OFFICE OF INSPECTOR GENERAL

Catalyst for Improving the Environment

Ombudsman Report

Ombudsman Review of the Marjol Battery Site, Throop, Pennsylvania

Report No. 2004-P-00017

MAY 18, 2004

Report Contributors: Gary R. Greening
Stephen R. Schanamann

Abbreviations

EPA	Environmental Protection Agency
OIG	Office of Inspector General
PADEP	Pennsylvania Department of Environmental Protection
RCRA	Resource Conservation and Recovery Act

Cover photo: Aerial view of the Marjol Battery Site, courtesy of EPA Region 3.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
INSPECTOR GENERAL

May 18, 2004

MEMORANDUM

SUBJECT: Final Ombudsman Report:
Ombudsman Review of the Marjol Battery Site, Throop, Pennsylvania
Report No. 2004-P-00017

FROM: Paul D. McKechnie *Paul D. McKechnie*
Acting Ombudsman
Office of Inspector General

TO: Donald S. Welsh
Regional Administrator
Region 3

Attached is our final report regarding issues surrounding the Marjol Battery and Equipment Company Site, Throop, Pennsylvania. The subject Ombudsman review was conducted by the Office of Inspector General (OIG) of the U.S. Environmental Protection Agency (EPA). This report contains findings that the OIG has identified and corrective actions the OIG recommends. This report represents the opinion of the OIG and the findings contained in this report do not necessarily represent the final EPA position. Final determinations on matters in this report will be made by EPA managers in accordance with established audit resolution procedures.

Action Required

In accordance with EPA Manual 2750, you are required to provide a written response to this report within 90 calendar days of the final report date. The response should address the two recommendations. For corrective actions planned but not completed by the response date, please describe the actions that are ongoing and provide a timetable for completion. Reference to specific milestones for these actions will assist in deciding whether to close this report in our assignment tracking system. We have no objection to the further release of this report to the public. For your convenience, this report will be available at http://www.epa.gov/oig.

If you or your staff have any questions regarding this report, please contact me at (617) 918-1471 or Gary R. Greening at (202) 566-1504.

Background

Marjol Battery Site

The Marjol Battery and Equipment Company Site (the Site) is a former battery processing facility located at 600 Delaware Street on a 43.9-acre parcel in the Borough of Throop, Lackawanna County, Pennsylvania. From 1963 to1981, Marjol operations involved battery crushing, lead reclamation, and on-site disposal of spent battery casings. As a result of the plant operations, the ground surface at the Site became contaminated with lead. Fugitive dust emissions and lead in on-site soils were carried off-site by prevailing winds. Storm water runoff carried lead contaminated soil off-site into adjacent drainage ways. Sulphur Creek and the Lackawanna River, which border the Site, were also contaminated with lead. In May 1980, Gould, Inc. purchased the Site, and subsequently shut down plant operations in April 1982.

Prior to Site operations for lead recovery, the property was used primarily for surface strip mining and deep mining of anthracite coal. There are 12 coal seams beneath the Site, which, from shallowest to deepest, are the:

- Eight Foot Seam
- Five Foot Seam
- Top Split Four Foot Seam[1]
- Top Four Foot Seam
- Unnamed Seam
- Four Foot Seam
- Diamond Seam
- Fourteen Foot Seam
- Bottom Fourteen Foot Seam
- Clark Seam
- No. 2 Dunmore Seam
- No. 3 Dunmore Seam

Lead, the primary constituent of concern, is present in approximately 372,000 cubic yards of contaminated soil, battery casing material, and debris. Polyaromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) were identified in surface soil in former operational areas on the Site. Lead was also identified in off-site soils in the surrounding community. Approximately 5,500 people live within a one-mile radius surrounding the Site.

In June 1987, EPA determined that an imminent and substantial endangerment to the public health, welfare, and the environment may be present as a result of the release of lead from the Site. In April 1988, EPA issued a Comprehensive Environmental Response, Compensation, and Liability Act Consent Agreement and Order to Gould to address this potential health threat. Under EPA oversight, Gould hired contractors to remove contaminated surface soil from 135 residential and commercial properties near the Site. Lead dust was also removed from the interior of 107 residential units. In addition, actions were taken at the Site to prevent further releases of lead contamination from the Site into the surrounding community.

The current environmental conditions and cleanup of the property are being handled under the Resource Conservation and Recovery Act (RCRA). In May 1990, EPA and the Pennsylvania

[1] As a point of clarification, the *Top Split Four Foot Seam* is known as the *Top Split of the Top Four Foot Seam* in the EPA project file documents. As used here and in Dr. Keith Heasley's report, they mean the same.

Department of Environmental Protection (PADEP) entered into a RCRA 3008(h) Administrative Order on Consent with Gould. The purpose of the Order was to direct Gould to conduct a RCRA Facility Investigation to determine the nature and extent of the Site contamination, and it also required a Corrective Measure Study to identify remedial cleanup options.

The RCRA Facility Investigation Report was approved by EPA and PADEP in August 1994 following an intense review process. Gould submitted a Corrective Measure Study report to EPA in 1995 containing Gould's preferred remedy for the Site. EPA and PADEP disapproved the report in September 1995. The local community commented extensively on the report, and EPA met bi-monthly with the Throop Borough Council and local citizens to address their concerns. The most significant local concern was, and remains, the presence of abandoned mines beneath the Site and any impact they may have on the selected remedy. In November 1997, following a 2-year period of intense comment and response, EPA submitted a final response to Gould on the Corrective Measure Study report, identifying the report's deficiencies and requiring Gould to conduct a Mine Subsidence Investigation. That investigation was conducted between September and November 1998. In March 1999, EPA and PADEP approved the work completed during this investigation. The results of the Mine Subsidence Investigation were incorporated into the revised Corrective Measure Study report submitted by Gould on June 21, 1999.

On October 15, 1999, EPA and PADEP released a Statement of Basis that described the proposed remedy for the Site. A public comment period extended to January 15, 2000. During this time, several hundred comments were received by EPA from concerned citizens, elected officials, and Gould. EPA evaluated the comments and issued its final cleanup decision in a document entitled "Final Decision and Response to Comments," dated December 1, 2000. EPA selected the following actions to clean up the contaminated soils and waste material at the Site:

- The excavation of all material in the northern portion of the Site (north of the southern-most limit of the Five Foot coal seam), North Woods, and area adjacent to the Woodlawn Street playground exceeding 500 milligrams per kilogram lead.

- Treatment of approximately the top five feet of soil that will be placed under the cap using solidification/stabilization.

- A 10-acre cap over the remaining contaminated material, to be constructed on top of the contaminated material remaining on-site. The cap must comply with Federal and State standards, and the finished grade must not exceed a four-horizontal, one-vertical slope.

- Off-site disposal of all waste that does not fit under the cap.

- Implementation of dust control measures to prevent migration of contaminants.

- Modification of the Storm water Management Basin to prevent releases of contaminants to the Lackawanna River during implementation of the Final remedy. This would include, but not be limited to, cleaning out the floor of the Basin to the original grade prior to the beginning of on-site construction activities, maintenance of the gate valve, and upgrading the emergency spillway lining to rip-rap on both embankment slopes.

- Institutional controls, such as use restrictions, title notices, and proprietary controls to ensure the long-run safety of the cap.

- Maintenance of the Site, including the cap and storm water management basin.

- Confirmatory sampling after final remedy completion.

- Groundwater monitoring.

Due to community concerns regarding the delays in cleaning up the Site, U.S. Senator Arlen Specter (R-PA) requested in a letter dated April 13, 2000, that the former Ombudsman, then under EPA's Office of Solid Waste and Emergency Response, assess EPA's activities at the Marjol Battery Site. EPA suspended implementation of the final remedy decision on December 18, 2000, to allow the former Ombudsman time to provide recommendations to EPA. The former Ombudsman issued a preliminary report on October 10, 2001. EPA submitted a response on November 29, 2001.

OIG Ombudsman Involvement

In April 2002, the Ombudsman function was transferred from the Office of Solid Waste and Emergency Response to the OIG, and the former Ombudsman resigned. We (the OIG) reviewed the information transferred from the former Ombudsman's office regarding the Site, and evaluated the former Ombudsman's preliminary draft report, EPA Region 3's response, and relevant parts of the Administrative Record. On September 16, 2002, EPA Region 3 officials provided us a technical briefing on the Site. We also toured the Site on September 17, 2002. Based on our preliminary review, we determined that EPA Region 3 thoroughly and accurately addressed all of the findings in the former Ombudsman's preliminary draft report.

Throop's Special Environmental Counsel subsequently informed both EPA Region 3 and our office that the Borough had new information relating to coal mining issues, and a meeting was arranged for Throop to present the information to the EPA Region 3 Regional Administrator and us on September 20, 2002. That meeting was then postponed until November 8, 2002. The borough council subsequently voted not to attend the November 8 meeting with the Regional Administrator.

We received the new information from Throop's Special Environmental Counsel in late October 2002, and determined that it merited further consideration. Throop had received this information in the summer of 2002 during its litigation with Gould. The information was a draft report, dated December 22, 1992, on mine subsidence that had been prepared for Gould by a contractor. The draft report identified a geological feature on the Site that could have potentially affected the proposed remedy. This geological feature was omitted, without comment or explanation, from the final report officially submitted to and used by EPA Region 3 in developing the proposed Marjol final remedy. We provided EPA Region 3 and PADEP with copies of the draft report on October 29, 2002, for their consideration.

Anthracite Mining Expert Involvement

Due to the technical nature of the issues involved, we contracted with an environmental consulting firm to provide a professional opinion on the subsurface geological features and their potential effects on EPA's proposed final remedy for the Site. The work was to focus on the risk for mine fires and the amount of subsidence that could be expected at the Site. Dr. Keith Heasley led the analysis. Dr. Heasley is an associate professor of mining engineering at the West Virginia University who has a Doctorate in Mining Engineering. Specifically, we asked Dr. Heasley to opine on:

- The validity of calculations developed and used by PADEP's Bureau of Abandoned Mines and Reclamation concerning the potential for, and estimating the amount of, subsidence that can be expected at the Site and the risk of coal bed fire.

- The validity and persuasiveness of: (a) the mine subsidence report submitted to EPA Region 3; and (b) Throop's rebuttal.

- The validity and persuasiveness of: (a) a draft report on mine subsidence issues at the Site provided to this office by lawyers for the Borough of Throop; (b) the rebuttal provided by Gould to the draft report; and (c) the evaluation of the draft report by PADEP and its Bureau of Abandoned Mines and Reclamation.

Findings

After reviewing the available documents; meeting with the associated EPA, PADEP (including the Bureau of Abandoned Mines and Reclamation), Gould, and Gould's contractor personnel; and generating and analyzing a geologic computer model, Dr. Heasley's professional opinions on the critical issues at the Site were as follows.

1. Over-excavating the Five Foot Seam and ensuring a reliable noncombustible barrier is established between the Five Foot Seam and the Battery Casing Material (as specified in the Final Decision) will sufficiently ensure the long-term safety of the Site.

2. The Top Split Four Foot, Top Four Foot, and Unnamed Coal Seams do not contain any significant mining.

3. There is not a significant chance of a fire in the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap.

4. There is not a significant chance of subsidence from the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap.

5. The Four Foot Seam is too deep and too well extracted to be a significant fire or subsidence hazard.

6. There has been extensive fracturing of the bedrock across the entire Site due to past mine subsidence. However, the large fissures on the north side of the property are probably unique, and the potential for future large fracturing is probably insignificant.

7. The surface strains from any expected subsidence should be calculated at the Site and compared to allowable strains for the permanent solidified cap.

Regarding the last issue, from an engineering design viewpoint, the magnitude of the maximum subsidence is not the critical parameter; rather, the **surface slopes** (tilt) and **surface strains** generated by the subsidence are the key parameters. For instance, a very large area could all be subsided (lowered) many feet. If this subsidence was even, such that an entire structure (or permanent cap) was lowered several feet smoothly, there would be no tilts, cracks (strains), or damage to the structure. If, on the other hand, one side of the structure subsided a couple of feet while the other side remained where it originally was, there would be tilt and elongation (strain) on the structure. If the structure could not withstand the applied elongation, it would crack.

Obviously, if the change in subsidence between one side of the structure and the other were very abrupt, there could be extensive cracking. Thus, it is not the total magnitude of the subsidence that is important, but rather the differential subsidence and the associated tilting and elongation/compression. In fact, knowing the total potential subsidence does not really provide any directly usable design information. Obviously, the greater the potential subsidence, the more chance for damage, but without knowing (or assuming) the differential subsidence, the damaging strain to a structure cannot be determined. At the Marjol Site, tilting the permanent cap would not be a problem, but subsidence strains on the cap would have to be within cap design limits.

A complete copy of Dr. Heasley's report is available at our web site or can be provided upon request.

Subsequent Events

On February 9, 2004, we met with citizens from Throop, staff of Gannett Fleming (the contractor consultant for Throop), staff from Region 3 and PADEP, and Dr. Heasley. The discussions centered around the possibility of conducting additional borehole sampling to confirm whether extensive mining operations had taken place in the Top Split Four Foot coal seam and the Top Four Foot coal seam. Dr. Heasley made the point, with concurrence from EPA and PADEP staff, that the chance of these two seams having been extensively mined was less than 1 percent, since he believed they were too thin to be mined commercially. Gannett Fleming staff repeated their position that they believed there was a chance that these seams had been mined and that there was not sufficient evidence to prove either way. Therefore, Gannett Fleming believes there remains a chance for mine fires in these coal seams that would be directly under the proposed cap.

At the end of the meeting, a suggestion was made to explore the feasibility of drilling an additional 8-12 boreholes through the two seams to definitively conclude whether these seams had been mined extensively. Gannett Fleming staff agreed that if additional boreholes showed no evidence of extensive mining, there would be no risk of mine fires from these seams, and they would remove their objections to the proposed final remedy.

