VI. ABATEMENT MEASURES

A. GENERAL APPROACH TO ABATEMENT MEASURES

1. General Comments

a. Hydrologic Factors

In general rainfall reaching the ground in an area containing both strip mines and deep mines either:

1. Evaporates in a return cycle to the atmosphere (at a rate dependent on the temperature and humidity).

2. Drains as sheet flow surface runoff, eventually collecting in natural swales, ditches and streams.

3. Returns to the atmosphere via vegetation transpiration (at rates dependent on seasonal variations).

4. Percolates into the ground and becomes part of the ground water system and/or enters a mine water pool.

5. Drains as runoff to the strip pits or in the case of extensive stripping is trapped directly. If the stripping overlies a mine pool this precipitation also enters the mine pool.

b. Areas Where Abatement Can Be Performed

With respect to the various remedial measures to abate AMD all of the above must be considered. However, there are three separate areas where AMD can be abated:

1. Prevent or minimize AMD formation at the source.

2. Minimize or prevent the AMD entry into the streams once it is formed.

3. Treat the AMD prior to entering the streams if no other remedial action is adaptable to a specific source.

c. Recommending Abatement Measures

In this report we have endeavored to propose all feasible "Civil Engineering" types of projects first. We are not enthused about the concept of treatment due to its apparent "ad infinitum" feature. It is impossible to determine over such a short time if the problem is, in fact, diminishing. However, others who have watched the problem over a long period of years note improvement in the streams of the anthracite region. It is doubtful if the problem will ever completely abate itself by "letting time take its course", since there may always have been some natural acidity in the streams of the region through natural weathering processes. This might be a limiting factor in the "time" equation. Of more importance the noted improvement may have been since the many large mines stopped pumping and ceased operations. Once the large mine pools formed, oxidation of remaining carbonaceous shale in the mine complexes was reduced. However, there still remains a large system of deep mines at higher elevations which are not flooded and which drain acid to the mine pools.

d. Major Sources of Acid Discharges

In the course of analyzing the various pollution sources we have integrated these sources in terms of acid load produced (lbs/day) to determine a composite average acid load for the study area.This total figure of 9,059 lbs/day is reasonably close to the average for the study year (8,962 lbs/day) as recorded at Sampling Station GS-61. It is very difficult not to duplicate part of acid loads from sourcesfurther upstream in the watershed regimen. In developing this composite AMD, the average estimated daily acid production for refuse banks and slush dams was also included at the rate of 18 lbs/day/acre (as developed earlier in the report).The significant contribution of AMD from refuse appeared to be one of the more surprising results of the survey. This fact is contrary to much early published literature which states that refuse is only a very minor contributor. However, we believe such statements are generalities and probably not based on field studies. From Plate No.61 it can be seen that this average estimated acid production is 3,072 lbs/day or approximately 30 percent of the total acid produced in the study area. This acid is flushed out during periods of heavy rainfall. The refuse is estimated to measure 18,760,000 cu. yds. and cover 420 acres within the study area.

It became apparent early in the study that the overflows from the mine pools in the study area were the major acid contributors. These five mine pools contribute approximately 68 percent of the flow and 61 percent of the acid load. One of these mine pools lends itself to complete remedial action while the remaining ones, within the limits of existing technology, do not appear to lend themselves to feasible and/or economical direct solutions, although their total acid loads can be partially reduced by the various "Civil Engineering" projects recommended. As an example, one mine overflow alone (Tracy Overflow from the Middle Creek Mine Pool - Sampling Station C-34) discharges over 47 percent of the total average acid load into the study area which is contained in an average 2,471 g.p.m. discharge (flow). This fact reluctantly has led us to recommend a central treatment plant to neutralize acid flows from five major sources - three mine pools, one abandoned mine, and one active mine (see also Section VI-C discussion on active mines). These five sources recommended for treatment account for 57 percent of the total acid discharged.

The acid produced is directly related to the amount of water coming in contact with various pyritic materials.Therefore it is imperative to alter in any way possible the existing hydrologic regimen through which acid is formed.

One of the major disruptions in the original hydrologic cycle, of course, is the extensive stripping carried out mainly during the Second World War and directly thereafter. Of course this was an expedient measure during wartime and little or no attention was given to restoration. It is reported that the streams of the area have been affected by deep mining to a degree since before the turn of the century. However, since then they have become "biological deserts" after the stripping was performed. One of the considerations should be either partial or total regrading of these strippings with accompanying planting of the disturbed areas. The cost analysis (Section VI-D) indicates that the reclamation of strippings is costly, however, it offers a permanent solution with limited maintenance, and is recommended along with other remedial work.

Reclamation of the strippings by regrading and planting will:

l. Reduce the flow and infiltration to the deep mines whereby acid is produced in both the strip mine spoil and the deep mines. Approximately 83 percent of the runoff is estimated to be captured runoff since the strippings are generally parallel to the contours and normal to the direction of runoff.

2. Increase runoff to the streams to provide additional dilution for aquatic life.

3. Increase evapotranspiration. As a result this water would then not be available for acid production.

4. Minimize or eliminate the release of acidic water from spoil material to the ground water system, strip lakes, and area streams. During extensive rainfall spoil (and refuse) material cause a slugging effect from the flush-out of acid salts produced during periods of no rainfall. This release of acidic water continues at a sustained rate long after rainfall has ceased.

e. Natural Buffering Capacity

Unfortunately there is no limestone in the study area and, with minor exceptions, none in the entire anthracite region of Pennsylvania. The cap rock is, generally sandstone with little or no natural alkalinity and buffering capacity. We have no evidence that large amounts of pyrite are contained in the sandstone, although no detailed tests were performed in this regard.

f. Interstate 81

With the exception of extensive strippings and the deep mines the recent construction of Interstate 81 was the other major development in the area to alter drainage patterns. In some cases the roadway drainage serves to drain strippings where the water level previously was stabilized. Generally drainage flows concentrated by the highway are discharged and eventually find their way to trip pits and hence deep mine pools. In one case, an airway to a mine was used to receive drainage. (This information was relayed to the proper authorities and the Contractor promptly remedied the situation since the project was still under construction during the sampling phase of this study). Other drainage system modifications are recommended in this report.

Such practices were common in prior years when little was understood about the nature and production of acid mine drainage. However, the present environmental emphasis has created notification and review procedures where the total environment can be considered.

2. Minimizing or Preventing Acid Formation

a. Water Flooding of Deep Mines

It is not intended to discuss here the chemical reactions by which AMD is formed since this subject has been covered by many writers in the past. Briefly, acid mine drainage is caused by the exposure of air to the pyritic materials associated with coal seams. The products of oxidation of the pyrites are then dissolved by normally non-acidic ground water forming acid water. Other minerals (principally iron) in the surrounding strata are then dissolved by the acid water. (Laboratory tests in this study were limited to total iron and in some cases ferrous iron. As directed by the Department no attempt was made at this time to determine the amount of manganese, aluminum etc. present in the water).

Remedial measures, during the last forty years, have centered on eliminating or minimizing any one of the principal ingredients - pyrite, oxygen or water. If one of these can be excluded or limited the chemical series of reactions will be disrupted or limited.

For this reason mine air sealing, commencing in the 1930's, was performed with doubtful results. This occurs principally due to the fact that in large deep mines some fracturing of the overburden is always present allowing the entrance of air. This is particularly true where robbing of the pillars has created surface subsidence,as in the Anthracite Region. Subsidence in the Bituminous Regions tends to seal itself in time, but in Anthracite Regions this is not the case.

Hydraulic mine seals to date have not been extensively used, but many such installations are being considered at the present time in various Appalachian States. These seals should achieve the following results:

1. Flood the bony material remaining adjacent to the mined-out coal measures, thus preventing air contact (the amount of air contained in water is very limited).

An anomaly appears to exist in that vast mine pools are in this study area already whose overflows discharge acid water. These mine pools are mainly located in the valley area.It is believed that the actual AMD is produced in the travel of the drainage through the strip pit spoil and thence through the exposed deep mine levels lying above the mine pool.By the time the water reaches the mine pool it is acidic.

2. Raise the pool level so that better quality water is discharged from the top of the pool. (The bottom of the pool should be of progressively poorer quality).

The Tracy Overflow from the Middle Creek Pool has the poorest quality water of any in the study area - 32 to 250 mg/l of acidity. The extreme length through which water must travel in the workings may account for this higher acidity compared to the other mine pool overflows. The area of strippings requiring regrading and which lie above mine pools gives some indication of this:

Mine Pool	Area Requiring Regrading (Acres)
Middle Creek	622
Good Spring No.1	300
Good Spring No.3	240
Colket	215
Indian Head	165

Another important reason is seen from a review of the Mammoth Vein - reportedly the coal vein having the highest sulfur content in the area. In the Fisher Basin area (above the Middle Creek Pool) the vertical distance to the level of the mine pool is the most extreme:

Mine Pool	Estimated Water Elevation of Mine Pool	Average Ground Elevation at Mammoth Vein	Difference
Middle Creek	885±	1300±	415±
Colket	945±	1300±	355±
Good Spring No.1	1185±	1450±	265±
Good Spring No.3	1152±	1300±	148±
Indian Head	827±	900± *	73±

* Average ground elevation above pool. The Mammoth Vein does not exist in this area.

Fluctuating levels of mine pools undoubtedly have some effect by dissolving acid salts in the remaining carbonaceous shale material. During three different field checks at the Middle Creek Shaft (Middle Creek Mine Pool) we have noted changes in water level of 6 feet. The intermittent flow at our Sampling Station GS-96 also indicates a fluctuating pool level (Good Spring No.1 Pool). Most of the time the discharge is through the boreholes and trench to the East Branch of Bausch Creek. However, during extended rainfall the pool level rises and some flow is discharged at Sampling Station GS-96. When dry, depths of 6 to 10 feet below ground surface have been noted at this airway (Sampling Station GS-96).

A new Federal-State project commenced in December, 1970, to monitor the pool levels and their acidity within the abandoned anthracite mines of Pennsylvania. This data is necessary to provide more detailed information concerning characteristics of mine pools, the major problem in the anthracite region.

b. <u>Inundating Refuse</u>

The movement and burying of the very large refuse banks in the study area is not recommended. However, some of the scattered small refuse piles should be buried along with the regrading of strippings.

Many of the comments regarding flooding of deep mines are also true in the flooding of refuse.In selecting strippings for burying refuse material first priority should be given to those strip pits which normally contain standing water. Second priority should be given to strip pits which are not directly over or connected to deep mines. Particularly, strip pits should be avoided which lie at some vertical height above the level of mine pools.

c. Erosion Reduction of Refuse Banks and Spoil Areas

Severe erosion occurs in refuse banks and spoil areas which continually exposes new pyritic faces. Therefore additional experimentation should be carried out with respect to the development of a successful hydroseeding procedure. It has been demonstrated many times that spoil material associated with strippings, along with proper amounts of lime and fertilizer, can achieve successful planting. It may be that refuse material, per se, cannot be successfully planted without the addition of some soil. We have observed that the eastern and part of the northern slopes of the Westwood Slush Dam have been recently covered with spoil material to repair the dam. It might be necessary to similarly cover the perimeter banks of all inactiveslush dams with spoil in order to achieve successful planting. Inactive refuse banks might also be reduced in height to a low mount with maximum 3 : 1 side slopes, to help retain soil moisture and prevent erosion, covered with 8" to 12" of spoil material, and planted.

