FINAL REPORT

FEASIBILITY INVESTIGATION ABATEMENT OF ACID MINE DRAINAGE LANGELOTH-FRANCIS MINE COMPLEX RACCOON CREEK WATERSHED WASHINGTON COUNTY, PENNSYLVANIA

PROJECT NO. SL-130

I.0 Introduction

The Raccoon Creek watershed, an area of approximately 184 square miles in southwestern Pennsylvania, has been extensively mined for coal over the past 100 years. The creek and its tributaries have been seriously polluted by acid mine drainage from the many abandoned deep and strip mines in the watershed. A report prepared by the Federal Water Pollution Control Administration in November 1968* identifies over 150 sources of mine drainage in the watershed. According to this report, the subwatershed of Burgetts Fork, a tributary which enters Raccoon Creek near Burgettstown, contributes about 53,000 pounds per day acidity to Raccoon Creek

The first source of mine drainage into Burgetts Fork is a borehole into the Langeloth Mine opposite the town of Slovan. The FWPCA investigation measured a flow from this borehole of 270 gpm, carrying nearly 5800 lb/day acidity (1765 mg/l). Above this point, Burgetts Fork was found to be relatively unpolluted, with a pH of 7.3, no acidity, and low iron (0.9 mg/l). Downstream of this point, several more mine discharges enter Burgetts Fork and the quality of the stream near its confluence with Raccoon Creek deteriorated to a pH of 4.7, acidity of 421 mg/l, and iron, 42 mg/l.

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Sources of. Coal Mine Drainage Pollution, Raccoon Creek Watershed, Pennsylvania,,
Work Document No. 28, Federal Water Pollution Control Administration, Ohio Basin Region, Wheeling, West Virginia, 1968.

As an initial, part of a study of the feasibility of eliminating or substantially reducing the acid mine drainage into Raccoon Creek, E. D'Appolonia Consulting Engineers, Inc., was retained by the Department of Environmental Resources to investigate the feasibility of sealing the abandoned Langeloth Mine, the furthest mine upstream on Burgetts Fork discharging acid drainage (Fig. 1). As the investigation proceeded, it was found that the Langeloth Mine was. interconnected with the Francis and Patterson mines to the north (downstream), and the investigation was expanded to include these mines. The study involved collection of available mine maps, an extensive field investigation, discussions with local residents familiar with the mines, and limited boring and water quality sampling programs. 2.0 Mining History

Very little information is available concerning the history of the Langeloth, Francis and Patterson mines. Patterson Mine was operated by Carnegie. Coal Company in the early 1900s. The Langeloth Mine was opened about 1914 by the American Zinc and Chemical Company, which operated a zinc smelter adjacent to the mine entries. The Francis Mine was opened about the same time by the Greensburg-Connellsville Coal and Coke Company. Following World War II, the zinc smelting operation was closed and the Langeloth Mine was sold to the Greensburg Connellsville Coal and Coke Company, who operated it in conjunction with the Francis Mine until the middle 1950s.

In the late 1950s or early 1960s, the portion of the Francis Mine north of the Penn Central Railroad was completely stripped out by Starvaggi Industries (Weirton Ice & Coal Company and Pennweir Construction Company). Earlier, in the late 1940s, a small area was strip mined at the northeast corner of the Langeloth Mine immediately adjacent to Burgetts Fork. Currently, the old workings of the

Patterson Mine north of Plum Run and adjacent portions of the Francis Mine are being strip mined by Bologna Mining Company

3.0 Review of Available Information

Maps of the Langeloth and Francis Mines were obtained from George S. Baton and Company, owner of Greensburg-Connellsville Coal and Coke Company, the last operators of these mines. Maps of the entire workings at a scale of l" = 300' and working maps at a scale of l" = 100' were obtained. Nearly complete coverage of the Langeloth Mine at the larger scale was obtained, but larger scale maps of several areas of the Francis Mine were not available.

The maps were studied to identify and locate areas of interest for the field investigation; e.g., boreholes, shafts, drift entries, and outcrops. Figure 2 shows the principal features of the Langeloth-Francis Mine Complex superimposed on the surface topography of the area. Figure 3 shows the plan of the Langeloth and Francis mines with the contours of the bottom of coal plotted. The portion of the Francis Mine north of the Penn Central Railroad is not shown since it has been completely strip mined.

