# ABATEMENT MEASURES

## A. GENERAL APPROACH TO ABATEMENT MEASURES

### 1. Major Sources of Acid Discharges

The method used to analyze the various sources was an integrated summation of each pollutant tested for. The result was an average loading in lbs/day for each source tested over the water year.

It became apparent early in the study that the overflows from the abandoned deep mines in the study area were the major acid contributors. These mines contribute approximately 2.4 percent of the flow and 50 percent of the acid load. 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.

### 2. Natural Buffering Capacity

There are limited amounts of limestone in the study area. The Upper Freeport Limestone is inferred near the Village of Penfield, near Tyler Point State Forest, and in the higher elevations from Dixon Run to Spring Run. The Vanport Limestone, when it occurs, lies between the Clarion and Lower Kittanning veins. It has been quarried in small amounts in the Winslow Hill area. The cap rock is generally shale and sandstone with little or no natural alkaline buffering capacity. There is evidence from water quality analysis performed on the spoil and refuse areas that some pyrite is contained in the shale and sandstone strip mine spoil. The test method employed to determine the relative concentrations was established by the Mellon Institute of Industrial Research and is listed in the Commonwealth's "Mine Drainage Manual".

### 3. Recommended Abatement Measures

#### a. Terrace Regrading of Strip Pits

Reclamation of the strippings by reversing the terrace away from the highwall and revegetating will:

Reduce the flow and infiltration to the deep mines whereby acid is produced in both the strip mine spoil and the deep mines where such a condition exists.

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

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

The reasons for terrace regrading have been previously discussed. Reducing the slope of the highwall, although aesthetically desirable, does not abate AMD and is therefore not authorized under Scarlift funding. It would also approximately double the cost of this type of remedial work. An average estimate of cost for terrace regrading is difficult to assess since it varies with the location. For planning purposes, regrading costs vary from $1,000/acre upwards to $3,000/acre.

Regrading and recompacting strip pits up-dip from deep mines reduces both the infiltration into and the air circulation within the workings when the two mining operations are interconnected. The backfilled spoil material should be compacted to the greatest extent possible by the movement of equipment through the strip pits.

b. <u>Diversion Ditches and Channel Reclamation</u>

In addition to reversing the terrace of strip mines, the construction of ditches above the highwall is recommended to divert runoff from the strippings and deep mines. Ditches, which carry the runoff across strippings will also require flumes in conjunction with regrading.

Acid contributions from highly saturated pyritic refuse and/or spoil-type materials, along with leaching where streams cross croplines, can be limited by constructing an impervious layer in the channel through this reach.

c. <u>Strip Pit Pond Regrading</u>

Once AMD has formed various means can be used to prevent or minimize its entry to streams. Overflowing strip pits, which are acidic can be a significant source. This acid discharge can originate from intercepted storm surface runoff, groundwater table fluctuation or by leachate from acid bearing overstrata. Strip pit ponds are not permitted by current regulations (Standard Conditions Thirteen and Sixteen dated March 31, 1967), and are generally limited to older strippings. Major examples of this occur at Sampling Stations T-30, TT-132 and CH-189. It is recommended that terrace reclamation be completed to fill the pits and at the same time reverse the terrace. If conditions warrant and the overburden is determined to be acidic the terracing should be raised to insure that adequate cover will be above the pyritic material.

d. Burying Refuse In Strip Pits

The movement and burying of refuse banks in the study area is recommended in conjunction with the regrading of strip mines.

e. Covering and Revegetating Refuse Banks In Place

Severe erosion occurs in refuse banks which continually exposes new pyritic faces. When burial in adjacent strip pits is not suitable, abandoned refuse banks might also be reduced in height to a low mound to help retain soil moisture and prevent erosion, covered with 8 inches or 12 inches of spoil material, and planted.

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

f. Deep Mine Sealing

Briefly, acid mine drainage is caused by the exposure of pyritic materials associated with coal seams to air. The products of pyrite oxidation are then dissolved by ground water, forming an acid mine discharge. Other minerals (principally iron) in the surrounding strata then react in solution with the acid water. (Laboratory tests in this study were limited to total iron and 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.

Mine air seals, commencing in the 1930's, were constructed and have yielded doubtful results. In the large deep mines some fracturing of the overburden is usually present allowing air to enter and is particularly evident when retreat mining or robbing has created non-uniform or unscheduled surface subsidence.

Hydraulic mine seals (double bulkhead type) should result in flooding the acid bearing material remaining adjacent to the mined-out coal measures, thus preventing air contact (the amount of air contained in water is very limited).