In order to achieve successful planting of spoil various alkaline materials can be added. These include lime, limestone, water treatment sludge, sewage treatment sludge or industrial alkaline sludge.

The water treatment plant at Pottsville uses chlorine and soda ash injected into the distribution system but there is no waste product.

Pottsville has a sewage treatment plant under construction and Tremont reportedly has one under design. The Village of St. Clair has a sewage treatment plant providing primary treatment (35 - 40 percent sludge removed) for some 450-550,000 gal/day. This sludge and/or the sludge effluent is available although transportation costs may make it impractical.

The Alcoa plant at Cresona has a caustic waste product which is about 25 percent sludge and the remainder is in liquid form. It has a pH of 14, although only 2,000 gal/month are available.

With respect to refuse banks and slush dams several types of chemical bonding offer promise, although they are somewhat costly. There has been recent research into carbonate bonding and silicate treatment of the surface areas of refuse.

Research has been done with respect to the removal of sulfur from refuse for commercial profit.This too offers promise to abate or eliminate AMD production in refuse material.

d. Stream and Ditch Restoration

Drainage from streams and ditches which presently are diverted to strippings usually emerge at mine pool overflows as AMD. Any such projects are highly recommended due to their demonstrated need and low cost.

The Pottsville Office has completed stream restoration projects on Gebhard Run, Middle Creek, Coal Run and Bailey Run.

Where streams cross above mine pools and pass through loosely compacted spoil material or old strip pits they lose water through their streambeds. Impervious linings are recommended to prevent this from occurring.

Ash (U.S.B.M.) reports that loss of water through streambeds may occur through the following factors in addition to loosely compacted spoil material:

1. Fissures and cracks caused by subsidence.
2. Bedding planes in the rock strata.
3. Natural cleavage planes.
4. Faults.

"The loss is not a function of the amount of water passing a given point in the stream but rather the number and size of openings lying within the wetted perimeter of the stream."

Ditches which cross strippings also require flumes in conjunction with regrading.

e. Regrading Strip Pits

The PenAg Strippings in the Lykens Valley Nos.2 and 4 Veins are good examples of partially regraded strippings using available material to effect positive drainage control.

However, sometimes total regrading may be required in the valley areas to effect drainage, return the land to productive use, or to repair impaired aesthetics where this may be a consideration.

In general, partial regrading (using available material) is recommended since it normally achieves the desired result of serving to abate AMD production. Along with associated planting, the area can be returned to a reasonably aesthetic condition at a reduced cost when compared to total regrading. An average estimate of cost is difficult to give since it varies with the location. However, partial regrading costs range from $1,000/acre to $l,700/acre and total regarding ranges from $l,500/acre upwards to $3,000/acre. The additional costs of total regrading are principally the handling and trucking costs for borrow material to make up the backfill deficiency.

Partial regrading maintains swale drainage while total regrading effects sheet flow runoff. Maintenance of partial regrading will be greater due to the necessary maintenance of drainage control. This is particularly critical in the case of cropfalls within the graded swale resulting in an associated loss of drainage to the deep mines.

It has been observed that required maintenance of recent regrading where active deep mining exists (East Branch Rausch Creek) is quite extensive, and is probably due in part to earth movements in robbing of pillars, etc. In the project study area, except for a few small mine operations, much of the deep mining has ceased. In the PenAg regrading referred to above, even though no maintenance has been performed for several years, only two cropfalls were observed near the outfall of this extensive stripping. These cropfalls should be repaired since all drainage is currently lost at these points.

Regrading and recompacting the strip pits along with reducing infiltration also reduces the air circulation in the abandoned areas of deep mines where more or less direct connections exist. Therefore the exposed bony material above the level of the mine pools will not as readily oxidize. The backfilled spoil material should be compacted to the greatest extent possible as can be achieved by the movement of equipment through the strip pits. At the same time all cropfalls should be repaired as necessary for both drainage and safety.

Restripping methods have been used in the Bituminous Regions to effect proper backfilling under existing law. Because of the folding of coal veins in the Anthracite Regions, thicker coal veins, and the resulting deeper strippings it is likely that restripping would tend to increase the backfill deficiency if contour regrading (total regrading) were considered. Partial regrading following restripping may be feasible and economical at higher elevations where drainage control is more practical.

In Section VI-B - Recommended Abatement Measures - where planting is recommended it is deemed to include proper amounts of lime and fertilizer, subject to soil tests. Planting may include grass seeds and/or tree seeds. Often small tree seedlings are used exclusively in the Anthracite Region because the cost to the operator is approximately one-half that of planting grass. However, combination grass and trees should be required on the steeper slopes to prevent erosion until the ultimate crop (trees) is fully established.

f. Interceptor Ditches and Flumes

When large scale deep mining was in progress sometimes longitudinal ditches were dug to help reduce the water infiltrating to the workings, although usually these were confined to protecting mine entries, colliery areas and large mine operations. For the same reasons interceptor ditches are now recommended above the major stripping areas to prevent infiltration and hence ADD formation. In this case they are recommended to be 8 foot wide (except in rock areas) for easier machine construction and since they likely will rarely be maintained.

g. Repair Subsidence Areas

Several methods are available to remedy subsidence areas. These include:

1. Excavate out the subsidence area and recompact it to provide drainage.

2. Fill the depression to drain.

3. Construct ditches on the uphill side to "detour" the drainage.

4. Place bentonite, fly ash, limestone, slag and other material in the fissures.

Method l. is recommended as the most practical to provide as much as possible a permanent and economical solution.

3. Minimizing AMD Entry to Streams

a. Impervious Plugs and Dikes at Strip Pit Overflows

Once AMD has formed various means can be used to prevent or minimize its entry to streams. Overflowing strip pits are the third most significant source of acid (behind mine pool overflows and refuse banks). Two of the major examples of this occur at Sampling Stations GS-119A and MC-l. In these cases impervious (clay) plugs and/or dikes are recommended to contain the AMD discharges to prevent their entry into the streams. The technique is generally limited to the headwaters of streams near the mountain crests where the ground water is usually somewhat depressed.

b. ReSrade Strip Pits

Much of the previous discussion on regrading of strip pits also applies to minimizing the flow of AMD (produced by loose spoil material) into the streams. The compaction of this material should also considerably reduce the infiltration rate to the underground workings. Researchers have reported that the infiltration rate through ungraded spoil is about 7 to 10 times faster than through graded spoil. However, the top several feet should not be compacted to aid in the survival rate of trees and grasses through retention of rainfall.

C. Dikes and Grout Curtains Adjacent to Major Refuse Banks

The surface runoff and the seepage from beneath refuse banks now find their way directly to the streams. Low impervious dikes and grout curtains may be one method to contain all but the most severe low frequency storm runoffs and to provide an evaporation basin. Excess rainfall will be discharged during periods of high rainfall when the dilution factor will be greatest.

The seepage from beneath the banks is a special problem. Chemical grouting of subterranean water can be achieved through use of nonviscous chemical solutions that will penetrate masses through which water flaws. Later they turn to a stiff gel in a controlled period of time.

However, the preferred method is to regrade the refuse piles and plant them as previously discussed.

d. Hxdraulic Mine Sealing

One example of containing AMD through hydraulic mine sealing is the studies and designs now underway on the Bowman and Coleman Mine. This mine seal may contain water up to a head of 200± feet. An artificial overflow may be created at a certain point to control this head. However, again this water will be from the top of the pool, and therefore should be of much improved quality.

e. Relocate Slush Dam Ponds

During the course of the study it was noted that a pond of water always was present at the northwest corner of the vast inactive Indian Head Slush Dam.Since this is also over the southern fringe of the Indian Head Mine Pool it is felt that the pond should be relocated as far to the south as possible (keeping the excavation of refuse to a minimum) and draining water to this point by a new channel across the surface of the slush dam. The material thus excavated can be deposited in the existing pond. The natural drainage under the slush dam is to the south since this was the original channel location for Middle Creek before it was relocated. Most of the seepage from beneath the relocated pond will be retained by the recommended dike and grout curtain at the south end of the slush dam.

The pond should be preserved since it also appears to have some recreational value for duck hunting even though it contains little vegetation.

f. Use of Refuse Material For Other Purposes

Various research programs are presently underway to determine possible uses for refuse materials.

Among the possibilities being considered are:

(l) Use as a fuel by power generating companies utilizing new fluid bed processes which accommodate a high ash material (as much as 40 percent). Refuse, if necessary, may be supplemented by higher quality anthracite to increase the BTU value to an acceptable level. However, to date such proposals appear to be projected only in the Northern Anthracite Field. In order to reduce the many large refuse piles in the Southern Field, such a plant would appear to offer the best long term solution to removal of these monuments to the past. At present only a non-coal burning combustion turbine generator is planned (1975) to be constructed at Pottsville. The prospects of a future power generating plant in the Southern Anthracite Field which would use anthracite/refuse is not promising.

(2) Construction uses:

a. Anti-skid roadway materials
b. Use of burned-out refuse "red dog" for minor roads and driveway material. This material is normally not acidic. (Some "red dog" exists north of Donaldson on both sides of Route 125).
c.Building block and brick
d.Embankment construction.

(3) Other uses may consist of crushing the material and hydraulically filling mine voids to prevent subsidence and as land fill in the development of housing and industrial sites.

4. Treatment of AMD

The detailed discussion of the recommended collection and treatment facility is contained in the next Section of the report.

Many different types of treatment are being experimented with to treat AMD. However, lime neutralization appears to be the only important type of treatment at the present time due to low cost.

Hydrated lime is recommended due to its proven operational advantages. However, limestone has been advocated by some as a neutralizing agent for treatment of AMID, particularly for weaker acids and low iron. Limestone also has some advantages such as:

l. Difficult to over treat.
2. More rapid settlement of sludge
3. Greatly reduced sludge volume
4. Lower cost

Some active mines use limestone in treatment. Current research is being conducted in this type of treatment and also in combined limestone - lime treatment.

If for some reason the hydraulic mine seals recommended for the Good Spring No.3 Mine Pool cannot be effected, it has been noted by others that this overflow could be diverted to the Colket Pool by creating a deliberate breach in the top of Pillar XIX. This would minimize costs of collection of this AMD should it be necessary to provide treatment. However, in general it is not a good practice to mix waters from different mine pools and there may be certain legal problems involved.

5. <u>Other</u>

a. <u>Sulfate Damage</u>

Where concrete has been used in flumes, drop structures, etc. in other watersheds and where the concrete has been in place for some years, sulfate damage to the concrete has been observed. In some cases the aggregate is being eroded away to the point where the life of the facility is being threatened. Where concrete is used to control AMD it is recommended, where possible, to use sulfate resistant concrete and/or a 20 to 30 mil coating of coal tar epoxy. This might also be considered in existing flumes if the water analysis indicates an aggressive water or evidence of damage to the flume invert is observed.

b. <u>Co-treatment</u>

Co-treatment of normally alkaline sewage and AMD has been investigated in recent years. A desirable ratio appears to be approximately 6 : l, that is 6 sewage to 1 of AMD.