The Pittsburgh coal seam was mined in the complex, and it dips
to the south in this area. The lowest point in the mine complex is approximately El. 810, at the barrier between the Langeloth and Atlas mines in the southeast corner of the Langeloth Mine. The highest point in the complex is approximately El. 1080 in the northwest corner of the Francis Mine. Because of the dip, the entries to the Langeloth Mine opposite Slovan were shaft and slope entries, the depth of coal at this point being approximately 100 feet, while the main entries to the Francis Mine, along the Penn Central Railroad, were drift or shallow slope entries. The entries to the Patterson Mine, along the Penn Central Railroad on the north and along Plum Run on the south, were all drift entries.

The principal entries to the Langeloth Mine, on the east side of the mine opposite the town of Slovan, consist of a vertical main shaft (Location 1), a vertical air shaft (Location 2), and a slope entry (Location 6). Near the western boundary of the mine workings is a vertical air shaft (Location 14). Several boreholes into the mine exist: one in the vicinity of the main shafts (Location 3); one adjacent to the railroad, 2500 feet south of the main entries (Location 9); one adjacent to an unnamed tributary to Burgetts Fork, 2000 feet south of the main entries (Location 7); and one near the reservoir, 3000 feet southwest of the main entries (Location 8). These were apparently all pump boreholes for draining the mine workings. Two utility boreholes also exist; one on the hilltop near the abandoned zinc works, 900. feet west of the main shaft entry (not positively identified in the field); and the other, 5500 feet west of the main shaft near the town of Langeloth (Location 10).

The mine maps show a set of headings extending northeast from the main shaft entries toward Burgettstown. This area was later strip mined and the available maps indicate that the stripping operation intercepted these deep mine headings.

The main entries to the Francis Mine, adrift entry (Location 32), a slope entry (Location 33), and an airway (Location 31), are adjacent to the Penn Central Railroad, one. mile west of Burgettstown. Approximately 6000 feet southwest of the main entries is a vertical air shaft (Location 42), and approximately 2000 feet south-southeast of the air shaft is a borehole (Location 45). About 1500 feet west of the main entries a pair of headings (Location 36) extend to the northwest and under the railroad and road to the portion of the Francis Mine workings which has been almost totally strip mined.

Several drift entries to the Patterson Mine are shown on the limited maps available. They indicate six drift entries on the northern side of themine adjacent to the Penn Central Railroad (Locations 27 and 28), two or three drift entries on the south side of Plum Run (Locations 22 and 23)'. The entries on the north side of Plum Run (Location 26) have been eliminated by the current strip mining operation./ At least some of the entries on the north side of the mine (Locations 27 and 28) have also been eliminated by the strip mining.

The maps show that water entering the Langeloth-Francis Mine Complex, through outcrops, subsidence fractures, natural jointing of the rock, or by other means, tends to flow toward the south. If the barrier between the Langeloth and Atlas mines is intact, the water. will pond until it reaches the elevation of the lowest surface opening to the mine. At this point, it will discharge to the adjacent surface stream, as it does from the Langeloth borehole. Depending on the flow capacity of the lowest opening and the existence of other openings at similar elevations, other discharges from the main mine water pool may also occur. Other mine water pools may also exist as the result of the local mine floor topography, roof falls, or in-mine barriers, and additional surface discharges from these pools may exist.

The mine maps show a 100-foot barrier between the Langeloth and Atlas mines and between the Francis and Bertha mines, with no indication that these barriers were ever penetrated. The maps also show a 100-foot barrier between the Langeloth and Francis mines, penetrated near the western limit of the mine complex in the area of most recent mining. The barrier between the Patterson Mine and the Langeloth and Francis mines is probably of questionable integrity, since there reportedly has been a fire in the Patterson Mine.

