DEEP MINE SEALING

by

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INTRODUCTION

Deep mine sealing has been defined as the closure of mine entries, drifts, slopes, shafts, subsidence holes, fractures and other openings into underground mines with clay, earth, rock, timber, concrete blocks, brick, steel, concrete, fly ash, grout and other suitable materials. The purpose of mine sealing as discussed in this paper is the abatement of mine drainage pollution in bituminous coal mines. When water and air enter a coal mine, a reaction with the disulphide minerals in the exposed coal and rock usually results in the formation of sulphuric acid and iron sulfate. This will cause a low pH and a high iron concentration in the mine discharge. Mine seals have been classified into three general types. The function for each of the three types are as follows:

> The function of the dry seal is to prevent air and water from entering the mine.
>
> The function of the air seal is to exclude air from entering the mine but permitting normal flow of water at the discharge.
>
> The function of the wet or hydraulic seal is to create a hydraulic head to flood the mine. In the wet seal, air is excluded by inundation.

PRIOR METHODS AND PRACTICES

In the early 1900's, any mine sealing work at the portals was generally performed as a safety precaution rather than a mine drainage consideration. However, mine dams were used during this period as a means of confining water to certain parts of the mine. These bulkheads or underground dams were used to control mine water from flooding the active areas and as an aid in pumping. Mine dams were also used for the purpose of flooding a mine to extinguish mine fires or to hold back mine gases. These bulkheads ranged from dams made of timber and puddled clay (Figure 1), to wedge-shaped wooden dams, flat wooden dams, masonry dams and brick dams (Figures 2 and 3). The double bulkhead brick dam with the concrete or clay center (Figure 3) is a forerunner of many of the mine seals in use today.

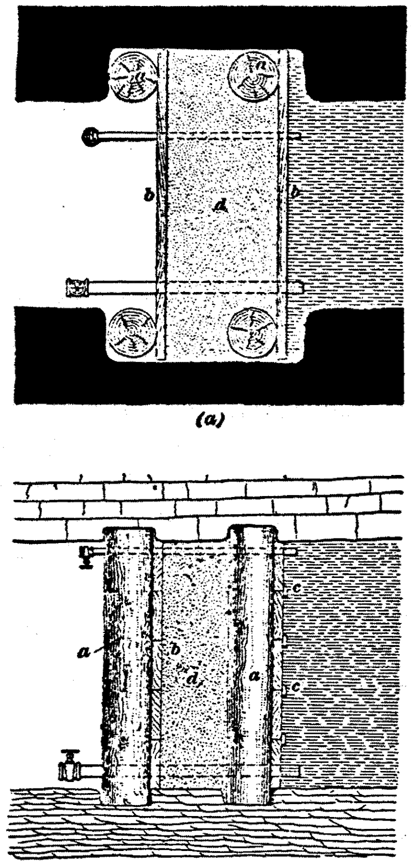


FIGURE 1

DAMS OR SEALS FOR LOW WATER PRESSURE

-Source-

International Library of Technology

Hoisting - Haulage - Mine Drainage

1906

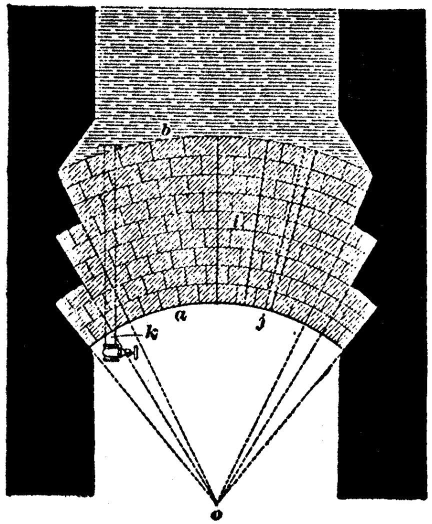


FIGURE 2

BRICK DAMS

-Source-

International Library of Technology

Hoisting - Haulage - Mine Drainage

1906

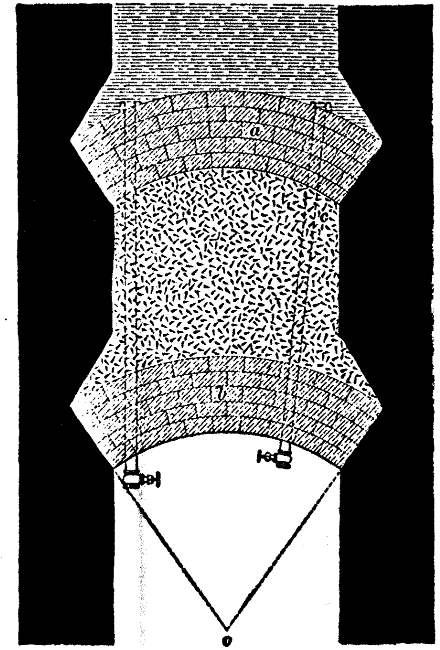


FIGURE 3

BRICK DAMS WITH CONCRETE CENTER

-Source-

International Library of Technology

Hoisting - Haulage - Mine Drainage

1906

The concept of sealing coal mines as a means of reducing acidity was the subject of discussion in several technical papers in the 1920's and early 1930's. Much of this research was performed by the Bureau of mines. Some of the investigations revealed drainage from abandoned mines that were sealed by caving were not as acid as the discharges from other adjacent open or active mines. An experimental mine sealing project was started in 1932 in which three mines were sealed with a water trap designed to exclude the air from entering the mine but at the same time maintain the normal rate of flow. The analysis of the drainage samples collected over a period of a year indicated a decrease in the acidity. As a result of these studies, a mine sealing program was started in 1933 under the Works Progress Administration. This program was reported to cost about $5.4 million. There were several studies performed to determine the effectiveness of the WPA mine sealing program. The U. S. Public Health Service estimated a 28 percent reduction in acid loading in the Ohio River due to the abandoned mine sealing program. However, in many areas the work performed was not adequate to exclude air from the underground workings and/or the mine seals failed after several years. In others, the acid water found new discharge openings.

During the 1940's and 1950's, research work on sealing abandoned coal mines and other aspects of mine drainage were carried out by the Bituminous Coal Research, Inc., Mellon Institute, U. S. Bureau of Mines and by various universities and State agencies.

A Symposium on Grouting was presented at the AIME meeting in New York in 1948. Experts in grouting discussed the various techniques used in mine grouting. Most of this work was channeled along the lines of preventing waters from entering the mines.

During the 1950's and 1960's, underground bulkheads were designed and installed in various coal, hard rock and metal mines in many countries of the world. Many of these underground dams utilized both concrete and grouting procedures in their installation. Some of these dams were designed to withstand water pressures in excess of 1,000 feet of head. Again most of these dams were designed to prevent the inflow of water into the mine or to contain the water within certain areas of the mine.

During the past decade, various research and demonstration projects have been performed relative to mine sealing by the Environmental Protection Agency (formerly FWPCA, FWQA) and the U. S. Bureau of Mines. Both the U. S. Geological Survey and the U. S. Army Corps of Engineers have aided in these studies relative to mine drainage. Presently, most of the States in the bituminous coal fields have had or are engaged in some form of research work relative to mine sealing. Organizations, other than those previously mentioned, such as the Ohio River Valley Water Sanitation Commission (ORSANCO) and the Mine Drainage Work Group of the Susquehanna River Basin Commission have been active in studies relative to mine sealing.

Until the 1960's, most of the deep mine seals in mine portals with discharges were generally air seals. Many of these were the seals installed in the W. P. A. mine sealing projects of the 1930's. Because some of these resulted in "blow-outs" during the 1940 s and 1950's, there has been a reluctance by some mining men to try any deep mine sealing at the mine portals.

New developments in water pollution abatement including hydraulic deep mine sealing techniques for both active and abandoned mines are a result of the increased interest in the field of environmental control. From 1966 through 1969, the Halliburton Company had a contract with the Federal Water Pollution Control Administration (now Environmental Protection Agency) to develop and field test new concepts for watertight mine seals and bulkhead construction. Both the Report of Mine Drainage Project MD-8A (Moraine) of May 10, 1968 and the Slippery Rock Creek Mine Drainage Pollution Abatement Report of August 12, 1970 recommend hydraulic mine seals to abate mine drainage in designated abandoned deep mines.

In February 1969, B. H. Mott & Sons, Inc. started construction work on 73 deep mine hydraulic seals in the Moraine State Park for the Pennsylvania Department of Mines and Mineral Industries (now Department of Environmental Resources). This project is now completed. In August 1970, the Allied Asphalt Company, Inc. started work on a contract for 34 deep mine seals in the Argentine area of Pennsylvania for the Department of Environmental Resources.

These projects are a few of the abandoned deep mine sealing projects being performed by governmental agencies. The Clean Streams Law of 1966 in Pennsylvania requires that all active mines not only prepare plans to indicate how pollution will be prevented during the active operations but, in addition, submit plans of how a pollutional discharge will be prevented after completion of mining. As a result, designs for mine seals, in addition to those shown in this paper, have been prepared by engineers for the various mining companies.

GENERAL CONSIDERATIONS

A thorough examination of the topographic, geologic, hydrogeologic and mining conditions must be made in the area and each mine must be individually examined and evaluated before any mine seals are constructed. This study should include, but not be limited to the following factors:

1. Topography, surface drainage and ground water levels.
2. Structure, strike and dip of strata, folding, anticlines, synclines, fracturing, joints, washes and faults.
3. Composition and stratigraphy of coal beds and associated strata.

4. Condition and extent of mine workings in the mine to be sealed and its relationship with other mines, active and abandoned, in the same and other coal seams in the area.

5. Mine drainage conditions in the mine to be sealed and its relationship with drainage conditions in other mines in the area.

