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MANUAL FOR ABANDONED UNDERGROUND MINE INVENTORY AND RISK ASSESSMENT

Office Of Infrastructure

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16. Abstract:

This manual presents a process to manage roadway sites beneath which abandoned underground mines exist. The process is comprised of four basic activities: 1) the establishment of an inventory of all roadway sites beneath which abandoned underground mines may exist; 2) the assessment of the risk to safety of the traveling public which each site represents; 3) the remediation of sites, if necessary, and; 4) the permanent monitoring of sites. The process can be applied to one or all sites within a state.

The principles and the basic risk management process documented in this manual can also provide a basic framework into which other states might insert their own state-specific criteria to produce a risk management system for similar geologic conditions such as karst or for other geologic hazards.

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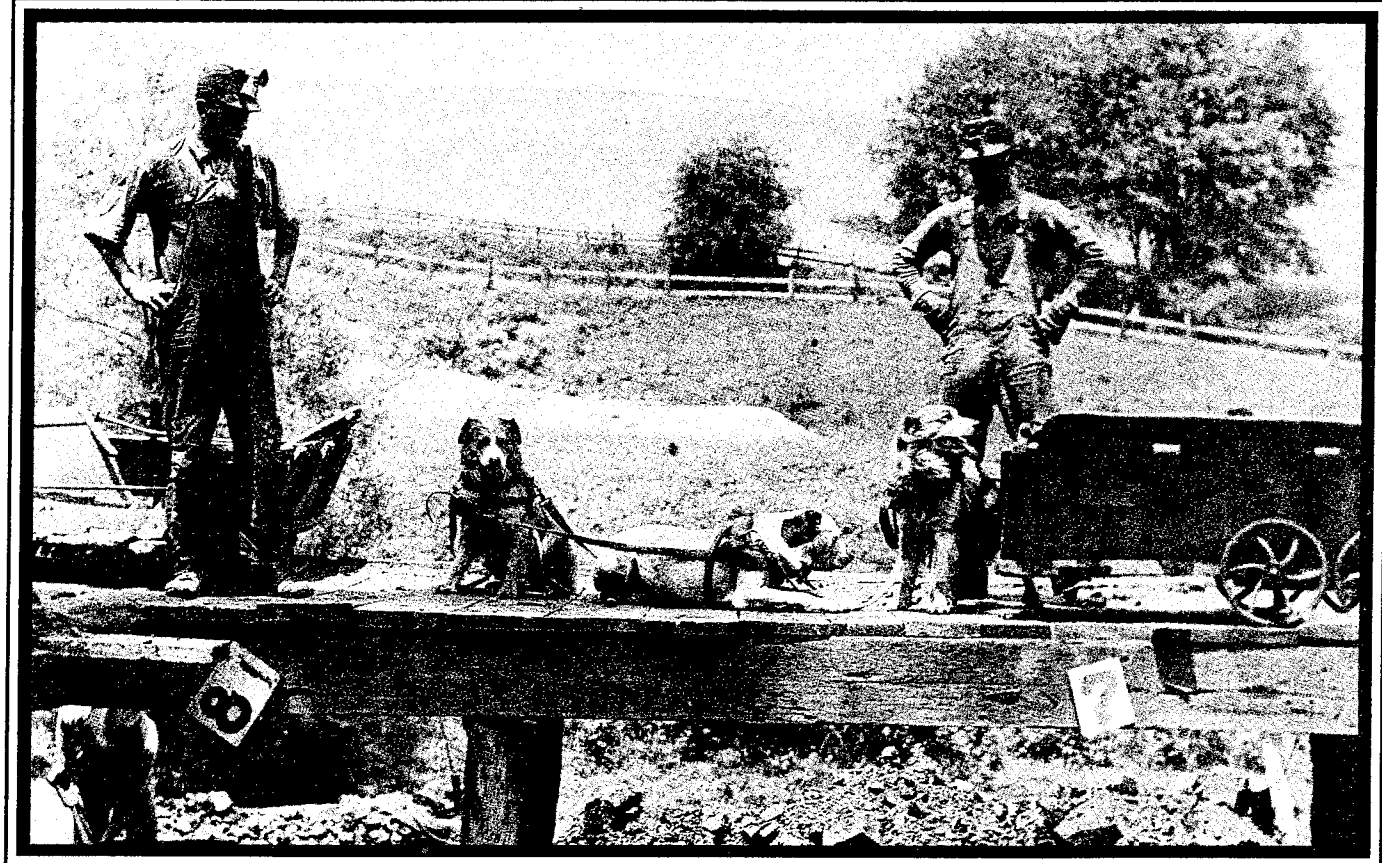
MANUAL FOR

