

EXHIBIT R

Commonwealth of Pennsylvania
Department of Mines and Mineral Industries

**MD Pollution Abatement Measures
for the Beech Creek Watershed**

EVALUATION OF AMD ABATEMENT MEASURES

I. Preventive Measures

	<u>Inundate Deep Mine Workings</u>	<u>Reconstruct Stream Channels</u>	<u>Construct Surface and/or Ground Water Diversion Ditches</u>
Purpose	Raise ground water table to eliminate atmospheric oxygen contact with acid producing material and improve quality of outflows at higher elevations when they occur	Eliminate stream discharge to deep mine workings	Convey surface and/or ground waters around or across strip mine or around deep mine opening to a water course
General Construction Procedure	Seal by closing entries, curtain grouting and/or excavating and placing impermeable material around periphery of deep mine workings, to extent necessary to inundate	Repair breaks and place liner in existing stream channel	Construct diversion ditch to required depth
Anticipated AMD Reduction Assuming Proper Construction and Maintenance Volume	None after inundation occurs, except where mine workings are limited and no outflows occur	Stream volume prevented from entering the mine	Surface and/or ground waters captured in ditch
Iron and Acid Concentration	After initial increase, a significant reduction	None	None
Experience with Measure Extent of Construction Maintenance Performed Data Accumulated on Effectiveness	Extensive Limited Limited	Extensive Extensive to none Limited	Extensive Extensive Limited
Performance of Measure Constructed	As anticipated	As anticipated	As anticipated
Comments	Most effective when inactive workings are completely inundated; limited applicability in areas where overburden is heavily fissured; inundation of some deep mines below gravity drainage points has occurred naturally after mine drainage pumping has ceased	In some instances a new channel may be excavated in lieu of lining existing channel	Requires considerable earth moving where ground waters are diverted
Applicability to Beech Creek Watershed	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans

	<u>Restore Strip Mines</u>	<u>Move Refuse Into Strip Mines</u>	<u>Eliminate Deep Mine Workings</u>
Purpose	Induce runoff rather than impoundment	Reduce number of AMD discharge points	Raise ground water table to eliminate atmospheric oxygen contact with acid producing materials; eliminate infiltration to and water flow routes through deep mine workings
General Construction Procedure	Backfill strip mine to desired grade	Move Refuse from ground surface into strip mines	Use heavy earth moving equipment to excavate overburden, regrade and plant; and/or use explosives to collapse overburden, to eliminate deep mine workings.
Anticipated AMD Reduction Assuming Proper Construction and Maintenance			
Volume	Surface waters and direct precipitation, captured prior to construction, less normal infiltration	None	Surface and ground waters entering deep mine workings
Iron and Acid Concentration	None	None	After initial increase, significant reduction
Experience with Measure			
Extent of Construction	Extensive	Limited	None
Maintenance Performed	Limited to none	None	—
Data Accumulated on Effectiveness	Limited	None	—
Performance of Measure Constructed	Some as anticipated; others not as anticipated	No data available	No data available
Comments	Past limited success has been caused by variance in backfilling practice; elimination of AMD discharges from strip mines is potential benefit	Only benefit realized is elimination of Refuse AMD discharge points	Requires considerable earth moving and rock excavation during construction; and/or requires extensive preparatory work where overburden is to be collapsed
Applicability to Beech Creek Watershed	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans

	<u>Excavate and Restore Subsidence Areas</u>	<u>Close Deep Mine Entries</u>	<u>Chemically Neutralize Strip Mines</u>
Purpose	Induce runoff rather than impoundment	Prevent discharge of surface waters and direct precipitation to deep mine workings through Entries	Neutralize impounded water and acid producing material in strip mine, thus eliminating formation of AMD
General Construction Procedure	Excavate subsidence area and backfill	Place seals in Deep Mine Entries	Pump lime slurry into impoundments and spread lime over entire Affected Area
Anticipated AMD Reduction Assuming Proper Construction and Maintenance			
Volume	Surface waters and direct precipitation captured prior to construction, less normal infiltration	Surface waters and direct precipitation tributary to Entries	None
Iron and Acid Concentration	None	None	Significant reduction over three year period
Experience with Measure			
Extent of Construction	Limited	Extensive	Limited
Maintenance Performed	None	Limited to none	Limited to none
Data Accumulated on Effectiveness	None	No data available	Limited to none
Performance of Measure Constructed	No data available	No data available	No data available
Comments	In certain instances, excavation may not be required	The primary benefit of the Works Progress Administration's air sealing program was the reduction of AMD volumes	Particularly applicable to very large strip mined areas which would require huge expenditures for restoration and in which much of the acid potential has leached out
Applicability to Beech Creek Watershed	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans	Applicable; used in development of Abatement Plans