Because shale and fractured sandstone in the study area afford limited soundness when exposed to the elements, seepage or even a rock failure must be considered in seal designs. Hydraulic mine seals, which generate static heads over 40 to 50 feet must be considered with great care because of the stresses placed on the rock face.

g. 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:

(1) 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 coal to increase the BTU value to an acceptable level.

(2) Use of burned refuse banks "red dog" for minor roads and driveway material. This material is normally not acidic. ("Red dog" exists in considerable quantities near some major deep mine drifts and tipples).

(3) Anti-skid roadway materials.

(4) Building block and brick.

(5) Embankment construction.

h. Treatment of AND

To date many different forms of treatment are being evaluated to reduce the AMD. The ensuing results have indicated that there will be no universal answer and that each problem will require individual examination based upon the proposed water use. Economically, lime neutralization appears to be the predominate method at the present time for source discharges designated for treatment within the study area.

Even though hydrated lime is recommended due to its proven operational advantages, limestone has received considerable attention as a neutralizing agent for weaker acid solutions and iron concentrations. Limestone has some advantages such as:

1. Difficult to overtreat with calcium carbonate.
2. Greatly reduced sludge volume
3. Lower cost.

Limestone by itself has serious disadvantages due to its slow reactive rate and its difficulty treating high iron concentrations.

Some active mines use limestone in treatment. Current research is being conducted using either limestone or a combined limestone - lime agent for treatment.

4. Significant Acid Sources

A significant source table is included and 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 part of the year. Engineering judgment was necessary in listing the significant sources. A maximum acid load of 100 lbs/day was arbitrarily used as the lower limit for ranking 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) |
|---|---|
| 5 | 5,000 |
| 11 | 1,000 to 5,000 |
| 10 | 500 to 1,000 |
| 25 | 100 to 500 |

# SIGNIFICANT AMD MEASURED BY SAMPLING STATIONS WITHIN STUDY AREA

| Order of Magnitude | Sampling Station | Acid Loading (lbs/day) Max. | Avg. | Description |
|---|---|---|---|---|
| 1 | M-15 | 45,436 | 5,787 | Proctor #2 |
| 2 | CA-99 | 8,346 | 3,294 | Shawmut #31 |
| 3 | P-22A | 7,185 | 2,717 | Proctor #2 |
| 4 | CA-109 | 5,938 | 2,017 | Shawmut #31 |
| 5 | P-34 | 5,553 | 2,578 | Proctor #1 |
| 6 | BB-21 | 3,599 | 1,891 | Tyler #14 |
| 7 | C-56 | 2,683 | 674 | Shawmut #41 |
| 8 | CA-107 | 2,661 | 1,053 | Shawmut #31 |
| 9 | TR-38 | 2,207 | 444 | Tyler Mines |
| 10 | CA-108 | 1,563 | 839 | Proctor #3 |
| 11 | TR-37 | 1,414 | 287 | Tyler Mines |
| 12 | CA-105 | 1,388 | 958 | Shawmut #31 |
| 13 | UN-183 | 1,374 | 626 | Penfield Coal & Coke #2 |
| 14 | T-26 | 1,230 | 483 | Proctor #1 |
| 15 | MO-7 | 1,164 | 356 | Gobblers Knob #1 |
| 16 | SC-54 | 1,049 | 160 | DeLullo (Proctor #1) |
| 17 | CA-111 | 980 | 190 | Shawmut #31 |
| 18 | BH-139 | 886 | 413 | Tyler Mines |
| 19 | TR-35 | 867 | 548 | Tyler Mines |
| 20 | M-14 | 785 | 172 | Proctor #2 |
| 21 | TT-123 | 756 | 489 | Coal Bank Run Strippings |
| 22 | T-29 | 664 | 238 | Five Points |
| 23 | SC-51 | 640 | 137 | DeLullo (Proctor #1) |
| 24 | CA-104 | 553 | 171 | Shawmut #31 |
| 25 | CA-103 | 552 | 221 | Shawmut #31 |
| 26 | CH-190 | 540 | 245 | Chase Hollow Stripping |
| 27 | T-30 | 497 | 153 | Five Points Mine |
| 28 | C-58 | 480 | 404 | Shawmut #41 |
| 29 | BR-71 | 469 | 376 | Shawmut #41 |
| 30 | UN-180 | 467 | 216 | Tyler Mines |
| 31 | SC-49 | 446 | 114 | Proctor #1 |
| 32 | CH-193 | 419 | 268 | Winslow #2 |
| 33 | TR-42 | 410 | 232 | Tyler Mines |
| 34 | M-18 | 307 | 60 | Proctor #2 Refuse |
| 35 | MP-135 | 274 | 110 | Mine/RefuseMt.Pleasant Church |
| 36 | BR-72 | 252 | 74 | Shawmut #42 |
| 37 | K-83 | 230 | 19 | Gustafson |
| 38 | K-90 | 222 | 78 | Shawmut #31 |
| 39 | MO-4 | 208 | 40 | Penfield Coal & Coke #3 |
| 40 | TR-43 | 188 | 68 | Tyler Mines |