Since Gannett Fleming, Throop's consultant, has said they will remove their objection to the proposed final remedy if the additional boreholes show these two seams have not been mined extensively, we believe that obtaining additional mine-fire risk data associated with these two seams would help move the remedy forward and lessen the mine-fire concerns of the Throop citizens. While we continue to agree with our expert that the chance of these two seams having been extensively mined is low, this issue addresses a potential safety risk to Throop citizens. Effectively dealing with the issue of potential mine fires, as raised by Gannett Fleming, would provide the added assurance of safety for Throop citizens, long after the governments and responsible party have completed their work.

Recommendations

We recommend that the Regional Administrator, Region 3:

1. Calculate the surface strains from any expected subsidence and design, and implement the cap to meet or exceed those calculations to make a more reliable cap, since we believe this will improve the final remedy at the Site.

2. Work with Gould, PADEP, and the Borough of Throop to reach agreement on the method, such as borehole drilling, to properly address the safety issue of potential mine-fire hazard associated with the Top Split Four Foot and Top Four Foot Coal seams on the Marjol site.

Agency Response and OIG Evaluation

In responding to the draft report on April 8, 2004, Region 3 concurred with the seven findings on the mine-related issues at the Site. Region 3 concurred with the first recommendation on calculating surface strains, stating that the strains will be evaluated during cap design and the cap will be constructed to accommodate the potential strains from possible future subsidence at the Site. However, Region 3 did not concur with the second recommendation on drilling additional boreholes. Region 3 believes there is no technical basis for the recommendation and points out that our own expert, Dr. Heasley, concluded that the Top Split Four Foot coal seam and the Top Four Foot coal seam have not been mined extensively. Finally, the Region suggested some changes to the language of the report and, in most cases, we modified our report language accordingly. See Appendix A for a complete copy of the Region's response.

In our view, the Region's response to the first recommendation is appropriate and should, when fully implemented, adequately address our recommendation. We will need a time line for implementation to close out this recommendation.

We agree with the Region's response to our second recommendation that our expert did not find a technical basis to the recommendation for additional borehole drilling. We stated in our draft report and in this final report that we agreed with Dr. Heasley's analysis and conclusion that the chance of these two coal seams having been extensively mined is low and, therefore, the risk of mine fires in these two seams would be low. However, as we have documented, there is a difference of opinion among the experts that have reviewed the available data.

Gannett Fleming, Throop's consultant, is a well-known and well-respected international consulting engineering and construction management firm with almost 90 years of experience. The firm's staff does not believe there is enough data to definitively conclude that these two seams have not been mined extensively. Gannett Fleming has said they will remove their objection to the proposed final remedy if additional boreholes show these two seams have not been mined extensively. We have recommended that all parties reach agreement on the process, whether it be borehole drilling or some other method, which will provide the additional data that properly addresses the safety issue of potential mine fires, .

Scope and Methodology

This Ombudsman review was conducted by the OIG to address the outstanding issues identified by the previous Ombudsman, whose files were transferred to the OIG in April 2002. The previous Ombudsman issued a preliminary report on October 10, 2001, that identified a number of what he considered outstanding issues on the Site, including whether the Site should be cleaned up under the Comprehensive Environmental Response, Compensation, and Liability Act versus RCRA; the condition of the cover on the high hazard stock pile; and the potential for subsidence and mine fires under the proposed cap. Subsequently, we learned the Region had addressed each issue in its rebuttal dated November 29, 2001. After we received new information from Throop's Special Environmental Counsel in late October 2002, we hired an environmental consulting firm to provide a professional opinion on the subsurface geological features and their potential effects on EPA's proposed final remedy for the Site. Additionally, we met with Congressional staffers, Throop citizens, Throop's consultant, Region 3 staff, PADEP staff, and Gould staff. We reviewed the administrative record and participated in a site tour.

We conducted our field work from June 26, 2002, through December 19, 2003. We performed our Ombudsman review and analysis in accordance with *Government Auditing Standards*, issued by the Comptroller General of the United States. We issued our draft report to Region 3 on March 9, 2004, and Region 3 responded on April 8, 2004. We held an exit conference with Region 3 staff on May 11, 2004, where we obtained additional comments that we incorporated into our final report.

This report's findings and recommendations are limited to the scope of this review. This report is not intended nor should it be used for purposes outside the scope of review.

Appendixes

Appendix A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

SUBJECT: Region III's Response to the Draft Ombudsman's Review of the Marjol Battery Site, Throop, PA

original stamp dated April 8,2004

FROM: Donald S. Welsh (3DA00)
Regional Administrator

TO: Paul D. McKechnie
Acting Ombudsman
Office of the Inspector General

The Region's response to your draft Ombudsman's Review of the Marjol Battery Site Throop, PA, issued by your office on March 9, 2004, is attached.

As directed in the draft Report, this response addresses the following:

- concurrence or non-concurrence with each finding,
- concurrence or non-concurrence with each proposed recommendation,
- recommended alternative actions for non-concurrence with recommendations,
- an assessment of factual accuracy, and
- corrective action already initiated or planned.

This response also includes an evaluation of the report, Review of Subsidence and Fire Potential at the Marjol Battery Site, prepared by the independent mining expert hired to review the mining issues at the Marjol Site. The Mining Report, which was attached to your draft Report, forms the basis of the technical evaluation in your draft Report.

In summary, Region III's response concurs with all findings and with one (1) recommendation. The response does **not** concur with the recommendation to conduct additional investigation at the Site. The recommendation appears to be based upon a mistaken assumption that at the meeting with Congressman Kanjorski "...all of the participants agreed with the suggestion to explore the possibility of drilling an additional 8-12 boreholes..." As stated in our response, Region III strongly asserts that it did NOT agree with this suggestion. Since there was not such an agreement, the final report should be amended to remove that recommendation, especially since the additional investigation is not supported by the technical evaluations in the Ombudsman's report. Thank you.

Customer Service Hotline: 1-800-438-2474

RESPONSE TO DRAFT OMBUDSMAN'S REPORT
REVIEW OF THE MARJOL BATTERY SITE, THROOP, PA

The Region III Marjol project technical team has reviewed the draft report: Ombudsman's Review of the Marjol Battery Site, Throop, PA (Ombudsman's Report), issued by your office on March 9, 2004, and the Review of Subsidence and Fire Potential at the Marjol Battery Site (Heasley Report), included as an attachment to the Ombudsman's Report. As required by the Ombudsman's Report, the following comments are provided for your assessment.

Findings

The Ombudsman's Report presents seven (7) findings on the mine-related issues at the Site. We concur with all seven (7) findings.

Recommendations

The Ombudsman's Report makes two recommendations.

Recommendation #1: Calculate the surface strains from any expected subsidence, and design and implement the cap to meet or exceed those calculations to make a more reliable cap, since we believe this will improve the Final Remedy at the Site.

> *Response:* We concur with this recommendation. The subsidence strains will be evaluated during the cap design, and the cap will be constructed to accommodate the potential strains from possible future subsidence at the Site.

Recommendation #2: Work with Gould and the Borough of Throop to agree on the number and exact location for the additional boreholes. Drill, sample, and analyze the additional boreholes through the Top Split Four Foot coal seam and the Top Four Foot coal seam to definitively conclude whether extensive mining was done in these seams on the Site.

> *Response:* We do not agree with this recommendation.
>
> The recommendation for additional investigation has no technical basis in the findings of the Ombudsman's Report or the Mining Expert's analysis (Heasley Report). The technical findings in these documents state that these coal seams do not contain any significant mining, and, therefore, there is not a significant chance of a fire in these seams. The Ombudsman's Report does not provide any technical information to contradict the Heasley Report findings or to support the need for additional investigation.
>
> The presence of mined areas in the Top Split Four Foot coal seam and the Top Four Foot coal seam is relevant to the risk of a future mine fire, since only mined coal seams successfully propagate a mine fire. Unmined coal seams do not contain a sufficient oxygen supply to sustain combustion.

As noted in the Heasley Report, mine fires require an *ignition source, fuel (coal), and oxygen*. Dr. Heasley provided a detailed evaluation of each coal seam at the Marjol Site in determining whether significant mining occurred to create the voids necessary for an oxygen supply. He also addressed the potential for an ignition source to these coal seams. His evaluation supports the finding that there is not a significant chance of a fire in these seams. It is noted that the Heasley Report does not include a recommendation for additional investigation.

The Heasley Report includes the following information regarding the possible mining of Top Split Four Foot and Top Four Foot coal seams (i.e., void spaces to provide an oxygen supply).

- Mine maps show no mining in these seams on the Marjol Site.

- Core samples (from borings) from the Site show no evidence of mining in these seams. Although there is a slight chance that undocumented mining may have occurred, it would be very limited.

- Core samples of the Top Split Four Foot seam show that the coal is very thin, averaging one foot in thickness. This seam is too thin for economic or even practical recovery.

- Core samples of the Top Four Foot seam show that the coal is thin, averaging two feet in thickness. The limited, highly variable thickness of the seam along with a weak roof material above the coal would be detrimental to mining.

- Dr. Heasley's conclusion: These seams are certainly not extensively mined. Any limited, undocumented mining, if it occurred at all, would not present a fire hazard.

Dr. Heasley's report includes the following information regarding possible ignition sources for the Top Split Four Foot and Top Four Foot coal seams.

- Since the coal seams are certainly not extensively mined, coal fire propagation from a remote site is not expected. There is no history in Pennsylvania of an unmined seam successfully propagating a fire.

- Chances of a local fire ignition are very small since there are no visible outcrops of coal, or even bedrock, on the Site or on the hillside adjacent to the Site.

The following additional information supports the Region's position that mine fires are not a hazard to the containment remedy.

- The coal seams are not in contact with the combustible waste material. A buffer of soil/rock separates the waste material from the coal.

- The PA Bureau of Abandoned Mine Reclamation (BAMR) provided technical support to EPA for the mine subsidence and mine fire evaluations at the Site. The BAMR staff has substantial mining and mine fire experience in the anthracite coal area of northeastern Pennsylvania. The BAMR staff has concluded that there is not a significant risk from a coal bed fire impacting the Site.

- In the very unlikely event of a coal fire in the vicinity of the Marjol Site, the fire could and would be extinguished in a timely and effective manner by BAMR and/or the US Office of Surface Mining.

The Ombudsman recommends the additional investigation to move forward with the Final Remedy for the Site if additional boreholes show no evidence of extensive mining in these coal seams. As detailed later in this response (page 5 of this response: Subsequent Events), the Throop Borough representative at Congressman Kanjorski's meeting did not agree to move forward with the remedy even if additional investigations further confirm the EPA and PADEP conclusion that these seams do not present a mine fire hazard.

Alternative Action: The Ombudsman's Report recommendations should be based on the technical evaluation of the site information. The recommendation for additional investigation should deleted.

Factual Accuracy

The following corrections/clarifications are provided for your consideration.

Ombudsman's Report

Page 3, paragraph 2: The Report states that twelve coal seams were deep mined beneath the Site.
Comment: Three of these twelve seams were not mined *beneath the Site*, as is documented in the Heasley Report. The unmined seams are: Top Split Four Foot Seam, Top Four Foot Seam, and Unnamed Seam.

Pages 4 and 5: Description of EPA selected clean-up actions.

Comment: The summary of the clean-up actions would be more accurate if the following changes, noted below in strike-out and bold type, were made.

- The excavation of all material in the northern portion of the Site (north of the southern-most ~~portion~~ **limit** of the Five Foot coal seam), North Woods, and area adjacent to the Woodlawn Street playground exceeding 500 milligrams per ~~killigram~~ **kilogram** lead.

- Treatment of **approximately** the top five feet of soil that will be placed under the ~~RCRA~~ cap using solidification/stabilization.

- A 10-acre ~~RCRA~~ cap over the remaining contaminated material, to be constructed on top of the contaminated material remaining on-site. The ~~RCRA~~ cap must comply with Federal and State standards, and the finished grade must not exceed a four-horizontal, one-vertical slope.

- Off-site disposal of all waste that does not fit under the ~~RCRA~~ cap.

- Implementation of dust control measures to prevent migration of contaminants.

- Modification of the Storm water Management Basin to prevent releases of contaminants to the Lackawanna River during implementation of the Final Remedy. This would include, but not be limited to, cleaning out the floor of the Basin to the original grade prior to the beginning of on-site construction activities, maintenance of the gate valve, and upgrading the emergency spillway lining to rip-rap on both embankment slopes.

- **Institutional controls, such as** ~~U~~use restrictions, title notices, and proprietary controls to ensure the long-run safety of the ~~RCRA~~ cap.

- Maintenance of **site, including** ~~RCRA~~ cap **and storm water management basin**.
- Confirmatory sampling after final remedy completion.

- **Groundwater monitoring.**

It should be noted that the term "RCRA cap" is a general term used to describe the conceptual landfill cap that includes layers of both soil and synthetic liners. There is not yet a design specification for the proposed cap at Marjol.

Page 5: Ombudsman's Involvement - The Report states, "Throop's Special Environmental Counsel subsequently informed both EPA Region 3 and our office that the Borough had new information concerning the *coal seam*..."

Comment: The information concerned several issues related to the Site investigation. It would be more accurate to characterize the information as *relating to coal mining issues*.

Pages 7 and 8: Subsequent Events - This section documents the discussions that took place during the February 9, 2004, meeting in Congressman Kanjorski's office.

Comment: At that meeting, Paul Gotthold represented the Region's technical program. His recollection of the discussions, as they differ from the summary in the Ombudsman's Report, is provided below.

The Report states that it was generally agreed that if additional boreholes showed no evidence of extensive mining, there would be no risk of mine fires from these seams and the Final Remedy could move forward.