On the basis of this information and data, the feasibility for mine drainage pollution abatement can be made. This will include a recommendation for the type and location of the applicable seal or seals.

Abandoned deep mine portals in which mine sealing projects are contemplated fall into two general classifications; accessible and inaccessible, defined as follows:

Accessible: mine entries which are open from the portal to the construction area or can be reopened with minor effort.

Inaccessible: mine entries are caved at the portal and would require a major expenditure to re-open.

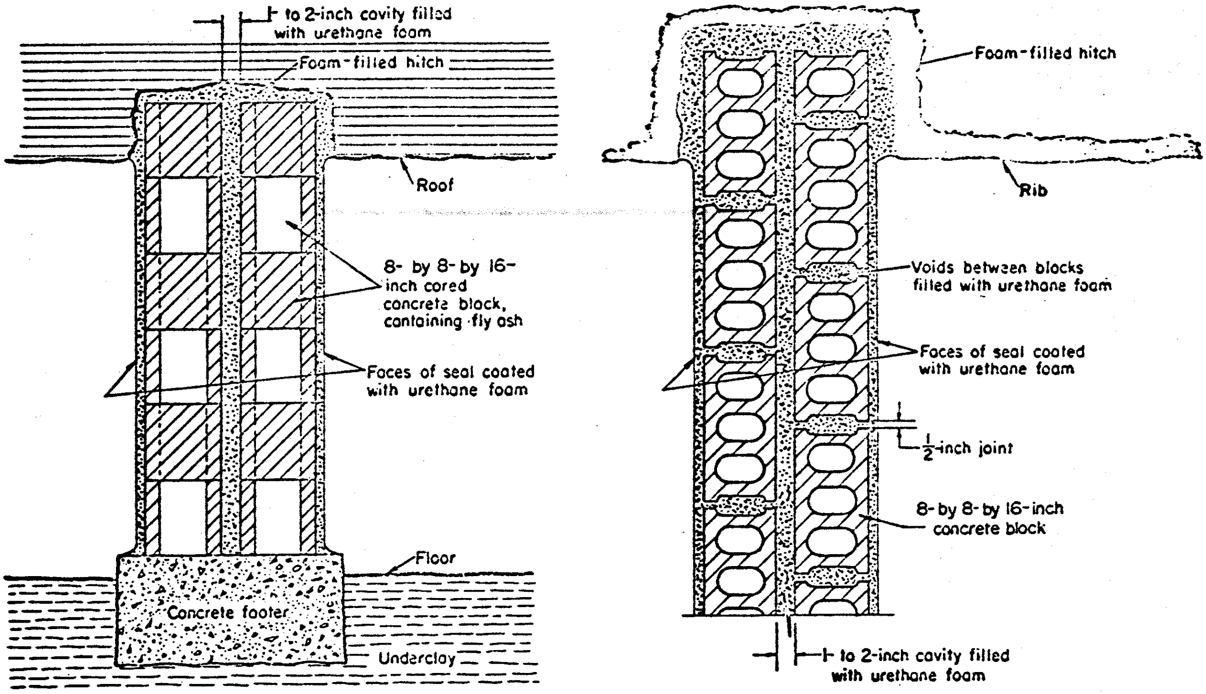
Accessible conditions are required for the construction of mine sealing work as indicated on Figures 4 through 13 and Figure 21. The construction work for the installation of seals as indicated in Figures 14 through 16 can be performed in either accessible or inaccessible entries.

Accessible entries affords the opportunity for visual "on-site" inspection of the construction work and conditions. Figures 19 and 20 are photographs from an "on -site" inspection.

Exploratory drilling is generally required to determine the general alignment and location of the inaccessible mine entries. Inaccessible entries can be further "examined" through the use of a borehole camera survey. Figures 17 and 18 are photographs of an underground survey taken by the Pennsylvania Drilling Company. In addition, certain geophysical and infrared scanning techniques can be employed in areas of inaccessible entries.

DRY SEALS

The installation of dry seals or surface sealing, as is sometimes referred to, consists of the closure of mine drifts, slopes, shafts and subsidence areas where there will be very little or no hydrostatic pressure in the area of the seals. This work is generally confined to the openings on the "high" side of the mine where the body of the mine workings lie to the dip. In many cases, this type of work is designed to prevent the flow of water into the



Cross-Sectional View of Masonry Seal Showing Method of Construction, Hitching Into Roof, and Concrete Footer.

Top View of Masonry Seal Showing Method of Construction and Hitching Into Rib.

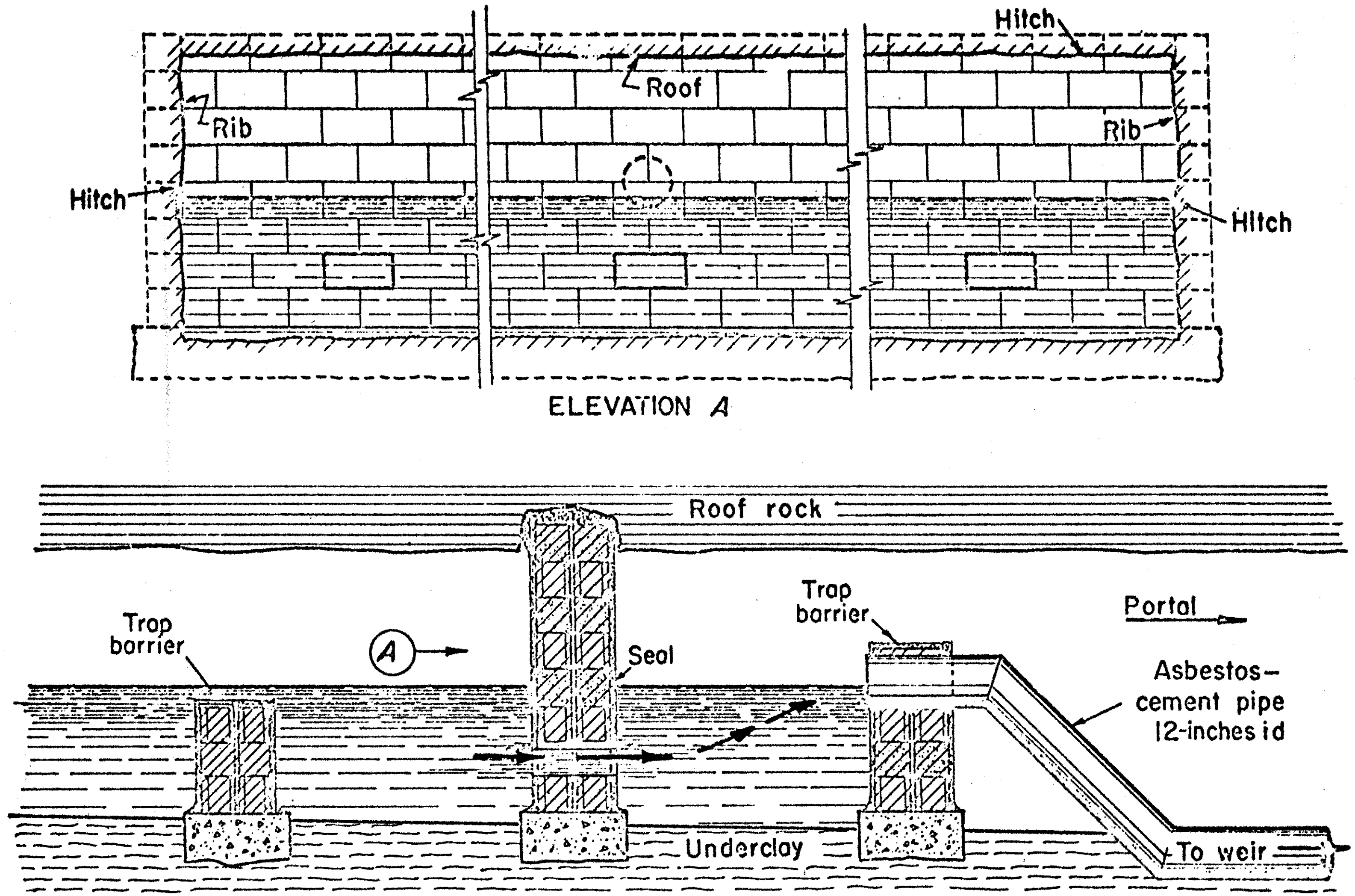
FIGURE 4

-Source-

Air Sealing Coal Mines To Reduce Water Pollution

USBM Report 7354

March 1970



General Arrangement of a Wet Seal With Air Trap.

