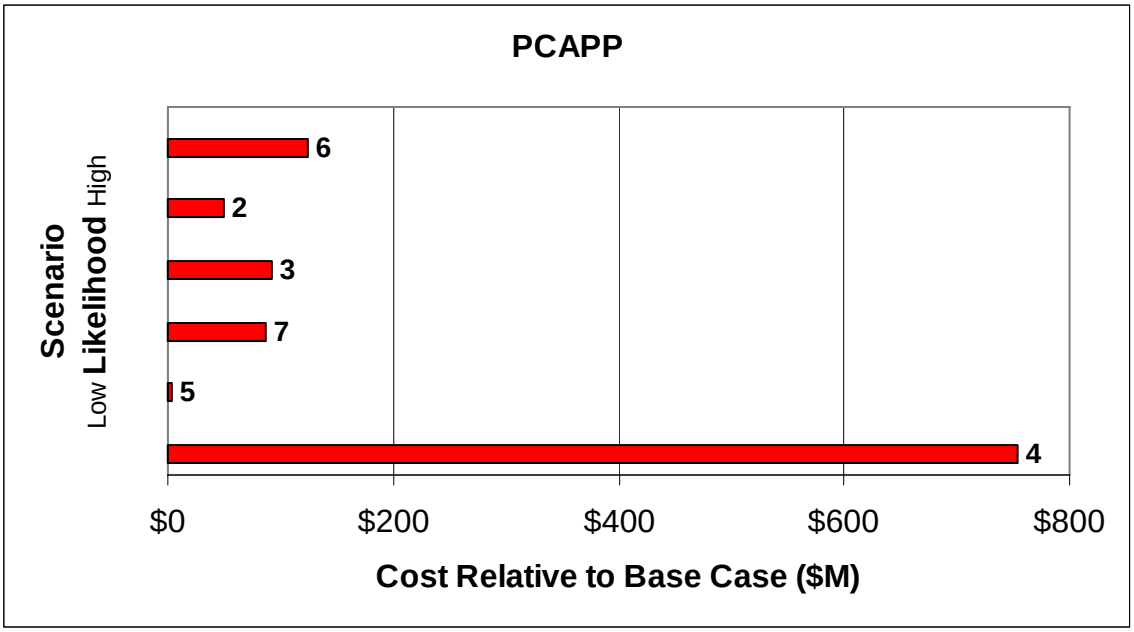


Figure 7-1. Relative Cost Changes for PCAPP Scenarios

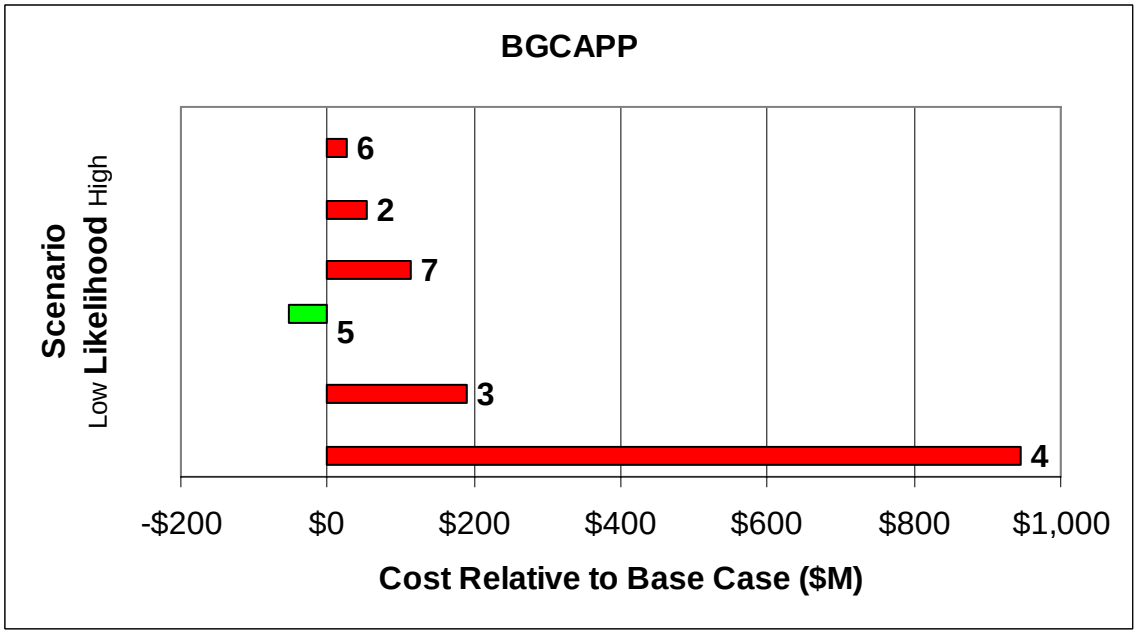


Figure 7-2. Relative Cost Changes for BGCAPP Scenarios

Scenario 7 shows that postponing the decision to treat hydrolysates off-site leads to increased costs relative to both scenarios 1 and 5, in which the decision is made earlier. This appears to

result from the timing of permit changes; postponing the decision means that permit changes would occur later in the process, when they are potentially more disruptive to construction. In this analysis, postponing the decision to treat hydrolysate off-site causes longer delays than an earlier decision.

Finally, cost-savings from off-site hydrolysate treatment could only be realized for PCAPP if deep-well injection were used as a treatment technology. At BGCAPP, greater cost savings from off-site hydrolysate treatment could be realized if deep-well injection were used. This is because biotreatment (with associated pretreatments for some BGCAPP hydrolysates) is more expensive than deep-well injection. Alternatives to scenario 5 using deep-well injection as the off-site disposal technology rather than biotreatment show that net savings relative to the base case would be about $35M at PCAPP and $106M at BGCAPP. However, the more likely outcomes would be delays due to litigation and permitting issues, which would result in additional costs relative to on-site hydrolysate treatment. Even using deep-well injection, such delays will eliminate any possible cost savings under all but the most optimistic circumstances.

Analysis shows that in general, every month of delay costs roughly $15M to 19M. Therefore, any delay over 6 months, regardless of cause, would be expected to erase all possible savings, even for off-site deep-well injection at BGCAPP. Moreover, there is increased programmatic risk with deep-well injection because OPCW has not yet been asked to accept deep-well injection as the endpoint of destruction for chemical warfare agents. The risk is difficult to mitigate because OPCW will negotiate the terms for accepting an off-site hydrolysate treatment as part of the facility agreement, which would take place only after PM ACWA is committed to a specific TSDF and treatment technology.

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Appendix

Stakeholder Concerns

Mitretek Systems conducted a series of meetings with interested stakeholders in Colorado and Kentucky. This Appendix provides a summary of the discussions at those meetings.

A.1 Summary of Meetings with PCAPP Stakeholders

On 12-14 April, 2006, members of the Mitretek project team met with citizens, members of the Colorado Chemical Demilitarization Citizens' Advisory Commission (CAC), local government officials, regulators from the Colorado Department of Public Health and Environment (CDPHE), and a staff member from Senator Salazar's office. This section provides summaries of the concerns raised by these groups.

In each meeting, Mitretek began the meeting by reviewing the nature of its task with PM ACWA and a summary of its corporate characteristics relating to independence. Mitretek reiterated its desire to gather information on stakeholder concerns and how they impact the decision-making process, and with whom it would be speaking during our trip to Colorado. Mitretek then asked for the group's opinions on the pursuit of shipping agent hydrolysate from PCAPP to a properly permitted treatment facility elsewhere if safe destruction of the chemical stockpile could be accomplished sooner and at a greater savings to the taxpayer. The sections that follow summarize these discussions.

A.1.1 Summary of Meetings with Local Citizens

This section summarizes two meetings with local citizens.

After Mitretek's introduction, one citizen began by stating that local jobs will be lost if the hydrolysate were treated off-site. He also questioned how the government could make a decision concerning off-site shipment of hydrolysate without having identified a specific destination. He indicated that his position was the less that has to be transported, the better. Another citizen voiced his concern about the relative volumes of hydrolysate and the salt residue from biotreatment.

Another citizen stated that she was concerned about the transportation of any material from the site, adding that she could not see any reason to transport material from the site. She was concerned about the consequences of an accident during transportation. It did not matter whether the accident occurred in Pueblo or elsewhere, people will be harmed. It did not make sense to do that when the hydrolysate can be treated at the site. Another citizen asserted that PCAPP should treat all the waste on-site. Another citizen suggested that the study needed to consider the high cost of fuels.

Another citizen added that the hydrolysate should be treated on-site to save jobs for the local residents.

Another citizen noted that Boone has lived close to chemical weapons for 60 years, and asked why they should now worry about the hydrolysate.