Comment: It was not generally agreed that such information would move the project forward. The Gannett Fleming representatives agreed that they would remove their objections to the remedy; however, the Throop Borough representative was non-committal.

The Report states, "Region 3 staff did not expressly disagree at the meeting, but later stated that they are unable to proceed without the Ombudsman's Report and have no internal consensus on what the results of borehole sampling would mean."

Comment: Mr. Gotthold stated that he would take the proposal under advisement. Region III subsequently explained to both the Congressman's staff and the Ombudsman's office that Region III does not agree that all stakeholders committed to allow the remedy to move forward if additional borings confirmed current data and analysis. The Borough representative only stated that "more information is good."

<u>*Heasley Report*</u>

Pages 4 and 5: Description of EPA selected clean-up actions.

Comment: The summary of the clean-up actions would be more accurate if the changes noted in the Ombudsman's Report review comments were made to this section.

Plates 2 and 3: These plates show a "surface outcrop" for the Top Split Four Foot and the Top Four Foot coal seams.

Comment: Neither of these seams actually crop out at the surface; rather, they subcrop beneath soil overburden. The Report acknowledges this fact on page 17. The Report does not explain how these "outcrop" lines were derived.

<u>*Both Reports*</u> - As a point of clarification, it should be noted that the coal seam identified as the *Top Split Four Foot* seam is identified as the *Top Split Top Four Foot* seam in the EPA project file documents.

<u>Corrective Action Already Initiated or Planned</u>

No corrective action has been initiated. Recommendation #1, the design of the cap to accommodate expected surface strains, will be implemented during the design of the remedy. Action on Recommendation #2, borehole investigation, will be determined after your final report is issued.

Appendix B

Distribution

Regional Administrator, Region 3 (3RA00)
Assistant Administrator, Office of Solid Waste and Emergency Response (5101T)
Director, Waste and Chemicals Management Division - Region 3 (3WC00)
Associate Director, RCRA - Region 3 (3WC00)
Chief, PA Operations Branch - Region 3 (3WC22)
Region 3 Audit Follow-up Coordinator (3PM70)
Comptroller (2731A)
Agency Followup Official (the CFO) (2710A)
Agency Audit Followup Coordinator (2724A)
Associate Administrator for Congressional and Intergovernmental Relations (1301A)
Associate Administrator, Office of Public Affairs (1101A)
Inspector General (2410)

Final Report

Review of Subsidence and Fire Potential at the Marjol Battery Site

Prepared for:

U.S. Environmental Protection Agency
Office of the Inspector General, MD: N283-01
Research Triangle Park, NC 27711

Dr. Rick A. Linthurst
Senior Science/Systems Advisor

Prepared by:

Aarcher, Inc.
7040 Bembe Beach Road, Suite 100
Annapolis, Maryland 21403
(410) 280-8545

Keith A. Heasley, PE, PhD
Mining Engineer / Aarcher Associate

Submitted on:
September 8, 2003

Revised:
October 26, 2003

Review of
Subsidence and Fire Potential at the
Marjol Battery Site

CONTENTS

Page

Executive Summary

The Office of the Inspector General (OIG) of the US Environmental Protection Agency (USEPA) contracted Aarcher, Inc., through A&T Systems, Inc., to provide a professional opinion on the subsurface geological features and their potential effects on the USEPA's proposed final remedy for the Marjol Battery Site. The work was to focus on the risk for mine fires and the amount of subsidence that could be expected at the site. Aarcher enlisted Dr. Keith Heasley to lead the analysis.

The Marjol Battery Site is located in Throop Borough, Lackawanna County, Pennsylvania. From 1963 until 1981, this site operated as a lead battery reclamation plant with on-site disposal of Battery Casing Material (BCM). As a result of the plant operations, the site and surrounding area became contaminated with lead. Prior to site operations for lead recovery, the property was used for mining of anthracite coal, with nine coal seams being extracted beneath the site. After extensive investigations of the site by contractors and federal and state agencies, the USEPA has proposed a final remedy for the site, which the Borough of Throop opposes. The third party expert opinion in this report was requested by the OIG, to help mediate the dispute between the USEPA and Throop Borough.

The following steps were taken to develop a thorough understanding of the mining-related issues associated with the Marjol Battery Site and to formulate a professional opinion on the most significant issues:

1. Review available documents;
2. Meet with the USEPA Region 3 Project Manager and Geologist;
3. Visit the Marjol Battery Site for a thorough site inspection;
4. Meet with Pennsylvania Department of Environmental Protection (PADEP) Project Manager and Geologist;
5. Meet with the Director of Environmental Affairs from Gould, Inc. (Gould) and with their contracted Project Manager;

6. Meet with the Pennsylvania Bureau of Abandoned Mine Reclamation (PABAMR), Division of Mine Hazards' Chief and Geologist;
7. Gather other available pertinent information;
8. Generate a three-dimensional geologic computer model; and,
9. Generate a final report.

Technical issues at the Marjol Battery Site have been divided into three general topic areas**:** **Mine Maps, Mine Fire**, and **Mine Subsidence**. Under each of these topic areas, a brief discussion of the current knowledge base is presented and specifically interpreted for the Marjol Battery Site. The specific interpretations and opinions are typically presented by individual coal seam.

After reviewing the available documents, meeting with the associated USEPA, PADEP, PABAMR, Gould and Advanced Geoservices Corporation (AGC) personnel, and generating and analyzing a geologic computer model, our professional opinions on the critical issues at the Marjol Site are as follows.

1. Over-excavating the Five-Foot Seam and ensuring a reliable noncombustible barrier is established between the Five-Foot Seam and the Battery Casing Material (as specified in the Final Decision) will sufficiently ensure the long-term safety of the site.

2. The Top Split Four Foot, Top Four Foot, and Unnamed Coal Seams do not contain any significant mining.

3. There is not a significant chance of a fire in the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap.

4. There is not a significant chance of subsidence from the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap.

5. The Four Foot Seam is too deep and too well extracted to be a significant fire or subsidence hazard.

6. There has been extensive fracturing of the bedrock across the entire site due to past mine subsidence. However, the large fissures on the north side of the property are probably unique, and the potential for future large fracturing is probably insignificant.

7. The surface strains from any expected subsidence should be calculated at the Marjol Site and compared to allowable strains for the permanent solidified cap.

Background

The Marjol Battery Site in Throop, PA, was formerly known as the Marjol Battery and Equipment Company and owned by Mr. Lawrence Fiegelman from 1963 until 1980. It operated as a lead battery crushing and reclamation plant between 1963 and 1981. Approximately 6 to 7 tons of lead, recovered from the batteries, was processed daily in a melting pot. Crushed BCM were discarded into on-site strip mining pits, a drainage way to the south, and an area in the eastern portion of the site referred to as the primary BCM fill area. As a result of the plant operations, the ground surface at the site became contaminated with lead. Fugitive dust emissions and lead contained in onsite soils were carried offsite by windborne transport. Stormwater runoff carried lead contaminated soil offsite into adjacent drainage ways toward a creek that borders the site. This creek, Sulphur Creek, was also contaminated with lead. Gould purchased the Marjol Battery and Equipment Company in May 1980 and ceased operations at the site in April 1982.

Prior to site operations for lead recovery, the property was used primarily for surface strip mining and deep mining of anthracite coal. Nine coal seams were deep mined beneath the site by various coal companies prior to 1961. PADEP, PABAMR, contractors for Gould, contractors for the Borough of Throop, and the USEPA Region 3 Technical Assistance Team have all conducted investigations at the Marjol site. Subsequently, USEPA Region 3 conducted site remediation consisting of contaminated soil removal and battery casing removal from the site and nearby residential areas, site stabilization, and consolidation of offsite material onsite in two stockpiles; a high hazard stockpile and a low hazard stockpile. USEPA has proposed, and PADEP and PABAMR agree with, a final remedy for the site, which the Borough of Throop opposes. The fina1 remedy includes the following:

- Excavation of all material in the northern portion of the Site (north of the southern most portion of the 5-foot coal seam), North Woods, and area adjacent to the Woodlawn Street playground exceeding 500 mg/kg lead;
- Treatment of the top 5 feet of soil that will be placed under the cap using solidification/stabilization;

- A 10-acre cap over the remaining contaminated material;
- Off-site disposal of all waste that does not fit under the cap;
- Implementation of dust control measures to prevent migration of contaminants;
- Modification of the Stormwater Management Basin;
- Use restrictions, title notices, and proprietary controls to ensure the long-run safety of the cap;
- Maintenance of the cap; and,
- Confirmatory sampling after final remedy completion.

Scope of Services

The Scope of Services provided by OIG required a report discussing and providing opinion on the subsurface geological features and their potential effects on the USEPA's proposed final remedy for the site, focusing on the risk for mine fires and the amount of subsidence that could be expected at the site. The Scope specifically required the consultant to opine on the following:

1. The validity of calculations developed and used by PABAMR concerning the potential for and estimating the amount of subsidence that can be expected at the Marjol site and the risk of coal bed fire (*two letters dated July 13, 1999, from Ernest F. Giovannitti to Joseph Brogna and a letter dated February 19, 1999, from Ernest F. Giovannitti to Joseph Brogna*).

2. The validity and persuasiveness of (a) the mine subsidence report submitted to USEPA Region 3 (*dated January 28, 1999 from Advanced GeoServices Corporation to Sibyl Hinnant and Leonard Zelinka*); and (b) Throop's rebuttal (*Gannett Fleming, Inc. reports prepared April 20, 1999 and July 18, 2002, for the Throop Borough Council*).

3. The validity and persuasiveness of (a) a draft report on mine subsidence issues at the Marjol Battery Plant site provided to the USEPA's OIG by lawyers for the Borough of Throop (*letter dated October 22, 2002, from Douglas R. Blazey to Mary M. Boyer that transmitted the December 22, 1992, GAl Consultants draft report and other documentation*); (b) the rebuttal provided by Gould to the draft report (*letter dated February 17, 2003, from James F. Cronmiller to Maureen Essenthier*); and (c) the evaluation of the draft report by PADEP and PABAMR (*e-mails dated January 14, 2003, from Timothy Altares to Maureen Essenthier and February 11, 2003, from Leonard Zelinka to Maureen Essenthier*).

Approach

We reviewed and analyzed the documents on the Marjol Battery Site that USEPA provided. From this review, we observed the following major technical issues that were still being debated about the site:

1. What is the exact location of the Eight-Foot, Five-Foot, Top Split Four-Foot, Top Four-Foot, and Four-Foot seams in relation to the BCM disposal area in regard to possible fire, and possible trough and/or pothole subsidence?

2. Is the Top Split Four-Foot or Top Four-Foot seam mined, and what is the subsidence and fire potential of these seams.

3. What is the potential for previous subsidence cracking on the south side of the site?

To better understand the technical aspects of these major issues for best formulating a professional opinion, we resolved to perform additional investigation:

1. Visit the USEPA Region 3 office in Philadelphia to discuss the Marjol site and technical questions with the EPA's Project Manager, Maureen Essenthier, and Geologist, Joel Hennessy;

2. Visit the Marjol Battery Site to observe the present site conditions, investigate a few of the drill cores (specifically: MW-B-5A, MSB-2, MSB-3, and TB-107), and discuss technical questions with the PADEP Project Manager, Leonard Zelinka, and Geologist, John Mellow; and with Gould's contracted Project Manager, Barbara Forslund of AGC;

3. Visit PABAMR to discuss the details of the "Act 17" subsidence calculation and the site fire potential with the Division of Mine Hazards' Chief, Steve Jones, and Geologist, Tim Altares;

4. Obtain copies of all of the available geologic information and mine maps;

5. Generate a three-dimensional geologic computer model from the available drill hole data and surface contour information to get a better understanding of the geology, and to generate thicknesses, outcrops and overburdens maps of the pertinent seams; and,

6. Generate a three-dimensional subsidence model of the site to allow calculation of past and potential subsidence and surface strains.

All of the tasks listed above, with the exception of number 6 (because of time constraints), were accomplished and form the basis for the following technical discussions and opinions.

Technical Discussion and Opinion

This report separates the technical aspects of the site into three general topic areas: **Mine Maps, Mine Fire**, and **Mine Subsidence**. Each topic area includes a discussion of the associated knowledge base, followed by our professional opinions of how the present knowledge base and site data can be specifically interpreted at the Marjol Battery Site.

This report considers 12 specific seams at the site, from shallowest to deepest**:** the Eight Foot Seam, the Five Foot Seam, the Top Split Four Foot Seam, the Top Four Foot Seam, an Unnamed Seam, the Four Foot Seam, the Diamond Seam, the Fourteen Foot Seam, the Bottom Fourteen Foot Seam, the Clark Seam, the No. 2 Dunmore Seam, and the No. 3 Dunmore Seam. These seams are grouped differently throughout this report, depending on the intended analysis. For instance, the top five seams may be grouped together because they outcrop somewhere on the site, or the bottom six seams may be grouped together because they are all below the water table.

Mine Maps

As a result of the recent Quecreek Mine inundation and rescue, almost everyone in coal country is aware that old mine maps can be unreliable. Generally, if a mine map shows mining, then one can be fairly certain that mining occurred in that area (barring surveying errors). However, as in the case at the Quecreek Mine, the latest available maps may not show the ultimate extent of mining. Also, there certainly can be undocumented (unofficial, illegal, etc.) mines and/or coal extraction in an area where individuals have simply dug into the hillside to extract house coal, or where small companies (either legally or illegally) have created small mines or robbed pillars in old mines.

When examining an old mining area, such as the Marjol Battery Site, there is the possibility that mining in the deep mines or strip mines may extend further than documented on the mine maps. In addition, there is the possibility that some undocumented, generally small, excavations may have occurred at the outcrop.