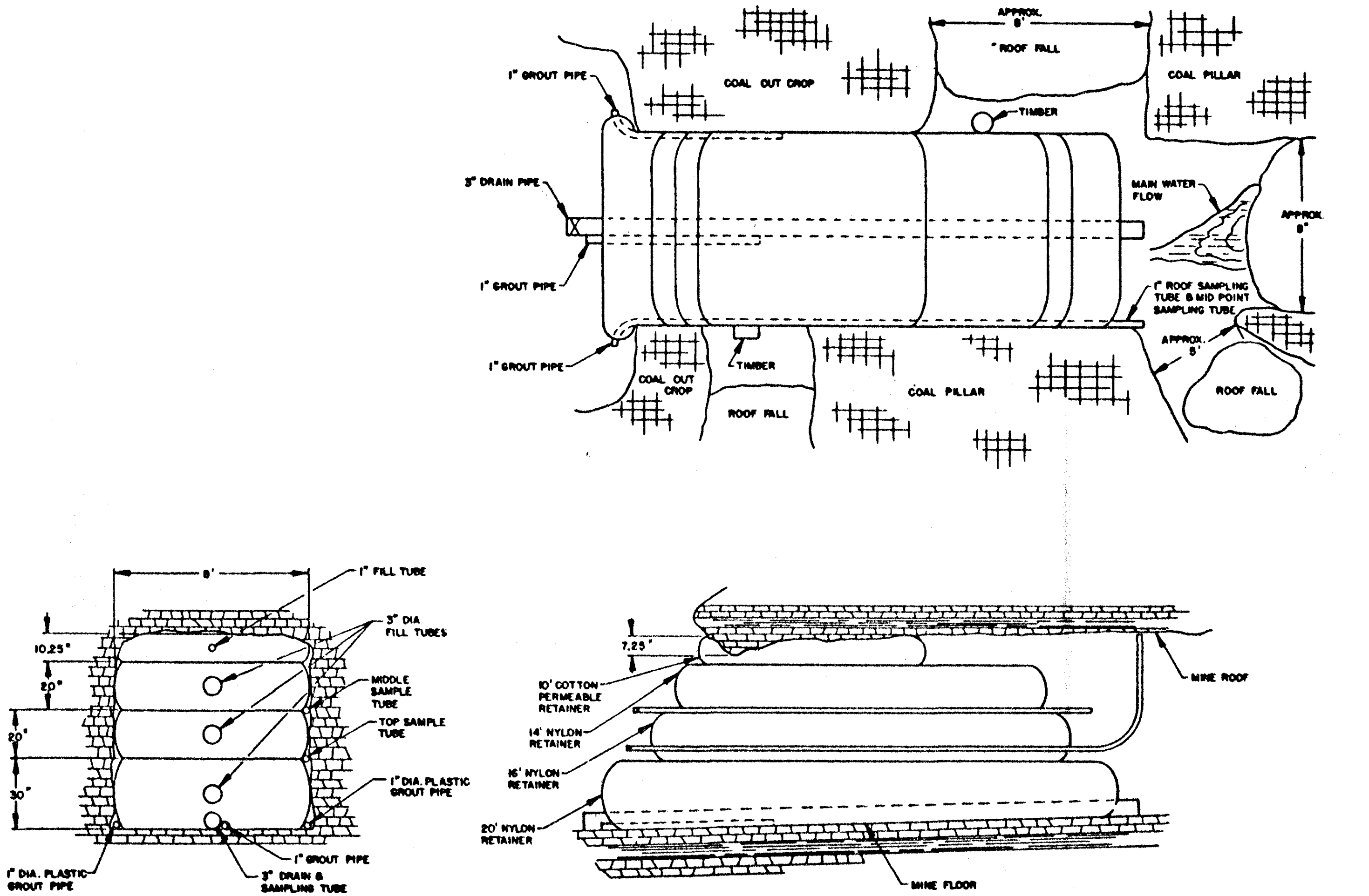
FIGURE 5

-Source-

Air Sealing Coal Mines To Reduce Water Pollution

USBM Report 7354

March 1970



MINE SEAL INSTALLATION

MINE NO. 14-042A

HARRISON COUNTY, WEST VIRGINIA

FIGURE 6

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970

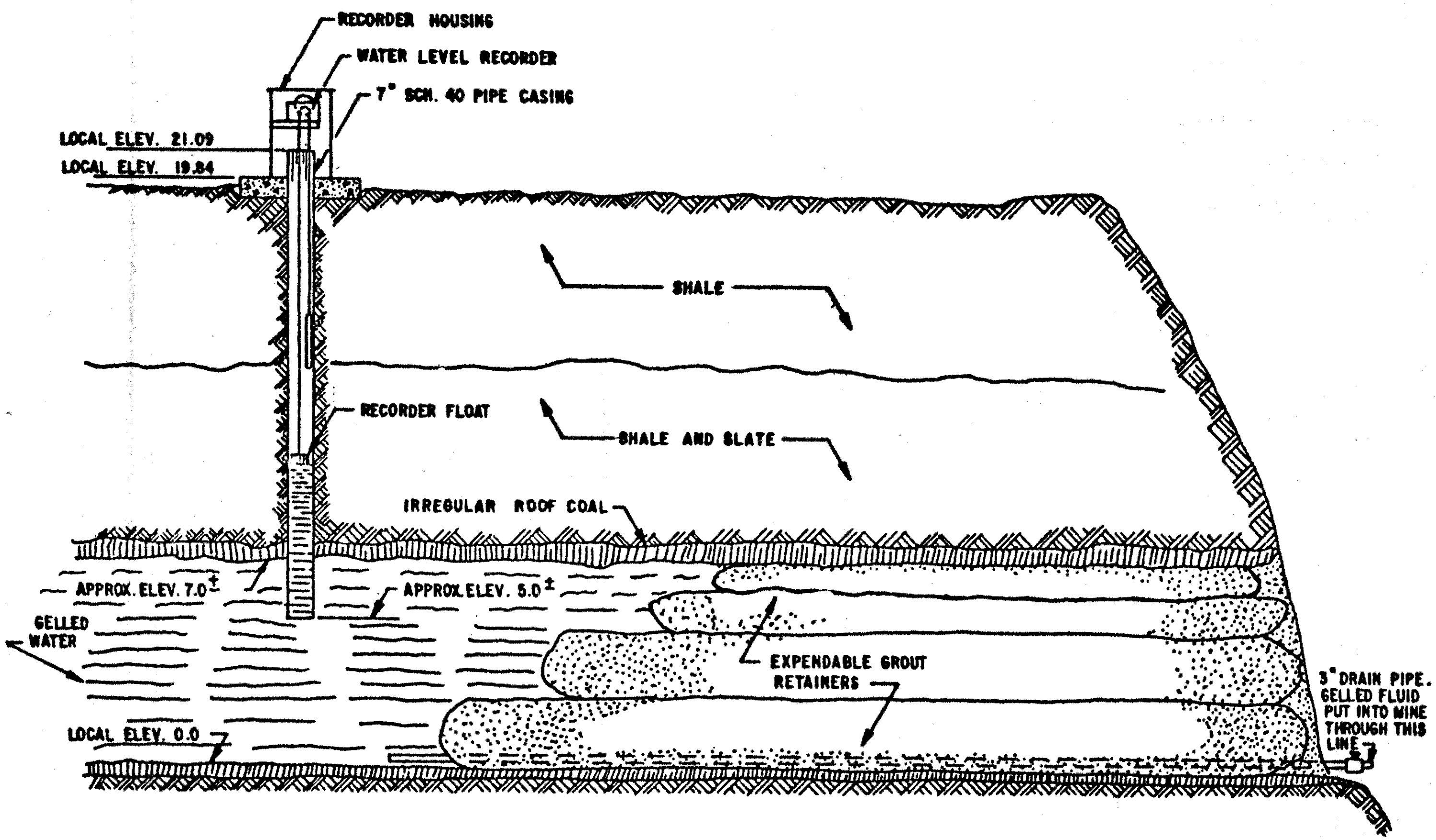


FIGURE 7 - SECTION THROUGH MINE NO. 14-042A

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970.