Tremont does not have a treatment plant at the present time although it is understood that plans for one will be developed. At this time co-treatment does not appear to be practical at least in this situation. Considering only the Tracy Overflow, for example, the ratio to the potential sewage flow for Tremont is about 20 : 1 in the wrong direction. There are also considerable operational problems with co-treatment in that daily sewage flow may vary by a factor as much as 2.5 times the average flow.

c. <u>Maintenance and Closures of Existing Facilities and Mines</u>

In the course of the study several areas were noted in this category.

The relocated Middle Creek eroded to a very considerable amount below the Indian Head Slush Dam and before the stream joins with Coal Run. This occurred during the severe storm of April 2 and 3, 1970. While apparently no AMD is being created, further eroding might carry back into former stripping areas. Stepped rock sills should serve to prevent further eroding.

Also many hazardous mine openings exist throughout the area, particularly in the headwaters of Middle Creek. These openings are of no direct concern with respect to the scope of this report (no AMD is being discharged); however, they do offer some hazard to people walking in the area (hunters, etc.)

d. <u>Clark and McCormick Drift</u>

The Tremont reservoir has several small streams and springs which supply water to it. The Clark and McCormick Drift is one of these. (A trough leads from the mine to the reservoir).

A station was set up at this source (Sampling Station GS-74) and the results indicate this closed mine entry is generally alkaline or neutral. However, on occasion acidity up to 8 mg/l was noted.

The measured average discharge is 165 g.p.m., and its average acidity/alkalinity is 4 lbs/day of alkalinity. The maximum acid load is 22 lbs/day. The pH range is 5.3 to 6.6.

As a check the water at the overflow from the reservoir was sampled on four occasions. In all samples the overflow was alkaline ranging from 8 mg/l to 74 mg/l of alkalinity. The pH range was 5.2 to 6.5.

e. Significant Acid Sources

At the end of this Section a significant source table lists the maximum acid load (lbs/day) for various sources in the study area. For convenience in relating the sources to each other they are listed in order of decreasing magnitude of acid load.

The maximum acid load was used in considering candidates for abatement measures. The average acid load can be somewhat misleading in the headwaters region of streams (such as this area) since some sources are dry for part of the year. Engineering judgment was neces sary in listing the significant sources. A maximum acid load of 10 lbs/ day was used for the abandoned sources.

For these significant sources as listed in the table the number and grouping by maximum acid load range is as follows:

Number of Sources	Range of Maximum Acid Load (lbs/day)
1	> 5,000
3	1,000 to 5,000
2	500 to 1,000
10	100 to 500
2	50 to 100
20	10 to 50

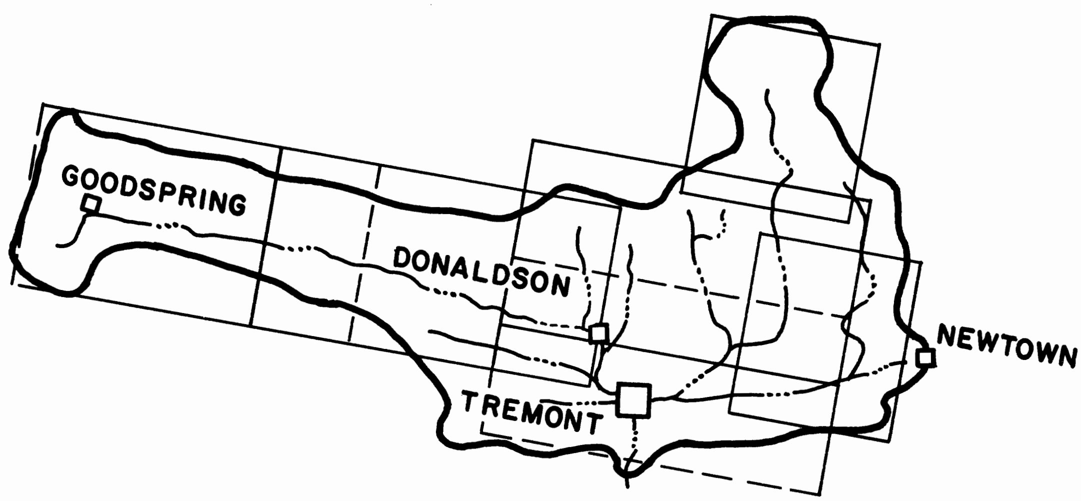
In the following Recommended Abatement Measures Section of the report the various sources are presented in logical groups, according to the various sub areas of the watershed where they occur. Therefore their priority numbers are not in any particular order. For a review of such a listing refer to the Cost Analysis Section of the report.

SIGNIFICANT AMD MEASURED AT SAMPLING STATIONS WITHIN STUDY AREA

Order of Magnitude	Sampling Station	Maximum Recorded Acid Load lbs/24 hrs.	Description
1	C-34	11,580	Tracy Overflow (Middle Creek Mine Pool)
2	GS-95	3,475	Tracy Airhole (Good Spring No.3 Mine Pool Overflow)
3	MR-53	1,983	Colket Water Level Tunnel (Colket Mine Pool Overflow)
4	C-37	1,639	Marshfield Slope (Indian Head Mine Pool Overflow)
5	GS-119A	756	Overflowing Strip Pits
6	MC-1	507	Otto Stripping (Overflowing Strip Pits)
7	MR-52	480*	Mercury Water Level Tunnel (Active Mine)
8	GS-124	267	Overflowing Strip Pits (GS-116, GS-117, GS-118 Collectively)
9	C-38	196	Marshfield No.2 Outfall (Indian Head Mine Pool Overflow)
10	GS-106	156	Underground Seepage to Surface
11	MC-11	149	Renninger Water Level Tunnel (Active Mine)**
12	GS-62	126	Fasnacht Drift No.1 (Abandoned Drift Mine)
13	GS-96	125	Airhole - Tracy Vein (Good Spring No.1 Mine Pool Overflow)
14	B-47	120	Bailey Run above confluence with Good Spring Creek
15	G-21	113	Gebhard Run above Route 125
16	MC-2	107	Kocher Stripping (Overflowing Strip Pit)
17	GS-78	72	Abandoned Drift Mine
18	GS-79	58	Abandoned Drift Mine
19	GS-92	49	Bowman & Coleman Water Level Tunnel (Abandoned Mine)
20	GS-118	36	Overflowing Strip Pit
21	GS-137	36	Overflowing Strip Pit
22	MC-3	27	Miller Mine (Abandoned Deep Mine - Active Pumping)
23	GS-112	27	Discharge from Donaldson Slush Dam
24	G-23	23	Abandoned Deep Mine
25	GS-102	23	Overflowing Strip Pits (GS-100, GS-101 Collectively)
26	GS-74	22	Clark & McCormick Mine (Abandoned Drift Mine)
27	GS-100	22	Overflowing Strip Pit
28	GS-136	22	Seepage from Strip Pit and Spoil
29	GS-72	20	Spangler's Drift (Abandoned Drift Mine)
30	GS-117	20	Overflowing Strip Pit
31	GS-73	19	Eckel's Tunnel (Abandoned Drift Mine)
32	MR-54	16	Colket Mine (Active)
33	GS-120	14	Proving Trench
34	G-22	13	Federovich Mine (Active)
35	GS-116	12	Overflowing Strip Pit
36	GS-138	12	I-81 Swale Drainage
37	MC-8	11	Hatter Mine (Active)
38	GS-99	11	Senawaitis Brothers Mine (Active)

* Combined gravity flow and pumping

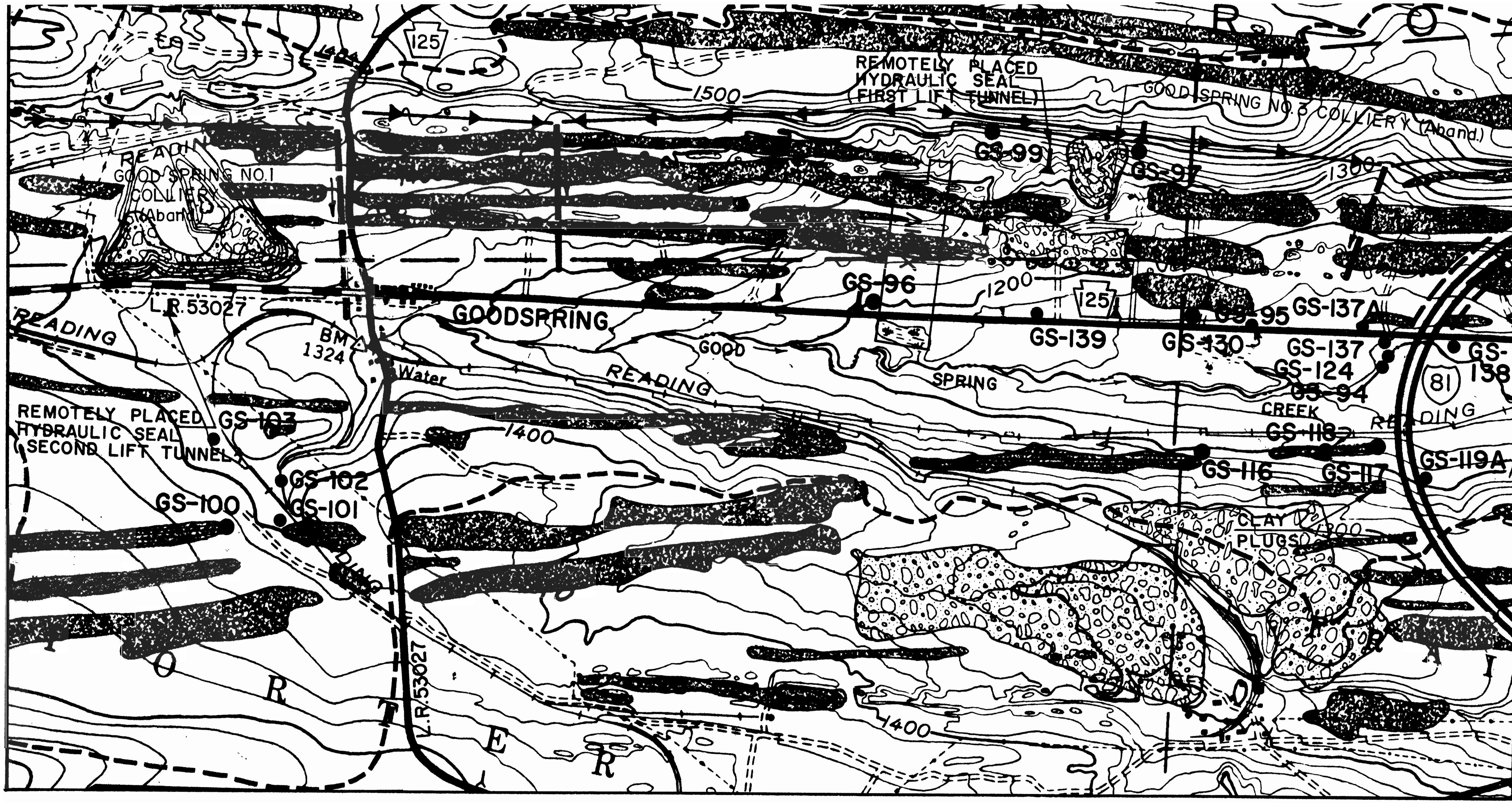
** Mine was abandoned in June, 1970

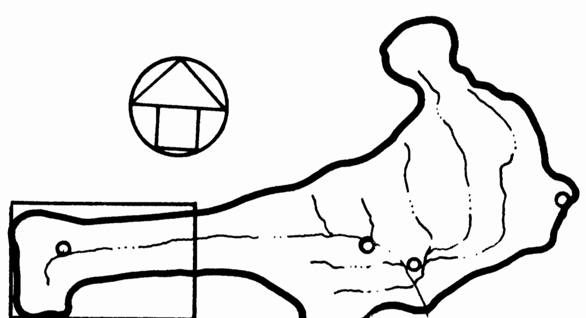


MINE DRAINAGE POLLUTION ABATEMENT

LEGEND

- STRIP MINES
- REFUSE BANKS AND SLUSH DAMS
- PROPOSED STRIP MINE REGRADING, SPECIFIC AREAS
- PROPOSED GROUT BLANKET
- WATERSHED LIMITS
- PROPOSED FLUME AND LINED DITCH
- PROPOSED INTERCEPTOR DITCH
- PROPOSED STREAM RELOCATION
- PROPOSED AMD DIKE
- PROPOSED TREATMENT COLLECTION POINT
- PROPOSED TREATMENT STORAGE BASIN
- TYPICAL MAJOR ACID PRODUCING SOURCE
- TYPICAL PROPOSED HYDRAULIC MINE SEAL