ABANDONED UNDERGROUND MINE INVENTORY AND RISK ASSESSMENT



MAY 15, 1998

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Cover photo: Three coal-mine dogs hitched in tandem at an underground mine in Muskingum County. Ohio Division of Geological Survey file photo by State Geologist Wilbur Stout in 1917.

To Manual Holders:

For initial registration, the form below has been provided in order to ensure you will receive future revisions and updates to the Ohio Department of Transportation's Abandoned Underground Mine Inventory and Risk Assessment Manual. When initially receiving this manual, please complete the form and mail to:

Ohio Department of Transportation
Office of Materials Management
Geotechnical Design Section
1600 West Broad Street, Room 2033
Columbus, Ohio 43223-1298

Abandoned Underground Mine Inventory and Risk Assessment Manual

REGISTRATION FORM

Name:____

Organization:____________________________________

Address:______________________________________

City:____________________ **State**________________

Zip Code:__________________ **Phone:**_______________

5/15/98

Cover photo: Three coal-mine dogs hitched in tandem at an underground mine in Muskingum County. Ohio Division of Geological Survey file photo by State Geologist Wilbur Stout in 1917.

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Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Disclaimer

The ODOT Abandoned Underground Mine Inventory and Risk Assessment process documented in this manual is a proactive method for identifying and prioritizing, through risk assessment, sites where such mines exist beneath the roadway. These roadway locations represent an existing, undefined and yet possibly significant risk to the safety of the traveling public. At the outset of this process, the amount of work required for implementation and the existing threat to the traveling public, which all sites collectively represent, is undefined.

This process is designed to begin with an existing situation in which a roadway authority has an unknown number of sites at unknown locations having unknown levels of risk. The process then develops a comprehensive inventory of sites from existing information which ranks all sites into a logical, prioritized site risk assessment listing. This listing is then utilized to investigate, and remediate if necessary, the sites in a prioritized manner. The overall purpose of this inventory effort is to enhance the safety of the traveling public.

Prior to individual priority site investigations, all assessments of risk are made based on existing information and one site visit. The accuracy of the existing information is unknown. The form and amount of available information can vary greatly between the different sites. Actual subsurface conditions can also vary greatly between even closely spaced adjacent sites due to highly variable geologic conditions.

The Ohio Department of Natural Resources (ODNR), Division of Geological Survey (DGS) has detailed abandonment maps for over 4,000 underground mines. In addition to those mines for which detailed maps are available, the Division of Geological Survey estimates there are approximately 2,000 mines in Ohio for which no detailed maps of the mine workings are available. Therefore, implementation of the ODOT Abandoned Underground Mine Inventory and Risk Assessment will not identify and bring under risk assessment management those sites for which there are no records.

Due to the above-described variability of existing information and undocumented individual site geological conditions, subsidence events may still occur at identified sites prior to remediation being performed as a part of this inventory process. It is possible that subsidence events may occur within the roadway at sites with a lower priority ranking prior to sites with a higher ranking. It is impossible to predict the precise time and location of subsidence events. The process described in this manual is an attempt to identify roadway sites with the highest probability of future subsidence events and furthermore rank these sites with the greatest safety impact on the traveling public.