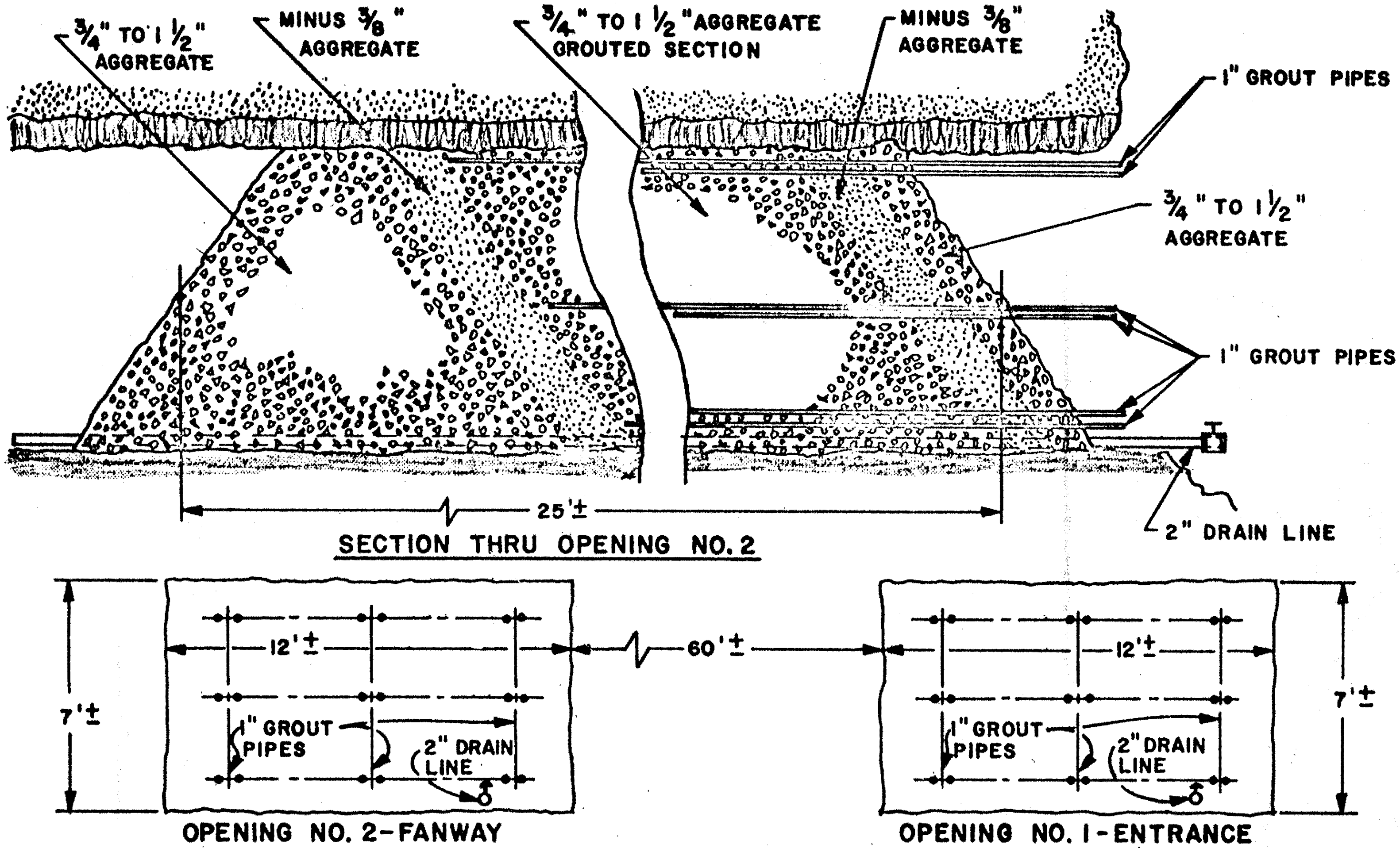
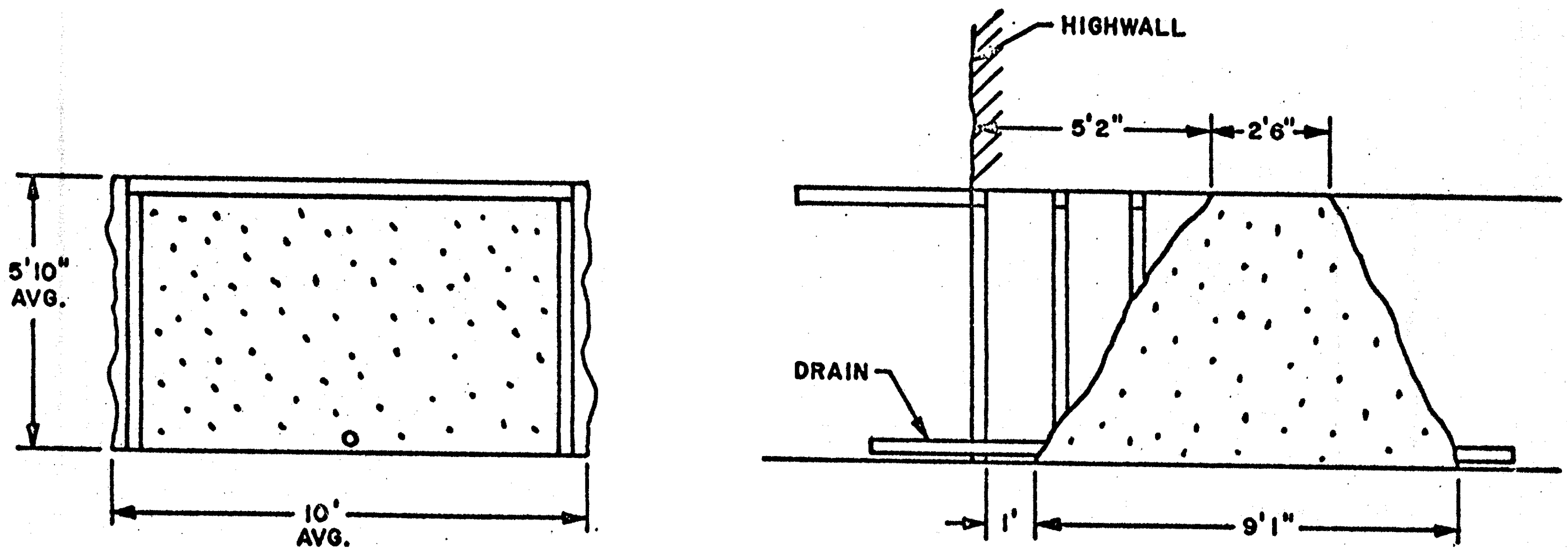


FIGURE 8 - AGGREGATE PLUG DETAIL - MINE 40-016

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



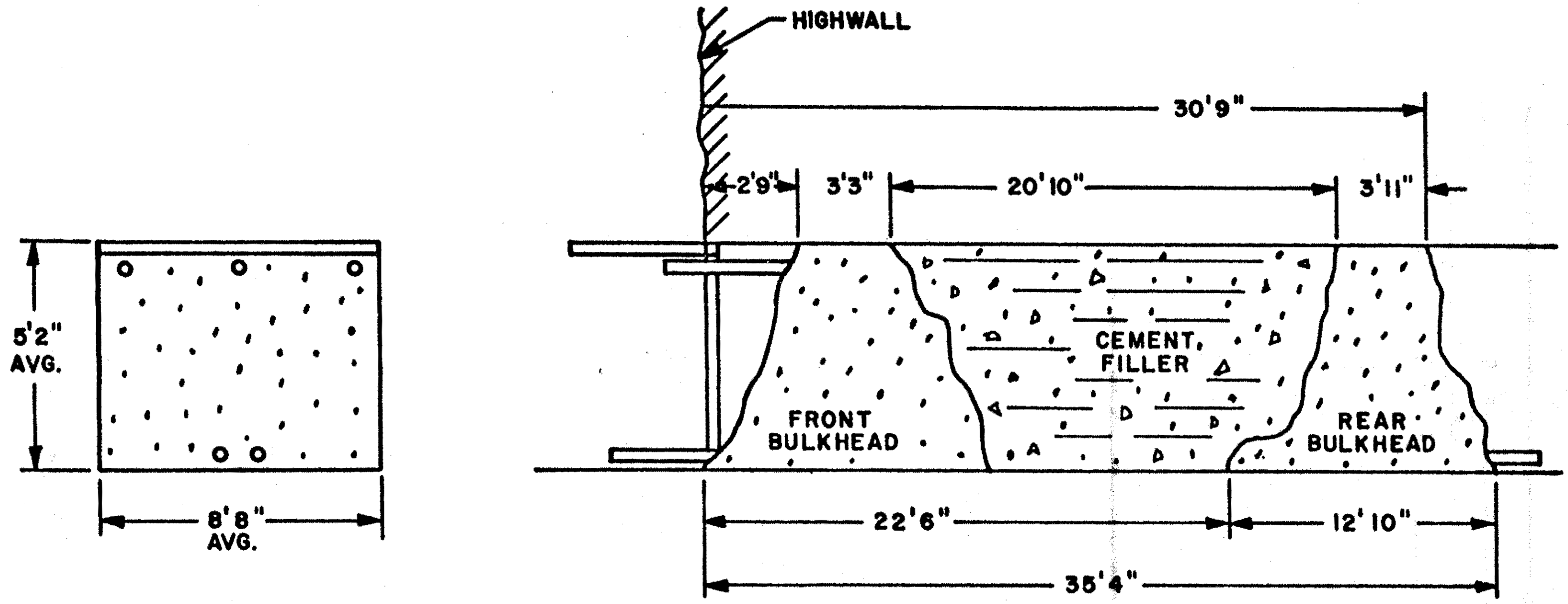
SECTION - QUICK SETTING BULKHEAD - OPENING NO. 4 - MINE NO. 62-008

FIGURE 9

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



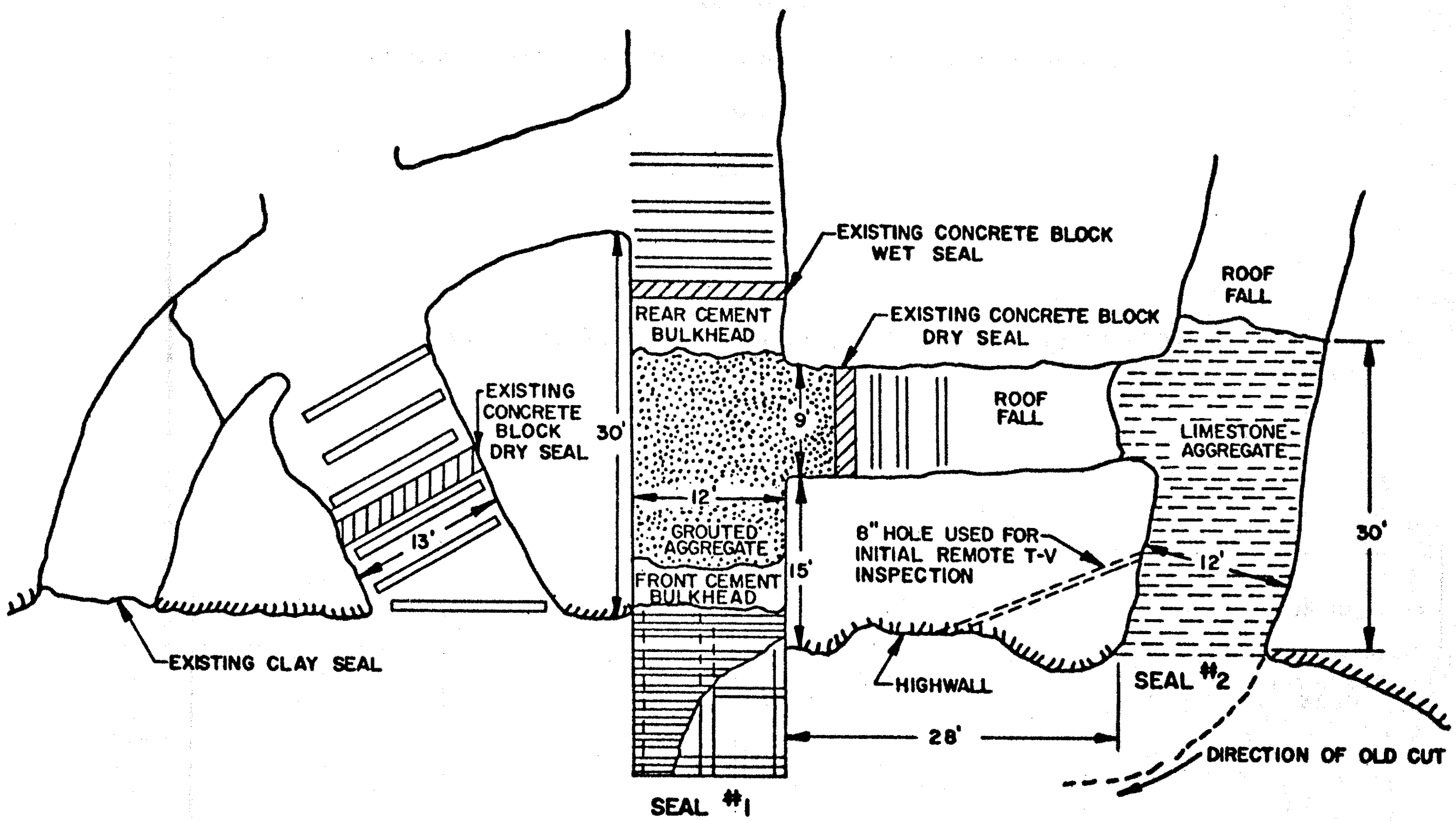
SECTION - MINE SEAL - OPENING NO. 5 - MINE NO. 62-008