Another citizen indicated that she was opposed to shipping hydrolysate off-site. Another citizen reiterated her worries about any material being shipped from the site.

Another citizen raised the issue of providing potable water to the surrounding communities. There was some discussion concerning water treatment issues resulting from ground water contamination at Pueblo Chemical Depot.

Three citizens agreed that hydrolysate treatment should be performed at PCAPP. Another citizen reiterated her position that it should not be shipped off-site.

Two citizens allowed that their view might change if off-site hydrolysate treatment could be done at lower cost, although they were skeptical that this was the case. One of them argued that the potential for harming people outweighed cost savings, noting that there would always be the potential for some accident.

A citizen said that a third party evaluation by the Centers for Disease Control and Prevention was unlikely to change his opinion. Another citizen added that such studies were not likely to be believed if they were performed by another government agency. They would have more confidence if the study were done by an independent party not controlled by the government. They felt very strongly that the hydrolysate should be kept in one place and treated there. The first citizen added that he was concerned about terrorist attacks interfering with shipments.

The citizens were notably skeptical that off-site treatment of hydrolysate from PCAPP could be a less expensive option, primarily based on their perception of the costs of transporting hydrolysate, especially considering the current cost of gasoline. The general feeling from the local residents is that all these delays in the destruction of the munitions at Pueblo is not helping them at all. They have lived with the stockpile for so long; they just want to “get it over.”

Another citizen indicated that she agreed with the consensus of the Colorado Chemical Demilitarization Citizens' Advisory Commission and the community that hydrolysate should be treated at PCAPP. She stated that the major issue revolves around Avondale’s proximity to the chemical munition storage site over many years, which has not been an asset to the community. She reports that the community’s perception is that now that it has the opportunity to benefit from activities related to the munitions, the community should take that opportunity.

The citizen stated that there is a concern because of the large concentration of senior citizens and Spanish-speaking residents in Avondale, which would pose particular challenges in the event of an accident that required evacuating residents.

The citizen indicated that she has concerns about delays in the destruction of munitions if the off-site hydrolysate option is selected, adding that people do not feel comfortable with the government and its ability to get the job done quickly. Anything that delays the project will be costly. Another significant issue is trust; information from other government agencies such as the Centers for Disease Control and Prevention may not be accepted. In the past, government agencies have had a bad record on water contamination issues. Based on past experience, the community will require trustworthy information, delivered to them in a form they can understand; the common view is that the federal government will use big words to avoid engaging citizens in a discussion of the real issues.

The citizen suggested that local citizens would be willing to listen if it could be shown that off-site treatment of hydrolysate would result in earlier destruction of the munitions at Pueblo or if it could be shown that there would be no net loss of jobs.

The citizen concluded by stating that local citizens want the Army to respect them enough to explain things to them in words that they can understand.

A.1.2 Summary of a Meeting with Members of the Colorado Chemical Demilitarization Citizens' Advisory Commission

After Mitretek's introduction, a CAC member noted that the CAC was on record as opposing the option. The member outlined two reasons for that opposition:

- Economic impact: the CAC believes that if it is decided to ship agent hydrolysate for off-site treatment, litigation is highly likely to follow, which would slow the process and lead to increased costs.
- Political impact: the local community has united behind the combined neutralization/biotreatment process as a whole; the CAC worries that community support that has been built up over a long period would be lost. The member noted that the Army's relations with the community were damaged by the interruption in funding of PCAPP, and that this change could push the relationship past a tipping point.

Another CAC member added that the political impact could include changes to laws, noting the statements made by certain lawmakers in New Jersey and Delaware concerning changing laws to prevent the shipment of Newport hydrolysate to DuPont. The member noted that communities along any transportation route were likely to have concerns and cited the potential costs of protecting communities along any route from PCAPP to a waste disposal facility, similar to CSEPP program and equipment costs in the storage communities. Delays could also occur in obtaining transportation permits. The public perception is not so much that the hydrolysate is safe, but that the hydrolysate is a derivative of a chemical weapon which by perception makes it unsafe. The member added that there might be a potential for civil protests of hydrolysate transports. The member noted that risk assessments have considered the potential for accidents resulting in fatalities or injuries, but stated her belief that even a minor accident could result in a program-wide shutdown.

The member also stated that there was community opposition to a tank farm for long term hydrolysate storage at PCAPP, and mentioned the CAC's concerns about environmental justice issues related to off-site disposal. Finally, the member raised the issue of water costs, noting that Colorado has costs for "consumed" water that are higher than for recycled water. The State of Colorado has different costs to the user of water. If one uses water that through recycling or disposal through a waste water treatment facility allows the water to return into use, even if that use is downstream run-off into the Arkansas River, the cost is one price. That is the price that will primarily be paid for use of the water from the wells. If, however, the water doesn't return to an additional use, the water is consumed and the cost is higher. This would be the cost paid if the hydrolysate is shipped off-site because the water will not return to the Arkansas River complex. Therefore, PCAPP would not only be paying for more water consumed, but it would be at a

higher cost because the water would be consumed and not merely used. The Pueblo community will not accept water brought back from the facility treating the agent hydrolysate.

When asked what would be the basis of the litigation, should the off-site disposal of hydrolysate be pursued, another CAC member indicated that this would be the toxicity of the hydrolysate as well as the safety of waste shipment.

The member added that the Pueblo Chemical Depot is covered under the Base Realignment and Closure (BRAC) program, so there would be some additional administrative costs associated with delays in the PCAPP schedule. There will be lost economic opportunities for the community if transfer of base property is delayed.

Another member said that the costs of litigation should also be considered, even if they come from the Department of Justice rather than the Department of Defense because they still represent costs to the taxpayer. The member elaborated on the previous point, suggesting that Mitretek look at Chemical Material Agency costs on the back end of operations if BRAC transfers, which require permit completion, are delayed. The member stated that even low-level maintenance represents real costs that could be saved if hydrolysate was treated on-site and the base was transferred at an earlier date to the Development Authority. The member also asked if the trucks to be used to transport the hydrolysate will be dedicated trucks to be purchased by the Army, how many trucks would be needed and if the Army would be purchasing these trucks or whether they would be included in a contract with the receiving TSDF.

In response to a question on the precedent set by the Aberdeen facility, another member noted that the number of states transited by hydrolysate that would have had standing to litigate in that case was limited to Delaware, whereas many states would be transited by PCAPP hydrolysate. The member also noted the shorter distance from Aberdeen to DuPont when compared to the distance from PCAPP to any possible disposal facility.

The member stated that he did not think that the Aberdeen hydrolysate disposal option would be possible now, because the scrutiny brought on by the Newport case has changed everything. The member suggested that Aberdeen waste disposal was not done as safely as it could have been done on-site. The member asserted that the benefits and the risks are unequally distributed and that moving wastes such as hydrolysate is perceived by many people as unfair.

Another member stated that this is often perceived as providing savings to the taxpayer at the expense of others. Another member indicated that this is a way of government programs externalizing the risk and costs.

The member indicated that failing to perform biotreatment at PCAPP loses the ability to recycle water at the facility, which could adversely impact public support.

The member then noted his belief that off-site treatment of hydrolysate could invalidate a large measure of the rationale for permitting PCAPP under a research, development, and demonstration (RD&D) permit. The member suggested that there was a high probability of litigation intended to force PCAPP to use a Part B permit under RCRA. Another member added that she agreed that an RD&D permit might not be possible without biotreatment, adding that the RD&D permitting strategy allowed a staged approach to permitting whereas a Part B permit

requires a single evaluation of a completed design, which will not be available until this fall of 2006 at the very earliest for PCAPP.

When asked whether an evaluation of the risks posed by hydrolysate by a third party such as the Centers for Disease Control and Prevention (CDC) could affect public perception, another CAC member indicated that CDC has no presence in the Pueblo area, and so is unlikely to change the community's perception. Another member added that community perception is unlikely to be affected by the "it's as safe as what is already on the highways" argument. What is "already on the highways" and railways is increasingly controversial.

Another CAC member raised homeland security issues as concerns, citing threats to reservoirs in the event of a terrorist attack on a shipment of hydrolysate. Another member then recounted an example of how even people familiar with the chemical process industry were opposed to movement of agent-derived materials.

In a discussion of how treatment options might affect acceptability of hydrolysate treatment, another CAC member indicated that incineration of hydrolysate would likely incite considerable opposition, biotreatment might be the most acceptable option, and deep-well injection was perceived as having problems. Another member stated that the treatment options were a minor consideration relative to the desire to process the hydrolysate on-site. The member stated that the Sierra Club's position is that waste should be managed at the site where it is generated. Another member reiterated that the process was sold to the public as a whole.