At the other extreme, one has to understand that there can still be some coal in areas where mine maps show that pillars have been completely robbed or retreated. Certainly, some coal may be left scattered on the floor or attached to the roof simply due to the inefficiency of the coal recovery method. Also, when miners are robbing pillars, a number of situations, such as the roof falling prematurely or “bad” mining conditions, may result in pillar “stumps” or remnants being randomly left in the robbed area, even though the area may be marked as completely robbed on the mine map. With sufficient overburden stress, these stumps typically crush and do not significantly affect subsidence. At the Marjol Battery site, these pillar remnants may show up as coal in a drill core in an area that is marked on the mine map as completely robbed, or they may contribute, along with caved, broken and bulked roof rock, to a void at the mine level. One can never be absolutely certain that a room-and-pillar retreat area marked as completely mined on the mine maps does not have some remnant coal remaining.

When analyzing a mine map where first mining with rooms and pillars is shown, it must be understood that roof falls may have occurred in the rooms and the pillars may have crushed over time, or the rooms may be open and the pillars stable, and they may be stable indefinitely or could still fail some time in the future. The specific condition of any old room-and–pillar section depends on numerous site-specific factors, such as: depth, roof geology, roof support, roof weatherability, pillar size, adjacent mining, etc. Generally, it is very difficult to exactly predict the roof and pillar stability of an old mine by only examining the mine map.

Mine Maps: Marjol Site Interpretation

Eight Foot Seam – The accuracy of the mapping and the exact outcrop of the Eight Foot Seam is not a significant issue, since the seam decidedly outcrops well above the proposed permanent cap area.

Five Foot Seam – The accuracy of the mapping and the exact outcrop of the Five Foot Seam is an issue since the southernmost part of the seam may outcrop under the proposed permanent cap. In the available maps, there is extensive underground and surface mining shown for the Five Foot Seam. In fact, the majority of the seam appears to have been retreat mined, first mined or surface mined with only minimal outcrop barriers still remaining on the Marjol Site, and in reality, these outcrop barriers may have been extracted, wholly or in part, by undocumented surface pits, undocumented drift mines, or the undocumented extension of the underground mining.

In addition, defining the exact outcrop of the Five Foot Seam is difficult with the available data. Only three core holes penetrated the Five Foot Seam. Of these three, only one, MW-B-5A, obtained a good core and elevation for the seam. In the other two core holes, the location of the Five Foot Seam had to be interpreted from drill cuttings (MSB-3) and the remains of the mined-out seam (MSB-4). (In MSB-3, the original interpretation of the coal seam at 38-39 feet deep seems in error after a more detailed analysis. Likely, the coal seam was in the range of 56-68 feet deep where little information was obtained.) For lack of better information, we used the bottom elevation of the Four Foot seam and added the 140 feet of interburden, as indicated in the one really good core, MW-B-5A, to obtain our best estimate of the bedrock outcrop of the Five Foot Seam (as shown in Plate 1). Clearly, the Five Foot Seam may outcrop under the Northern edge of the proposed permanent cap.

Given the degree of uncertainty in the exact extent of mining and the location of the outcrop of the Five Foot Seam, it seems very reasonable to over-excavate to, or past, the Five-Foot Seam and ensure a sufficient noncombustible barrier is established between the Five-Foot Seam and the BCM under the proposed permanent cap, as specified in the Final Decision.

Top Split Four Foot Seam – The Top Split Four Foot Seam apparently outcrops under the proposed permanent cap location (Plate 2). For this reason, the seam has to be comprehensively analyzed for a potential fire or subsidence impact on the BCM.
In relation to mining in this seam, there are not any maps that show mining on the Marjol site. One mine map shows limited mining some distance into the northern Olyphant Colliery. From the drill hole information, this seam appears to be too thin for economic, or even conceivable, recovery. One drill hole did encounter 2 feet of coal but the average thickness

from the six drill holes that intersected the Top Split of the Top Four Foot Seam was less than 1 foot. It has been suggested that the thin coal intercepts represent previous mining. We observed the core from two of these core holes (MSB-3 and MW-B-5A) and did not see any indication that the seam was mined. In addition, we do not believe that anyone would mine a 2-foot thick seam and leave 6 inches of coal behind.

The mine maps and core hole data indicate that the Top Split Four Foot Seam was certainly not extensively mined under the Marjol Site. There is a slight chance that undocumented, limited mining occurred from the outcrop. It is expected that any undocumented mining was very limited, if it occurred at all, and very near outcrop. With the amount of earthwork that has been done on the site in the past, there is a good chance that any small, near-surface excavations would have been filled in. With no hard evidence showing mining in the Top Split Four Foot seam, and the feasibility of mining in the seam being extremely unlikely due to the limited thickness, we do not believe there is a significant issue of any unknown mining significantly altering the fire or subsidence potential of the Top Split Four Foot Seam.

<u>Top Four Foot Seam</u> – The Top Four Foot Seam outcrops under the proposed cap (Plate 3) and is in a similar situation to the Top Split Four Foot Seam. Available mining maps do not show mining on the Marjol Site, although there is fairly extensive mining shown in the adjacent Olyphant Colliery. The seam is relatively thin on the site, with an average thickness of about 2 feet, but ranging from 0.25 to 3.25 feet at 11 drill hole intercepts. The larger seam thickness areas might have been reasonably extracted in a discontinuous manner. Our limited observations of the core (MSB-2) did not reveal any evidence of mining and indicated a very weak material for the immediate roof, which would be detrimental to mining. We do not believe that the thin coal intercepts represent previous mining.

Once again, the mine maps and core hole data indicate that the Top Four Foot Seam was certainly not extensively mined under the Marjol Site. There is a slight chance that undocumented, limited mining might have occurred from the outcrop (more chance than with the thinner Top Split Four Foot Seam). It is expected that the undocumented mining is very limited, if it occurred at all, and very near outcrop. With no hard evidence showing mining in the Top Four Foot seam, and the feasibility of mining in the seam being unlikely due to the limited, highly variable thickness and weak roof, we do not believe there is a significant issue of any unknown mining significantly altering the fire or subsidence potential of the Top Four Foot Seam.

Unnamed Seam – There is a very consistent, thin unnamed coal seam intercepted in 14 of the drill cores. This seam is approximately 25 feet below the Top Four Foot Seam and 45 feet above the Four Foot seam. The seam averages about 1-foot thick with several holes showing a thickness of 1.5 feet (Plate 4). It is not very deep under the proposed BCM fill area and may outcrop just south of the permanent cap. There is no mining shown on any maps for this seam, and the thinness suggest it would not be economic or practical to mine. However, since it does outcrop in the area, there is a very slight chance that undocumented, limited mining might have occurred from the outcrop. It is expected that the undocumented mining would be very limited, if it occurred at all, and very near outcrop. With no hard evidence showing mining in this Unnamed Seam, and the feasibility of mining in the seam being unlikely due to the very limited thickness, we do not believe there is a significant issue of any unknown mining significantly altering the fire or subsidence potential of the Unnamed Seam.

Four Foot Seam – The available maps of the Four Foot Seam show that it was completely extracted under the Marjol Site except for the barrier pillars around the property boundaries. All of the drill hole data are consistent with this interpretation. Most holes found broken roof and no coal or voids. A couple of drill holes found some thin lost coal and a couple of other drill holes found some voids still open. We do not believe that there are any significant issues concerning the accuracy of the mine mapping for the Four Foot Seam at this site.

Diamond Seam – Available maps of the Diamond Seam show that it was retreat mined on the east side of the property and only first mined on the west side of the property. The drill hole data are consistent with this interpretation. We do not believe that there are any significant issues concerning the accuracy the mine mapping for the Diamond Seam at this site.

Fourteen Foot Seam, Bottom Fourteen Foot Seam, Clark Seam, No. 2 Dunmore Seam, and No. 3 Dunmore Seam – The Fourteen Foot Seam shows extensive retreat mining under the site. The Bottom Fourteen Foot Seam shows first mining under the west side of the site and no mining under the east side of the site. The Clark shows first mining under the east side of the site and retreat mining under the west side of the site. The No. 2 Dunmore shows first mining under the site. And, the No. 3 Dunmore shows first mining under the west side of the site and no mining under the east side of the site.

All of these mines are deeper than 300 feet below the site. In general, the maps from these larger, deep mines are typically more accurate than from smaller mines. In addition, the problem with undocumented outcrop mines does not apply to the deep mines, and small discrepancies in the accuracy of the mine mapping would have minimal effect on the surface subsidence from these depths. We do not believe that there are any significant issues concerning the accuracy the mine mapping for these deeper seams at this site.

Mine Fire

A mine fire at the Marjol site would require an ignition source, the coal for fuel, and oxygen. It is generally agreed that anthracite coals have an extremely low affinity for spontaneous combustion (a self-heating temperature of greater than 140 °C was found in one study (Smith and Lazzara, 1987)). Therefore, a fire in one of the seams would have to ignite from a surface fire at an outcrop location.

The second requirement for a coal fire to propagate underground is a sufficient oxygen supply. Of course, any seams below the water table would not be capable of sustaining a fire in their flooded condition. In addition, for seams above the water table, some type of mine entries are generally necessary to provide sufficient oxygen/air circulation to propagate a fire through the seam. (The PABAMR does not have any record of an un-mined seam that has sustained an underground fire.)

In regard to a fuel source, any extensively retreated seam would have the roof caved and the majority of the coal removed. These caved (or gob) areas would certainly help curtail any fire trying to propagate across that area towards the Marjol site, although fires have propagated across caved areas assumedly due to carbonaceous (burnable) material in the roof and floor and/or remnant coal left in the seam and voids left in the broken roof.

If a fire occurred on the site, it would only be a hazard to the cap area if the fire contacted the BCM and caused it to burn, or if the fire consumed the coal and caused subsidence sufficient to damage the integrity of the cap. For isolating any mine fire from the BCM, utilizing a barrier of noncombustible material is a reasonable approach. In the old Pennsylvania regulations for separating landfill material from combustible material, a noncombustible barrier of a minimum thickness of 25 feet was specified. This specification was a general rule-of-thumb and has subsequently been removed from the new regulations, which now require a case-by-case analysis. Logically, the thickness of a barrier for isolating combustible materials should be related to the thickness and extent of the burnable material.

Finally, we believe that PABAMR would take any underground mine fire near the Marjol site very seriously and would utilize whatever resources are necessary to extinguish that fire. Also, because the Marjol site is located on a hillside, the number of directions for a fire to advance onto the site area is limited, thus providing an advantageous geometry for effectively isolating the cap area from any potential fire, and limiting the length of any necessary fire break.

Mine Fire: Marjol Site Interpretation

Eight Foot Seam – The Eight Foot Seam is not a significant fire issue in relation to the permanent isolation of the contaminated material, since the seam decidedly outcrops well above the proposed permanent cap area. A fire in the Eight Foot Seam on the Marjol Site would not be directly detrimental to the permanent cap, and could burn completely without affecting the permanent cap.

Five Foot Seam – As previously discussed, the Five Foot Seam outcrops in the vicinity of the BCM; however, the bottom of the high walls in the old Five Foot pits on the site have been naturally covered with soil and rock debris that has eroded from the highwalls over the many years since the active strip mining. This natural cover appears sufficient to protect the seams from any casual fire that may occur in the pit. In addition, the Five Foot Seam has extensive areas of second mining and strip mining where the majority of the coal is removed. These caved or spoiled areas would certainly help curtail any fire trying to propagate across that area towards the permanent cap. However, it is conceivable for a fire to start off site, or in one of the open pits. Because of the extensive mining, such a fire could conceivably propagate through the Five Foot Seam to the permanent cap area. In all probability, if a fire was initiated and detected in the Five Foot Seam it could be successfully extinguished by PABAMR.

However, given the degree of uncertainty in the success of detecting and extinguishing mine fires, and the nearness of the open pits for possible ignition, it seems very reasonable to over-excavate the Five-Foot Seam and ensure a sufficient noncombustible barrier is established between the Five-Foot Seam and the BCM under the proposed permanent cap as specified in the Final Decision.

Top Split Four Foot Seam, Top Four Foot Seam, and Unnamed Seam - The Top Split Four Foot Seam, the Top Four Foot Seam, and the Unnamed Seam are all in essentially the same situation in regard to a mine fire at the Marjol Site. These seams all outcrop under, or near, the proposed permanent cap (Plates 2, 3 and 4). In the mine maps, there is no mining shown directly on the Marjol Site, although there is some mining shown in the adjacent Olyphant Colliery for the Top Split Four Foot Seam, and the Top Four Foot Seam. All of the seams are relatively thin on the site with the Top Split Four Foot Seam and the Unnamed Seam averaging about 1 foot of thickness and the Top Four Foot Seam averaging about 2 feet in thickness.

As previously stated, there is some slight chance that undocumented, limited mining might have occurred from the outcrop in any of these seams. It is expected that the undocumented mining would be very limited, if it occurred at all, and very near outcrop. With no hard evidence showing mining in any of these seams, and the feasibility of mining in the seam being unlikely due to the limited thickness, We do not believe there is a significant issue of any unknown mining significantly enhancing the fire potential of the Top Split Four Foot Seam, the Top Four Foot Seam, or the Unnamed Seam.

Since these seams do outcrop on or near the site, there is some chance of a fire initiating on the site. However, since there are no obvious surface pits or visible outcrops of coal or even the bedrock from these seams directly on the site or on the hillside in the adjacent area, we believe that the chances of a fire initiating locally are very small. Further, since there is no history in Pennsylvania of any un-mined seams successfully propagating a fire, we would not expect a local, or remote, surface fire in the Top Split Four Foot Seam, the Top Four Foot Seam, or the Unnamed Seam to propagate under the proposed cap area. Finally, from our discussions with PABAMR personnel, we believe that PABAMR would take any surface or underground coal fire near the Marjol Site very seriously and would utilize whatever resources are necessary to extinguish that fire.