FIGURE 10

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



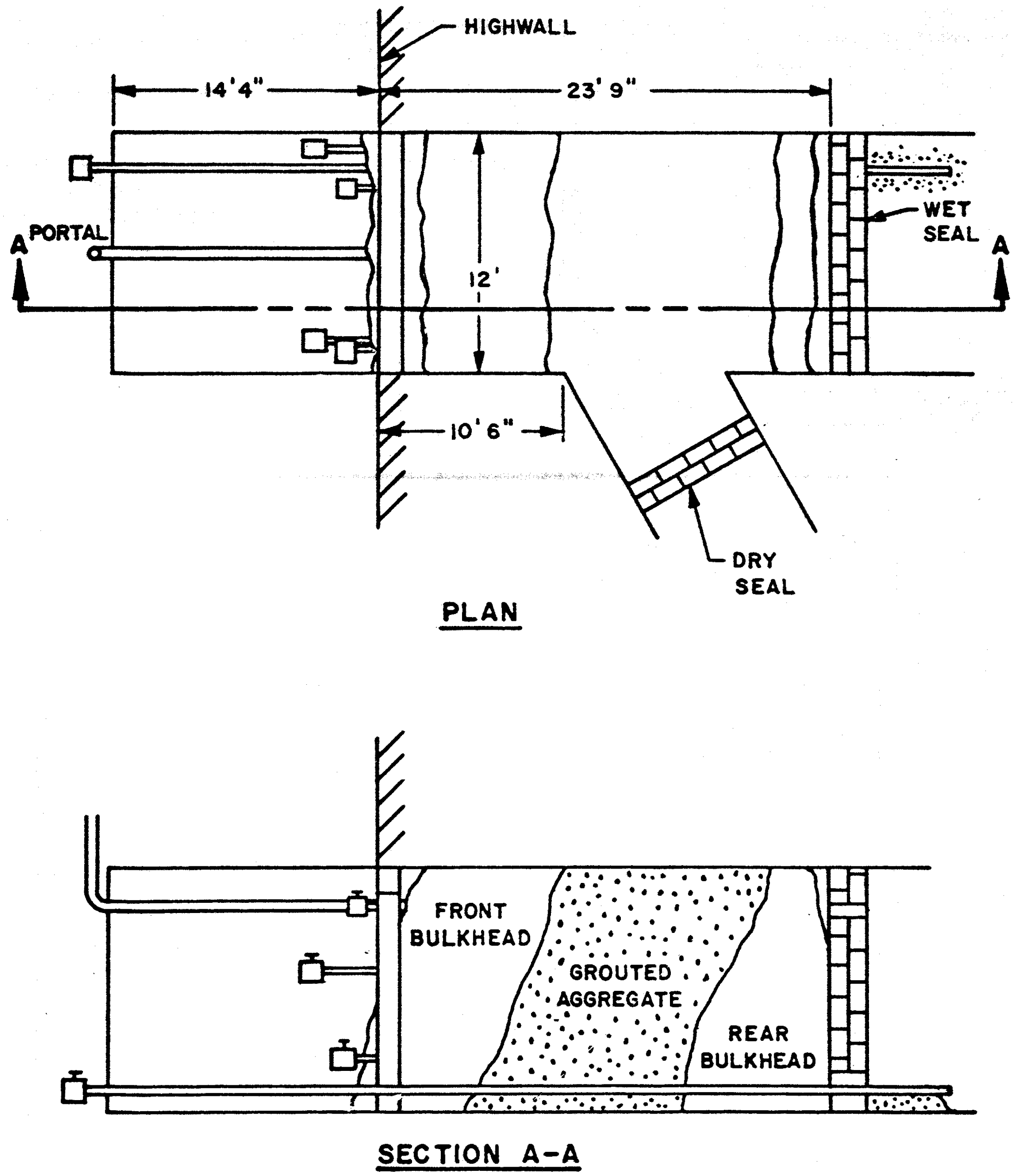
PLAN VIEW OF REMEDIAL CONSTRUCTION - MINE NO. RT5-2

FIGURE 11

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



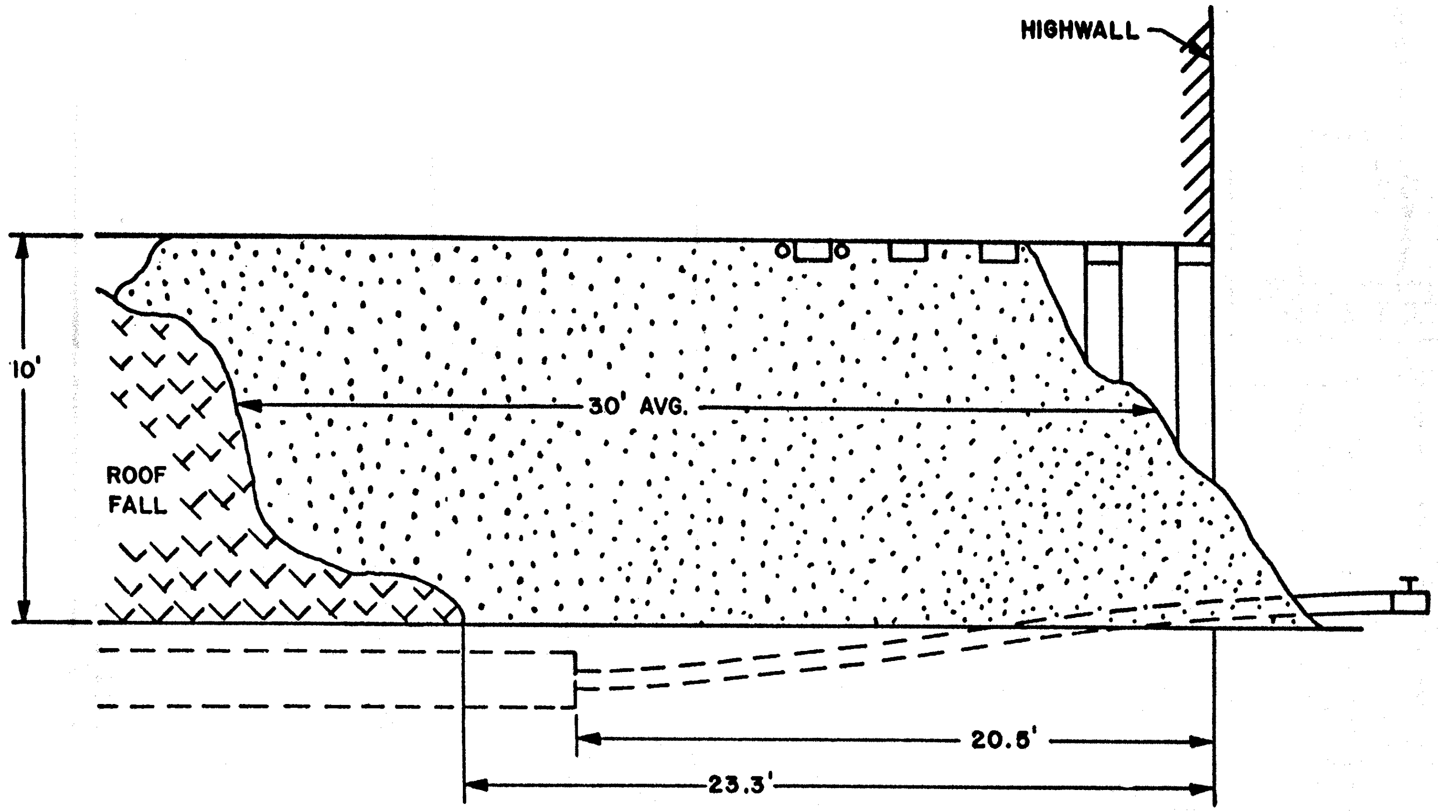
CONSTRUCTION DETAIL
SEAL NO. 1 - MINE NO. RT5-2