Scale: 1 Inch = 1000 Feet

MINE DRAINAGE
POLLUTION ABATEMENT

PLAN

PLATE NO.22

B. RECOMMENDED ABATEMENT MEASURES

l. SAMPLING STATION GS-95 PRIORITY No.2

TYPE OF DISCHARGE: GOOD SPRING NO.3 MINE POOL OVERFLOW (TRACY AIRHOLE)

This discharge represents the overflow from the Good Spring No-3 Mine Water Pool. The pool is contained between Barrier Pillars XIX and XXIV. The water discharges to the surface through an airhole in the Tracy Workings located between the Villages of Good Spring and Donaldson, approximately 2000 feet west of Interstate 81 and 30 feet north of Pennsylvania Route 125. The estimated amount of water in the mine pool as determined by the U. S. Bureau of Mines is 471,000,000 gallons based on data compiled in 1945. However, the quantity now is undoubtedly more since some pumping was in progress at that time in the PenAg (northernmost) portion of the pool. After emerging from the airway the effluent from the workings ponds behind a small dam prior to flowing south through a culvert under Route 125 into Good Spring Creek. The reputed elevation of the mine pool is Elevation 1152± (U.S.B.M.) which corresponds to the elevation of the Tracy Airhole (Sampling Station GS-95).

Measurement data at Sampling Station GS-95 indicates an average flow of 1,758 g.p.m., an average acid load of 794 lbs/day, and a maximum acid load of 3,475 lbs/day. The pH range has been determined to be 3.1 to 5.1. This is the second worst source in the study area.

A total of 240 acres of strip mine lands communicate with the Good Spring No.3 Mine Water Pool. This pool in actuality is two pools; the Good Spring No.3 Mine Complex (early 1900's) is connected by the First Lift Tunnel to the more recent PenAg Workings which were abandoned in 1966. (See Plate No.6 and the special plan "Underground Mine Water Pools Study Area and Vicinity" in back cover folder). The PenAg portion of the pool is reputed to be 16 feet higher, or Elevation 1168±. The Good Spring No.3 Mine was located in the valley area while the PenAg workings are in the Lykens Valley No.2 Vein at higher elevations on the south side of Broad Mountain,

The proposed abatement measures recommended for this source include a series of four progressive hydraulic mine seals, the first being a remotely placed deep mine seal in the north-south oriented First Lift Tunnel, located about 1200 feet west and 1500 feet north of the Tracy Airhole discharge point. Depth of the tunnel varies from 250 to 470 feet below the ground surface. The estimated rate of water flowing through the tunnel between the two portions of the pool is 0,06± f.p.s. which must be considered in the remote sealing. Debris and "Yellowboy" in the tunnel will also have to be considered.

The seal will isolate the PenAg Workings from the Good Spring No-3 portion of the pool since the First Lift Tunnel is the only connection between these mine complexes. It is also in the PenAg workings which are only partially flooded where much of the AMD is formed, The water in the PenAg Workings will then rise 145± feet to a new discharge point in the No.1 Water Level Tunnel - Sampling Station GS-97 at Elevation 1313 (See Plate No.6). The influx of ground water should be proportionately reduced by the rising water in the pool, While the acidity of the water emanating from the No.1 Water Level Tunnel is not expected to improve, the reduced flow is estimated to effect a reduction in "total acid" from the PenAg Workings of approximately 50 percent. The difficulties in placing this remote seal should not be underestimated due to the unknown condition of the tunnel (amount of debris, age of workings, etc.). Various technological studies such as TV borehole inspection etc. should be employed. A final decision should consider safety factors etc. in effecting a remote seal and means should be used after construction to evaluate its effectiveness.

A second mine seal is proposed at the No.1 Water Level Tunnel, This seal need not be placed remotely, although provision would have to be made to control the flow of water in the tunnel during construction. After the Second Seal construction the water will rise an additional 72 feet to discharge at the No.4 Slope (Elevation 1385) in the eastern end of the PenAg Workings. It is probable that the approximate location of the original ground water table at the crest of Broad Mountain (Elevation 1549±) prior to mining, could be as much as 200± feet below the crest of the mountain. Therefore the ground water may reach an equilibrium condition and the flow from the No.4 Slope may be very small. Even if there is a small acid discharge it is not practical to effect a third seal at this point since water would quickly flow from one of the many old regraded crop falls in the Lykens Valley No.2 Vein (the Lykens Valley Nos.2 and 4 Vein strippings in this area are good examples of partially regraded strippings. They are some of the few such examples in the study area. However, they have not been maintained in recent years and a minimal amount of maintenance is required due to several cropfalls at the eastern end of these strippings. The estimated abatement of AMD from the PenAg portion of the pool will therefore be nearly 100 percent.

In addition to the Tracy Airhole, it is believed that the underground deep mine pool surfaces near Good Spring Creek in a swampy area south of Pennsylvania Route 125 and in several non-flowing strip pits north and east of Sampling Station GS-95 at elevations slightly lower than the airhole.

Another airway also exists approximately 1200 feet west of the Tracy Airhole. Both of these airways are in the Tracy Vein Workings. It has been reported that the Tracy Vein contains generally less sulphur and therefore yields better quality water. However all of the water discharging from the Good Spring No.3 Mine Water Pool must plunge downward and southerly through another first lift tunnel (north-south oriented) connecting the Tracy Vein Workings to the remainder of the pool. This downward movement of water contributes to the eventual discharge of poorer quality water which is characteristic of water at lower levels in mine pools. Therefore it is proposed that the third and fourth mine seals should be in these two Tracy Vein airways. Following the construction of the third and fourth seals, any new overflow would be in the strippings mentioned in the preceding paragraph - probably the Orchard Vein Stripping. Any significant raising of the pool level would not occur, therefore consideration of the effectiveness of the barrier pillars as dams is not a factor in the third and fourth mine seals. In this manner more of the infiltrating water to this mine pool should remain near the top of the pool, and hence be of better quality. Any discharge from the strippings can be controlled to discharge to Good Spring Creek. The series of four seals is estimated to abate 75 percent of the total acid discharging from the mine pool overflow.

The remaining reduced flow is estimated to contain 25 percent of the total acid load. This reduced flow will originate from the basic surface infiltration and ground water contribution emanating above the Good Spring No.3 Mine Pool (excluding the PenAg portion of the pool).

A proposal has previously been made to the Department to regrade the strip pits above the mine pool adjacent to Interstate 81 (at least l,000 feet each side of I-81). This should further reduce the total acid by 12 percent. If the entire area of the mine pool is regraded (barrier pillar to barrier pillar), including interceptor ditches and flume construction across the partially regraded strippings and planting as recommended, it is estimated that nearly the entire remaining 25 percent of total acid will be abated. This will facilitate runoff to Good Spring Creek and prevent entrapment of this water in strip pits as now occurs. This regrading is recommended to be partial regrading to effect positive drainage control using available spoil material. The cost is estimated to be $246,400. If refuse material and other fill is used to make up the deficiency then total regrading can be effected to produce drainage "sheet flow", improved land use and optimum aesthetics. This is estimated to cost a total of $866,400.

The following abatement measures are recommended:

l. Series of four progressive hydraulic deep mine seals as described above.

2. Interceptor ditches above the Mammoth Strip Mine Complex. These ditches will also intercept water being discharged from the previously regraded and higher PenAg Strippings.

3. A flume (north-south) across the strippings about 1300 feet east of Sampling Station GS-95. (See Plate No.23).

4. Partial regrading of 240 acres of strip pits above the mine pool to drain freely by gravity.

5.Planting of the entire area of 240 acres.

6. Hydroseeding or sealing by chemical bonding the Refuse Bank and the outside perimeter of the PenAg Slush Dam. (See also other "in lieu of" treatments in Section VI-A-2c).

Care should be taken in completing abatement measures in the Good Spring No.3 Mine Water Pool. The Senawaitis Brothers Mine in the Buck Mountain Vein is a small but still active mine which could conceivably be affected by the deep mine seals. However, precautions can be taken with respect to safety by increasing the distance between the mine and the proposed seals.

The estimated costs for the remedial measures in the vicinity of the Good Spring No.3 Mine Water Pool are as follows:

1.Progressive Deep Mine Seals (Series of four hydraulic deep mine seals) $240,000
2.Interceptor Ditches6,500
3. Fluming 32,000
4. Regrading Strip Mines (using available material) 246,400
5. Planting 60,000
6.Hydroseeding or sealing by chemical bonding, etc.6,800

For total regrading of the 240 acres of stripped mines to original contours, add to Item No.4 an additional: $620,000