| Order of Magnitude | Sampling Station | Acid Loading (lbs/day) Max. | Avg. | Description |
|---|---|---|---|---|
| 41 | TR-40 | 180 | 70 | Tyler Mines |
| 42 | TT-132 | 178 | 61 | Strip Pit Chase Hollow |
| 43 | TR-44 | 172 | 82 | Tyler Mines |
| 44 | SC-52 | 171 | 95 | Proctor #1 |
| 45 | ST-118 | 144 | 56 | Pine Valley |
| 46 | MO-5 | 127 | 25 | Cropline Seepage Moose Run |
| 47 | CH-189 | 121 | 78 | Chase Hollow Strip Mine |
| 48 | K-85A | 106 | 30 | Refuse at Byrnedale |
| 49 | K-82 | 106 | 40 | Shawmut #31 |
| 50 | C-62 | 102 | 26 | Proctor #1 Refuse |
| 51 | TR-41 | 100 | 34 | Tyler Mines |

B. <u>ABATEMENT CONSIDERATIONS OF LOW RELIABILITY</u>

In addition to the proposed methods of abating mine drainage previously discussed, several other procedures were reviewed and are generally considered to be of a low reliability nature for projects within Bennett Branch.

Gunite Seals - requires tunnel surfaces to be shaped and cleaned - applicable to accessible areas only.

Single Bulkhead Seals - easily damaged - not applicable to high hydraulic head.

Clay Seal - material must be high quality plastic clay - requires hand placement - effective only against low heads to 30 feet.

Permeable Aggregate Seal - depends upon precipitate formation to clog voids - low hydraulic head application only (6 to 10 feet).

Grout Bag Seals - entry must be accessible - difficult to conform to tunnel shape.

Regulated Flow Seal - applicable only in conditions which require a constant discharge (treatment plant influent).

Air Seal disregards air entry to the mine through factures and subsidence - inefficient seal.

Gel Seal - has not been successful to date - expensive.

Trench Seal - has application in weak rock areas that have thin overburden - excavation costs can be prohibitive.

Contour Grading - requires moving large backfill quantities.

Area Grading - controlled by terrain to plateaus or gently rolling lands with small overburden ratios.

Highwall Reduction - limited use in controlling mine drainage.

<u>Internally Placed Deep Mine Seals</u>

The possibility of sealing the five large abandoned deep mine acid contributors in the Hollywood - Tyler - Caledonia areas is heard often enough that it warranted investigation. Therefore, a procedure was evaluated for sealing the mines internally with drainage tunnels for positive water control, grout curtains and selectively placed double bulkhead seals. The seals would develop regions within the mine that would flood to relatively low hydraulic heads. This method is presented for information only and if used would be in lieu of the treatment facilities. The costs-per-pound of acid abated is expensive, but could prove economical over an extended period of time when compared to the treatment plants' annual operating costs. See Plates C3 to C8 for suggested tunnel routes and supplemental double bulkhead seals for the following mines:

| Mine | Costs | Est. Ave. Acid Load (mg/l) | Efficiency | Est. Acid Abated | Cost/Lb Acid Abated |
|---|---|---|---|---|---|
| Proctor No.2 (D206) | $7,259,000 | 8,793 | .70 | 6,155 | $1,178 |
| Shawmut No.31 (D214) | 5,360,000 | 7,011 | .70 | 4,908 | 1,092 |
| Proctor No.1 (D209) | 9,425,000 | 3,332 | .70 | 2,332 | 4,042 |
| Proctor No.3 (D215) | 1,820,000 | 1,958 | .70 | 1,370 | 1,328 |
| Shawmut No.41-42 (D209) | 9,250,000 | 1,473 | .70 | 1,030 | 8,980 |

Mapping for the Tyler Mines (D211) is sparse and thus a procedure to seal internally was not evaluated.

Using the hydraulic seals internally, approximately 15,800 lbs/day of acid would be removed from Bennett Branch and would cost an estimated $33,105,000.