FIGURE 12

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



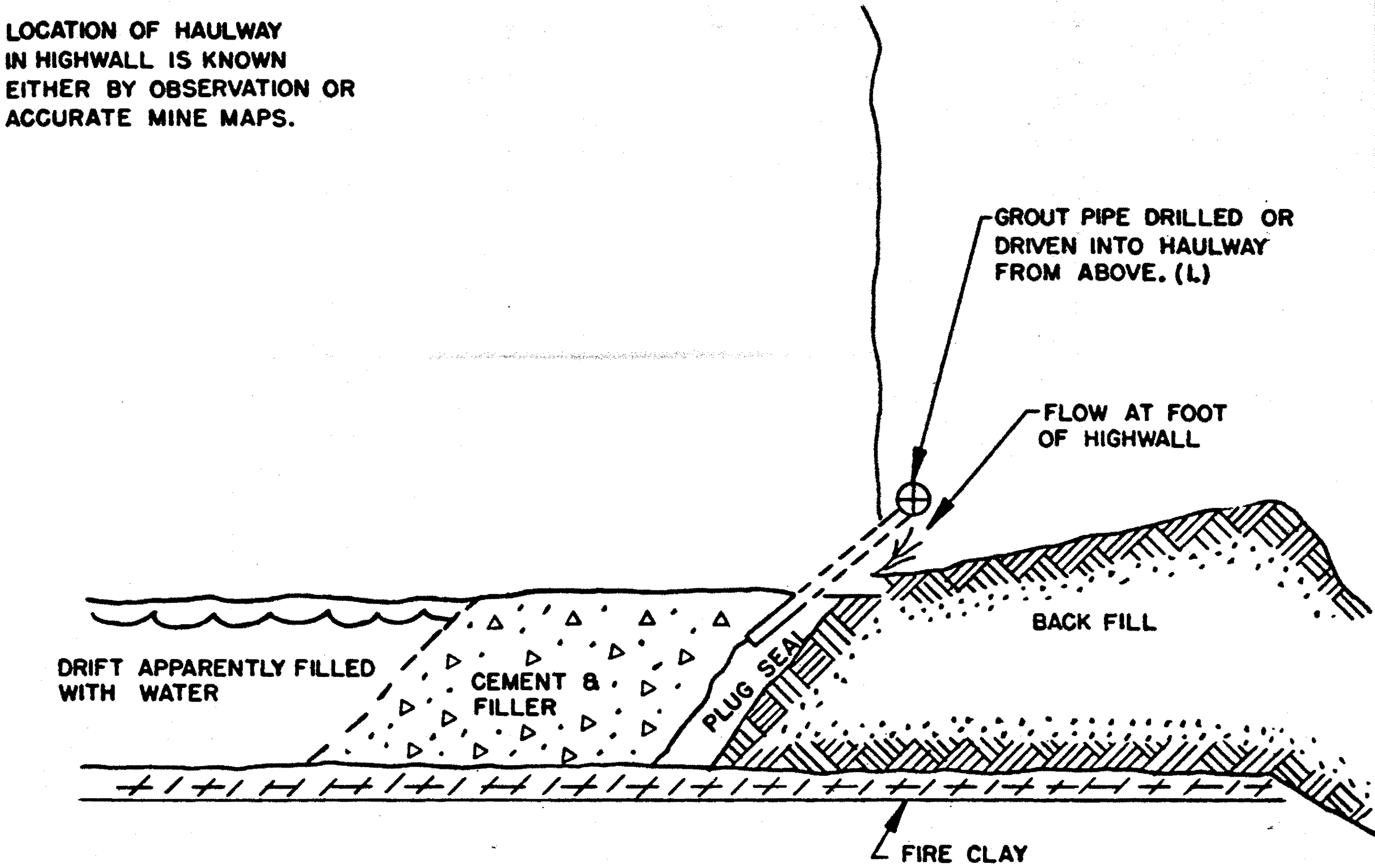
SECTION VIEW OF SEAL - OPENING NO. 2

FIGURE 13

-Source-

New Mine Sealing Techniques for Water Pollution Abatement

March 1970



TYPICAL DRIFT MINE - CONDITION III - CASE C

FIGURE 14

-Source-

Feasibility Study on the Application of Various Grouting Agents, Techniques and Methods to Abatement of Mine Drainage Pollution
Part I
FWQA - Halliburton Co. Report August 9, 1967

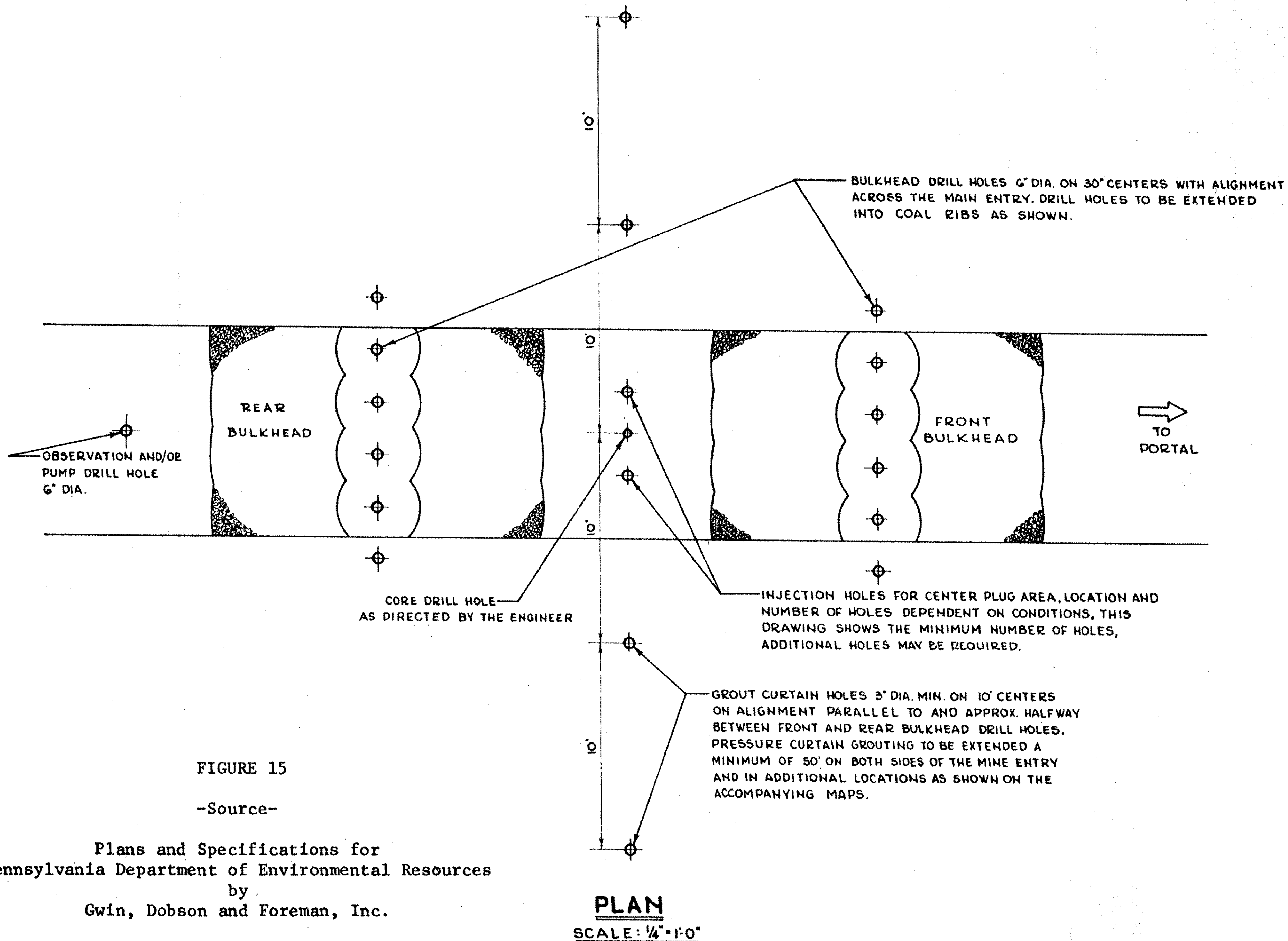
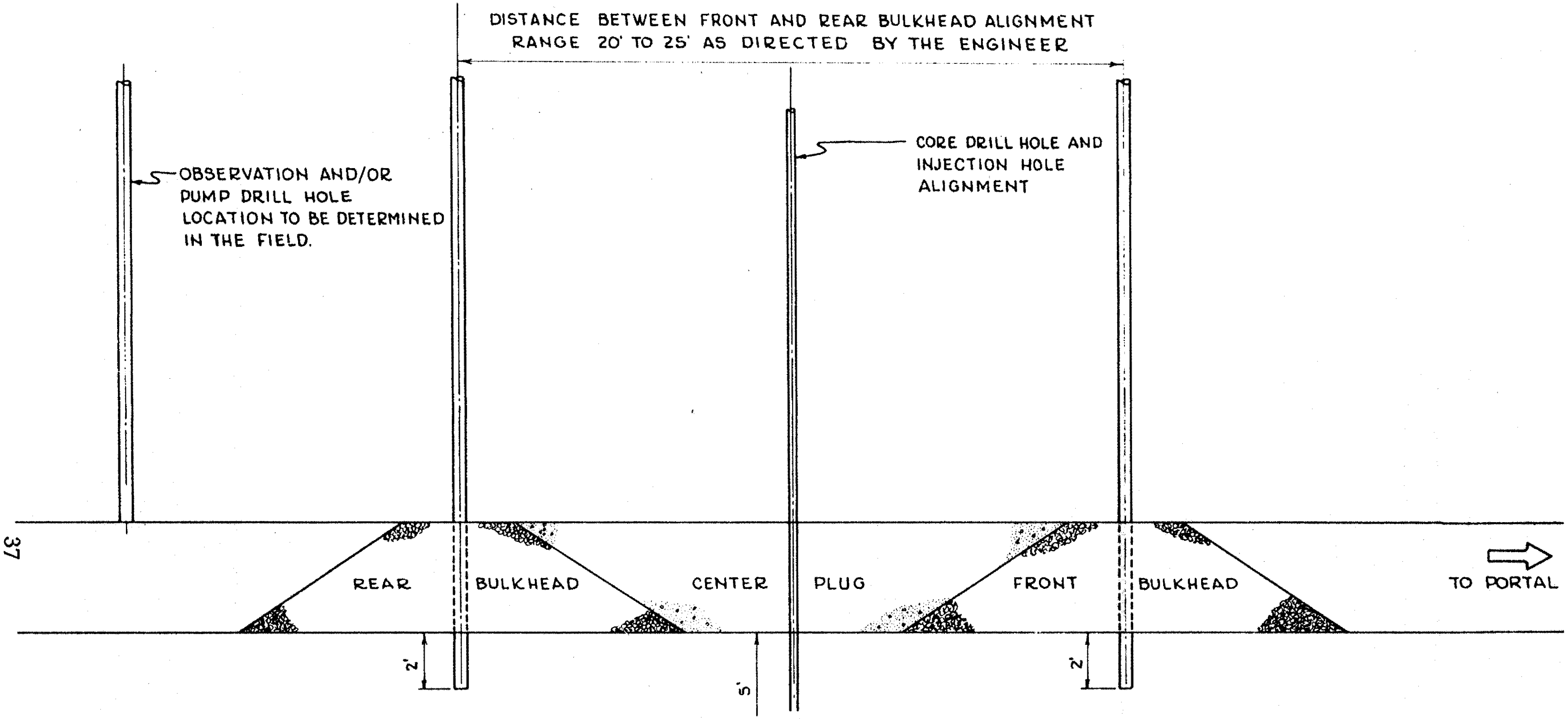