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SECTION 1:

Introduction

1.1 GENERAL DISCUSSION

The ODOT Abandoned Underground Mine Inventory and Risk Assessment process was conceived as a proactive response to the need to locate and assess the risk of all mapped or otherwise identified roadway sites beneath which abandoned underground mines exist. The scope of such an undertaking is extremely formidable. Hundreds of such roadway sites potentially exist in Ohio. The age of the majority of the abandoned underground mines associated with these sites ranges from 50 to 150 years. Available records for these mines can vary greatly between the different sites.

The process documented in this manual is the most logical and practical approach to establishing such an inventory. Due to the large number of sites, it is not logistically or financially responsible to commit limited forces and funding to investigation and remediation of random sites. A cornerstone of this inventory and risk assessment process is the concept of "being as informed as possible" before ever committing limited resources to individual sites for detailed investigations and, if necessary, remediation. The sites which pose the greatest threat to public safety should be assessed as having the highest priority

This document is not a design manual. The purpose of this manual is to provide a means of site inventory and risk assessment. English units of measurement are utilized in this manual since a large part of this process involves review of historic documents using English units. Detailed design work and construction documents which might be undertaken as a result of the site inventory and risk assessment process documented in this manual should be prepared in metric units or dual units of measurement.

1.2 OVERVIEW

The process documented in this manual is comprised of four basic activities: 1) the establishment of an inventory of all roadway sites beneath which abandoned underground mines may exist ; 2) site monitoring ; 3) the assessment of the risk to the safety of the traveling public which each site represents and; 4) remediation, if necessary. A process flow chart is presented as Figure 1.1. The definitions of commonly used terms in this manual are provided in Appendix A: Glossary of Terms.