In a discussion of the effect of approval by a potential receiving locality, another member noted that when transport of munitions from Pueblo to Tooele was being considered, the Tooele County government was inclined to approve the transfer because of the economic benefits, whereas the Governor of Utah threatened to call out the National Guard to stop the munitions at the state line.

Another member offered the perspective that the CAC has agreed to off-site shipment of items such as uncontaminated dunnage and propellant, but made the distinction that the CAC agreed not to oppose the off-site disposal of uncontaminated bursters, noting that this position was arrived at under duress. The member noted his belief that if the energetics could be recycled at the Army's Hawthorne plant rather than destroyed, there would be a change in the dynamics of the debate about energetics treatment. The member added that the CAC is worried that Pueblo could get stuck with the bursters if the off-site treatment process somehow falls through. The member commented that the CAC has been sensitive to the argument that on-site treatment of some components is problematic; hence, they did not oppose off-site treatment of propellant and other components as such problems could cause increased health and safety risks to workers and result in further processing delays.

Another member noted that he does not think that anyone who has been involved with the process of gaining public acceptance for PCAPP could be convinced that off-site treatment could be done less expensively. The member suggested that in the event that the Department of Defense imposed off-site hydrolysate treatment, that political support for PCAPP would be lost and the Congress would likely intervene to reverse such a decision. The member stated that the community could be threatened into accepting off-site treatment, but at the cost of losing all

support. The member stated that the Pueblo public trusts PM ACWA, which is an asset that could be squandered if hydrolysate is treated off-site.

An attendee commented that given the volume of hydrolysate and the distances between PCAPP and potential treatment sites, shipping was likely to be costly. A CAC member added that chemical engineers generally try to avoid paying to ship water, which is the largest component of hydrolysate.

Another CAC member discussed the local CD process; she noted that the local government is relying on the state to perform the technical analyses pursuant to RCRA, but is not relying on the state for a transportation analysis. The CD requires an analysis of the population density and road network within 50 miles of a site, but the scope of the analysis would require negotiation between the local government and the Army. The member added that the 50 mile radius includes Colorado Springs, which would raise the visibility of PCAPP in that community, where it is not currently an issue. The member noted that the analysis could result in significant costs and schedule impacts.

Another CAC member noted that the analysis might need to consider terrorist threats.

In a discussion of the sensitivity of the stakeholder support to the transportation mode, another CAC member indicated that the issue of trucks required to get hydrolysate to a railhead needed to be considered. Another member suggested that rail may be somewhat safer than trucking, but that it was probably not significant enough to alter public perception one way or the other.

Two attendees provided information on the state of the rail connections in the vicinity of PCAPP. Rail transport of hydrolysate would require some upgrades to the infrastructure, either improving the currently inadequate tracks on the Depot grounds or adding transfer systems with appropriate containment at the Avondale rail yard to allow transfer from trucks to rail cars. Furthermore, rail transport would require more handling of the waste containers, increasing the potential for accidents and the risk to the workers.

A.1.3 Summary of a Meeting with Pueblo County Officials

A Commissioner called the meeting to order.

After Mitretek's introduction, a Commissioner responded that he was concerned about a lack of progress for PCAPP and the changes made at each phase of the process. He was frustrated at the costs of delay in the process, and wishes to move the process forward.

Another Commissioner stated that he was uncomfortable with transport of hydrolysate out of the community and wishes to see it treated at PCAPP.

The former attorney for the County explained that the process has proceeded slowly and that there have been many changes. He discussed speeding up the process and provided a historical perspective of the design development. He noted that it has been a frustrating process because the Pueblo community was not given full information on what criteria were to be used by the Department of Defense for programmatic decisions.

The attorney indicated that hydrolysate transportation was considered to be a "line in the sand;" the acceptance of transport of energetics was the compromise. He explained that off-site hydrolysate treatment was a different design concept and would require a modification to the CD. That modification must consider safety concerns regarding transportation, including the consequences of spills locally and along the transport route. He added the 100% consumption of water in a process was considered unusual in Colorado.

The attorney indicated that the holding of hydrolysate waiting for transportation was a potential concern.

The attorney stated that the citizens of Pueblo County have "put up" with the chemical munitions for 60 years, and resent the possibility that a significant portion of PCAPP jobs could be sent elsewhere if hydrolysate is treated off-site. The fact that they do not know where the hydrolysate will eventually be sent increases their concern. He added that political opposition along the transportation route and at the destination site is a concern. He mentioned that the Colorado experience with transport of nuclear wastes from the Rocky Flats plant, which resulted in a 10 year delay, was a factor in public opposition.

The attorney requested that backup designs be included so that on-site treatment of hydrolysate remains an option if the plan for off-site treatment falls through.

The attorney noted that some preliminary estimates of cost savings from the off-site treatment of hydrolysate have given a figure of $77 million, which he does not find realistic. He believes this savings will be used up by delays to the entire process. He also asked at what point would the uniqueness of the process that justifies the Research, Development, and Demonstration (RD&D) permit would be lost.

A Commissioner agreed with the attorney's observations, reiterating his opposition to off-site shipment because of safety issues.

Another Commissioner noted that there was a similar political issue in Colorado in which CDPHE declined the proposed import of contaminated soil into the state. He questioned the fairness of exporting wastes when importing waste was prohibited.

The attorney raised the economic impact of the decision on the community. He stated that off-site treatment of hydrolysate would "chip away" at jobs available to the community.

The former County attorney and the current County attorney explained the legal basis for the CD in Colorado State Law, C. R. S. Sections 25-15-501 through -515, as amended. A copy of the Pueblo County regulations (Chapter 17.176) enacted to implement the CD law was provided to Mitretek for use in its analysis.

The County attorney explained that the local certification process was based on the state's RD&D permitting process, with the submittals being provided at the same stages used in the state process. The submittals are intended to address the standards provided in C.R.S. Section 25-15-505, which require the County to consider the risk of accidents as hazardous materials are transported to, from, and at the site; the types of process byproducts and the processes for byproduct disposal.

The County attorney indicated that he expected that changes to the PCAPP process would result in footprint changes requiring relatively minor modification to the phase 1 CD, but that larger issues would be encountered in the phase 3 certificate. He noted that times required for processing applications for certificates of designation are included in the County regulations that were provided to Mitretek.

The County attorney stated that the County was concerned about the impacts of court action along the hydrolysate transportation route on extended storage of hydrolysate at PCAPP.

The former County attorney compared transportation of hydrolysate to a chain, in which the weakest link will cause delay in the process at Pueblo. He stated that PCAPP would be at the mercy of the most sensitive locations along the hydrolysate transportation route.

A Pueblo County official explained the scope of the phases of the project: Phase 1 for site clearance; Phase 2 for fencing, lighting, site preparation, and staging areas; and Phase 3 for construction, with Phase 3 being the key. He indicated that changes to the process have resulted in a Class 1 modification to the current CD, and that the modification will run into real issues if the underlying concept of PCAPP is changed. The three phases each result in a separate CD, and changes may affect previously granted certificates.

The County attorney explained the judicial review features of the CD process. Review occurs in the State District Court, with the potential for appeals to the State Court of Appeals and ultimately to the Colorado Supreme Court. In this process, there is a possibility that a preliminary injunction may be granted against the entire CD; such injunctions are not uncommon in reviews of land use decisions. Appeals of the County decision on a CD must be filed within 30 days of the approval, District Court filings generally require 1-2 months and decisions are typically reached in 2-8 months. If the District Court decision is appealed, the Court of Appeals process can require upwards of a year.

The former County attorney declared that the consensus behind the neutralization-biotreatment process is starting to fracture, and that community patience is starting to wear thin.

A Commissioner described the contributions that Pueblo had made to their colleagues involved with BGCAPP, and hailed the cooperation. The former County attorney raised the issue of whether the explosives from Pueblo could be recycled rather than destroyed, and if this was part of Mitretek's study, which it is not.

A Commissioner adjourned the meeting.

A.1.4 Summary of Meeting with the Colorado Department of Public Health and Environment

After Mitretek's introduction and in response to a question regarding the applicability of the Research, Development, and Demonstration (RD&D) permitting strategy for PCAPP, CDPHE indicated that several other aspects of the plant would qualify it for an RD&D Permit; the strategy therefore would remain applicable if hydrolysate were treated off-site. The new disassembly and washout technologies as well as the novel thermal treatments, *e.g.*, the munitions treatment unit, justify the RD&D approach. Integration of the unit processes in novel ways is also a consideration. Removal of the biotreatment process at PCAPP will not change the

basis for granting an RD&D permit. CDPHE has a stable permit writing staff, so changes to the process should not present undue challenges.