4.0 Field Investigation

Following a detailed review of the available mine maps and preliminary field work, a detailed surficial investigation of the area surrounding the Langeloth-Francis-Patterson Mine Complex was conducted. All openings or potential openings to the mine, as indicated on the mine maps, were located and inspected, and the entire area was searched for other openings, particularly potential sources of inflow to the mine complex. A very limited subsurface investigation was conducted in the vicinity of the Langeloth Mine, and limited water quality samples-were taken from mine discharge points and streams.

4.l Surface Reconnaissance: All openings investigated are located and described on Fig. 2. They are numbered in the order of their investigation in the field, but they have been arranged in the table in order of increasing elevation.

The known openings into the Langeloth Mine are a vertical main shaft, two vertical air shafts; a slope entry, and five or six boreholes. The main vertical shaft (Location l) is capped with a concrete cover but is not filled. The adjacent vertical air shaft (Location 2) has apparently been backfilled with soil, rock and debris, and. then capped with concrete. The vertical air shaft at the western limit of the mine (Location 14) has been capped with reinforced concrete but has not been backfilled. The slope entry adjacent to the main vertical shaft (Location 6) was blocked by soil and debris dozed into the opening to prevent children from entering, but recent construction at the site has partially opened the entry. All boreholes except the flowing borehole 2000 feet of the main entries (Location 7) appear to be at least partially sealed. The borehole shown on the mine maps immediately adjacent to the main entries (Location 3) has not been located and is apparently buried.

Approximately 3000 feet north of the main entries to the Langeloth
Mine is a backfilled strip mine. A stream crosses this area and discharges into Burgetts Fork. Near the northern edge of the stripped area is a bow-shaped pond (Location 13), and although no apparent inflow into the pond can be observed, the pond continually discharges as much as 200 to 250 gallons per minute. The quality of the water in the stream crossing the stripped area is relatively good, while the water discharging from the pond has characteristics similar to acid mine drainage. The pond elevation is approximately 20 feet lower than the. elevation of the top of the flowing borehole (Location 7) (and the elevation of water in the Langeloth Mine). The mine maps show three headings extending into the area of the strip mine. Although no records. have been found to support this conclusion, it appears that the strip mining intercepted the headings of the deep mine behind the block or brick stoppings constructed by the deep mine operators. In backfilling the strip pit, these headings have been buried under 15 to 20 feet of material and there is no surface evidence of their existence. Water from the deep mine apparently discharges into the strip mine backfill from these headings. This water surfaces in the pond and then discharges to Burgetts Fork. Piezometers installed in the headings during the subsurface investigation support this hypothesis, and on several occasions, an upwelling of water from the bottom of the pond has been observed.
Across the railroad from the main entries to the Langeloth Mine, a riveted iron pipe (Location 5) discharges water into Burgetts Fork. The flow is relatively small and it is not known if the source of the water is the mine.

As noted in the table on Fig. 2, two drift entries to Patterson Mine on the south side of Plum Run (Locations 22 and 23) are at nearly the same elevation as the flowing Langeloth borehole (Location 7). Approximately 200 gallons

per minute flows from one of these caved entries. All other openings to the three mines are above the apparent present pool elevation of about El. 1019. A significant discharge from the Patterson Mine north of Plum Run (Location 26) existed until the present strip mining began, but this was apparently water entering the Patterson and Francis mines which could not flow into the main pool because of the mine floor topography and roof falls. The water previously discharging from Patterson Mine north of Plum Run is now intercepted by the stripping operations, collected and treated before being discharged to Plum Run.

No mine water discharges directly from the Francis Mine have been observed. This is to be expected since the mine dips to the south away from the mine entries. A drain between the road and the railroad (Location 35) emerges approximately 1000 feet west of the main Francis Mine entries (Locations 31, 32 and 33) from the headings which extended to the northern portion of the Francis Mine (Location 36). This drain discharges acidic water, although the workings north of the road have been almost completely stripped out. The water is apparently groundwater seeping through the strip mine backfill. Some pollution is contributed by mine refuse banks which extend into the small stream paralleling the Penn Central. Railroad near the Francis Mine entries. The magnitude of this contribution is quite variable and difficult to define quantitatively.