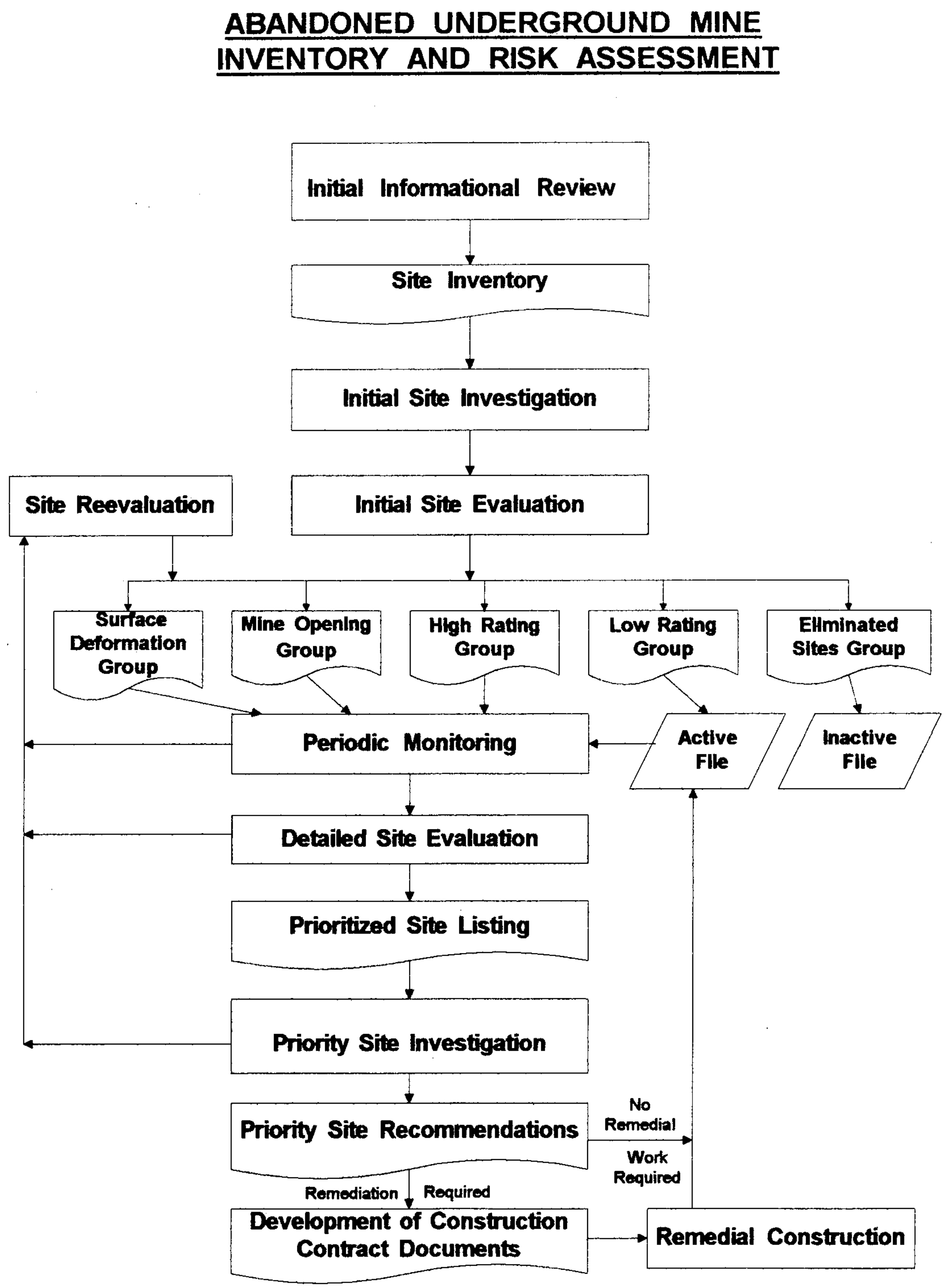

Figure 1.1: Process Flow Chart

1.2.1 Establishing An Inventory of Sites: An initial comprehensive site listing should be established for the inventory area. This effort will include review of available records for abandoned underground mines within the inventory area. Field report forms should be discussed and provided to roadway authority personnel for the purpose of gathering field information which might reflect mine-related problems beneath the roadway. Such reports should then be investigated by staff who are involved with the inventory process and are familiar with signs of mine-related problems.

Next all sites should be visited and certain field information should be recorded. Every effort should be made to obtain enough information from one site visit to allow for the risk assessment of the site through Initial and Detailed Site Evaluations as described in this manual. Following this initial site visit, each site shall be subject to periodic monitoring.

1.2.2 Site Monitoring: Interim periodic monitoring will be initiated on all inventory sites. The frequency and extent of required monitoring activities will depend on site conditions as well as they can be identified at this point in the process. All sites will ultimately be periodically monitored on a permanent basis. Frequency of monitoring will be determined on a site-specific basis.

1.2.3 Risk Assessment: The risk assessment portion of this process takes into account two basic factors: 1) the existing site conditions and; 2) the level of the traveling public's exposure to those existing site conditions.

1.2.3.1 Initial Site Evaluation: An Initial Site Evaluation of all sites in the established inventory will be performed by applying applicable site evaluation criteria to available information and field observations. This Initial Site Evaluation process will determine into which of the five risk-assessment site groups each site will be placed. The Low Rating Site Group will be placed under a permanent monitoring program and remain as active files in the inventory program. The Eliminated Site Group will become inactive permanent record files in the inventory program.

1.2.3.2 Detailed Site Evaluation: Detailed Site Evaluation risk assessment will be performed on the Surface Deformation, Mine Opening, and High Rating Site Groups as determined by the Initial Site Evaluations. This work will be performed for each site group in order of their group's priority level of risk. All sites within a site group will be evaluated using site evaluation criteria considered pertinent to the nature of the sites within the group. Detailed Site Evaluation risk assessment will be completed utilizing existing information and information gathered during the initial inventory site visit. The result of the Detailed Site Evaluation process will be a prioritized listing of the sites for the Surface Deformation, Mine Opening, and High Rating Site Groups as defined by the Initial Site Evaluation process.

1.2.3.3 Priority Site Investigations: Priority Site Investigations will be performed on each site within each of the three Detailed Site Evaluation site groups. These site investigations shall be performed in the order of the prioritized listing of the sites for each of the Detailed Site Evaluation risk assessment site groups. All sites within the particular Detailed Site Evaluation risk assessment group will be individually evaluated before evaluation proceeds to sites in the next lower Detailed Site Evaluation group. These investigations will result in Priority Site Recommendations.