When CDPHE awards a permit, any party can appeal. Under Colorado law, such appeals go directly to a district court judge. For example, litigation concerning a Part B landfill in Colorado resulted in a construction delay of at least one year. The party appealing the permit must present a technical basis for the appeal and prove that at least some part of the permit reflects arbitrary or capricious decision-making by the Department. Therefore, successful appeals are not likely but could be time-consuming.

The decision regarding on-site or off-site hydrolysate treatment would be reflected in the upcoming Stage 3 permit application, which is expected in September.

CDPHE has recently experienced delays in gaining access to information on the PCAPP design, which appears to be connected to operational security reviews. The perception is that when design work for PCAPP was stopped, CDPHE was left out of the process. When design work resumed, CDPHE was no longer provided all design information. Design documents are not readily available due to operational security issues. CDPHE is concerned that ACWA/Army operational security delays in providing information may translate into permitting delays. CDPHE permitting files are open to the public, so operational security restrictions could potentially cause problems if not resolved.

CDPHE does not believe that any additional time required to process the Stage 3 permit would necessarily translate into overall schedule delays as long as the application with sufficient information is submitted on time, and because the RD&D permit should be completed before construction of major buildings is scheduled to start. There is a reasonable time gap between issuance of the Stages 1 and 2 permit modifications and any approval of the Stage 3 permit modification.

CDPHE will need to understand decisions and contingencies related to hydrolysate treatment before the Stage 3 permit can be issued. The permit cannot be issued if CDPHE does not know how the hydrolysate will be handled. The plan for treatment of the hydrolysate must be presented in the Stage 3 permit application; permit modifications can be requested if this plan changes. On-site storage of hydrolysate would be restricted to one year; if it turns out that after the plant is constructed and there was no workable destination for the hydrolysate, CDPHE may restrict operation of PCAPP. One possibility could include operation of PCAPP with a pilot-scale bio-treatment operation (at a capacity much less than that which might be required on a full-scale production basis) in order to identify any technical concerns and risks that may be associated with full-scale operations.

Changing the hydrolysate treatment method after a permit was issued would more than likely require a class 3 modification, with 60 days allowed for public comment when the modification is received, and an additional 45 days (which could be extended) allowed for public comment when the draft permit decision is completed.

CDPHE has not yet received adequate data to fully address public health and safety issues related to mustard hydrolysate. There is insufficient characterization of the hydrolysate from munitions at Pueblo, although CDPHE is trying to obtain data on mustard hydrolysate from the Aberdeen Chemical Agent Disposal Facility. CDPHE will evaluate the hydrolysate on the

technical information that supports its characterization and would consider the corrosive hydrolysate to be relatively free of agent if adequate data are provided that demonstrate destruction of the agent, including sulfonium ions and other vesicant species that may be present in the heels of the mustard agent projectiles and mortars.

CDPHE indicated that delisting hydrolysate might not be possible because the hydrolysate will likely retain the toxicity characteristic due to metal contamination. This issue is pending receipt and analysis of data on the hydrolysate composition. This is important because delisting can only apply to the entire waste stream.

If biotreatment is performed at PCAPP, CDPHE is willing to work with Pueblo Chemical Depot to facilitate endpoint disposal of biotreatment effluent. Under the land disposal restrictions (LDR) standards, there is some flexibility for biomass disposal, which could occur at hazardous waste landfills in Colorado.

The amount of hydrolysate that could be accumulated on-site depends on the permit from CDPHE, but would in any event be restricted to a year of storage prior to final disposal. Violations of this LDR storage prohibition could result in fines of up to $25,000 per violation per day. It does not appear that such fines would be waived if violations resulted from interruptions in the ability to transport or treat hydrolysate off-site.

Water reuse and other issues connected to off-site hydrolysate treatment could cause protests from the public during the CDPHE permitting process.

There is an EPA mandate under RCRA for waste minimization, which is considered in the permitting process; this is generally encouraged, however enforcement cases involving waste minimization are rare.

CDPHE predicted that based on past experience, there could be delays in permit decision issuance if they are not involved in early design reviews.

Finally, CDPHE noted that storage of hydrolysate for extended periods would trigger Colorado waste volume fees of $6.75/ton/year.

A.1.5 Summary of a Meeting with Senate Staff Member

After Mitretek's introduction, the staff member reported that Sen. Salazar's office has received public comments that are overwhelmingly against the off-site treatment of hydrolysate from PCAPP, and that public opinion is strongly opposed to transporting the material off-site. She also noted that the deep-well injection option for waste disposal might present a problem particularly in Colorado because of public perception of a risk of ground water contamination.

The staff member suggested that public safety and a respectful view of the community are more important considerations than cost and schedule. Schedule slippage at PCAPP due to objections by communities along the route over which hydrolysate would be transported is a particular concern. Support from the destination community may not translate to support in Pueblo.

The staff member stated that transport by rail has economic and safety implications. Freight is very important to the State of Colorado. Shutdown of the rail system because of an accident

associated with hydrolysate shipment could have serious impact on the state's economy. She noted that rail westbound from Pueblo is a significant concern. Rail access to the west runs along the Arkansas River, which is a major water source, recreation area, and road corridor. Accidents in that corridor would have a devastating impact on Colorado.

The staff member indicated that any study justifying off-site hydrolysate treatment would need to show a tremendous cost savings and to include the costs associated with litigation, which she considered likely.

The staff member suggested that truck transport might be slightly favored over rail transport for some of the reasons discussed previously, but indicated that either mode is subject to large concerns. She concluded by adding that quality of water issues are very important in Colorado.

A.2 Summary of Meetings with BGCAPP Stakeholders

On 2-4 May 2006, members of the Mitretek project team met with local citizens, members of the Kentucky Chemical Destruction Community Advisory Board (CDCAB), local government officials, and regulators from the Kentucky Department for Environmental Protection (KDEP). This section provides summaries of the concerns raised by these groups.

In each meeting, Mitretek began the meeting by reviewing the nature of its task with PM ACWA and a summary of its corporate characteristics relating to independence. Mitretek reiterated its desire to gather information on stakeholder concerns and how they impact the decision-making process, and with whom it would be speaking during our trip to Colorado. Mitretek then asked for the group's opinions on the pursuit of shipping agent hydrolysate from BGCAPP to a properly permitted treatment facility elsewhere if safe destruction of the chemical stockpile could be accomplished sooner and at a greater savings to the taxpayer. The sections that follow summarize these discussions.

A.2.1 Summary of Meetings with Local Citizens

This section summarizes two meetings with local citizens.

After Mitretek's introduction, a local citizen stated that he would like to know what element of risk is associated with off-site shipment. He added that he would prefer to see both cost savings and schedule savings before he approved the concept rather than cost or schedule savings alone. He also advocated comparing the cost savings with the sustainable economic benefit to the region. The citizen indicated that potential economic development after BGCAPP completes its mission is more significant because it will have a lasting impact.

The logistics of shipping concern the citizen; he is worried that the apparent savings would not be tangible once the logistics are formalized.

The citizen stated that a great deal of planning has taken place based on the decision to include SCWO in the design. A reversal of the decision to include SCWO would have an adverse impact on public trust. In addition, it would require altering community plans for worker training programs, which have a long lead time, because it alters the mix of skills required for the work force. The citizen pointed out that the chambers of commerce for Madison County, Berea, and

Richmond were working cooperatively, under a joint committee on economic development, looking at impacts a decade from now.

The citizen suggested that the public does not distinguish between elements of the government. He argued that for a significant proportion of the population, a core distrust of any governmental entity would make convincing the public a difficult, resource-intensive task. The citizen predicted that the issue would become very emotional, and that polarization could set in quickly. He added that the debate could become irrational if rumors began to spread that hydrolysate transportation was unsafe; he compared it to the issue of nuclear generation of electricity.

The citizen stated that he would view reports of tolerance for receiving hydrolysate at the destination with skepticism. Active opposition in the destination community would lead him to oppose shipment of hydrolysate. This factor is more significant than the savings in time and money. He added that this factor is more significant than either cost or schedule savings; he would be more willing to consider off-site hydrolysate shipment if it were tolerated at the destination.

After Mitretek's introduction, a local citizen asked about the composition of hydrolysate, and there was some discussion about hydrolysate as the product of the "neutralization" portion of the "neutralization-SCWO" process.

Another citizen compared the risk of transporting nerve agent to ordinary traffic risks, and offered several examples of past handling practices. The citizen discussed his historical perspective on weapons destruction by providing examples of his 40 year career. He noted that no one has ever been killed during that period, and that the Depot had no accidents for over 50 years. The citizen advocated transporting the rockets to one of the existing incinerators. He stated that he would agree with moving hydrolysate, but noted that incineration would not require generating hydrolysate.