	<u>Cover Refuse Material</u>	<u>Construct Barriers In Deep Mine Workings</u>	<u>Construct Impermeable Seal On or Below Ground Surface</u>
Purpose	Eliminate Refuse AMD discharge	Inundate portions of deep mine workings to eliminate atmospheric oxygen contact with acid producing material, and/or divert mine water flow into areas where there will be less contact with acid producing material	Eliminate AMD discharges by preventing infiltration to deep mine workings
General Construction Procedure	Prepare Refuse area and cover with impermeable material; construct surface water diversion ditch uphill from Refuse	Seal existing deep mine water flow routes	Prepare ground surface and place impermeable covering or bentonite layer approximately 4 feet below ground surface
Anticipated AMD Reduction Assuming Proper Construction and Maintenance			
Volume	Discharge eliminated	None	Discharges eliminated
Iron and Acid Concentration	—	After initial increase, a significant reduction	—
Experience with Measure Extent of Construction Maintenance Performed Data Accumulated on Effectiveness	Extensive Extensive Limited	Extensive Extensive Limited	None — —
Performance of Measure Constructed	As anticipated	Some as anticipated; others not as anticipated	—
Comments	Refuse can be moved into strip mine and covered, or covered in place; spontaneous combustion possible if precautions not taken	Past limited success due to doubtful condition of barriers; extensive preparatory work necessary in abandoned deep mine workings to insure safe working conditions	To be effective, impermeable seal must be used where ground water migration through deep mine workings does not exist; considerable preparatory work must be done prior to placing impermeable covering; faults in subsurface layer difficult to locate
Applicability to Beech Creek Watershed	Applicable; not used in development of Abatement Plans	Not applicable	Applicable; not used in development of Abatement Plans

	<u>Air Seal Deep Mine Workings</u>	<u>Apply Surface Sealant To Acid Producing Materials In Deep Mine Workings</u>	<u>Lower Ground Water Table</u>
Purpose	Eliminate atmospheric oxygen contact with acid producing material	Eliminate atmospheric oxygen and water contact with acid producing material	Eliminate ground water migration into deep mine workings
General Construction Procedure	Seal all openings into deep mine workings to prevent inflow of air	Prepare, and place impermeable sealant on acid producing material	Drill boreholes and install deep well pumps for pumping ground water to the surface
Anticipated AMD Reduction Assuming Proper Construction and Maintenance			
Volume	Some reduction in volume can be anticipated	None	Ground water prevented from entering deep mine workings
Iron and Acid Concentration	Complete	Complete	None
Experience with Measure			
Extent of Construction	Extensive	Limited	None
Maintenance Performed	Limited to none	Limited to none	—
Data Accumulated on Effectiveness	Limited	Limited	—
Performance of Measure Constructed	Not as anticipated	Not as anticipated	—
Comments	Past limited success due to difficulty in sealing all openings, fissures, etc. through which air can enter deep mine workings, and poor maintenance; changes in atmospheric pressure inside and outside of the deep mine workings can also cause atmospheric oxygen entry into deep mine workings	Past limited success due to difficulty in placing and maintaining sealant; extensive preparatory work in abandoned deep mine workings necessary to insure safe working conditions	Most effective if used at the start of deep mining, effectiveness lost if pumping stopped at completion of deep mining; will not eliminate infiltration through overburden
Applicability to Beech Creek Watershed	Not applicable	Not applicable	Not applicable