Four Foot Seam – According to the available mine maps, the Four Foot Seam was completely extracted under the Marjol Site except for the barrier pillars around the property boundaries. There is no outcrop of the Four Foot Seam in the immediate area, and based on the drilling data, the minimum bedrock thickness above the Four Foot Seam is approximately 50 feet on the south side of the Marjol Site (Plate 5).

Since the Four Foot Seam does not outcrop on or near the site, there is no reasonable chance of a fire initiating locally. However, because the seam is extensively mined, a remote fire in the seam could conceivably propagate under the site. However, there is probably very limited Four Foot coal remaining under the site to burn very strongly (or to cause subsidence) and also, there is a minimum of 50 feet of bedrock separating the seam from the BCM. It does not appear that a fire in the Four Foot Seam is a significant risk to the BCM.

Diamond Seam, Fourteen Foot Seam, Bottom Fourteen Foot Seam, Clark Seam, No. 2 Dunmore Seam, and No. 3 Dunmore Seam - The Diamond Seam, the Fourteen Foot Seam, the Bottom Fourteen Foot Seam, the Clark Seam, the No. 2 Dunmore Seam, and the No. 3 Dunmore Seam are all below the water table and pose no significant fire hazard since the ground water would naturally quench any fire and displace necessary oxygen.

Mine Subsidence

In the following discussion of mine subsidence mechanics and characteristics, the vast majority of our present body of subsidence knowledge was obtained from the bituminous coal fields across the United States, Britain and Europe in the last half of this century. Coal mining subsidence did not become an important research issue in the U.S. until the late 1960s and 1970s; therefore, the subsidence characteristics of the anthracite mining in the U.S., which was mostly extinct by that time, were not able to be analyzed with the detail that has been applied to the present bituminous coal industry. This lack of specific anthracite subsidence information is evident in the derivation of the PABAMR anthracite subsidence equation (see the section later) where less than 15 subsidence case studies where available for input. In comparison, there has been literally hundreds of bituminous subsidence case studies performed in the U.S.

However, the mechanics of overburden subsidence do not change just because anthracite coal was removed as opposed to bituminous coal. Most of the important subsidence characteristics are similar between the Marjol site and a typical bituminous location. The stratigraphy at the Marjol site (unlike a lot of anthracite geology) is essentially level like the U.S. bituminous coal field, and the room-and-pillar mining methods used under the site are essentially comparable from a subsidence perspective to the room-and-pillar methods used in the bituminous coal fields. Also, the geology at both the Marjol site and the bituminous coal fields is predominately stratified sedimentary rocks. The one significantly different subsidence characteristic between the Marjol site and the majority of bituminous coal fields is the higher percentage of thicker stronger sandstones and siltstones layers in the anthracite overburden (although bituminous coal mines in the Southern Appalachia area have similar competent overburden). In general, stronger sedimentary overburden would reduce the magnitude and extent of the surface subsidence, but the essential mechanics of the overburden would remain the same. Therefore, in the following subsidence discussion, we believe it is entirely reasonable to give an overview of mining subsidence mechanics and characteristics that encompasses both the U.S. bituminous coal fields and the Marjol anthracite site.

Generally, subsidence is divided into two types: trough and pothole. Trough type subsidence is associated with relatively deep, thin horizontal seams where a large area of coal has been removed and where the overlying strata (relatively) gently bends in to fill the void, thereby forming a subsidence trough on the surface. Alternatively, pothole type subsidence is associated with relatively shallow, small openings where the immediate roof breaks and falls underground and then the roof breakage propagates up to the surface. (Chimney subsidence may be considered a special case of pothole subsidence where the seam is vertical or near-vertical, and the surface material can fall quite far down the seam. Since the coal seams are generally horizontal at the Marjol site, chimney subsidence is not an issue.)

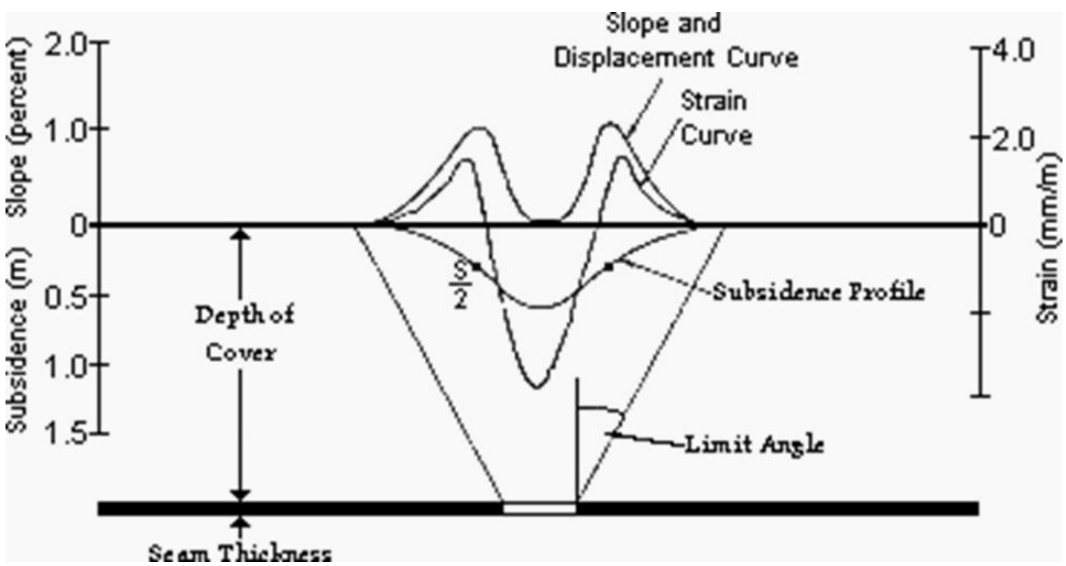


Figure 1. Schematic displaying surface subsidence, slope and strain.

Trough Subsidence - With trough-type subsidence, the coal is removed over a relatively large area. Essentially concurrent with the coal removal, the immediate roof breaks and caves into the mine. The pieces of the immediate roof tumble and fall, and generally occupy more volume than the original intact rock, a phenomenon called "bulking." (Sedimentary coal-measure rocks have bulking factors that run from 1.05 to 1.35 (5 to 35%)). The overburden zone that tumbles and falls is known as the "**complete caving zone**" and generally extends to a maximum of 2 to 6 times (4 average) the seam thickness into the roof. As roof caving moves up through the strata, the bulked immediate roof starts to somewhat support the super-adjacent strata, which will break and fall, but will generally maintain its original orientation and not tumble. This next zone is known as the "**partial caving zone**," and generally extends to a maximum of 8 to 12 times (10 average) the seam thicknesses into the roof. Further up through the strata, the layers fracture, but remain mostly intact and settle onto the lower stratum. This area is known as the "**fracture zone**" and generally extends to a maximum of 42 to 60 (50 average) times the seam thickness into the roof. From the top of the fracture zone up to the surface, the overburden layers generally just bend, with little or no fracturing, into the subsidence trough. This area is known as the "**bending zone**."

As the original mined volume propagates up through the overburden, it is generally reduced by the bulking of the rock. In the complete and partial caving zones, the broken and tumbled rock accounts for most of the bulking; however, there is some additional bulking that occurs in the fracture and bending zones. In the Northern Appalachian bituminous coal fields (which have been studied most extensively), only about 60-70% of the original mined thickness appears as subsidence on the surface. This percentage of mined thickness that manifests as subsidence is known as the **subsidence factor**. (From the PABAMR anthracite subsidence formula, the nominal subsidence factor is essentially 53.5% (see below). This reduced subsidence factor seems reasonable based on the higher percentage of competent rocks in the anthracite overburden.)

As the original mined volume propagates up through the overburden, it also spreads out over the edges of the adjacent un-mined area. The arc tangent of the ratio of the distance that the subsidence spreads outside of the mined panel to the depth of mining is known as the "**limit**

angle" or "**angle-of-draw**"(see Figure 1). In the Northern Appalachian bituminous coal fields, an average angle-of-draw of 21° is generally used. In the British coal fields, an average angle-of-draw of 35° was found to be appropriate. In general, the angle-of-draw may range from 10° to 35°, depending primarily on the depth, seam thickness, and geology. (The PABAMR anthracite formula only predicts the maximum subsidence in the center of the subsidence area and does not reproduce the entire subsidence curve; therefore, it does not consider an angle-of-draw. However, because of the competent overburden, the angle-of-draw at the Marjol site would be expected to be less than the bituminous 21°.

There is also a time aspect to trough subsidence. If the coal is completely removed from an area and the influence of active mining is distant, approximately 90% of the surface subsidence occurs essentially immediately. The other 10% of the surface subsidence occurs slowly over time, and is known as **residual subsidence**. The residual subsidence is generally assumed to be caused by time-delayed failure and compaction of the overburden. The residual subsidence is considered to decay exponentially over time. If the subsided area is re-disturbed by sub-adjacent mining, additional subsidence in the previous robbed areas can be generated.

In a deep mine where room and pillars are left standing, subsequent roof falls and pillar failure or floor failure (pillars punching into the floor) can also cause trough-type surface subsidence. This subsidence would occur at the time the mine structure fails. The trough subsidence associated with a room-and-pillar section failure would generally be much less than the subsidence associated with complete coal removal in that area. First of all, the surface subsidence would be directly reduced by the volume of coal left in the section. Only the extracted volume can propagate to the surface as subsidence. In addition, in a room-and-pillar section failure, it would be expected that the failed pillars would still provide some support to the overburden, further reducing the expected surface subsidence.

With the trough-type of subsidence, the original mined volume at the seam level appears as a three-dimensional subsidence trough on the surface (Figure 1). This trough is enclosed by the limit angle (angle-of-draw) on the sides, and has a maximum subsidence in the center, as determined by the subsidence factor (and possibly the sub-critical nature of the excavation). On each side of the subsidence trough, the ground is tilted towards the center of the trough. In addition, as the ground bends into the trough at the edges, the surface is put into tension, and then as the surface levels again in the center of the trough the ground goes into compression (Figure 1). The magnitude of the surface slopes and strains are directly proportional to the extracted seam thickness and inversely proportional to the seam depth. In addition, the subsidence and resulting slopes and strains from multiple seam subsidence are cumulative. It is considered standard subsidence calculation practice to just add (using the proper directional vectors) the calculated subsidence, tilt, and strains from multiple seams in order to obtain the final resultant values.

From an engineering design viewpoint, the magnitude of the maximum subsidence is not the critical parameter; rather, the **surface slopes** (tilt) and **surface strains** generated by the subsidence are the key parameters. For instance, a very large area could all be subsided (lowered) many feet. If this subsidence was even, such that an entire structure (or permanent cap) was lowered several feet smoothly, there would be no tilts, cracks (strains), or damage to the structure. If on the other hand, one side of the structure subsided a couple feet while the other side remained where it was originally, there would be tilt and elongation (strain) on the structure. If the structure could not withstand the applied elongation, it would crack. Obviously, if the change in subsidence between one side of the structure and the other was very abrupt, there could be very extensive cracking. Thus, it is not the total magnitude of the subsidence that is important, rather the differential subsidence and the associated tilting and elongation/compression. In fact, knowing the total potential subsidence does not really provide any directly usable design information. Obviously, the greater the potential subsidence, the more chance for damage, but without knowing (or assuming) the differential subsidence, the damaging strain to a structure cannot be determined. For human habitation, anything tilted more than 1° is generally considered objectionable, and strains of 0.25% or more (on a 75-foot long building) are considered appreciable. (At the Marjol site, tilting the permanent cap would not be a problem, but subsidence strains on the cap would have to be within the cap design limits.)

The geology directly affects the subsidence in a couple of ways. The softer shales and siltstones in the caving zones do not bulk as much as the stronger blockier sandstones and limestones. In the fracture zone and surface tension zones, the softer shales and siltstones tend to break readily and smoothly bend in the subsidence trough. On the other hand, the stronger sandstones and limestones tend to localize the strains into a few relatively large fractures/joints forming blocks that rotate into the subsidence trough.

There are a number of available computer programs that can compute surface subsidence and associated slopes and strains for various mining scenarios. In order to be most accurate, these programs need site-specific parameters, typically determined from measured subsidence. However, rough estimates of the expected slopes and strains can be determined by using average and/or estimated parameters. Based on present technology, we would expect that the historical amounts of surface strain and possible future surface strains from worst-case scenarios would be calculated at the Marjol Site and compared to allowable or design strains for the permanent solidified cap.

<u>Pothole Subsidence</u> - Pothole type subsidence is normally associated with a single shallow mine opening. Mine openings are typically supported and intended to remain open (at least for the working life of the opening). Over time, the roof support may fail and/or the geologic material may deteriorate, resulting in a roof fall into the entry. The roof fall will propagate up through the immediate strata until a stable arch is formed, the bulking fall material stabilizes the super-adjacent strata, or the fall reaches the top of the bedrock or surface. When the fall propagates up to the surface, this is called pothole subsidence. If there is not much soil cover, the surface pothole can be very abrupt and open; however, with substantial soil cover, the soil will typically fill in the voids and soften the surface expression of the pothole.

The roof fall material in a potential pothole situation responds somewhat as described earlier. The immediate roof material breaks and tumbles with considerable bulking (complete caving zone). The zone above this breaks but does not tumble, with only limited bulking (partial caving zone). Typically, the mine opening and associated fall are not wide enough or high enough to generate a fracture zone in the overlying strata. Therefore, if the fall does not intersect the surface by the top of the partial caving zone, the overlying strata will generally be supported by the bulked fall material. At any location above the mine roof, a competent layer can successfully arch over the fall and terminate the roof fall at that point. (This previous pothole subsidence description applies to essentially horizontal seams. It does not apply to vertical or near-vertical seams and "chimney" type subsidence.)