Percent of total acid abated: 9.2% average

PRIORITY NO. 2 — PROPOSED FLUME ACROSS GOOD SPRING NO.3 POOL

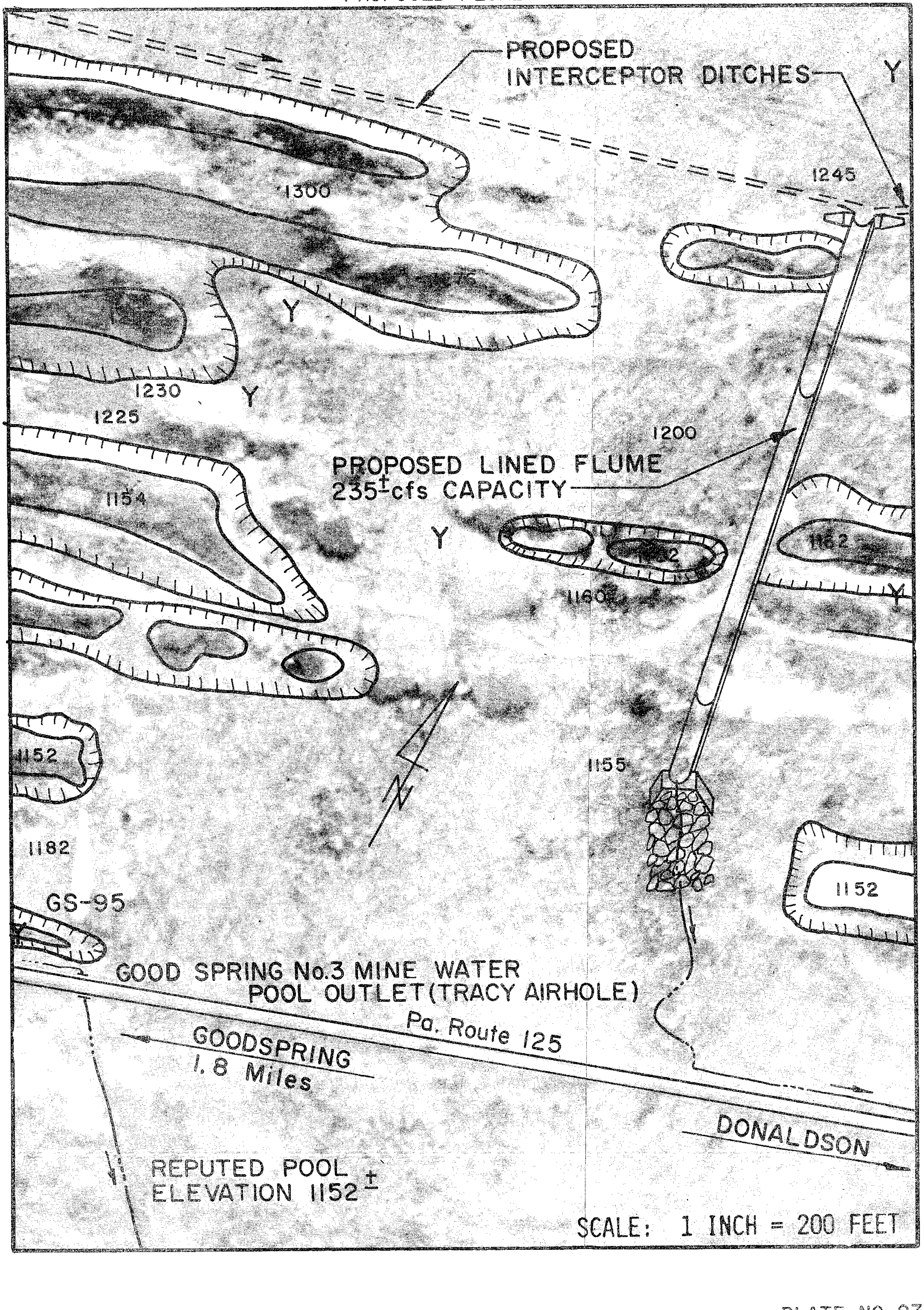


PLATE NO. 23

2. SAMPLING STATION GS-96 PRIORITY No.9

TYPE OF DISCHARGE: GOOD SPRING NO.1 MINE OVERFLOW POOL
SECONDARY DISCHARGE (AIRHOLE)

This source, monitored by Sampling Station GS-96, is a secondary outlet for the Good Spring No.1 Mine Water Pool. The pool is contained between Barrier Pillars XXIV and XXVII. With an estimated quantity of 915,000,000 gallons of water, this is the largest mine pool in the general area, approximately 60 percent of which lies within the subject study area. The pool is approximately three miles in total length.

The general flow of the water in the mine pool is west out of the Good Spring Creek Watershed into the Rausch Creek Watershed.However, at irregular intervals the pool water level is sufficiently high that there is a secondary discharge within this watershed through the airhole. The airhole is the most easterly one in the mine directly adjacent to Barrier Pillar XXIV and is in the Tracy Vein. Specifically it is located 5050 feet east of the Village of Good Spring and 50 feet north of Route 125.

The elevation of the ground surface at the airhole is 1198. The main discharge point for the pool is several artesian boreholes located approximately two miles west of the Village of Good Spring and directly adjacent to Barrier Pillar XXVII. From mine maps the main discharge borehole has an elevation of 1186.5 which approximates the reputed elevation of the mine pool (Elevation 1185). The difference may be attributable to slightly different datums, etc.The flow from the boreholes enters the East Branch of Rausch Creek which flows westerly to eventually join with Pine Creek near Valley View.

At a location just south of the above mentioned boreholes, the Wilson Coal Company had constructed at considerable expense a trench plus a cut and cover tunnel at Elevation 1097±. The trench proceeded easterly to intercept and partially drain the Orchard Vein and hence the Good Spring No.1 Mine Water Pool to the East Branch of Rausch Creek. The lowered water level would have allowed the taking of coal not otherwise economically recoverable. However, the flow in the tunnel never reached more than 1400± g.p.m. and then considerably diminished, probably due to silt in the old workings which tended to restrict the flow. Some flow still emanates from this trench along with the flow from the boreholes.

Field measurements at Sampling Station GS-96 indicate an average flow of 185 g.p.m. and an average acid load of 40 lbs/day. (For extended periods this source has no flow). The measured maximum acid loadis 125 lbs/day. The pH range is 3.6 to 5.9.

A study of the topography in this area confirms that the boreholes and the airhole have nearly the same surface elevation, even though they are at the westerly and easterly limits of the pool, respectively, The ground rises between these points toward a crest which occurs just west of the former Good Spring No.1 Colliery. (Elevation 1125±, adjacent to the Tracy Vein).

As previously stated 60 percent of this mine pool is within this study area. The remainder to the west is under study by another engineering firm. It is felt that since the main surface overflow points for this mine pool are in another watershed, the various remedial measures should be coordinated.

There is a considerable similarity between this mine pool and the Good Spring No.3 Mine Pool, previously discussed. As in the Good Spring No.3 Pool, the Tracy Vein gangway in the Good Spring No.1 Pool is isolated from the main part of the mine by a single north-south oriented horizontal tunnel. With reference to the Tracy Airhole AMD discharge (Sampling Station GS-96), a series of three progressive hydraulic mine seals is suggested. These seals would not raise the height of the pool significantly but rather would force all of the pool discharge to the East Branch of Rausch Creek where a treatment plant is under con-struction.If necessary additional boreholes could be made to facilitate the increased flow.

It is known that at least five small active mines exist at higher elevations in the Lykens Valley Veins above the mine pool in the East Branch Rausch Creek portion of the pool. Finally, as discussed later, a breach exists in Barrier Pillar XXIV which might preclude further mine seals north of the Orchard Vein.

The first seal is recommended to be a remotely placed mine sealin the above mentioned tunnel to isolate the Tracy Vein Workings. Such a mine seal would have to be placed at a depth of b20± feet in the north-south oriented Second Lift Tunnel or in the beginning of the Second Lift East Tracy Gangway.

The effect on the intermittent flow quantity at the airhole (Sampling Station GS-96) would then be monitored since the ground water recharge area to the mine pool would be substantially reduced.

The effect on the water quality at the sampling station should be considerable, approaching a 75 percent improvement, based on the following discussion and recommended mine seal location. It is a recognized fact that at deeper elevations in mine pools the water quality is progressively worse. In the present situation water from the northern portion of the pool must plunge downward and through the Second Lift

Tunnel to reach the airhole overflow. After the mine seal is successfully constructed further discharge at the airhole should be of better quality since the East Tracy Workings consist of only one level. It should also be remembered, as previously discussed in the report, the Tracy Vein has reportedly less sulfur content and therefore when the workings are isolated should also yield a better quality water.

Two possible locations were suggested for the mine seal. From the standpoint of the quality of the airhole discharge it would be preferable if the seal were placed at the beginning of the Second Lift East Tracy Gangway. Contrary to the terminology there are two lifts in the West Tracy Workings and only one level in the East Tracy Workings. The first lift West Tracy Workings lie generally above drainage at Elevation 1200. Since they are subject to air contact they thus have an acid production potential through infiltrating surface and ground water. By placing the dam as described, the western portion of the Tracy Vein Workings as well as the northern segment of the complete mine workings, would be isolated from the East Tracy Workings.

Prior to deep mining, the ground water over the Tracy Vein likely followed the slope of the adjacent Good Spring Creek.However, the extensive mining in the Tracy Vein should cause the water to seek a level around Elevation 1200 as a result of ground water infiltration.

To raise the water level in the isolated East Tracy Workings it is further recommended that the airhole at Sampling Station GS-96 (Elevation 1.198) be sealed. In a westerly direction from the above airhole the next two airholes in the Tracy Vein Workings have progressively higher ground surface elevations of 12251 and 1250±, respectively. Since there is no stripping in the extreme eastern end of the Tracy Vein the airhole at Elevation 1225 might also be sealed `.o raise the water level in the East Tracy Vein Workings a total of 6' feet (Elevation $_{1185}$ to 1250±). There is evidence of limited stripping in the area of the third airhole (Elevation 1250) so that further sealing might be impractical. rther sealing, even if practical, would likely force water to exit via old cropfalls, causing the pool level to stabilize at that point.

Any final decision to raise the pool level will have to consider the condition of the adjacent pillars and their ability to withstand a change in water elevation. A detailed study would have to review the effective height and condition of Barrier Pillar XXIV at the intersection with the Tracy Vein. h and Kynor (U. S. Bureau of Mines - Bulletin 526) report the effective height of the Pillar at Elevation 1856. This is the result of a breach in the Bottom Split Mammoth Vein, located 1300 feet north of the Tracy Vein, and should not affect any operation performed to control the airhole discharge near Sampling Station GS-96.

Various "Civil Engineering type" remedial measures in the subject study area portion of the Good Spring No.1 Mine Complex (Orchard through Mammoth Veins, etc.) are also recommended to aid in abating the borehole and trench acid discharge to the East Branch of Rausch Creek. These recommended abatement measures include the following:

1. Series of three progressive hydraulic deep mine seals as described above.

2. Interceptor ditches above the Mammoth Vein Strippings from the Good Spring No.l Colliery to Barrier Pillar XXIV.

3. A ditch and/or flume, including energy dissipating devices, along the west side of Pennsylvania Route 125 (north-south) to Good Spring Creek, which will involve backfilling the eastern tip of two strip pits adjacent to the highway.

4. Flume (north-south) about 2,000 feet east of Good Spring, (See Plate No.24).

5. Partial regrading of the stripped areas of 300 acres to drain freely (using available material).

6. Planting of 300 acres.

7. Hydroseeding or sealing by chemical bonding the refuse banks at the Good Spring No.1 Colliery. (See also other "in lieu of" treatments in Section VI-A-2c).