Another citizen suggested thinking about hydrolysate in the context of other hazardous materials moving around the U.S. in large quantities. He would like to see a new approach to this issue in general. He stated that there is skepticism towards information from official sources, and that it is difficult for citizens to make distinctions between different government agencies. He suggested that CDCAB is an appropriate venue for discussion of these issues.

Another citizen agreed that more hazardous chemicals were on the road than hydrolysate, and that he would not have real problems with hydrolysate shipments.

Another citizen said the he would depend on the Army to do its job.

Another citizen argued that Blue Grass was 35 years behind other depots in destroying nerve agent weapons. He added that the munitions have to be moved even to send them from the chemical activity to BGCAPP. He stated that his first choice was to ship weapons from Blue Grass to Anniston, his second choice was to build an incinerator at Blue Grass, and his third choice was to ship hydrolysate off-site to save time and money. The citizen concluded that it was time to do something, noting the increasing frequency of leakers.

Another citizen stated that it was most important to follow safety rules. He was concerned that private shipping firms might not follow safety rules as closely as would the Army.

Another citizen suggested that the ACWA Dialogue and CDCAB processes would be the best structure to resolve these issues, because the public can see what the debate is about. He added that this helps the public develop an informed position.

Another citizen said that BGCAPP provides an opportunity to demonstrate a new waste disposal strategy by bringing the disposal technology to the waste generation site. He advocated reducing the need to transport wastes in general.

Another citizen argued that SCWO was a bad way to approach the process of waste destruction. He cited a National Research Council report that appears to be questioning the effectiveness of the SCWO process.

A.2.2 Summary of a Meeting with Members of the Kentucky Chemical Destruction Community Advisory Board

This section summarizes two meetings with representatives of the Kentucky Chemical Destruction Community Advisory Board (CDCAB).

After Mitretek's introduction, a CDCAB member stated that public perception was a significant issue leading him to oppose hydrolysate shipment off-site. He noted that having 5 to 6 placarded tankers daily caused the public to perceive that this was an undesirable option. The member said that PM ACWA has significant public trust now, adding that public sentiment was that PM ACWA should "do it right" and not take chances with off-site shipment of hydrolysate.

Another CDCAB member said that the public had rallied around the 2003 decision and is ready to support execution of the neutralization-SCWO package. He stated that changing a major component part of the package by shipping hydrolysate for off-site treatment would undermine public confidence in the Army, which might cause problems for execution of the entire package.

Another CDCAB member posed the question of whether or not the public understands hydrolysate enough to think of it as a minor waste product or as a major part of the process. Another CDCAB member responded that he believed the public would regard it as a major part of the process, citing the difficulty in finding a disposal site for the VX hydrolysate currently being generated in Indiana. He added that the Governor of New Jersey had recently been quoted as opposing shipment of hydrolysate to New Jersey, and that similar difficulties were likely to be encountered with hydrolysate potentially being shipped from BGCAPP. He noted that decisions made now concerning hydrolysate shipment could potentially be impacted by other developments over an 8-year period.

Another CDCAB member asked whether hydrolysate was a known quantity. Another CDCAB member stated that it was not completely known, citing some characterizations of hydrolysate that did not account for all the substances present. The member also pointed out that trust issues extended beyond the chemical demilitarization mission, and would impact public acceptance of future missions at the Blue Grass Army Depot.

Another CDCAB member cited some of the cost savings figures from the Design Consideration (DC) 34 study, and noted that we are speculating about costs up to 10 years in the future. He stated that the process in Kentucky is known if followed including SCWO, but that the

alternatives are full of unknowns. If the Army moves through the process as agreed upon, there will be more confidence that the hydrolysate will be destroyed.

Another CDCAB member asked whether there were other justifications for off-site shipment of hydrolysate besides cost.

Another CDCAB member stated that schedule is cited as a potential justification, but that the schedule could be adversely affected. He noted that he worried about the hazards of prolonged storage of hydrolysate and about dealing with potential accidents and emergency management. He asserted that public perception is largely based on the origin of the hydrolysate with chemical agents, and does not respond to scientific assessments of the hazard posed by hydrolysate. The community will be viewed as "lousy" neighbors for sending hydrolysate for treatment somewhere else.

Another CDCAB member said that the CDCAB has brought together many diverse constituencies. Off-site shipment of hydrolysate could potentially damage the relationships between these constituencies. Another CDCAB member added that 20 different jurisdictions were cooperating, and the first CDCAB member noted that there were good relations between local officials and state regulators on demilitarization issues.

Another CDCAB member asked if a story appeared that off-site hydrolysate transportation would result in a huge savings, how would it be countered and what would be the effect. Another CDCAB member suggested that taxpayer savings to the federal government doesn't make much of an impact on the local level.

Another CDCAB member discussed the safety factor, and asked what might happen if the public is told that it would be safer to send hydrolysate off-site for treatment. Another CDCAB member used the Indiana situation as a comparison. He argued that people along the transportation route and at the treatment site would probably resist off-site treatment of hydrolysate. He added that regardless of the scientific studies performed to address safety concerns, people would still be doubtful that everything is known about hydrolysate. Another CDCAB member noted that there is not much that local governments could do to prevent shipment of the hydrolysate. Another CDCAB member stated that the scientific issues may change between now and when the hydrolysate would be shipped. He asserted that he did not want BGCAPP to be "held hostage" by some other jurisdiction.

Another CDCAB member noted that if hydrolysate is not treated on-site, it does not affect the Kentucky permitting process.

Another CDCAB member said that the unknowns related to off-site shipment of hydrolysate appear to outweigh what is known.

Another CDCAB member pointed out that Kentucky is unique because of the ongoing Blue Grass Army Depot (BGAD) mission. He noted that many believe that the SCWO units built for BGCAPP could develop into a safer destruction technology for conventional munitions. After noting the challenge in determining this value, he added that it will also be challenging to quantify costs associated with waste disposal 8-10 years from now.

Another CDCAB member asked whether there would be an issue related to loss of revenue from off-site shipment of hydrolysate. Another CDCAB member stated that he was more worried

by potential safety issues, noting the potential that BGAD could end up storing millions of gallons of hydrolysate in proximity to areas where open detonations are conducted routinely.

Another CDCAB member discussed sustainable economic development issues at BGAD. He noted that it is a strong part of the local economy. The member added that in performing outreach to gain acceptance of neutralization and SCWO, a grass-roots awareness of issues related to shipment of weapons and funding had been created in the area. He noted that there would likely be questions from the public even if it is hydrolysate rather than rockets being transported. He pointed out that there was a large grass-roots constituency interested in these issues.

In response to a follow-up question on views of the Aberdeen Chemical Agent Disposal Facility (ABCDF), a CDCAB member argued that ABCDF experienced some schedule slippage. He also questioned the relevance of ABCDF to BGCAPP because Aberdeen processed only mustard agent, but not nerve agent.

Another CDCAB member added that the activist community and politicians had not been as attuned to the ABCDF issues. He noted that mustard hydrolysate was not as sensitive an issue as the nerve agent hydrolysates, that the distances involved were relatively short, and that the regulatory regime under which ABCDF hydrolysate was treated did not require any public hearings. He stated that ABCDF was "under the radar," but that after Newport, that would not have been the case.

Another CDCAB member stated that shipments of hazardous liquid wastes are a particular concern, but that he did not believe the public to be as concerned about solid waste shipments. The member added that people understand that there are no legal alternatives to shipping solids off-site.

Another CDCAB member informed Mitretek that the Kentucky River is a source of drinking water for several million people, so any spill that could flow into the Kentucky River is a concern. He shared an experience in which a spill of a food ingredient triggered a hazmat-like response because of its proximity to the river.

Another CDCAB member asserted his belief that no legitimate case could be made for schedule and cost savings could be defended to the public because of the many variables involved. The longer the process keeps going, the costlier it becomes. Another CDCAB member noted that the requirement to forecast cost so many years in advance adds significant uncertainty.

Another CDCAB member stated that the community receiving hydrolysate is a particular challenge on the heels of the Newport experience, and that transportation routes are also a challenge. He said there was a high probability of controversy, even if extensive public outreach incorporating lessons learned from Newport were conducted.

Another CDCAB member speculated on the impact of gasoline prices of up to $5 per gallon on the cost savings.

Another CDCAB member asserted that environmental groups along the transportation route were likely to object, and that towns along the route would request assistance from PM ACWA to improve their hazardous materials response capabilities.

Another CDCAB member indicated that because it is perceived as simply another federal agency along with the Army, the Centers for Disease Control and Prevention would not be perceived as providing an independent third party for safety assessments. He suggested that the perception of independence would require community input into the selection of an expert panel from both inside and outside the government. Another CDCAB member added that a third party opinion on safety still does not address public views and political opinion on the issue.