Based on the distances previously quoted for the extent of the complete and partial caving zones, an opening that caves within 2-6 times the seam thickness of the surface (or the top of bedrock) should readily reach the surface and form pothole subsidence. If the seam was deep enough (greater than 8-12 times the seam thicknesses), the fall would not be expected to reach the surface. In addition, any competent layers between the seam and the surface may terminate the fall and eliminate the pothole subsidence. (In the documents concerning the Marjol site, the values of 5 and 10 times the seam thickness are referenced as the "likely" and "limit" thickness of the interburden. These values are in good agreement with the above explanation of strata mechanics.)

In the preceding descriptions of subsidence, trough subsidence is attributed to relatively deep seams and wide extractions, and pothole subsidence is attributed to relatively shallow seams and narrow extractions. In reality, seam depths and extraction widths cover a wide range, and an exact separation between trough subsidence and pothole subsidence cannot be made. The subsidence phenomenon is actually a continuum grading from trough to pothole type subsidence.

PABAMR Subsidence Calculation – The formula used by PABAMR was developed around 1990. The formula was based on previous subsidence theory and equations originally developed by the British National Coal Board (NCB), one of the prime originators of subsidence theory and prediction. Measured subsidence data from the anthracite-mining region was used to modify the site-specific parameters in the NCB formula to best fit the subsidence observed in the anthracite region.

$$\text{Maximum Subsidence} = 0.535\,(m - 0.017d)(f)(P)(F)$$

where:

m = seam thickness

d = depth of vein minus unconsolidated material

f = factor for reducing maximum subsidence for w/d ratio less than 1.2
(where w = width of the extracted area)

P = ratio of void area to total mine area

F = 0.1 for collapsed and compacted veins (boring proof necessary)
0.6 for flushed, stowed, or packed veins
1.0 for untreated veins

The approach of taking the form of an equation from another area and empirically modifying it with measured data to best fit the local site is standard subsidence engineering practice. In this case, we believe it was the best available option for deriving a simple empirical subsidence prediction formula for the anthracite region. The empirical curve-fitting approach works very well when the conditions in the predicted case match the conditions in the cases used to derive the equation. However, if the case to be predicted is outside of the range of the original database case histories, then the expected results are unknown.

The formula derived for the anthracite region agrees with generally accepted subsidence theories. It has a built-in subsidence factor of 53.5% (as compared to 60-70% for Northern Appalachia , see above). It is linearly proportional to the mining thickness. It reduces the amount of maximum subsidence for small width-to-depth ratios, based on the NCB formulas. The equation reduces the amount of maximum subsidence linearly in relation to the extraction ratio, a commonly accepted technique. The equation also reduces the amount of expected subsidence for retreat mining or backfilling with empirical parameters.

The one factor in the equation that seems in a bit of disagreement with modern subsidence prediction theory is the reduction in effective mining thickness with depth, the “0.017d” factor. This factor directly reduces the impact of the seam thickness on the subsidence as a mine gets deeper. It is generally accepted that there is some very slight reduction in the amount of subsidence strictly as a result of increasing depth (regardless of w/d ratio); however, all modern subsidence prediction programs of which we are aware ignore this factor as insignificant. In the anthracite subsidence equation, this factor is fairly significant with deeper seams. For instance, the equation would imply that an 8.5-foot thick seam at 500 feet of depth would not produce any surface subsidence regardless of extraction area. Obviously, if 8.5 feet of anthracite coal was extracted over a large enough area, there would be some significant measurable surface subsidence. For comparison, in the Northern Appalachian bituminous coal fields, an 8.5-foot thick coal seam at 500 feet of depth with a large extraction area would be expected to produce approximately 5 feet of surface subsidence. We realize that the anthracite coal fields generally have stronger rocks than the bituminous coal fields and would be expected to have less subsidence, but, based on our knowledge of the strata mechanics and the difference in geology, we do not believe that a reduction from 5 feet the whole way to 0 feet, as implied by the equation, is reasonable.

In the original derivation of the anthracite equation, there were only 13-15 subsidence case studies available. We did not have the opportunity to analyze the original document in great detail, but we suspect that a few anomalous case histories at the greater depths or a slight error in the degree of fit of the equation at the greater depths generated the "0.017d" factor. In addition, the anthracite region typically extracts room-and-pillar panels. There may certainly be a correlation between mining depth and how much coal is randomly left to help support the roof or the width of the extraction areas as the mines get deeper. The natural increase in the number of remnant pillars, or a natural reduction in the extraction area in the deeper mines, would greatly reduce the subsidence at the surface, and the empirical database may interpret this decreased subsidence as a function of depth (and not a function of extraction ratio, the amount of "artificial stowing," or extraction width). Certainly, the areas of first mining and retreat mining are very discontinuous in the deeper mines at the Marjol Site.

We believe that this "0.017" factor is very high and would give non-conservative (lower) subsidence predictions for deeper mines if all of the input parameters for the anthracite equation were taken at face value. This may certainly not have been a noticeable problem in the past or at the Marjol Site. It is the shallow mines that naturally cause the most damaging surface strains. The deeper mines, even with greater subsidence, produce very broad subsidence troughs with smaller surface strains that would cause little damage. In addition, this is no reason to believe that the subsidence behavior of the mines under the Marjol Site would not fall within the subsidence response of the empirical data used to create the subsidence prediction equation. These mines may certainly show greatly reduced subsidence with depth due to increased remnant pillars, piece-wise mining, stronger rock, or some other unknown factor that is naturally incorporated into the empirical equation.

In summary, the PABAMR anthracite subsidence equation generally agrees with modern subsidence theory and has been used successfully utilized for many years. However, the one "0.017" depth factor raises a few concerns and does not seem to fit with present subsidence understanding. However, this factor is only significant with deeper seams and can easily be eliminated to produce more conservative (higher subsidence) results.

Mine Subsidence: Marjol Site Interpretation

<u>Surface Fissures</u> – There are some fairly large (5 to10 feet across) surface fissures on the northern property boundary of the Marjol Site. In all likelihood, these fissures are due to the subsidence and associated surface tension generated by extraction of the lower seams. There has been a question as to whether similar surface fissures may form, or may have formed, on the southern property boundary. Our site investigation did not reveal any obvious fissures on the southern property boundary, but the ground surface had obviously been re-worked in the past, undoubtedly obscuring any historical fissures.

There are several factors that may have intensified the surface cracking on the north side of the property. First of all, the Eight Foot and Five Foot Seams are mined in that area, but are eroded away on the southern edge of the site. Secondly, the immediate bedrock on the northern edge of the property consists of sandstone, which tends to localize the surface subsidence strains into a few relatively large fractures/joints. By contrast, the southern boundary consists of softer geology. Finally, the area is sloped towards the center of the subsidence trough. This has been known to enhance surface cracks. In addition, the nearby strip mining may have allowed additional slope movement.

For the reasons stated above, any surface subsidence cracking on the northern boundary may have been more severe than on the southern boundary of the Marjol Site. However, we would certainly have expected some surface cracking to have occurred on the southern boundary, based on the thickness and depths of the underlying seams that were retreated. For instance, nominally 4 feet of coal was extracted from the Four Foot Seam at a depth of around 50 feet under the southern property boundary. In this situation, the fracture zone from the seam definitely would have extended up to the surface. Similarly, the fracture zone from the Fourteen Foot seam would probably have extended through the 200-300 feet of overburden to the surface. We believe that the entire site has probably been fractured at one time or another by the undermining. Some of these fractures may have been covered or closed over time, but the permeability of the bedrock has certainly been altered. Our belief that the bedrock has been fractured in the past is supported by the observed lack of any ponding or damp areas in the surface pits on the site. A calculation of subsidence induced surface strains across the Marjol Site would further help analyze the observed and possible future occurrence of surface fissures.

<u>Eight Foot Seam</u> – The Eight Foot Seam is not a significant subsidence issue in relation to the permanent isolation of the contaminated material, since the seam decidedly outcrops well above the proposed permanent cap area.

<u>Five Foot Seam</u> – It is anticipated that the Five Foot Seam will be over-excavated under the permanent cap area; and therefore, there will be no Five Foot coal remaining under the cap. Thus, it does not appear that the Five Foot Seam is a significant subsidence issue at the Marjol Site.

Top Split Four Foot Seam, Top Four Foot Seam, and Unnamed Seam - The Top Split Four Foot Seam, the Top Four Foot Seam, and the Unnamed Seam are all in essentially the same situation in regard to a mine subsidence at the Marjol Site. These seams all outcrop under or near the proposed permanent cap (Plates 2, 3, and 4). In the mine maps, there is no mining shown directly on the Marjol Site, although there is some mining shown in the adjacent Olyphant Colliery for the Top Split Four Foot Seam and the Top Four Foot Seam. All of the seams are relatively thin on the site with the Top Split Four Foot Seam and the Unnamed Seam averaging about 1 foot of thickness and the Top Four Foot Seam averaging about 2 feet in thickness.

As previously stated, there is a slight chance that undocumented, limited mining might have occurred from the outcrop in any of these seams. It is expected that the undocumented mining would be very limited, if it occurred at all, and very near outcrop. In addition, with the amount of earthwork that has done on the site in the past, there is a good chance that any small, near surface excavations would have been filled. With no hard evidence showing mining in any of these seams, and the feasibility of mining in the seams being unlikely due to the limited thickness, we do not believe there is an issue of any unknown mining causing significant subsidence from the Top Split Four Foot Seam, the Top Four Foot Seam, or the Unnamed Seam in the permanent cap area. Also, since there is no available conduit for initiating a local fire, the seams are nominally un-mined and incapable of propagating a fire, and the seams are fairly thin, the chances of a mine fire causing damaging subsidence are insignificant.

Four Foot Seam – From the mine maps and the site drilling, the Four Foot Seam is assumed to have been totally robbed under the Marjol site in the 1920s. Under these conditions, we would expect that essentially all of the immediate and residual surface subsidence would have already occurred.

In the PABAMR subsidence calculation, the minimum allowable factor (0.1) "for a collapsed and compacted vein with boring proof" was applied to the seam for an average expected future subsidence of 0.117 feet. Given the degree of extraction and extended time since the mining occurred, we believe that this value represents a conservative (high) estimate of any potential future subsidence.

Diamond Seam - The available maps of the Diamond Seam show that it was retreat mined on the eastern side of the property and only first mined on the west side of the property. The drill hole data are consistent with this interpretation. In particular, all of the drill holes in the retreat mined area encountered collapsed roof and all of the drill holes in the first mined area encountered either collapsed roof or failed pillars. Only limited and discontinuous voids were encountered in the drill holes. Given the extended time since this mining has occurred, one would expect that the subsidence has stabilized fairly well. The retreat mined areas should be finished with residual subsidence, and the first mined areas should have fallen (as indicated in the drill holes) or may be expected to remain standing indefinitely. However, the possibility of future stability problems in the first mined areas should be considered.

In the PABAMR subsidence calculation, for the robbed areas, the minimum allowable factor (0.1) "for a collapsed and compacted vein with boring proof" was applied to the seam (except for one drill hole were a void was noted and a factor of 0.4 was applied). For the robbed area, an average expected future subsidence of 0.325 feet was determined. Given the degree of extraction and extended time since the mining occurred, we believe that this value represents a conservative (high) estimate of any potential future subsidence.

For the first mined area, it was essentially assumed that none of the entries or pillars had previously failed and that the full subsidence from the 65% extraction was still possible. In addition, high estimates of the seam height were used. An average expected future subsidence of 1.413 feet was predicted for the first mined areas. Given the drill hole evidence of considerable failure in the first mining areas, we believe this subsidence estimate for the first mined area represents a conservative (high) estimate of any potential future subsidence.

Fourteen Foot Seam - The Fourteen Foot Seam shows extensive retreat mining under the Marjol Site. Similar to the Four Foot Seam, we would expect that essentially all of the immediate and residual surface subsidence would have already occurred. In the PABAMR subsidence calculation, the minimum allowable factor (0.1) "for a collapsed and compacted vein with boring proof" was applied to the seam, also the subsidence was calculated for both 6-foot and 14-foot (minimum and maximum) seam thicknesses. The final calculation shows 0.067 feet of potential subsidence for the 6-foot seam thickness and 0.495 feet of potential subsidence for the 14-foot seam thickness. Given the degree of extraction and extended time since the mining occurred, we believe that the 0.1 factor is conservative. In addition, we believe that the 14-foot seam thickness estimate is conservative. However, based on the previous discussion on the accuracy or suitability of the "0.017" depth factor, we question the conservativeness of the final 0.495 feet value**. If the depth factor were eliminated from the equation, a value of 0.749 feet would be obtained**. This later value, would be considered conservative in this calculation.

Bottom Fourteen Foot, No. 2 Dunmore and No. 3 Dunmore Seams **-** The Bottom Fourteen Foot Seam shows first mining under the west side of the site and no mining under the east side of the site. The No. 2 Dunmore shows only first mining under the site. The No. 3 Dunmore shows first mining under the west side of the site and no mining under the east side of the site. These deeper seams are primarily first mined or un-mined. In addition, the pillars are generally very substantial and not prone to major failures or squeezes. Even if there were major roof falls or pillar squeezes, we would expect the overburden to be mostly supported by the pillars or pillar remnants with little surface subsidence. Also, any major failures may have already occurred, and any surface subsidence from this depth would not create major surface strains. Therefore, we do not believe that the subsidence impact of these seams is a significant issue at the Marjol Site.

Clark Seam - The Clark shows first mining under the east side of the site and retreat mining under the west side of the site. The largest area of retreat mining is approximately 300 by 500 feet at an average depth of 600 feet. The surface subsidence from this retreat mining would have already occurred and any residual subsidence would be greatly reduced by the small width-to-depth ratio. Similar to the other deep seam, we would not expect pillar failure in the first mined areas to be a significant subsidence problem. Therefore, we do not believe that the subsidence impact of the Clark Seam is a significant issue at the Marjol Site.