All entries to the Francis Mine are backfilled or collapsed, except a sloping airway (Location 31) adjacent to the main entries and a vertical air shaft (Location 42) near the western limits of the Francis Mine, which has been capped with reinforced concrete. A sinkhole (Location 37), partly filled with broken concrete and brick, is located west of the main entries near the railroad. This was the site of a pump installation during the operating days of the mine and apparently provides access for water to enter the mine.

The Pittsubrgh coal outcrops near the lower end of Plum Run and in the lower end of the next valley north, along the Penn Central Railroad. The coal is also visible in the railroad cut near Dinsmore (Location 38), west of the main Francis Mine entries. The coal also outcrops in a small valley at the western limit of the Francis Mine, and several caved drift entries (Locations 40, 41, 43 and 44) exist in this valley. This is in the highest portion of the Francis Mine.

The principal source of inflow into the Langeloth-Francis Mine Complex appears to be general percolation of rainfall through the overburden over the entire area. Only three locations show potential for concentrated inflow into the mine. One is the sinkhole west of the main entries to Francis j Mine (Location 37). A second is the stripped area north of the Penn Central Railroad and the Francis Mine entries which may drain into the mine headings under the railroad and road. Some of this drainage is discharged to the unnamedtributary to Burgetts Fork through the previously discussed drainpipe (Location J 35), but it is also possible that a portion of this drainage continues through the headings into the workings to the south. The other potential major inflow source is the small reservoir above the Langeloth Mine, located southwest of the main Langeloth entries. When the mine was active, it was observed that the mine roof below this reservoir always dripped water.

4.2 Subsurface Investigation: A subsurface investigation was conducted and piezometers were installed by Sprague and Henwood under Contract No. SL 130-4, awarded by the Commonwealth on the basis of competitive bidding.

The subsurface investigation in the vicinity of the main entries to the Langeloth Mine consisted of two borings drilled at locations shown on Fig. 4.

The relationship of the borings to the mine workings, the boring logs, and details of the piezometer installations are also shown on this figure. These borings were made to determine the type and condition of the rock above and below the mine and the elevations of the coal seam.

Boring l, located immediately adjacent to the main vertical shaft, revealed competent rock of various types overlying an 11-foot void at mine level. One piezometer was placed at mine level to measure water level in the mine and a second was installed midway between the ground surface and the mine level to determine the" relationship between the groundwater and the mine water pool. Boring 2, located above the strip mine highwall north of the main entries, did not intercept .the mine. However, a second boring, Boring 2A, ten feet east of Boring 2, did intercept the mine void. Boring 2A was drilled at the contractor's expense to permit proper installation of piezometers. One piezometer was placed in the mine void and a second, in the same hole, was placed midway between the ground surface and the mine level. A piezometer was also installed in the coal seam in Boring 2. The water levels shown on the boring logs are those measured a few days after installation of the piezometers.

Figure 5 shows the piezometer levels over a one-year period following piezometer installation. The mine water pool (Piezometers lA, 2 and 2A) fluctuates much less than the shallow groundwater level (Piezometers 1B and 2B) which is more influenced by weather and seasonal changes. The mine pool averages about El. 1019 at the main entries, but Piezometers 2A and 2 show a mine pool at El. 1024. Apparently, there has been a roof fall between these points and two mine pools are being measured.

4.3 Water Quality Analysis: A detailed water quality survey was not included in the original scope of work of this investigation, and only a limited number of water samples were taken and flow rates estimated to determine the

quality and quantity of water flowing from the mines. Chemical testing was done by Seewald Laboratories, Williamsport, Pennsylvania, under a direct contract with the Department of Mines and Mineral Industries (now Department of Environmental Resources).

Water quality data for the streams and mine discharges are presented in Table I. The sampling locations are shown on Fig. 6. Burgetts Fork (Sample 1) above the flowing Langeloth borehole, was slightly alkaline and had low iron and sulfate concentrations. Downstream of the Langeloth entries near Burgettstown, Burgetts Fork (Sample 4A) had high iron and sulfate concentrations but continued to be alkaline, according to these limited data. The discharges from the Langeloth borehole (Samples 7A, 3B) and the strip mine pond (Samples 3A, 5B, 7B) north of the main Langeloth entries had low pH and high iron and sulfate concentrations.