The estimated costs for the recommended remedial measures for the Good Spring No.1 Mine Complex are as follows:

1.	Progressive Deep Mine Seals (Series of three deep mine seals) $174,000	
2.	Interceptor Ditches (East and west of Route 125)	5,400
3.	Ditch and/or flume to Good Spring Creek (adjacent to Route 125) 29,300	
4.	Flume East of Good Spring	33,400
5.	Partial regrading of Strip Mines 298,000	
6.	Planting 75,000	
7.	Hydroseeding or sealing by chemical bonding	35,800

For total regrading of the entire 300 acres of strip mines in this portion of the study area to approximate original contours, add to Item No-5 an additional: $213,400

Percent of total acid abated: 2.0% average

PRIORITY NO. 9 — PROPOSED FLUME EAST OF GOOD SPRING

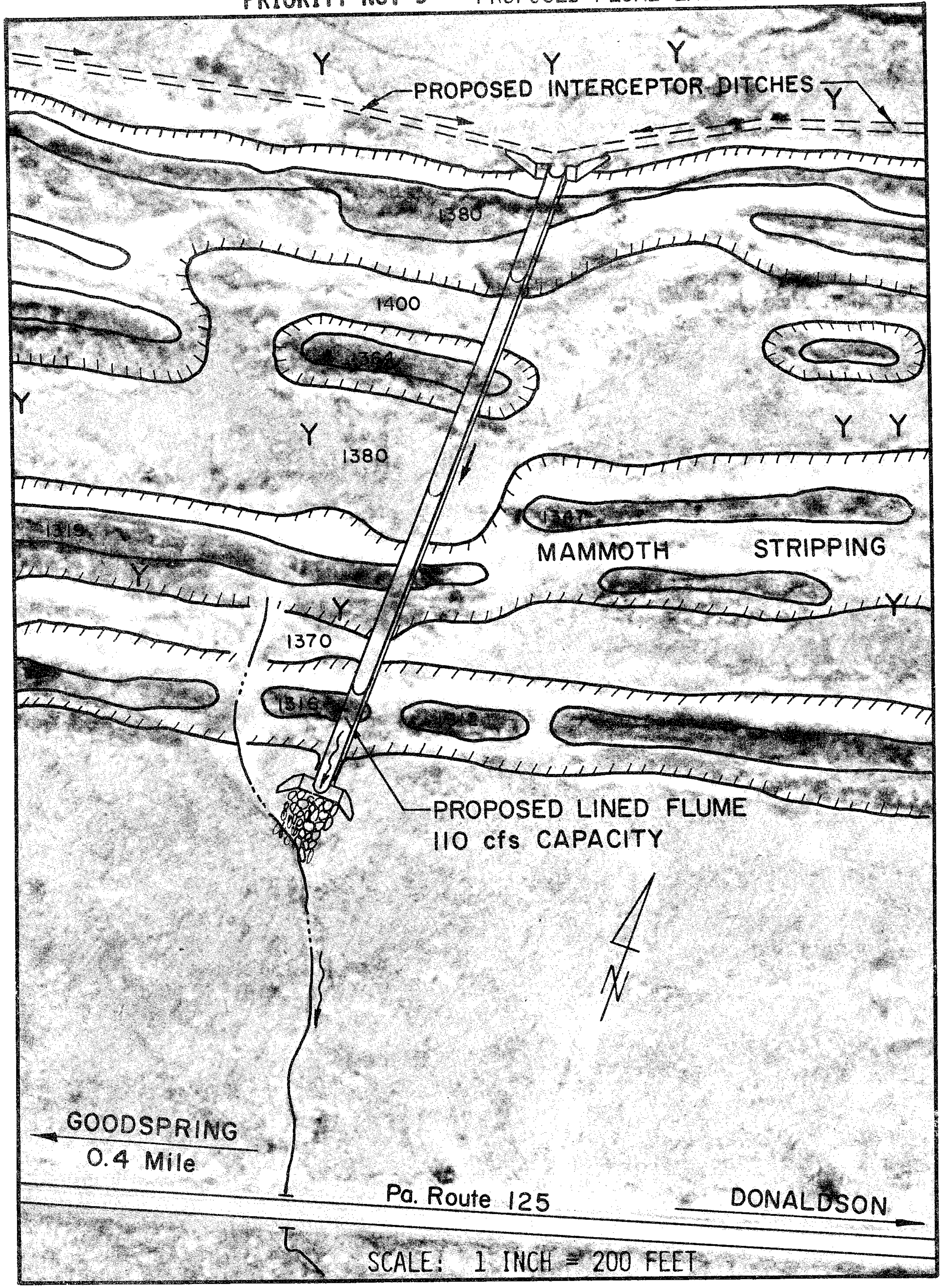


PLATE NO. 24

3. SAMPLING STATION GS-.100 PRIORITY No.19

TYPE OF DISCHARGE: GOOD SPRING CREEK HEADWATERS - STRIP PIT OVERFLOWS

During the sampling period Sampling Station GS-100 was located at the headwaters of Good Spring Creek, consisting of one of several overflowing strip pits south of the Village of Good Spring. The source overflowed its northern bank and formed Good Spring Creek about 2200 feet south of Pennsylvania Route 125 and 1100 feet west of L.R.53027.

Starting in January, 1971 this general area, of 8.2 acres, including the strip pit at Sampling Station GS-100, is being restripped from the Holmes through Diamond Veins by the Leon E. Kocher Coal Company. Pumping has lowered the water level to such a point that flow no longer enters Good Spring Creek.

An adjacent strip pit, measured by Sampling Station GS-101, has been excavated to such an extent that the two strip pits are now joined. When the ground water again stabilizes it is likely that the strip pits will overflow as a single discharge.

The strip pits which were sampled are in the Orchard Vein on the northern flank of the Big Lick Mountain Anticline. Runoff from Big Lick Mountain apparently collects in an aquifer or along the coal veins for several thousand yards west of the source outlet and then flows along the strike in an easterly direction. A reverse fault which lies along the coal vein axis could possibly be entrapping sufficient upstream ground water within the stripped areas to cause them to overflow.

Sampling Station GS-100 had a measured average flow of 114 g.p.m. Its average acid load was 10 lbs/day and its maximum recorded acid load was 22 lbs/day. The pH range was 3.8 to 4.8.

As previously stated, during the water year the strip pit measured by Sampling Station GS-101 was a separate strip pit. The measured average flow was 7 g.p.m. Its acid load was of better quality than that at Sampling Station GS-100. The average acid/alkaline load can be considered negligible (water quality ranged from 16 mg/l of acidity to 8 mg/l of alkalinity).

As a check the two sources were sampled further downstream as a single source below the point where they joined. This Sampling Station was GS-102. The average flow as measured at this station was 140 g.p.m. The average acid load was 10 lbs/day with a maximum of 23 lbs/day. The pH range was 4.0 to 4.9.

Further to the south lies the abandoned Tower City Mine, the central portion of which is within this study area. This mine drains away from the project watershed to the south through Keffer's Tunnel and hence to the Wiconisco Creek Watershed. The tunnel elevation is 1250±.

The Tower City Mine is contained between Barrier Pillars XXVI on the west and XXIII on the east. On the opposite side of Pillar XXIII lies the Jolliett Mine which is not within the study limits. This abandoned mine has formed a pool which reportedly overflows at a higher elevation across a breach in the pillar to the Tower City Mine.

There is a total of 220 acres of strip mines in this portion of the study area, some of which overlies the Tower City Mine. Regrading of this entire area would undoubtedly reduce the surface infiltration to deep mines discharging water to the Wiconisco Creek Watershed.

The recommended abatement measures for the sources at Sampling Stations GS-100 and GS-101 are as follows:

1. As prescribed by Act No.472, of June 27, 19+7 and as amended August 13, 1963, the operator is required to backfill the entire 11.2 acres of restripping (including 3.0 acres previously stripped east of L.R.53027). However: since the areas were formerly stripped by others, there will be a definite deficiency. It is recommended that these strip pits be further filled to original contour to provide natural overland drainage.

   Since these pits, comprising 12 acres, are normally water filled it is proposed to fill them with refuse material followed by a layer of impervious clay to prevent surface water infiltration. The refuse material thus inundated can be obtained from scattered small piles and haul roads at the site of the former Good Spring No.1 Colliery (north of Good Spring).Only sufficient topsoil should be placed over the clay layer to allow planting.

2. Backfill all strip pits of 26 acres west of the source to original contours in order to provide natural drainage overland and reduce the possibility of hydraulic pressure head at the strip pit located at Sampling Station GS-100.

3. Regrade remaining stripped areas of 190 acres to drain freely, using available material.

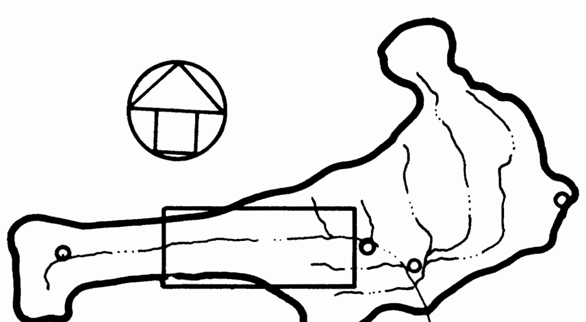
4. Planting of 228 acres

The estimated costs for remedial measures for the sources at Sampling Stations GS-100 and GS-101 are as follows:

1.	Regrade strip mines at Sampling Station GS-100	$ 12,700
2.	Regrade strip mines west of Sampling Station GS-100 $ 19,000	
3.	Regrade remaining stripped areas	$104,200
4.	Planting	$ 57,000

To regrade the entire 190 acres of disturbed land to original contour, add to Item No.3 an additional: $638,500'

Percent of total acid abated: 3.4% average



Scale: 1 Inch = 1000 Feet

MINE DRAINAGE
POLLUTION ABATEMENT

PLAN

PLATE NO.25

4. SAMPLING STATION P-53 PRIORITY No.4

TYPE OF DISCHARGE: COLKET MINE POOL OVERFLOW (COLKET WATER LEVEL TUNNEL)

This discharge point represents the overflow from the Colket Mine Water Pool. The Colket Tunnel Portal is located 900 feet north of Centre Street in the Village of Donaldson and 100 feet west of Martins Run. The overflow discharges through a water level tunnel which intersects coal veins from the Orchard through Little Buck Mountain Veins. The estimated quantity of water within this mine pool is 513,000,000 gallons. The discharge from the Colket Tunnel was measured at Sampling Station MR-53, located at a point below the tunnel portal. Acid mine water from the workings flows from east and west to the water level tunnel which subsequently discharges into Martins Run (See the special plan "Underground Mine Water Pools Study Area and Vicinity" in the back cover folder). The reputed elevation of the mine pool is 945 which is also the elevation of the tunnel. A total of 215 acres which affect the Colket Mine Pool have been disturbed by stripping.

Field measurements indicate an average flow from the source of 491 g.p.m. and an average of 382 lbs/day of acid. The maximum yield of acid recorded was 1,983 lbs/day. The pH range has been determined to be 3.2 to 5.3.

Previous deep stripping operations in the Mammoth Vein (estimated 40 feet thickness in this area) severed the Colket Tunnel causing drainage in the tunnel north of this point to be diverted to the Middle Creek Mine Water Pool. Because of this and the proximity of the tunnel above the Village of Donaldson it is deemed not practical to abate this mine pool overflow by sealing. All possible "Civil Engineering" type remedial actions are recommended to reduce the infiltration of water to this mine pool. The remaining discharge is recommended to be included in the collection and lime neutralization treatment plant proposed for the study area.

Abatement measures for the Colket Mine Pool discharge require work throughout the area affecting the pool and will include:

1. Runoff interceptor ditches above disturbed area between Martins Run and 1-81 (See Plate No.25).

2. Two flumes across the strip mines 800 feet north and 2000 feet west of Donaldson, respectively. (Plate No.26 shows an example of one of these recommended flumes. In this case the one 800 feet north of Donaldson).

3. Grading 215 acres of stripped areas to allow free drainage (using available material).

4. Planting of entire area of 215 acres.

5. Collection and piping of the acid mine discharge from Colket Tunnel to a lime neutralization treatment facility.(See discussion of treatment facility on page 154. Other sources at Sampling Stations MC-11, C-34, C-37, C-38 and MR-52 which are included for recommended treatment are discussed separately).