Maximum Subsidence vs. Surface Strain – All of the previous PABAMR subsidence calculations predict the maximum subsidence at the center of the expected trough subsidence. As previously stated, from an engineering design viewpoint, the magnitude of the maximum subsidence is not the critical parameter; rather, the surface slopes (tilt) and surface strains generated by the subsidence are the key parameters. Specifically, at the Marjol Site, one of the critical design criteria should be the expected subsidence surface strain (or worst-case surface strain) as compared to the allowable strain for the stabilized fill material. In reality, the maximum surface subsidence can be quite large if the site is lowered without bending. It is the surface bending and associated strain that may damage the remediation efforts. Based on present technology and good engineering practice, we would expect that the various surface strains from historical and worst-case scenarios would be calculated at the Marjol Site and compared to allowable or design strains for the permanent solidified cap.

Conclusions

After reviewing the available documents, meeting with the associated USEPA, PADEP, PABAMR, Gould, and AGC personnel, and generating and analyzing a geologic computer model, we developed a fairly thorough understanding of the mining-related issues associated with the Marjol Battery Site. We combined this site knowledge with our technical experience to produce our professional opinion on the significant issues at the Marjol Site.

1. We believe that over-excavating the Five-Foot Seam and ensuring a reliable noncombustible barrier is established between the Five-Foot Seam and the BCM (as specified in the Final Decision) will sufficiently ensure the long term safety of the site. We believe that the Five Foot Seam outcrops under the proposed permanent cap area, and because of this potential proximity to flammable BCM, the extensive previous mining, and the accessibility of local strip pits, that this seam poses a fair fire hazard to the BCM and that the Five Foot Seam requires specific isolation. We also believe that over-excavation of the Five Foot Seam will effectively mitigate any potentially significant subsidence impact from the Five Foot Seam on the permanent cap.

2. We do not believe that the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams contain any significant mining. There is not any significant map or drill hole evidence that indicates the existence of mining in these seams. In addition, the seams appear to be too thin for economic, or even practical, recovery. There is always a slight chance that undocumented, limited mining might have occurred from the outcrop. It is expected that any conceivable undocumented mining would be very limited and very near the outcrop. Therefore, the mining would not significantly impact the fire or subsidence potential of the seams.

3. We do not believe that there is a significant chance of a fire in the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap. As previously stated, we do not believe there is a significant issue of any unknown

mining significantly enhancing the fire potential of these seams. These seams do outcrop on or near the site, but there are no obvious outcrops of coal where the fire could be initiated locally. Further, there is no history in Pennsylvania of any un-mined seams successfully propagating a fire. Therefore, we do not expect a surface fire in any of the seams to propagate under the proposed cap area. Finally, based on discussions with the PABAMR, we believe that any surface or underground coal fire near the Marjol Site would be taken very seriously and that PABAMR would utilize whatever resources are necessary to extinguish that fire.

4. We do not believe that there is a significant chance of subsidence from the Top Split Four Foot, Top Four Foot, or Unnamed Coal Seams adversely affecting the permanent cap. We do not believe that there is any significant mining in these seams; therefore, the chances of subsidence are insignificant.

5. We believe that the Four Foot Seam is too deep and too well extracted to be a significant fire or subsidence hazard.

6. We believe that there has been extensive fracturing of the bedrock across the entire site due to past mine subsidence. However, the large fissures on the north side of the property are probably unique, and the potential for future large fracturing is probably insignificant.

7. We believe that the surface strains from any expected subsidence should be calculated at the Marjol Site and compared to allowable strains for the permanent solidified cap. We are fairly satisfied with the PABAMR subsidence calculations, although we question the accuracy and validity of the "depth factor." However, the PABAMR calculation only provides the maximum subsidence at the center of the expected trough subsidence. From an engineering design viewpoint at the Marjol Site, the magnitude of the maximum subsidence is not a significant parameter; rather, the surface strain generated by the subsidence is the key parameter.

Conditions

This report was prepared to address the Scope of Services presented at the beginning of the report. The report represents our understanding and opinions on the significant aspects of the Marjol Battery site in regard to mine mapping, mine fire, and coal seam subsidence. Neither Aarcher nor Dr. Heasley will be responsible for any misinterpretation of the discussions or opinions expressed in this report. It is recommended that Aarcher be contacted for clarification if any problem arises with interpretation.

The opinions expressed in this report are subject to the accuracy and reliability of the source data and information used as the basis of the report. The majority of this source data and information was collected by other parties, and Aarcher was not able to verify its origin, accuracy, or completeness. If additional information becomes available, or if the interpretation of previous information changes, then the opinions expressed in this report may no longer be applicable. It is therefore recommended that Aarcher be contacted to modify the enclosed opinions, if any significant new information or re-interpretations occur.

This report was developed in accordance with generally accepted mining engineering practices and principles. This statement is in lieu of all warranties, either expressed or implied. In the event of any alleged errors or omissions in the services rendered, Aarcher's sole and exclusive responsibility shall be the correction of the alleged error or omission in service.

Acknowledgements

"For this report, I was essentially tasked with spending a little bit of time reviewing a number of fairly extensive technical documents and then providing a professional opinion as to the validity and persuasiveness of these documents. I would certainly like to acknowledge all of the very dedicated and professional contractors, and state and federal employees who have devoted considerable time and effort to developing the technical documents for the remediation of the lead contamination at the Marjol Battery Site. In this report, by expressing my professional opinion on the technical issues at the Marjol Site, I am only striving to apply what I consider to be the best science and engineering to the technical problem. These opinions are not intended to belittle or detract from any of the high-quality, professional work that has been done to date."

-Keith A. Heasley, PE, PhD

References

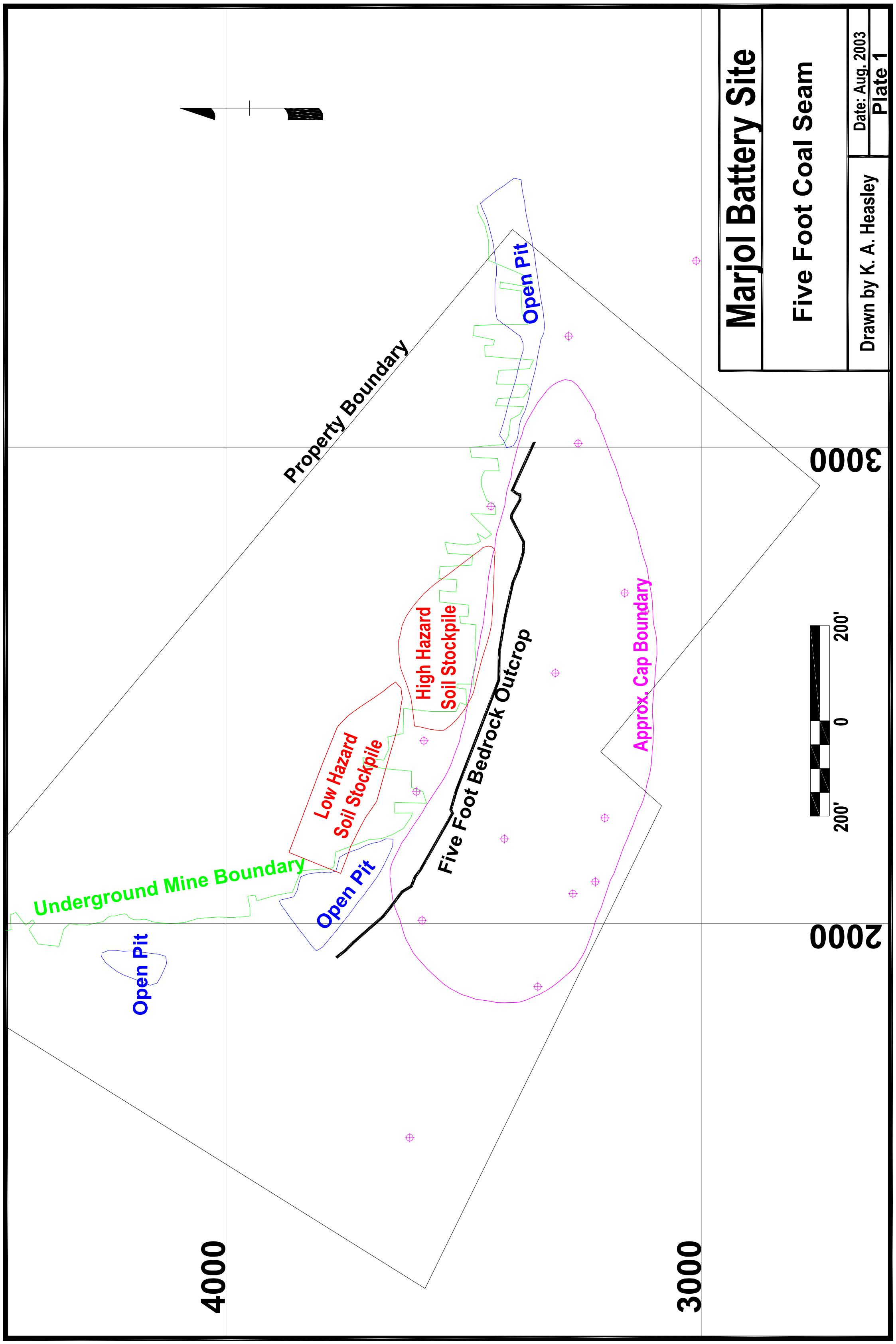
Ash, S. H., B. S. Davies, H. E. Jenkins and W. M. Romischer, 1952, "Barrier Pillars in Lackawanna Basin, Northern Field, Anthracite Region of Pennsylvania," USBM Bulletin 517, 114 pp.

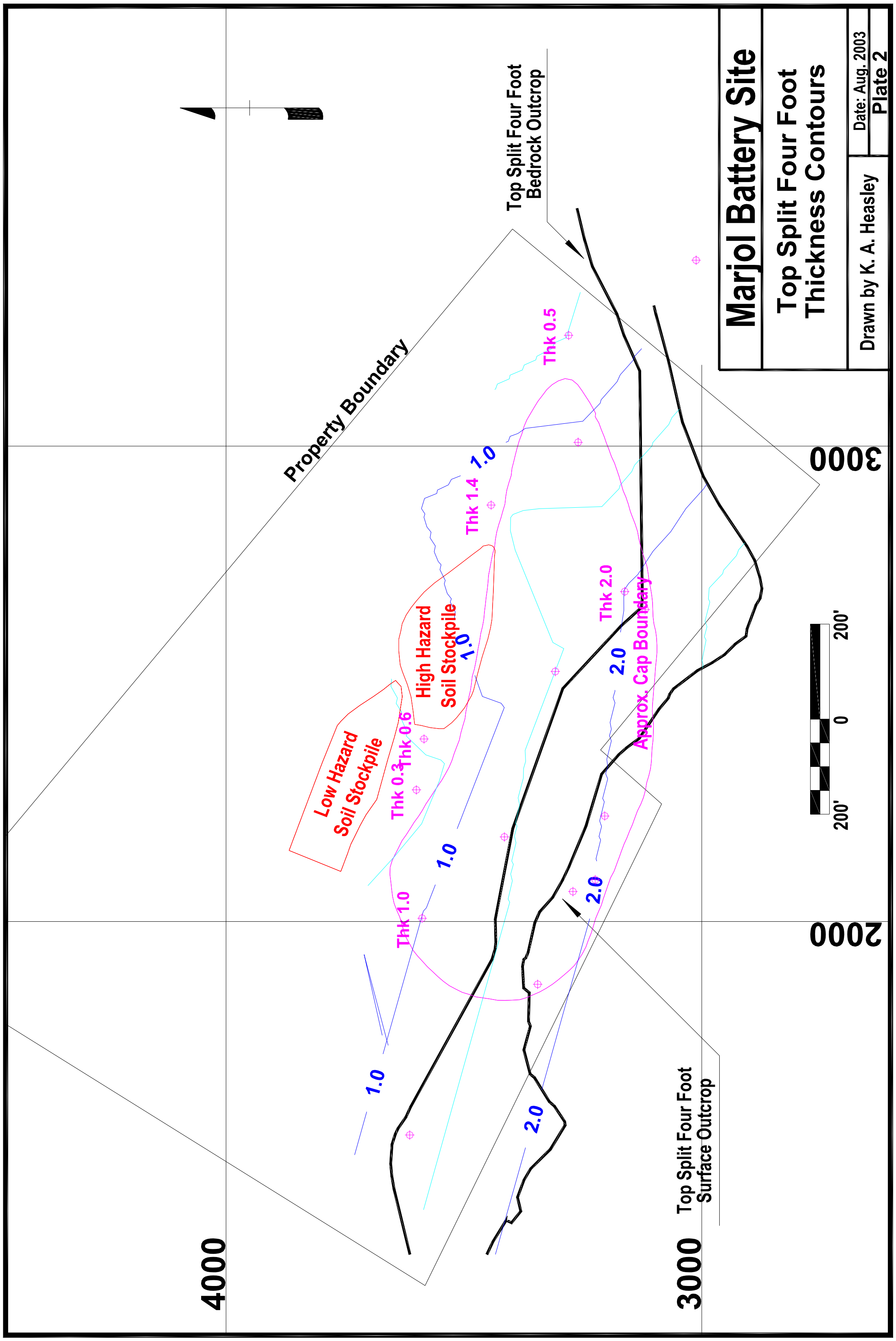
Peng, Syd S., 1986, **Coal Mine Ground Control**, John Wiley & Sons, New York, NY, 491 pp.