Plum Run (Samples 11A, 12A), above the Patterson Mine and the current strip mining, was also alkaline with low iron and sulfate concentrations. The Patterson Mine discharge (Sample 9A) was very acidic with high iron and sulfate content. Flow from the strip mined area north of Francis Mine (Sample 14A) was acidic and the small stream (Sample 15A) passing the Francis Mine entries and continuing on to Burgettstown was highly acidic over its entire length.

Only a few flow estimates were made at the time water quality samples were obtained, so estimates of pollution load are incomplete. However, the flow from the Langeloth borehole (Sample 7A, 3B) appears to be relatively constant, with a minimum of 200 gallons per minute and a maximum of 300 gallons per minute. The-acidity load from the borehole was measured to be 1500 to 2500 lb/day with an iron load of 1200 lb/day and a sulfate load of 10,000 to 15,000 lb/day. This is substantially less than the 5800 lb/day acidity reported in the FWPCA report, but both values are based on very limited sampling--a single sample in

the FWPCA case. The other principal discharge from the. Langeloth Mine, the strip mined area north of the main entries (Sample 5B), appeared to contribute no acid, but substantial amounts of iron and sulfate.

Monthly samples collected by the Ebensburg District Office, Department of Environmental Resources, from September 1974 through January 1975 correlates well with D'APPOLONIA data, except that samples of the dishcarge from the strip mine (Sample 13C) north of the main Langeloth entries showed significant acid load. The data is presented in Table II.

5.0 Abatement Methods

Abatement of acid drainage from the Langeloth-Francis Mine Complex
is to be achieved by sealing the. openings to. the complex to completely flood the workings and stop circulation of groundwater through the mine complex. It is presently thought that elimination of the exposure of the pyritic formations to oxygen from the air greatly reduces the production of acid, iron and sulfates. Limited experience to date on other recent Department of Environmental Resources projects, where sealing of drift entries has completely flooded the mine workings, has indicated significant reductions in acid drainage.

However, for the Langeloth-Francis Mine Complex, the potential interconnections with adjacent mines and the large number of possible openings to the mine workings make sealing of all openings and complete flooding of the workings very difficult. Due to the uncertainty of achieving complete inundation, construction of the seals in phases is recommended. In Phase I, the lowest openings should be sealed, raising the mine pool to approximately El. 1040, and the results observed. If the results of the first phase are satisfactory, a second set of higher openings should be sealed in Phase II, raising the mine pool to approximately El. 1070, again with the results observed. Finally, the highest openings should be sealed in

Phase III, raising the mine pool to approximately El. 1090. Continuing surveillance of the area throughout the phases is important to permit assessment of the results obtained and to observe quickly areas of potential difficulty. The sealing of the mine complex will require a -variety of seals. A number of boreholes should be reamed and grouted, vertical shafts should be backfilled and impermeable seals installed, and many slope and drift entries should be sealed with impermeable bulkheads, some constructed from within the mine and some placed remotely through boreholes. There are many ways to divide the construction work into phases, some including more phases and some fewer phases than the three phases suggested in this report. For any given number of phases, there could be several different groupings of tasks. The construction phases suggested here represent an optimum balance between the additional mobilization costs of more phases and the additional construction funds which must be committed for fewer phases. The tasks within each phase have been chosen based on the elevation of the openings and their proximity to other openings requiring sealing.

5.l Phase I Construction: The recommended Phase I construction is to seal the lowest openings to the Langeloth-Francis-Patterson Mine Complex. The proposed work includes the following:

1. The main shaft of the Langeloth Mine should be sealed as illustrated on Fig. 7. The existing concrete cap should be removed, the area around the shaft excavated to below the rock surface, the concrete shaft removed to the bottom of the excavation, the shaft backfilled from the mine level to a level suitable for placement of an impervious seal, the impervious seal placed, the remaining shaft capped with a reinforced concrete slab, and the entire area

backfilled. The level of, the impervious seal will be a function of the rock conditions and the water level within the shaft.