	<u>Displace Air In Deep Mine Workings</u>	<u>Place Bacteriophage In Deep Mine Workings</u>	<u>Place Refuse In Deep Mine Pools or Surface Impoundments</u>
Purpose	Eliminate atmospheric oxygen contact with acid producing material	Inhibit or eliminate action of iron oxidizing bacteria	Reduce number of AMD discharge points, and eliminate atmospheric oxygen contact with acid producing material
General Construction Procedure	Seal all openings and pump inert gas into deep mine workings	Introduce bacteriophage into mine water pools and flow routes	Move Refuse into deep mine or surface pools
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	None	None	None
Iron and Acid Concentration	Complete	Complete	After initial increase, a significant reduction
Experience with Measure			
Extent of Construction	Limited	Limited	Limited
Maintenance Performed	Limited	None	Limited
Data Accumulated on Effectiveness	Extensive	None	Limited
Performance of Measure Constructed	Not as anticipated	No data available	As anticipated
Comments	Past limited success due to difficulty in sealing all openings, fissures, etc., and displacing air from all portions of deep mine workings	Still in developmental stage	Most effective when Refuse can be completely inundated
Applicability to Beech Creek Watershed	Not applicable	Not applicable	Not applicable

II. Treatment Measures

	<u>Chemically Neutralize, Oxidize and Settle In Treatment Facilities</u>	<u>Demineralize</u>	<u>Chemically Neutralize In Underground Mine Water Pools</u>
Anticipated AMD Reduction Assuming Proper Construction, Operation and Maintenance Volume	None	None	None
Iron and Acid Concentration	To SWB MD discharge limitations	To SWB MD discharge limitations, or better	To SWB MD discharge limitations
Experience with Measure			
Extent of Construction	Extensive	Limited	None
Maintenance Performed	Extensive to none	Extensive	—
Data Accumulated on Effectiveness	Extensive to limited	Extensive to limited	—
Performance of Measure Constructed	Some as anticipated; others not as anticipated	As anticipated	—
Comments	Past limited success due to improper design, operation and/or main- tenance; will also remove approximately 50% of aluminum and 70% of manganese present in AMD discharges	Includes electro dialysis, distillation, ion exchange and reverse osmosis, generally still in developmental stage; has potential of pro- ducing extremely high quality effluent; in some cases MD must be pretreated before discharge to demineralization facilities	Difficult to secure adequate contact time between AMD alkali and oxygen for effective neutralization and oxida- tion
Applicability to Beech Creek Watershed	Applicable; used in development of Abatement Plans	Applicable; not used in development of Aba- tement Plans	Not applicable

**Chemically Neutralize At
On-Stream Facilities**

Anticipated AMD Reduction Assuming Proper Construction, Operation and Maintenance Volume	None
Iron and Acid Concentration	Significant acid reduction
Experience with Measure Extent of Construction Maintenance Performed Data Accumulated on Effectiveness	Extensive Extensive to limited Extensive
Performance of Measure Constructed	As anticipated
Comments	No facilities provided for the settling and removal of solids formed from operation of the facility; in some instances major operating problems encountered
Applicability to Beech Creek Watershed	Applicable; not used in development of Abatement Plans

III. Disposal Measures

	<u>Deep Well Injection</u>	<u>Controlled Discharge To Surface Streams</u>	<u>Spray On Ground Surface</u>
Purpose	Inject AMD into underground geological formation with no connection to surface streams	Regulate AMD discharge to surface streams to minimize pollutional effects	Utilize absorptive, evaporative and transpirative capacity of soil and its cover to prevent re-entry of AMD to deep mine workings, and surface runoff
General Construction Procedure	Drill wells and install pumps to inject AMD into underground geological formations	Construct AMD flow regulation facilities such as holding lagoons; stream flow regulation facilities such as dams may also be necessary	Provide pumping, conveyance and spray facilities necessary for applying AMD to ground surface
Experience with Measure			
Extent of Construction	None	Limited	None
Maintenance Performed	—	Limited to none	—
Data Accumulated on Effectiveness	—	Limited	—
Performance of Measure Constructed	—	As anticipated	—
Comments	Extensive subsurface information needed; solids plugging of strata needs extensive investigation; previous experience limited to industrial wastewaters other than AMD	Does not reduce AMD pollutional loading	Pilot testing needed to obtain information and data concerning design, operation and maintenance; soluble residue would remain in soil to be carried into surface streams during wet weather
Applicability to Beech Creek Watershed	Not applicable	Not applicable	Not applicable