Another CDCAB member continued that some views depend on the hydrolysate treatment option selected, although environmental justice issues might be a bigger concern than the specific technology. Another CDCAB member indicated that the technology selected did not to a large degree affect his views.

Another CDCAB member also raised the issue of how increasing chemical security prohibitions would affect hydrolysate treatment, noting that transportation of hazardous material is becoming increasingly difficult by both highways and rail. He added that the regulatory environment appears to be changing, and questioned whether it is possible to know what could be shipped where in 8-10 years.

The member then stated that jobs are an issue for some in the community. He said that some in the community believed that having lived with chemical weapons for nearly 60 years, the BGAD area had earned the right to receive some of the economic benefits now that the weapons were to be destroyed.

Another CDCAB member added that the job skills created by BGCAPP, in particular the SCWO, are transferable and will be useful to the community in the future.

Another CDCAB member reiterated that the community will feel betrayed should a decision to treat hydrolysates off-site be made. He further noted that the argument that this option is safer cannot be rationalized.

After Mitretek's introduction, a CDCAB member noted that time was equivalent to money, so that delays would increase costs. From a social and political standpoint, transportation seemed likely to cause controversy which would slow the process. She stated that she was reluctant to shift BGCAPP's problems to someone else, and predicted that citizens in Kentucky, the receiving communities, and along transportation routes will get involved, which would result in delays. The member argued that stakeholders did not want to see BGCAPP in the same situation as the Newport facility.

The member stated that from an engineering and permitting standpoint, off-site hydrolysate treatment might be feasible, but that political and social issues would result in delay. She added that there were also environmental justice issues, and that any potential cost savings would likely be consumed in responding to public concerns along the transportation route.

Another CDCAB member stated that he also feared that BGCAPP could find itself in the same situation as the Newport facility, with a completed facility but no place to send the hydrolysate. He asserted that although the Aberdeen Chemical Agent Disposal Facility was able to treat hydrolysate off-site, it processed only mustard whereas BGCAPP will have to process other agents and some energetics. Another CDCAB member noted that the state of New Jersey had recently renewed the permit for the DuPont facility with a prohibition against treating agent

hydrolysate. Another CDCAB member added that Maryland was closer to the DuPont facility than BGCAPP is to any treatment storage and disposal facility. The member also stressed that the risk of having no place to send the hydrolysate may not be apparent until BGCAPP is otherwise complete.

Another CDCAB member pointed out that SCWO was chosen as the environmentally preferred and safer method of treating hydrolysate, based on an extensive assessment of disposal options which were considered by citizens of Central Kentucky. This was a big piece of the technology decision, and sending hydrolysate off-site for treatment would be analogous to choosing technology anew. She suggested that the general public might not be widely aware that this issue is being reconsidered, because most people think the decision has been made and that, other than funding, the process is proceeding as planned.

Another CDCAB member stated that some people will approve of schedule and cost savings but that some would want to keep the jobs in the community. Another CDCAB member added that the use of SCWO for future conventional demilitarization missions at BGAD is viewed positively by some.

Another CDCAB member argued that he did not want to see hydrolysate disposed of by deep-well injection, because it does not treat the material. Another CDCAB member concurred, noting that citizens had rejected both incineration and deep-well injection as environmentally unacceptable methods, with an added risk of project delays and accidents during transport.

Another CDCAB member stated there is a coalition of stakeholders (both national and international) that agreed, fairly early on, that they would not promote shipping of these chemical weapons/wastes to other communities. The environmental justice and equity concerns of this coalition of local stakeholders are as important as their safety concerns.

Another CDCAB member stated that off-site shipment of hydrolysate posed an element of "backing out" by the Army. He added that he had questions about whether hydrolysate might degrade the environment. He also pointed out that it takes only a single community elsewhere to raise objections and this could result in a significant delay to the project. Another CDCAB member noted that local communities have adopted ordinances prohibiting transportation of chemical weapons, and that other communities could adopt similar ordinances related to hydrolysate.

Another CDCAB member argued that he would not want to see a plant built on the assumption that everything will go smoothly. He added that if problems developed around transportation, the community would be left with an incomplete solution.

Another CDCAB member believes that the general public perception will not be affected by probability-based studies such as those likely to be produced by the Centers for Disease Control and Prevention. They will accept the recommendation only if such a study can unequivocally say that there is no risk of an accident during transportation. Another CDCAB member noted that studies would also have to convince communities along the transportation route. Another CDCAB member added that the costs of meeting public information needs along the transportation route could use up much of the projected cost savings.

Another CDCAB member said ACWA has spent much time and effort to build public trust, but could jeopardize it over this issue. Another CDCAB member added that informed citizen participation has been a part of the ACWA program, and that most informed citizens in Kentucky oppose off-site shipment of hydrolysate. She continued that more equitable options where the hydrolysate was not treated in locations near underprivileged populations could possibly change her mind about this issue. Another CDCAB member noted that if every town along the transportation route is on board, he might change his mind on the issue.

The CDCAB member summarized the issues as follows:

- Trust; change could threaten the trust in the community for PM ACWA
- Politics along the transportation route, where one community could affect the process; Newport is an example—having a tank farm is the worst possible outcome
- Environmental impact—if the hydrolysate is treated on-site, the community is better able to keep an eye on things
- Jobs and equity issues are less significant to the CDCAB member, but still important

A.2.3 Summary of a Meeting with Local Officials

This section summarizes three meetings with officials from Madison and Estill Counties.

After Mitretek's introduction, a local official stated that the issue had received little press coverage in Estill County. A local Mayor indicated that he was not hearing much from his constituents concerning off-site hydrolysate shipment. A local official added that no one from Estill County served on the Citizen's Advisory Commission or on the Chemical Demilitarization Community Advisory Board, which has lessened the visibility of this issue in the county, although they have requested that the County Judge-Executive be a member of the CDCAB. A local official indicated that he cannot speak for the views of the residents in Estill County because very few know that off-site treatment of the hydrolysate is being considered. There has been no formal outreach from the Army informing them about this possible action.

When asked what information might be considered credible to establish the safety of alternative processes, the County Judge-Executive indicated his belief that non-Army government sources such as the Centers for Disease Control and Prevention would not be considered sufficiently independent of the Army to provide credibility with the public.

The County Judge-Executive stated that public safety is his biggest concern, and that he worries about potential accidents that could result in hydrolysate spills into the Kentucky River, which provides drinking water for many in central Kentucky. He added that the roads in Estill County are narrow and many have tight curves, making it difficult to accommodate large trucks.

A local official pointed out the importance of emergency responders being notified of hazardous waste shipments via established channels. He asked about the frequency of hydrolysate shipments in the off-site treatment alternative and the categorization of hydrolysate for emergency response planning. He noted that Estill County had mutual aid agreements with many of the counties closer to Interstate 75, so that even if hydrolysate did not pass through Estill County, he would still be interested in these issues.

A local Mayor asked how soon shipments of hydrolysate would start once weapons destruction begins; the hydrolysate storage capacity in the current design was discussed.

A local official suggested that some of the potential savings might not be realized, but instead be required to meet additional emergency preparedness requirements and to work out emergency response plans in the event that hydrolysate is transported.

The County Judge-Executive asked whether the impact of off-site treatment of hydrolysate on employment at BGCAPP was known, pointing out that this has some economic impact in Estill County.

A local official reported that Estill County has a hazmat ordinance that deals with spills, but not with transportation of hazardous materials through the county. He added that the county will likely review environmental permit applications and may submit comments to the state if warranted.

A local official suggested that there will be some people in Estill County who will be concerned as a result of learning about the potential for off-site treatment, and that there is a group of citizens who have been educated about demilitarization issues but are not yet aware of this potential. He added that people are aware of the process at the incineration versus neutralization level, but have not yet focused on issues such as how hydrolysate is going to be transported.

The group agreed that off-site transportation of hydrolysate does not appear to be a significant issue for Estill County citizens because of the low probability that shipments will come through the county. They did see a need for continued public outreach in Estill County to educate more people about this issue, as well as other issues affecting the status of the project. The group also indicated that they would support Madison County with whatever decisions they would make on these issues. Furthermore, they emphasized that even if there is no opposition now, should an accident occur outside of the plant (as a result of hydrolysate shipment), there will be a significant protest from Estill residents.

After Mitretek's introduction, a Berea City Council member stated that there was a Berea city ordinance requiring permits to transport hazardous waste within the city that could potential impact off-site treatment. He noted that the ordinance had originally been enacted to regulate transport of chemical agent, but that it could apply to hydrolysate.