2. The air shaft adjacent to the main vertical shaft should be sealed in the same way as the main shaft,, except that the air shaft has already been backfilled with miscellaneous material. Some of this backfill should be removed before placing an impervious seal.

3. It is proposed to seal the Langeloth slope entry with a bulkhead seal as illustrated on Fig. 7. These bulkheads can probably be placed from within the mine, since the slope is concrete lined and appears to be in good condition.

4. Three boreholes require sealing: the flowing borehole W (Location 7) south of the main Langeloth entries, a borehole adjacent to the railroad (Location 9) south of the main entries, and a borehole at the main entries (Location 3). These boreholes should be reamed, plugged at the mine level and backfilled with grout. The flowing borehole should have a pipe and valve of corrosion-resistant material installed to permit lowering of the mine water level if it becomes necessary.

5. Sealing the headings in the stripped area north of the main entries to the Langeloth Mine can be achieved in two ways as illustrated on Fig. 8. The piezometers at this location indicate the water level is substantially higher than the mine workings (Fig. 5). With the water at this level, the headings should be sealed by remote bulkheads.

However if it is practical to lower the water level in the mine (e.g., by pumping or by a drainage trench to Burgetts Fork), a compacted impervious embankment can be constructed against the old strip mine highwall.

6. One of the three known drift entries to Patterson Mine on the south side of Plum Run presently discharges a substantial flow of mine drainage (Location 22). All three entries are caved, and their condition will probably not permit installation of seals from within the workings. These three entries should be sealed by bulkheads placed remotely through boreholes.

5.2 Phase II Construction: Following evaluation of the results of the Phase I construction, Phase II should consist of the following construction items:

l. The main entries to the Francis Mine are three drift or shallow slope entries which will. require bulkhead seals. At the time of this investigation, the condition of the entries appeared to be good enough to permit construction of seals from within the mine, but the recent strip mining has probably removed much of the coal in the area. The area is now backfilled and a significant subsurface investigation will be required to determine the present conditions.

2. Six known drift entries on the north side of Patterson Mine (Locations 27 and 28) were caved, and the entries probably were not in satisfactory condition to permit

construction of bulkheads from within the workings. Conditions following strip mining are not known, but as a minimum, six seals placed remotely through boreholes will probably be required.

3. Two sinkholes (Locations 47 and 48) on Plum Run upstream of the Patterson Mine and the current strip mining operations should be excavated, sealed with impervious clay, and backfilled with well-compacted soil.

4. A sinkhole (Location 37) west of the main entries to the Francis Mine should be excavated, sealed with impervious clay, and backfilled with well-compacted soil.

5. Four drift entries to the Francis Mine, in the small valley

between Dinsmore and Bertha (Locations 40, 41, 43 and 44), are caved and will probably require bulkhead seals placed remotely through boreholes.

6. The headings between the northern and southern portions of the Francis Mine (Location 36), extending under the Penn Central Railroad and the Burgettstown-Dinsmore Road, should probably be sealed by remotely placed bulkheads to prevent inflow of water to the mine workings and, as the mine water pool rises, to prevent discharge at this point. However, the effects of the recent strip mining in this area should first be evaluated. Depending on the nature of the backfilling, further sealing may not be required.

7. Langeloth Borehole No. 2 (Location 8) will require reaming, plugging at the mine level and backfilling with grout.

5.3 Phase III Construction: Final construction to completely flood the mine workings will require sealing a drift entry to the Francis Mine at Dinsmore (Location 39) and sealing and grouting along the railroad cut near Dinsmore (Location 38) where the excavation has broken into the deep mine workings.

5.4 Additional Subsurface Exploration: Sufficient information is now available to permit design of seals and construction procedures for the items described under Phase I. An exception is the sealing of the three drift entries to Patterson Mine on the south side of Plum Run, but since remotely placed bulkheads are to be used here, a few preliminary exploratory borings can provide the information required to determine the best location for the seals. Additional subsurface exploration will be necessary prior to the design of seals for the other phases.

Additional borings will be required near the main entries to the Francis Mine, near the sinkholes along Plum Run, along the railroad cut near Dinsmore, and possibly in the area of the Francis Mine drift entries between Bertha and Dinsmore. This subsurface exploration can be conducted concurrently with, or immediately following, Phase I construction.