The estimated costs for the remedial measures for the Colket Mine Pool Discharge are as follows:

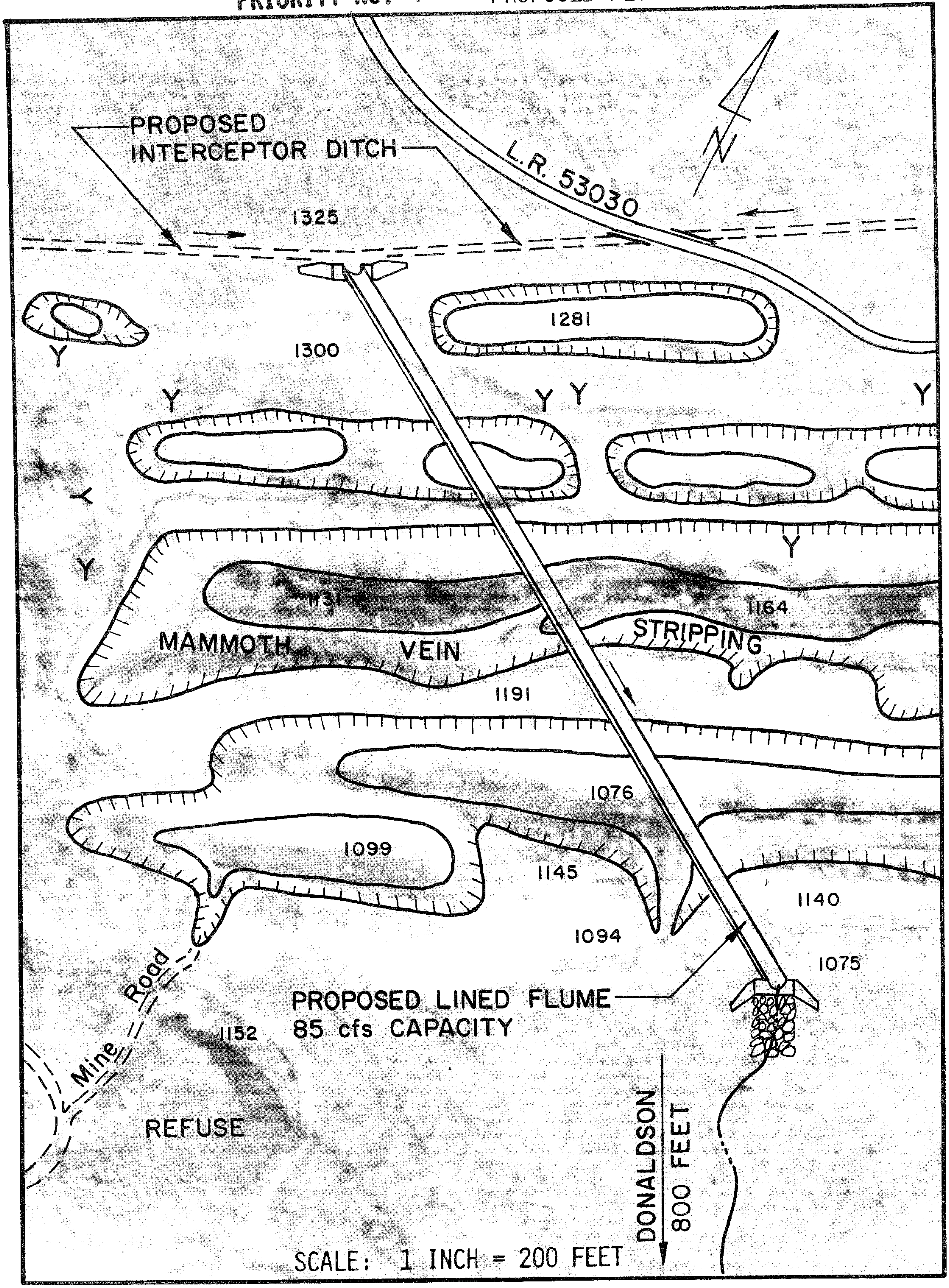
1.	Interceptor Ditches	$ 5,100
2.	Flumes across strippings:	
	a. Flume 100 feet west of Donaldson	43,300
	b. Flume 2000 feet west of Donaldson	58,200
3.	Strip Mine Regrading (using available material)	234,350
4.	Planting	53,800

5. Collection and piping to the lime neutralization treatment plant are incorporated into the lump sum cost for treatment - See Tracy Overflow (Sampling Station C-34) cost data and page 154.

For total regrading of the 215 acres to original contour, add to Item No.3 an additional: $650,900

Percent of total acid abated: 4.3% average

PRIORITY NO. 4 — PROPOSED FLUME NORTH OF DONALDSON



5. SA!?CPLING STATION GS-119A PRIORITY No.5

TYPE OF DISCHARGE: WESTWOOD AREA STRIP PIT OVERFLOWS

The area at the southern limit of the study area between the west side of Interstate Route 81 and the Westwood Refuse Bank has several sources of AMD. These are collectively measured on the east side of 1-81 (530 feet south of the Reading Railroad) where a weir, Sampling Station GS-.119A, could be conveniently located.

Sampling Station GS-119A field measurements indicate that the collective flow from these sources discharge an average of 415 g.p.m. with an average acid load of 319 lbs/day and a recorded maximum of 756 lbs/day. The p11 range is 3.3 to 5.8. This is the fifth worst discharge in the study area and the first in this listing of high acid sources to be discussed which is not from a deep mine pool overflow. Therefore, due to the importance of this acid discharge, considerable discussion follows with respect to the problem and its recommended solution.

As stated previously in another section of the report, the runoff from the east slopes of the Westwood Refuse Bank and the north and east slopes of the Westwood Slush Dam enters the study area (the remainder enters the Lower Rausch Creek Watershed).

Also between the Refuse Bank and 1-81 there are numerous water filled strip pits, mostly in the north flank of the eastward plunging Tremont Syncline. Interstate Route 81 which is in cut excavation in this area traverses normal to these pits, thus allowing water from the pits to enter the 1-81 drainage system. Three separate slope pipes drain these pits from the west side of 1-81 in the area of cut excavation.

The axis of the syncline is very much in evidence in the 1-81 cut slopes. Along the west slope, in particular, water can usually be seen exiting along the flanks of the syncline adjacent to sandstone strata and coal seams which have been exposed by the highway construction. In this same area a green algae can usually be seen on the west cut slope which is typical of acid mine water conditions. The possibility exists that ground water is carried for some distance along this synclinal axis and also has surfaced in the several strip pits when the veins were strip mined below the water table within the synclinal structure.

A limited field study on September 4th and 8th, 1970, indicates approximate data on the proportion of flows and water quality data from the various sources. It is recognized that the data is not precisely compatible, since it was determined on different dates due to the difficulty in rigging special flow measuring devices.The strip pit in the Orchard Vein on the west side of 1-81, and directly across from Sampling Station GS-119A, is the most significant contributor. Acidic flow from this strip pit can always be detected while the seepage from the cut face and the flow from the other two slope pipes are sometimes proportionately less or are at times dry. If this strip pit is called Strip Pit No.1 and the others located further to the South, Nos.2 and 3, respectively, then the approximate flow and water quality data at the time of this limited field study are as follows:

		Flow (g.p.m)	pH	Acidity (mg/l)	Iron (mg/l)	Sulfates (mg/l)
A.	Strip Pit No.1	100±	5.8	90	0.3	36
B.	Strip Pit Nos.2 & 3 and I-81 Roadway Drainage	72±	-	-	-	-
C.	Seepage from cut face and slope runoff measured in west side swale ditch	75±	3.7 to 4.7	30 to 94	0.1 to 0.5	260 to 560
	Total (Sampling Station 119-A)	247	3.4	80	11.4	460

There was a very significant acid flow from Sources B and C at the time of these measurements. However, as stated previously, the information is somewhat nontypical in that for some periods of the year these sources are dry or nearly dry.

Previous discussions have indicated that the direct runoff from the Refuse Bank would flush from the mantle approximately 70 percent of the acid salts. The remainder is carried into the interior of the pile and eventually reappears as seepage around the perimeter of the pile. Undoubtedly, most of this acid produced by the Refuse Pile eventually reappears in the water filled strip pits or enters the ground water system via an eastward movement along the synclinal structure of the Tremont Syncline. Indeed, it is quite probable that the acid water being collected in the 1-81 drainage system (measured at Sampling Station GS-119A) is being produced predominately by refuse material and to a limited extent - spoil material. To the north and west of the large Westwood Refuse Bank there is a very extensive slush dam still in active operation. The preparation plant is the Westwood

Washery at Jolliett, owned by the Manbeck Dredging Co., Inc. The total complex of refuse material including the Westwood Bank and Slush Dams extends in a westerly direction for approximately one mile and covers 120 acres.

One of the main difficulties arising from refuse banks is erosion forming deep gullies around the sides of the bank. This erosion may be as much as ten times that experienced in ordinary earth. The result is that new pyritic surfaces are continually being exposed.

An experimental hydroseeding project was performed on the Westwood Refuse Bank on July 13 and 14, 1971. As previously stated, the project was jointly carried out by The Pennsylvania State University and The Pennsylvania Department of Environmental Resources.

The hydroseeding was applied from a road cut around the bank about two-thirds of the way up the bank. A mixture of grass, seed, fertilizer and water was sprayed through a high pressure nozzle. Sometimes lime was added to neutralize acidic conditions. It is reported that, in general, a mixture of 100 pounds of PennDOT slope mix (80 percent tall fescue Kentucky 31, 20 percent creeping fescue), ten pounds of crownvetch, l,000 pounds of dried poultry manure and l,000 gallons of water per acre were used. The entire area was then covered with a hay mulch.

However, this experimental work was not successful in maintaining a grass cover.(Unfortunately, extremely heavy rains following the hydroseeding may have reduced its effectiveness). An improved hydroseeding method or some form of chemical bonding method should be performed on all of the large inactive refuse banks and slush dams in the study area which are not to be buried in the regrading operations. In lieu of the above an alternative solution might be to lower the refuse bank to a low mound, cover with 8" to 12" of spoil material and plant. The slush dam is active and if soil is added to the perimeter slopes attention will have to be given to slope stability, etc.

With respect to chemical bonding several types are under active research. These include carbonate bonding and silicate treatment.

Examination of the geologic map of this area indicates that at least some of the coal vein outcrops in this eastward plunging syncline progressively converge to form a "nose" underneath this refuse material. Other coal vein outcrops along the flanks of the syncline are quite close together. Acid water can possibly enter the synclinal structure of these veins since the slush dam is as much as 1200 feet in width in some areas and lies astride numerous mined and unmined coal veins. Therefore the entire area of refuse material could contribute varying amounts of acid mine water to this study area, even though geographically based on surface contours, most of the slush dam and one-half of the refuse bank lie in the Lower Bausch Creek Watershed.

Colliery maps do not indicate deep mining in the construction area of 1-81 from the southern limit of the study area to Route 125. However, in the construction of 1-81, as well as in previous mining studies including field drilling in conjunction with the highway design, some bootleg mining was uncovered.