When asked about general issues concerning off-site treatment of hydrolysate, the City Council member indicated that his basic question revolved around the issue of how safe was the hydrolysate. He noted that hydrolysate was a liquid with the potential to spill and to be mobile in the environment, and asked about the environmental impacts. He stated that the public would need to be educated about the safety issues and environmental impacts of hydrolysate. He noted that people in the community have been scared about transportation of nerve gas, and the perception is that the hydrolysate is just as bad. The education process must be done in such a way that allows people to understand and appreciate the savings in time and money.

The City Council member continued that whether the destination wants the hydrolysate and whether it can be safely transported are also important issues. He asserted his belief that if these concerns could be allayed, that people would probably accept off-site treatment of hydrolysate if

it resulted in cost and schedule savings. Nevertheless, current public sentiment is to treat the hydrolysate at BGCAPP.

The City Council member also reported that local citizens were concerned that an off-site facility might be willing to cut corners rather than dispose of hydrolysate responsibly.

The City Council member noted that there was some hesitation about trusting the military on this issue. He stated that agencies like the Centers for Disease Control and Prevention would be considered more believable than the Army. He added that citizens would probably not accept any official position at face value because they have been misled before, and that even local government positions might not be accepted. For a third party cost evaluation, he suggested that the Government Accountability Office (GAO) might be accepted as independent of the Army.

The City Council member noted that some citizens were looking for jobs and financial impacts of hydrolysate treatment as an important consideration.

The City Council member stated that safety of transportation was a paramount consideration, citing the dangers in the event of an accident. He believes that rail is perceived as less safe than highway transportation and also as cheaper, but that perceptions could be changed by suitable safety analyses. Safety should be a more important consideration than cost, and should be assessed by independent parties.

The City Council member reported that PM ACWA and Bechtel Parsons Blue Grass have a good reputation in the community, but that off-site hydrolysate treatment would be a "tough sell" even if it were perceived as less costly because of the widespread desire to treat it on-site.

The City Council member noted that there are already going to be hazardous waste streams being transported from the site, and wondered how the number of truckloads of hydrolysate that would be transported off-site compared to the number of truckloads of other hazardous wastes that would be generated if hydrolysate were treated on-site, *i.e.*, whether shipping hydrolysate might actually generate fewer truckloads of waste from BGCAPP.

The City Council member concluded that he could accept off-site transportation of hydrolysate if the safety issue could be explained and if he could be assured that BGCAPP would not end up having to store hydrolysate with no treatment facility available. He noted that many people were reluctant to "ship their problems to someone else."

After Mitretek's introduction and a discussion of the composition of hydrolysate and the hazards it poses, a local official raised issues of hazmat response, noting that local first responders generally set up a perimeter and let hazardous materials specialists direct any clean-up. His question concerns how long the response time would be and who would respond in the event of a spill. He suggested that these issues should be addressed as provisions in any hazardous waste disposal contract.

Another local official asked whether hydrolysate would require any specialized response.

Another local official asked whether it was even guaranteed that the hydrolysate could be shipped to an off-site destination. Another local official added that he feared that BGCAPP could end up as a perpetual storage site for millions of gallons of contaminated waste water.

Another local official discussed road versus rail transport. He pointed out that both modes of transportation go through both Berea and Richmond. Several in the group pointed out that local ordinances restricted the transportation of munitions, and suggested checking the language to ensure it does not apply to hydrolysate.

Another local official highlighted the need for emergency response guidelines to cover hydrolysate if it is shipped.

Another local official said that he worries about the effects of a spill on ground water as well as surface water. Another local official noted that hydrolysate did not seem in that regard to be much worse than materials already being transported over the road.

Another local official stated that it is good that local emergency officials will know about the consequences of hydrolysate accidents, but he worried that others in more distant communities would not have the same level of knowledge.

Another local official stated that updating the emergency response plan would require several months. The Madison County Judge-Executive needs to approve the plan before BGCAPP can begin operations.

Another local official noted that a four lane road was being built between the depot and the interstate. He stated his preference for hazardous waste trucks to travel as directly as possible to the interstate rather than using some of the smaller local roads.

A.2.4 Summary of Meeting with the Kentucky Department for Environmental Protection

After an introduction, Mitretek then requested that KDEP review the status of the state environmental permits for BGCAPP and provide the anticipated schedule for future permitting actions. KDEP indicated that BGCAPP currently had a Clean Air Act (CAA) Air Permit and a Resource Conservation and Recovery Act (RCRA) Research, Development and Demonstration (RD&D) Permit. BGAD has a RCRA part B permit for storage of hazardous waste including chemical munitions. Several Hazardous Waste Management Units, such as OB/OD are still on "interim status". The Air Permit will require modification. The RCRA Part B permit will be modified to include BGCAPP. The RD&D permit includes a compliance schedule, which requires information to be submitted to KDEP according to a schedule that will allow for modification of the Part B permit.

KDEP indicated that standard Part B permit review process takes roughly 2 years. However, KDEP has staff dedicated to BGCAPP (1 engineer, 1 inspector, 1 administrative, 1 geologist with another engineer position open), so the BGCAPP review is expected to proceed more quickly. The public review process generally requires 3-4 months. There is a 45 day period for public comments; the balance of the time is required for preparation and response to comments. KDEP will also schedule a public hearing for BGCAPP during the comment period. Permits are issued but do not become effective for 30 days to allow challenges. Challenges begin with an internal administrative hearing and, in some cases, mediation. The administrative hearing decision is then reviewed by the Secretary of the Environmental and Public Protection Cabinet. This process can take a year or longer. If the decision is not satisfactory to the challenger, the parties can appeal to the State Circuit Court. All permit conditions are in effect when the permit

is issued, even if certain conditions are challenged. Frequently, both parties will agree to a stay of the condition being challenged.

If the decision is made to ship hydrolysate off-site for treatment, KDEP may re-examine whether the RD&D permit is the appropriate approach for BGCAPP's RCRA permit. In the RD&D application, BGCAPP made several arguments to justify this approach. The integration of the SCWO process with neutralization is one of strongest justifications for the RD&D approach, and will no longer apply if hydrolysate is shipped off-site. Other justifications that no longer apply include demonstrating integration of the dunnage handling and shredding operation and the heated discharge conveyor. The metal parts treater, rocket separation, and development of GB neutralization remain from the original application. BGCAPP would probably need to re-file the RD&D application and it would be evaluated in light of all the design changes. In addition, if the state determines that the RD&D approach is no longer appropriate, it has the option to reopen the permit for cause. KDEP is trying to stay ahead of the issues with BGCAPP, so it is unlikely that it would get to the point of reopening the permit for cause; it would be somewhat less disruptive for BGCAPP to resubmit its application. If the RD&D permit is determined to be inappropriate, it would require that construction activities stop until a Part B permit could be issued. The potential for delay is the time required for Bechtel Parsons Blue Grass to complete the package of information required to support a full Part B application, and the time for KDEP to review the information in the application. Subsequent to the meeting, KDEP indicated in an e-mail message that if SCWO is dropped from the BGCAPP process, BGCAPP will "probably lose justification for a RD&D permit" and that the delay could be 3 or more years.

Off-site shipment of hydrolysate for treatment could require an amendment to the EIS. A completed EIS is required for a permit to be issued, but KDEP does not have oversight of the EIS process.

KDEP will require that BGCAPP have a contract, with treatment storage and disposal facilities (TSDF) to receive all secondary hazardous wastes generated, including hydrolysate, before BGCAPP could start operating. KDEP will also require reasonable assurance that the TSDFs will be able to overcome potential public opposition. KDEP requires the contract information one month in advance to allow the public time to respond. If waste disposal contracting is not complete, KDEP will not issue the letter that is required to begin sending munitions to BGCAPP; this letter is a requirement before operations can begin.

KDEP indicated that hydrolysate is considered a listed waste (chemical agent codes), based on the "derived from rule". It will have the specific Kentucky-waste codes for chemical agents. Delisting the hydrolysate is very difficult because it would have to be approved by a legislative committee (the legislature has review oversight over all state regulations in Kentucky).

Kentucky statutes require that the Madison County Judge-Executive certify that the infrastructure improvements identified in the Emergency Response Plan are complete, and that the Community Liaison position is filled before receipt of hazardous waste ("host community certification"). Kentucky statutes also require the Kentucky Emergency Management provide certification that there has been resolution of any critical shortcomings in the Emergency Response Plan before receipt of hazardous waste.

KDEP indicated that the air permit changes required in the event that hydrolysate was shipped off-site for treatment would have less of an impact than the RCRA permit changes. The air permit would have to be modified to reflect the loss of SCWO off-gas emissions and perhaps the increase in fugitive emissions from the truck loading rack.