FIGURE 15

-Source-

Plans and Specifications for
Pennsylvania Department of Environmental Resources
by
Gwin, Dobson and Foreman, Inc.



PROFILE

SCALE: 1/4" = 1'-0"

CONSTRUCTION DRAWING OF DEEP MINE SEAL

FIGURE 16

-Source-

Plans and Specifications for
Pennsylvania Department of Environmental Resources
by
Gwin, Dobson & Foreman, Inc.

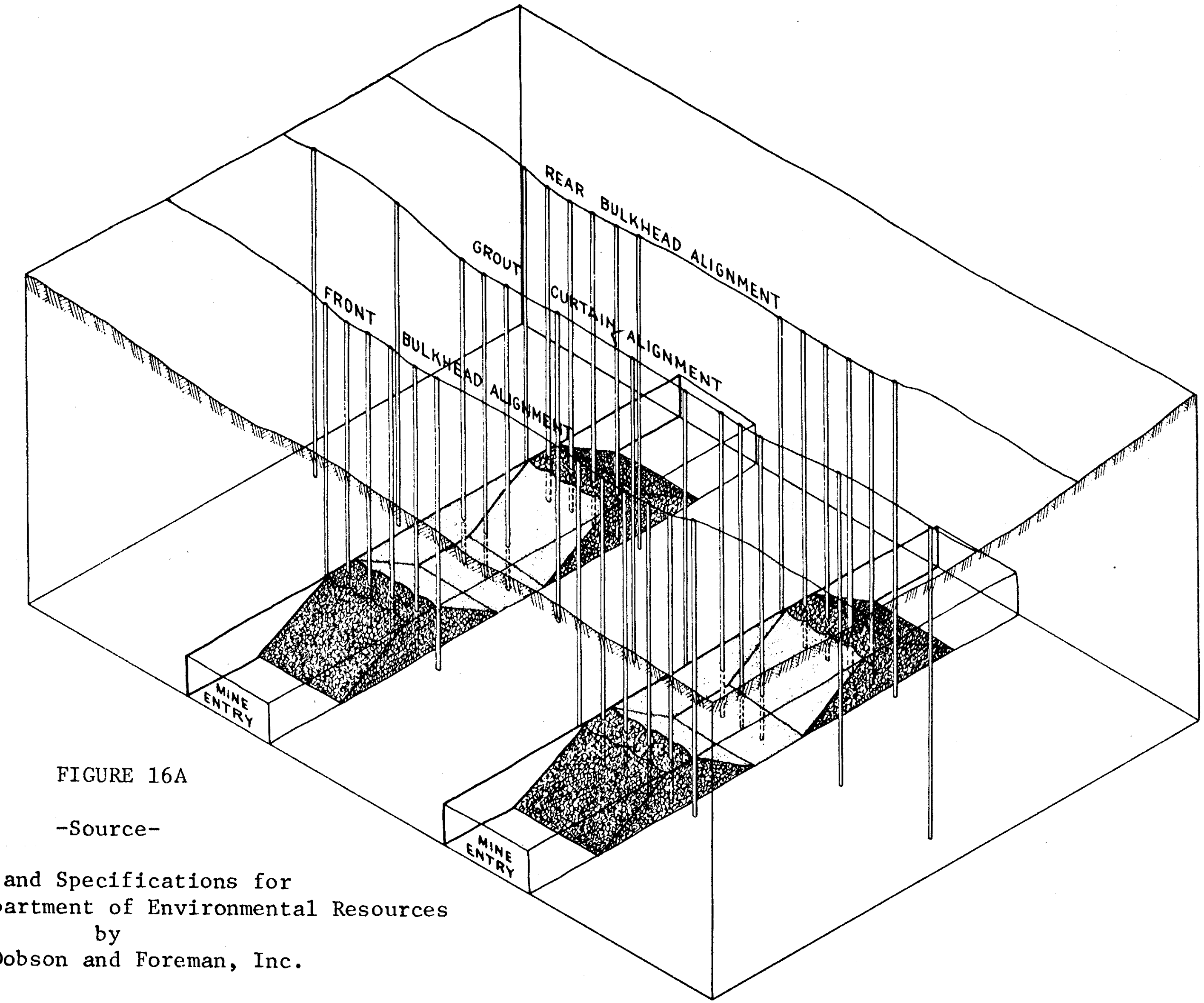


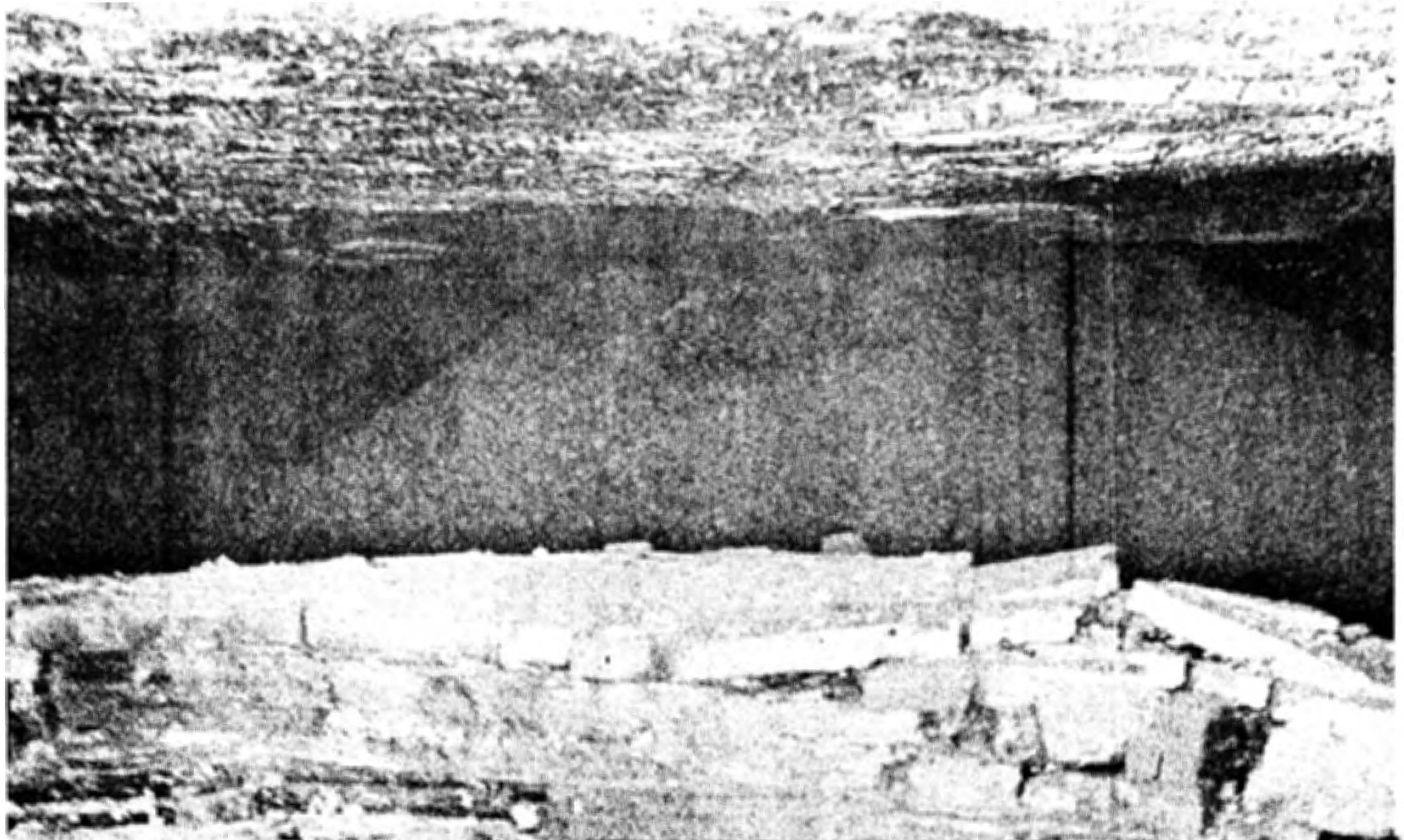
FIGURE 16A

-Source-

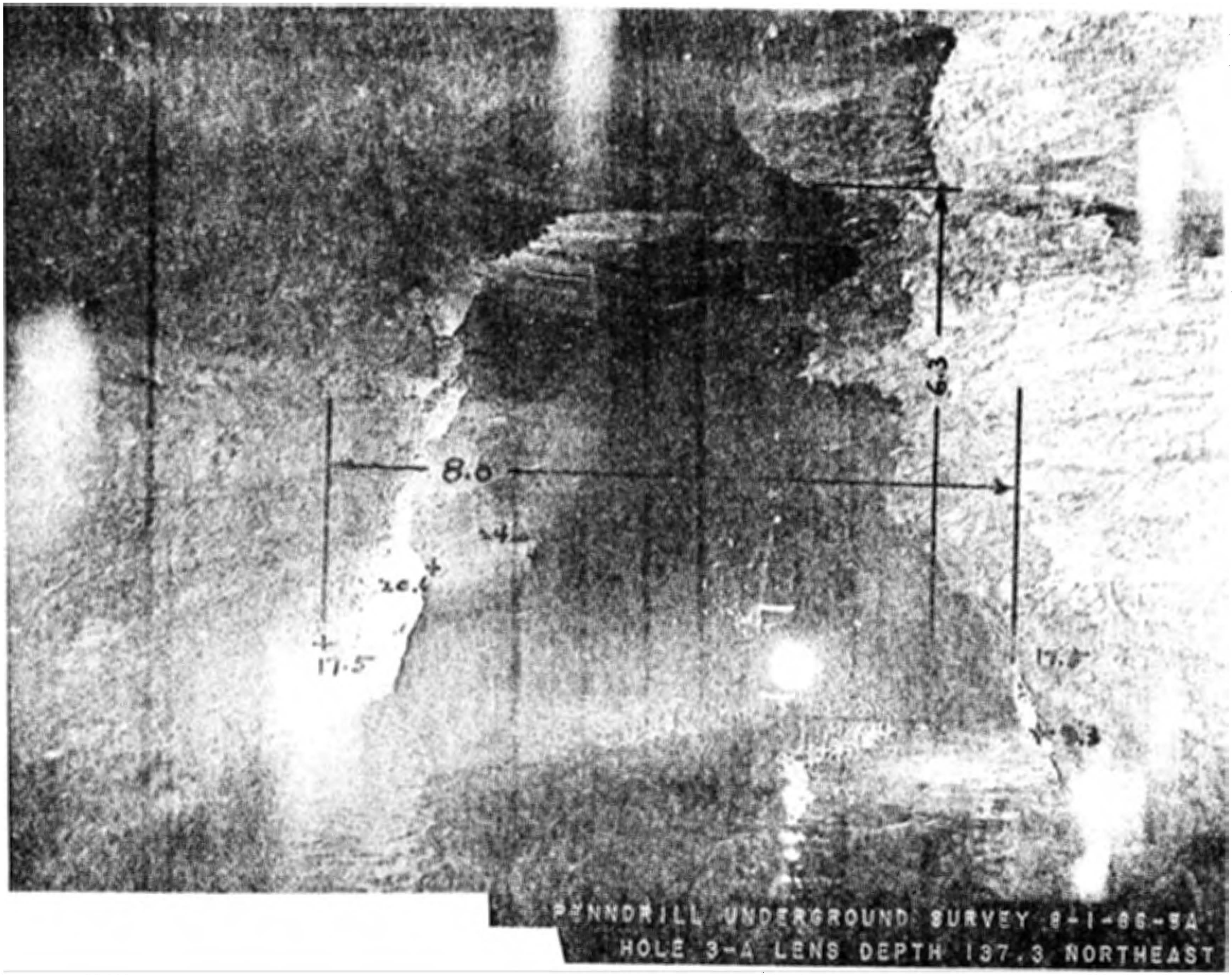
Plans and Specifications for
Pennsylvania Department of Environmental Resources
by
Gwin, Dobson and Foreman, Inc.

ISOMETRIC DRAWING OF DEEP MINE SEALS

NO SCALE



PIER 21 - 6 FT. DIAMETER ROOF CONTACT FROM ONE 6 IN. DRILL HOLE FIG. 17



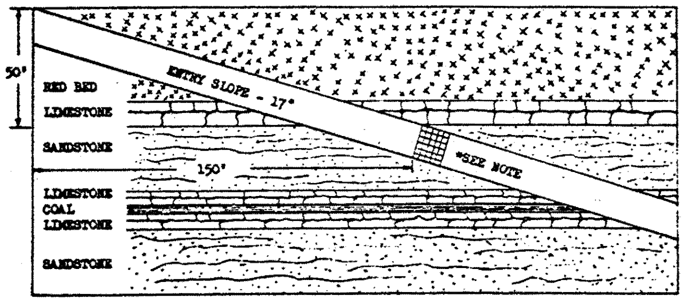
DISTANCE AND DIMENSION BY PENNDRILL SURVEY CHARTS

FIG. 18

Figure 19

Figure 20

CHEMICAL GROUTING TO PREVENT INFLOW OF WATER



**NOTE: HATCHED AREA SHOWS WHERE EXCESSIVE WATER SEEPAGE OCCURRED. SEE FRONT VIEW DIAGRAM FOR DETAILS ON CHEMICAL GROUTING.*

Figure 1. Side View-Entry Slope

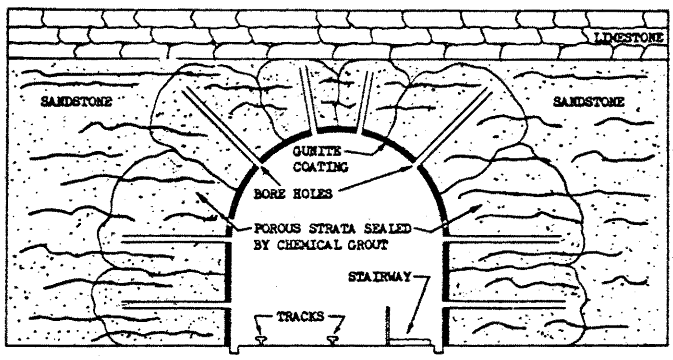


Figure 2. Front View-150 Feet Down Entry Slope (Vertical Depth - 50 Feet)

MINING METHOD: Underground mining.

LOCATION: Western Pennsylvania, Upper Freeport Seam.

RESULTS ACHIEVED: Inflow of water into mine stopped. This in turn eliminated severe icing conditions on the walls and ceiling of the mine slope near the entry. This resulted in improved safety conditions and in substantial savings in time and material. The method would be useful to control mine drainage.

FIGURE 21

-Source-

Principles, Practices and Case Histories in the Control of Acid Mine Drainage

ORSANCO REPORT March 1964

mine. Dry seals can vary from the concrete block or masonry construction (Figure 4) to the filling of openings with clay, concrete or other suitable materials.

AIR SEALS

Conventional air-sealing, as practiced from the 1930's to date, consists of sealing of all mine openings into the applicable mined area except for the one or more openings at the lower elevations of the mine. A mine seal with an airtrap, either the same as or similar to the example shown on Figure 5, is installed in the one or more openings at the lower elevations. The purpose of air-sealing is to prevent the air from entering the mine but permitting the flow of water from the mine. The effectiveness of a mine air-sealing project will depend on the ability to locate and seal off those openings which are a source of air supply to the mine. Air-mine sealing methods can be both difficult and expensive in mines which have been extensively worked under shallow cover resulting in numerous subsidence fractures. However, previous experience in some instances, has indicated limited improvement in the water quality of the discharge in mines where the degree of air exclusion was dubious.