The slush dam material overlies the extensive Westwood Deep Mine with the Westwood Refuse Bank approximately lying astride the barrier pillar. The slope-tunnel for this mine lies in a north-south direction. There was some probability that the northern end of this tunnel might have been severed by the surface strippings. However, even the lower strip pits in this area (Elev.12l4±) are several hundred feet higher than the mine tunnel (Elev.lOlO±). The northern end of this tunnel is connected by an airway to the Orchard Vein and could have been a secondary discharge point for water to the strip pits. Mining engineers report that a considerable flow occurred in the stripping at the time the vein was originally stripped.However, now that the area has been pumped down for new stripping the flow from the old Orchard Vein Stripping is still sustained, indicating that the deep mine overflow was not the major source of AMD. The Westwood deep mine drastically interrupted the hydrologic flow in this area, and formerly diverted considerable acid mine water via the mine portal to Lower Bausch Creek.(This is the subject of another engineering study by others).

It is believed that a significant portion of the acid water produced by the refuse material eventually enters the 1-81 drainage system in the subject study area. The remaining acid water could be produced during the eastward movement of this ground water in the synclinal structure since some fracturing of the structure is undoubtedly present allowing air to enter. Adjacent to the Slush Dam black silt with drainage channels etched through the silt has been observed in the strippings. This could be drainage emanating from beneath the slush dam or it could have occurred during a previous breach in the slush dam dike.

The recommended remedial action is opposite to that achieved in the construction of 1-81 in which the strip pits are continually drained, The contour mapping of the study area was made from photography taken prior to the construction of I-81. From the photogrammetric maps the numerous water filled strip pits in this area indicate an equilibrium elevation of the respective water surfaces of 1281 to 1288. This elevation (say 1285±) likely represented the ground water elevation near the crest of Big Lick Mountain. More recent aerial photography of 1-81 indicates that, with the exception of strippings partially drained by 1-81, the size and therefore surface elevations of the water filled pits remains much the same as measured prior to 1-81 construction. Therefore it can be assumed that the ground water elevation in this area has materially not changed, except for the area directly adjacent to 1-81 and the short term stripping now underway in the Westwood deep mine area.

It is recommended that a clay plug 100± feet long be placed in the ends of the three strippings directly adjacent to the west slope of 1-81 (See Plate No.27). This clay plug should be placed equal in height to the level of the surrounding ground surfaces. In this manner it is planned to form a dam in the ends of the strip pits to prevent further movement of the water towards 1-81 and to allow the water in the strip pits to seek an equilibrium elevation, as before.

The exception to the above could be Strip Pit No.1 (Orchard Vein) which had a former water surface elevation of 1244. The photography prior to construction indicates that this strip pit may have been overflowing. If this situation occurs after completion of the clay plug it is recommended that a dike with a clay core be constructed at elevation 1287 across the first stage construction (clay plug) and extended along the north side of the pit to tie into the existing ground surface, also at elevation 1287. (In lieu of this the entire stripping could be backfilled with a clay layer in the bottom of the pit).

With respect to the acid water seeping through the Tremont Synclinal Structure, it is recommended that a transverse grout curtain be placed to impede this water flow. If successfully completed the grout curtain should obtain this result since the syncline occurs almost coincident with the crest of Big Lick Mountain.

Abatement measures for the collective discharge measured at Sampling Station GS-119A can be summarized as follows:

l. Place impervious clay plug in eastern ends of three strip pits adjacent to 1-81. (Orchard, Diamond and Tracy Veins - north to south, respectively).

2.Impervious dike around east and north sides of Strip Pit No.l. (Orchard Vein Stripping).

3.Grout curtain across the Tremont Synclinal Axis west of 1-81.

4. Hydroseeding or sealing by chemical bonding the Refuse Bank and the north and east slopes of the Westwood Slush Dam. Other "in lieu of" treatments are discussed in Section VI-A-2c.

The estimated costs for the above acid abatement are as follows:

l.	Place clay plugs (3)	$15,000
2.	Dike	$ 7,000
3.	Grout Curtain	$ 8,000
4.	Hydroseeding or sealing by chemical bonding	$70,000

Percent of total acid abated: 3.5% average

PRIORITY NO. 5 — PROPOSED ISOLATION OF I-81 STORM SEWER SYSTEM FROM AMD

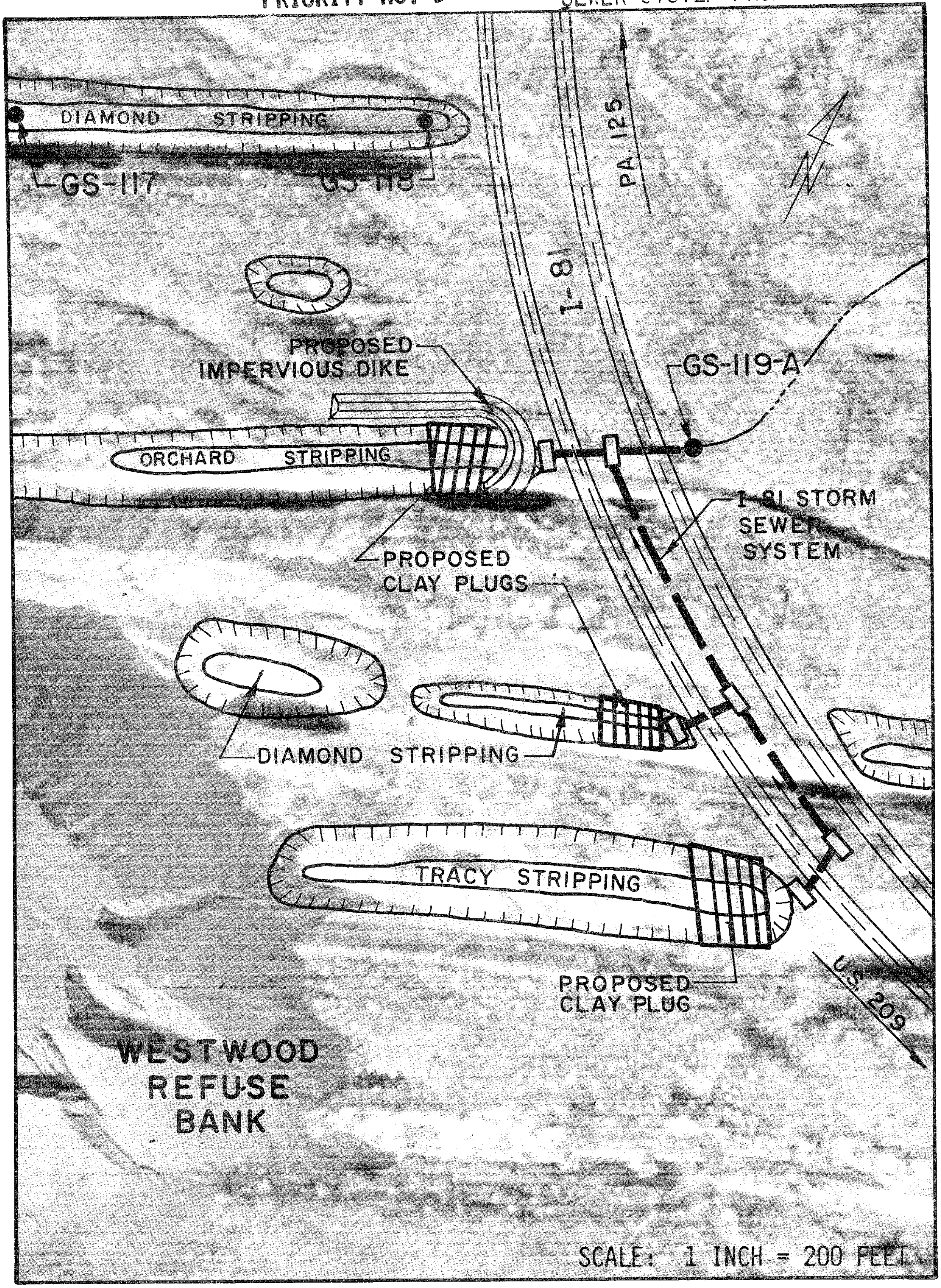


PLATE NO.27

6, 7. SAMPLING STATIONS GS-92, GS-122 PRIORITIES A, B

TYPE OF DISCHARGE: BOWMAN-COLEMAN WATER LEVEL TUNNEL DISCHARGE, INTERSTATE 81 RUNOFF INTO STRIP PIT

These sources are: 1. The acid mine drainage discharge from the abandoned Bowman-Coleman Water Level Tunnel 2. Drainage which crosses Interstate 81, and flows to the south where it enters a strip pit, and hence to the Colket Mine Water Pool. Neither source is related to the other, although they are in the same general area. This area is north of Route 125, near the Pennsylvania Power and Light Company high tension power line and somewhat south of I-81.

The discharge from the Bowman-Coleman Mine was measured by Sampling Station GS-92. Specifically, the station is located at the mine portal, 1000 feet south of Interstate 81 within the cleared P. P. & L. power line right-of-way. The tunnel intercepts coal veins from the Mammoth through Lykens Valley No.3, with the major workings in the Lykens Valley No.2 Vein.

This source discharges an average of 71 g.p.m. and yields a measured average acid load of 15 lbs/day with a maximum of 49 lbs/day. The pH range is 3.4 to 4.4.

The runoff from I-81 is via a 60 inch diameter culvert crossing the Interstate Route from a swampy area known as the "Donaldson Flats". It then continues along a natural swale ditch for approximately 600 feet where it enters a strip pit in the Mammoth Vein. The source was measured at Sampling Station GS-122 just upstream from the above described strip pit and 250 feet west of the P. P. & L. power line.

It appears that at one time the ditch continued past the strip pit, but at some point broke through its west bank into the stripping. Visual observation of high water marks show that the depth of flow down the steep side of the strip pit was as much as 2 feet.

Because the rate of flow is predominately rainfall runoff it is often very difficult to determine. At times the source is dry. The rate of average acid load is negligible and is estimated to be about 3 lbs/day. The pH is essentially 7.0. However, the important consideration is the acid potential of water entering the mine pool.

This project is recommended to the Department due to its obvious necessity and limited cost. As is true in all stream restoration work in this area, the main factor is the poor quality of the water as it emerges from the mine pool overflow rather than that of the influent to the strip pits.

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Abatement measures for the Bowman-Coleman Mine discharge are underway under Design Contract SL-126-2-A, dated January 15, 1971. Other field construction work developed from the design work will include clearing and shoring the tunnel and drilling of field test borings to determine the location for a hydraulic seal in the tunnel. Preliminary indications are that the seal should be back of the Buck Mountain Vein.

Abatement measures for the source measured by Sampling Station GS-122 are recommended to include:

1. Backfilling of 7 acres of adjacent strip pits to approximate original contour.

2. Flume across the stripped area (See Plate No.28).

3. Planting of disturbed area of 7 acres.

The costs for remedial measures for these two sources are as follows:

Bowman-Coleman Water Level Tunnel:

1.	Hydraulic Mine Seal	(Under active design "Quick Start" Project)

I-81 Runoff to Strip Pit:

1.	Regrading strip mines adjacent to ditch	$16,000
2.	Flume across the stripped area	$29,700
3.	Planting	$ 1,750

Percent of total acid abated* 0.1% average

*The strip mine influent is reflected in acid abated from the Colket Mine Water Pool Overflow (Colket Tunnel).