An important part of this subsurface work should be the installation of additional piezometers, at the locations shown on Fig. 9, to monitor the water level rise in the mine workings following completion of the Phase I construction. The piezometers proposed include one in the Patterson Mine workings south of Plum Run, one adjacent to the main entries of the Francis Mine, one in the air shaft at the western limits of the Francis Mine workings, one in the air shaft at the western limits of the Langeloth Mine workings, and one into the Francis Mine at the head of Plum Run. These piezometers will permit

an evaluation of the continuity between the various areas of the mine complex and will indicate whether a single mine water pool or several pools exist due to roof falls or other obstructions within the mine workings.

5.5 Post-Construction Surveillance: Important to the satisfactory completion of the proposed phased construction of seals in the Langeloth-Francis Mine Complex is the continuing periodic surveillance of the area following Phase I construction. This is particularly important since the project is in a populated area. All peizometers should be read on a regular basis, probably biweekly or monthly, depending upon the rate of water rise in the mine complex. At the same time the piezometers are read, all areas of potential leakage should be inspected, so that corrective measures can be undertaken immediately if leakage develops. The surface inspection should include observation of the entries to the Bertha Mine southwest of Dinsmore (Locations 51, 52, 53 and 54). Although .the mine maps show an unpenetrated barrier between the Francis Mine workings and the Bertha Mine workings, the actual condition of this barrier is unknown, and raising the water level in the Langeloth-Francis complex could increase the rate of discharge from the Bertha Mine. The condition of the barrier between the Langeloth Mine and the Atlas Mine is also unknown, although individuals who worked in these mines indicate that the barrier remains in good condition. The water level in the Atlas Mine, however, should be observed on a regular basis. It may be necessary to install a piezometer in the vicinity of the main Atlas Mine entries at Atlasburg, or it may be possible to monitor the mine water level using the existing vertical shafts.

Continued surveillance of the area through the Phase II and III construction periods and thereafter is also essential to ultimate satisfactory

completion of the project. In this manner, early warning of potential problem areas would permit quick identification and development of remedial measures.

5.6 Potential Problems: The discussion in this report has assumed that backfilling of the Bologna strip mine along Plum Run adequately sealed the entries to the Patterson Mine on the north side of Plum Run. Since this investigation was completed, the Bologna stripping operation has continued on the north side of Patterson Mine, and the six drift entry seals proposed as part of the Phase II construction may not be required. The sealing of these areas may have been done adequately in conjunction with backfilling of the strip mine.

Along the eastern edge. of the Patterson Mine north of Plum Run, a number of homes are constructed in the coal outcrop area. Although we have not investigated in detail the conditions in this area, it has been reported that mine water from the Patterson Mine has leaked into the basements of some of these homes. If this is true, raising the water level in the mine by the construction proposed in this report may cause additional seepage or flow into the basements. Possible corrective measures are (I) a grout curtain between the homes and the mine and (2) excavation of a trench to the bottom of the coal and controlled backfilling with impervious material. The latter alternative would be more positive and would permit more control. Grouting old mine workings is difficult and the results are unpredictable. While Bologna's strip mining operation was already removing about 100 feet of overburden, the most economical procedure probably would have been for this mining operation to continue through the hill behind the homes and then be backfilled under careful control to assure a continuous impervious seal. Sufficient impervious material probably would have been available from the stripping

operation. The Department of Environmental Resources could have negotiated to pay the extra cost of removing the additional 60 to 75 feet of overburden. Now that the operation is apparently complete, a trenching and backfilling operation would be very expensive. It is now probably more feasible to grout the mine workings, despite the uncertainty of the results.

.Property ownership in all the proposed work areas has not been determined. The flowing Langeloth borehole (Location7) is on the property of Mr. Gus Barbush and he has indicated complete cooperation. The strip mined area north, of Slovan into which headings extend is owned by the Climax Molybdenum Corporation and easements will not be difficult to obtain for this area. The property around the main Langeloth entries is owned by Mr. James Bongiorni, and Atlas Alloys, Inc., is operating a foundry using some of the old mine buildings. Mr. Bongiorni has indicated he will not permit the proposed sealing of the main shaft since the foundry is using it as a source of water. Details of this problem were submitted to the Department in letters dated January 4, 1972, and February 2, 1972. No other easement problems are anticipated since all other proposed work areas are away from habitation.