WET SEALS

The installation of "wet" or "hydraulic" deep mine seals consists of the sealing of the mine entries, drifts, slopes, shafts and adjacent strata where there will be hydrostatic pressure in the area of the seal.

Examples of some of the techniques and practices in the construction of wet weals are indicated on Figures 6 through 21.

Mine bulkheads or underground dams differ from surface dams, as the entire water surface area of the dam is subjected to practically the same pressure.

The installation of a water-tight bulkhead in the mine entry capable of withstanding the maximum hydrostatic head is essential; however, there are other factors to be considered in the construction of the complete seal. During the mining operations, the support from the overlying strata was removed which induces fracturing (in many cases, caving in the roof area). In addition, openings and fractures may develop in the mine bottom due to the release of rock pressure as a result of the mining. It is important that pressure grouting operations be performed in the strata adjacent to the bulkhead to prevent the flow of water through the strata.

To date, most of the hydraulic seals installed in the mine portals along the outcrop have been in mines having a maximum head of 100 feet or less, above the elevation of the seal. Although it is possible to design mine bulkheads to withstand pressure in excess of 1,000 feet or more, as presently used in underground dams, the limiting factor in the mine seals at the portals has been the nature of the strata adjacent to the outcrop. In many instances, the deep mine workings have extended into shallow cover near the outcrop. In these areas, many of which are extended a considerable distance along the outcrop, curtain grouting operations are required to alleviate the possibility of new discharges or seepage areas when wet seals are installed in the portals.

CONCLUSIONS AND RECOMMENDATIONS

The initial basis for any mine drainage control program should be source abatement. Detailed studies and analysis of specific conditions are recommended to determine the feasibility for the proposed abatement methods (deep mine sealing, surface sealing, strip mine reclamation, refuse pile abatement and others). Treatment methods (neutralization) should be employed only when source abatement plans are not economically feasible.

Each mine area should be individually examined and all applicable factors considered before any mine seals are constructed. Assuming average or normal mining conditions, and with good engineering design and supervision, an estimated reduction of 80 percent in acidity can be anticipated. Previous experience in recent deep mine sealing projects has indicated a range from about 40 to 100 percent reduction in acidity.