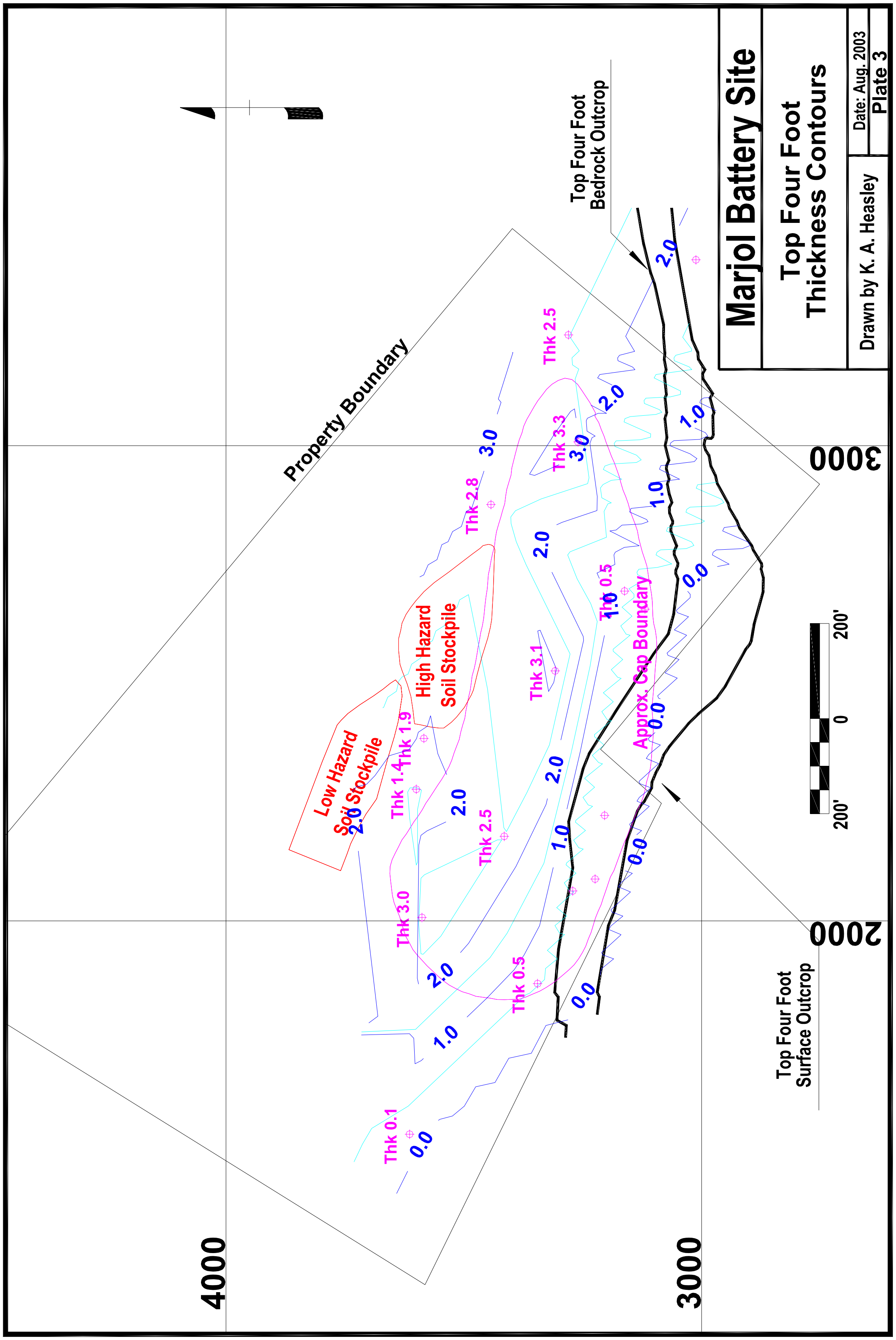
Peng, Syd S. and H. S. Chiang, 1984, **Longwall Mining**, John Wiley & Sons, New York, NY, 708 pp.

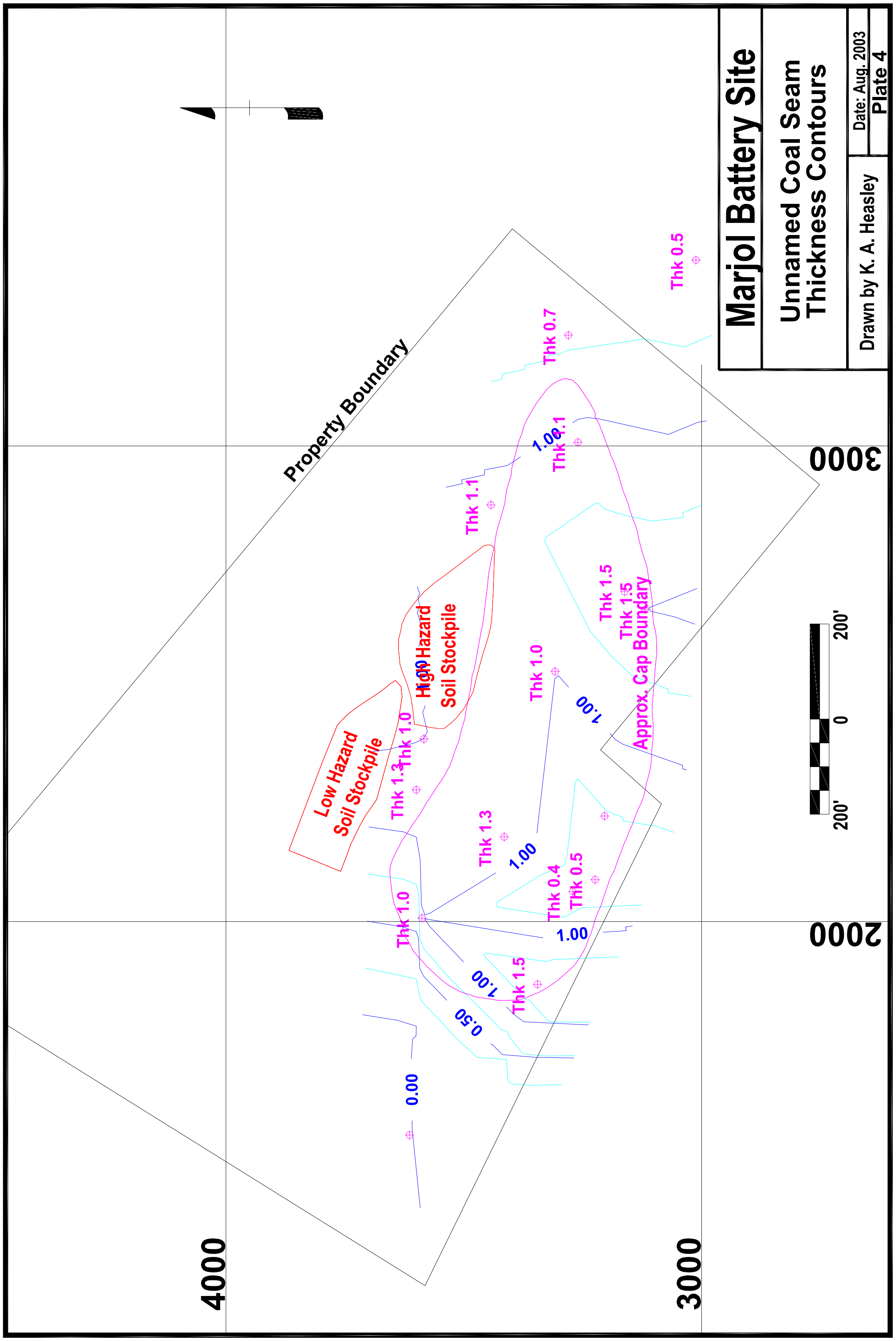
Smith, A. C. and C. P. Lazzara, 1987, "Spontaneous Combustion Studies of U.S. Coals," USBM RI 9079, 28 pp.

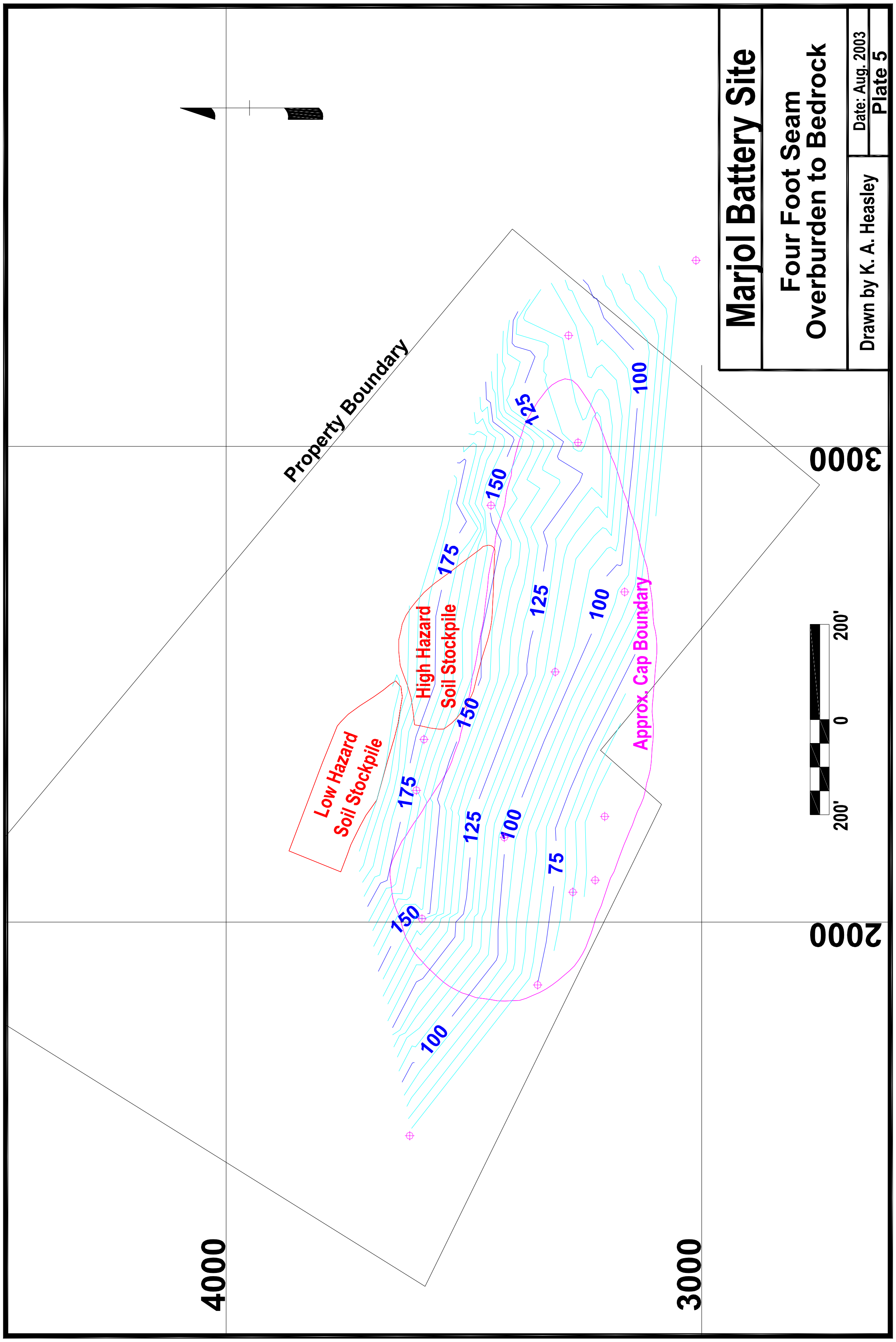
Stoek, H. H., 1902, "The Pennsylvania Anthracite Coal Field," USGS.


Marjol Battery Site
Five Foot Coal Seam
Drawn by K. A. Heasley
Date: Aug. 2003
Plate 1
Property Boundary
Open Pit
Open Pit
Open Pit
Underground Mine Boundary
High Hazard
Soil Stockpile
Low Hazard
Soil Stockpile
Five Foot Bedrock Outcrop
Approx. Cap Boundary
3000
2000
4000
3000
200'
0
200'


Marjol Battery Site
Top Split Four Foot
Thickness Contours
Drawn by K. A. Heasley
Date: Aug. 2003
Plate 2
Top Split Four Foot
Bedrock Outcrop
Top Split Four Foot
Surface Outcrop
Property Boundary
Low Hazard
Soil Stockpile
High Hazard
Soil Stockpile
Approx. Cap Boundary
Thk 0.5
Thk 1.4
Thk 2.0
Thk 0.6
Thk 0.3
Thk 1.0
1.0
2.0
3000
2000
4000
3000
200'
0
200'


Marjol Battery Site
Top Four Foot
Thickness Contours
Drawn by K. A. Heasley
Date: Aug. 2003
Plate 3
Property Boundary
Top Four Foot
Bedrock Outcrop
Top Four Foot
Surface Outcrop
High Hazard
Soil Stockpile
Low Hazard
Soil Stockpile
Approx. Cap Boundary
4000
3000
3000
2000
200'
0
200'


Marjol Battery Site
Unnamed Coal Seam
Thickness Contours
Drawn by K. A. Heasley
Date: Aug. 2003
Plate 4
Property Boundary
High Hazard
Soil Stockpile
Low Hazard
Soil Stockpile
Approx. Cap Boundary
Thk 0.5
Thk 0.7
Thk 1.1
Thk 1.1
Thk 1.5
Thk 1.5
Thk 1.0
Thk 1.0
Thk 1.3
Thk 1.3
Thk 0.4
Thk 0.5
Thk 1.0
Thk 1.5
1.00
1.00
1.00
1.00
1.00
0.50
0.00
200'
0
200'
3000
2000
4000
3000


Marjol Battery Site
Four Foot Seam
Overburden to Bedrock
Drawn by K. A. Heasley
Date: Aug. 2003
Plate 5
Property Boundary
High Hazard
Soil Stockpile
Low Hazard
Soil Stockpile
Approx. Cap Boundary
175
150
125
100
75
200'
0
200'
3000
2000
4000
3000