An initial check of the water supply for homes above the LangelothFrancis Mine Complex indicated that all received water from the Smith Township Water Authority. A more detailed review of the Water Authority records, however, shows that several of the more isolated homes do not receive water from the Authority. Determination of their water supply will probably require a door-to-door survey, which is outside the scope of the present contract.

The small reservoir above the Langeloth Mine, immediately east of Slovan, was apparently a water supply for the town of Langeloth at one time. It does not appear to be serving any function at the present time. Flooding

of the mine is not expected to have a significant effect on the pond, although seepage from the mine pool to the pond may be expected.

5.7 Estimated Construction Cost and Effectiveness: The preliminary estimate of the cost of construction for the proposed work is summarized in Table III. No detailed design work has been done. The estimate is based on the cost of similar work on other projects. Total estimated construction cost is $l,398,000, but this is very dependent on the changed conditions following the recent Bologna strip mining. Since this stripping was done after the investigation reported here was completed, details of Bologna's mining operation have not been investigated. The additional subsurface exploration required is estimated to cost $4.2,000, not including engineering supervision.

In assessing the results to be expected from sealing these mines, it should be recognized that the mine complex is presently about two thirds flooded. Major reduction in the production of acid will probably require nearly complete inundation of the mine workings. The extent to which this can be accomplished is uncertain at this time, but achievement of complete flooding is probably not to be expected. Substantial reduction in the circulation of water through the mine can be expected, and this should result in a significant reduction of the pollution load flowing from the complex.

6.0 Recommendations

To substantially reduce the acid mine drainage from the abandoned Langeloth-Francis Mine Complex, the following construction work is recommended:

Phase I - Sealing of the main Langeloth vertical shaft, the Langeloth air shaft, the Langeloth slope entry, three Langeloth boreholes, three Langeloth headings in the strip r mined area north of the main entries, and three drift entries to Patterson Mine on the south side of Plum Run.

Phase II - Sealing the three main entries to Francis Mine*, six drift entries on the north side of Patterson Min *, two sinkholes into Francis Mine on Plum Run, one sinkhole into Francis Mine west of the main entries, four drift entries to Francis Mine near Bertha, the two headings under the road and railroad toward the northern Francis workings west of the main entries to Francis Mine*, and one borehole into Langeloth Mine.

Phase III - Sealing a drift entry to the Francis Mine at Dinsmore and sealing and grouting areas where the railroad cut broke into the deep mine workings. A controlled overflow from the top of the pool is probably not required, but. the area must be carefully watched as pool rises to note any potential breakouts.

Additional subsurface exploration and additional piezometers are recommended to provide data for design and to permit monitoring of the results of each phase of construction.

A door-to-door survey of all homes above the mine complex not receiving water from the Smith Township Water Authority should be conducted to determine the number of wells which will be influenced by flooding the mine workings.

Continuing periodic surveillance of the area, including reading piezometers and observation of areas of potential leakage, is recommended,

The details and necessity of this work is dependent on conditions following the Bologna strip mining

especially following completion of Phase I construction, to permit quick identification of leakage problems and to develop remedial measures. However, surveillance should be carried through and beyond the completion of the project.

7.0 Conclusion

A detailed field study of the abandoned Langeloth-Francis Mine Complex, including review of mine maps, surficial reconnaissance, subsurface investigation and water quality sampling, was conducted to evaluate the feasibility of sealing these mines to eliminate or reduce the drainage of

acid water into Burgetts Fork of Raccoon Creek. This report proposes a threephase construction program to seal all known openings to the mines and completely flood the mines. The phased construction will permit evaluation of results as the work progresses. While complete flooding may not be achieved, the additional flooding developed and the elimination of circulation of water through the mine should significantly reduce the quantity of acid and other pollutants entering Burgetts Fork from this mine complex.

Respectfully submitted,

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Project No. 69-118

December 1975