Finally, KDEP stated that waste minimization applies to the Blue Grass Army Depot as a whole. Therefore, KDEP does not expect that changes to a single operation, *i.e.*, BGCAPP within the facility would adversely affect any waste minimization requirements. They also added that, even without the SCWO, there may be sufficient justification for an RD&D permit because the process of neutralizing GB has not been demonstrated on a commercial scale. Having said this, the justification provided as basis for issuance of the current permit will still need to be modified. However, as previously noted, KDEP indicated in a subsequent e-mail message that if SCWO is dropped from the BGCAPP process, BGCAPP will probably lose justification for a RD&D permit.

A.2.5 Summary of Meetings with Congressional Staff Member

After Mitretek's introduction, the staff member began by noting that Rep. Chandler was relatively new to Congress. Rep. Chandler had been more involved in BGCAPP funding issues, adding that he relies on others for information on questions of a technical nature. The Congressman's office has heard some sentiment from constituents against taking anything out of the Depot, although the staff member believes that much of that sentiment stems from the experience of the 1980s when moving chemical munitions was considered. The office has also heard from a segment of the community that favors abandoning neutralization in favor of incineration.

The staff member stated that there was so much citizen participation on the local level that there was not a strong driver for constituents to involve their representative. He noted that the office did get a lot of feedback from constituents when the BGCAPP funding issue arose, resulting in the Congressman's continuing involvement in BGCAPP funding. Congressman Chandler is cooperating with Senator McConnell's office in addressing the issue.

The staff member indicated his belief that the Centers for Disease Control and Prevention (CDC) would be considered a credible source of information within Madison County because citizens there seem to be following BGCAPP-related issues, but that transport involves other communities where CDC might be viewed with more skepticism. He added that off-site transportation of hydrolysate would run into political difficulties, and would be a "harder sell" outside Madison County. He stated that if people are not convinced from the outset that hydrolysate transportation is extremely safe, it would run into problems. He suggested that the Army would need to start with outreach to Madison County, and that acceptance by Madison County residents would help in reaching people in other areas.

The staff member said that he considered safety the number one issue, and that lack of trust in government factors into the mix.

Rep. Chandler has a very strong environmental record, and draws a lot of support from this issue. The staff member suggested that if the area receiving the hydrolysate shipments expressed opposition, the Congressman would be inclined to support the receiving area's concerns.

The staff member indicated that summaries of findings and basic explanations of the risks involved would be necessary to convince people of the safety of any option. He argued that opposition and concern often arise out of a lack of understanding. The discussion with the public needs to be at a level that is easily understood; much of the discussion so far has been too complicated. The staff member suggested breaking information down into components that people can easily understand. The staff member added that many people feel they do not need to know the details, but can rely on people they trust who do understand the issues.

The staff member suggested that some of the public opposition to hydrolysate transportation is a result of the BGCAPP funding freeze, which reawakened the issue of trust in the Army as well as increasing some fears. Trust was shaken when people discovered that the process was still subject to change. He believes that many people assume that the need to reduce cost will lead to a reduction in safety. The staff member indicated that there is a general uneasiness that citizens are faced with a choice between accepting more risk than they anticipated (less safe) or accepting more delays, and that increased risk is being thrust upon the community, with citizens losing control of their own safety.

Definition of Selected Terms and Acronyms

Numerical

°C	Degrees Celsius
°F	Degrees Fahrenheit

A

ABCDF	Aberdeen Chemical Agent Disposal Facility
ACWA	Assembled Chemical Weapons Alternatives Program
AFS	Aluminum Filtration System
ANS	Agent Neutralization System
APB	Agent Processing Building
APS	Aluminum Precipitation System
artillery shell	a projectile fired by machinery moved equipment: consists of 105-mm M60 & M360; 155-mm M104, M110, M121, & M121A1; 8-inch M426 munitions

B

BDF	Binary Destruction Facility
BGAD	Blue Grass Army Depot
BGCAPP	Blue Grass Chemical Agent-Destruction Pilot Plant
BNI	Bechtel National, Inc.
BPBG	Bechtel Parsons Blue Grass
BRAC	Base Realignment and Closure
BRS	Brine Reduction System
BTA	biotreatment area

C

CAA	Clean Air Act
CAC	Colorado Chemical Demilitarization Citizens' Advisory Commission
CD	Certificate of Designation
CDC	Centers for Disease Control and Prevention
CDCAB	Kentucky Chemical Destruction Community Advisory Board
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CSB	Control & Support Building
CSEPP	Chemical Stockpile Emergency Preparedness Program
CWC	Chemical Weapons Convention

D

DAB	Defense Acquisition Board
DASD(CD&TR)	Office of the Deputy Assistant to the Secretary of Defense (Chemical Demilitarization and Threat Reduction
DC 34	Design Consideration 34
DIMP	diisopropyl methylphosphonate
DOD	Department of Defense

DOT.....U.S. Department of Transportation

E

EA2192.....*S*-[2-diisopropylaminoethyl] methylphosphonothioic acid
EBH.....Energetics Batch Hydrolyzer
EHSO.....Environment, Health and Safety Online
EIS.....Environmental Impact Statement
EMPA.....ethyl methylphosphonic acid
energetic.....A highly reactive chemical compound or composition typically relating to explosive materials.
EPA.....U. S. Environmental Protection Agency
EPB.....Energetics Processing Building
EPP.....emergency preparedness plan
ERB.....Enhanced Reconfiguration Building
explosive.....An energetic substance, compound, or formula that rapidly produces gas and heat upon decomposition.

F

FOUO.....For official use only

G

GAO.....Government Accountability Office
GB.....Sarin, a nerve agent; methylphosphonofluoridic acid, (1-methylethyl) ester

H

H.....Levinstein sulfur mustard, a blistering agent (vesicant); 1,1'-thiobis(2-chloroethane)
HD.....distilled sulfur mustard, a blistering agent (vesicant); 1,1'-thiobis(2-chloroethane)
HSWA.....Hazardous and Solid Waste Amendments
HT.....A 60:40 mixture of H and bis(2(2-chloroethylthio)ethyl) ether
HVAC.....Heating, ventilation, and cooling

I

ICB.....Immobilized Cell Bioreactor
ICS.....Integrated Control System
IMPA.....isopropyl methylphosphonic acid
IPT.....integrated process team

J

K

KDEP.....Kentucky Department of Environmental Protection

L

LCCE.....life cycle cost estimate
LD_{50}.....median lethal dose

M

M.....million

mg/L .....milligram per liter
MDB .....Munitions Demilitarization Building
mortar .....a projectile fired by manually-transportable equipment: consists of the 4.2-inch M2/M2A1 munition
MPA .....methylphosphonic acid
munition.....the components and process related materials present in a fully assembled chemical weapon.
MPT.....Metal Parts Treater
MWS.....Munitions Washout System

N

NaOH .....sodium hydroxide, a caustic
NECDF.....Newport Chemical Agent Disposal Facility
NJDEP.....New Jersey Department of Environmental Protection
NSCMP .....Non-Stockpile Chemical Materiel Project

O

OPCW .....Organisation for the Prohibition of Chemical Weapons
ORR.....Operational Readiness Review
OSD .....Office of the Secretary of Defense
OTS.....Offgas Treatment System

P

PCAPP .....Pueblo Chemical Agent-Destruction Pilot Plant
PCBs.....Polychlorinated biphenyls
PCD .....Pueblo Chemical Depot, Colorado
PCI.....Pollution Control Industries
PM ACWA.....Program Manager for Assembled Chemical Weapons Alternatives
psi.....pounds per square inch
ppb.....parts per billion
ppm. .....parts per million

Q

Q-OH.....2,2'-[1,2-ethanediylbis(thio)] bisethanol

R

RCRA.....Resource Conservation and Recovery Act
RCM.....Rocket Cutting Machine
RD&D.....Research, Development, and Demonstration
RRS.....Rapid Response System
RSM.....Rocket Shear Machine

S

SCWO .....Supercritical Water Oxidation
SDG .....Standby Diesel Generator
SPB .....SCWO Processing Building
SVOCs.....semi-volatile organic compounds

T

TDG.....2,2'-thiobisethanol, thiodiglycol

T-OH .....2,2'-[oxybis(2,1-ethanediylthio)] bisethanol
TSDF .....treatment, storage, and disposal facility

U

UB.....Utility building
UIC .....Underground Injection Control

V

VX.....a nerve agent (AKA, methylphosphonothioic acid): *S*-[2-[bis(1-methylethyl)amino]ethyl] *O*-ethyl ester
VX thiol.....diisopropylaminoethanethiol

W

WAO.....Wet Air Oxidation
WRS .....Water Recovery System

X

Y

Z