1.2.3.4 Priority Site Recommendations: The Priority Site Recommendation shall either specify remediation of defined site conditions, with periodic monitoring to follow construction, or periodic monitoring only. Some recommendations may involve emergency action or temporary road closure. Interim, site-specific monitoring requirements will be specified for the period prior to the implementation of remedial construction or permanent monitoring.

1.2.4 Remediation:

1.2.4.1 Development of Construction Documents: In the case of Priority Site Recommendations requiring the remediation of potentially hazardous conditions, construction drawings, specifications and special provisions will be developed for each individual site. Regardless of the extent of investigations performed, the actual site conditions cannot be fully determined prior to construction. Therefore, this manual places emphasis on flexibility of methods, quantities and project limits.

Existing conditions may change, or new conditions may develop on the site in the period required for contract document development. Guidance is included in this manual for continued site monitoring during Development of Construction Contract Documents.

1.2.4.2 Remedial Construction: Remedial construction shall be performed on those sites where such work is recommended by the Priority Site Recommendations. Close inspection of the work, monitoring of time and materials usage, and accurate record keeping is important during construction. Accurate records will be invaluable for post-construction monitoring and reference in the case of future subsidence conditions occurring adjacent to the project area.

Existing conditions may change, or new conditions may develop on the site during remedial construction. Certain forms of remediation may unintentionally induce additional mine-related settlement. Site monitoring to detect possible changes during remedial construction should be performed.

1.3 SUMMARY

1.3.1 Expected Benefits:

1.3.1.1 Public Safety: The process will minimize the possibility of sudden abandoned underground mine subsidence in roadways, which could result in fatalities or bodily injuries.

1.3.1.2 Reduced Liability: The process will identify and prioritize high risk sites permitting a systematic response.

1.3.1.3 Budgetary Mechanism: This process will identify levels of risk and associated costs. This information can be used to develop budgets to reduce risks to a predetermined level. This is a proactive process to identify high risk locations. Accordingly, these locations with the highest risk of failure will be identified and remediated first resulting in fewer instances of sudden collapses requiring emergency treatment.

1.3.1.4 Informational Resource: This process will create a new database of information available to all staff. This database will be a tool which can be utilized to avoid or anticipate potentially unstable underground conditions during project planning, design, construction and maintenance.

1.3.2 Governing Principles:
Basic principles governing this process include:

A. Working on the highest risk identified site at all times.

B. Being as informed as possible before committing resources to a site.

C. Being prepared to encounter "worst case" conditions for the nature of the site to be investigated or remediated.

SECTION 2:

Initial Informational Review

2.1 GENERAL DISCUSSION:

Three forms of information have been identified as sources to be utilized in initially identifying ODOT Abandoned Underground Mine Inventory and Risk Assessment sites. These three sources of information are: 1) ODOT Field Reports and associated Office Investigations; 2) several forms of ODNR, DGS abandoned underground mine documents, and; 3) reports of subsidence activity adjacent to the roadway documented by other state and federal agencies.

2.2 FIELD REPORT FORMS:

Distribution and completion of field report forms to district employees should be undertaken. The information gathered through the use of these forms may document actual physical changes in or under the roadway which may be related to mapped or unmapped abandoned underground mines. These Field Reports are very important for they may, in some cases, be the only documentation of sites which will be placed in the highest priority, Detailed Site Evaluation Surface Deformation Site Group. All field reports shall be assigned a number upon receipt. A sample copy of this form is provided as Figure 2.1

All Field Reports should be investigated and documented through the use of the Office Investigations of Field Report form. This form should be assigned the same number as the Field Report being investigated. A sample copy of this form is provided as Figure 2.2

2.3 ODNR, DGS ABANDONED UNDERGROUND MINE DOCUMENTS:

Each District should acquire and review copies of the Abandoned Underground Mine Map Series maps (U.S.G.S.Quadrangle based) available at the Ohio Department of Natural Resources, Division of Geological Survey (DGS). A sample copy of a portion of one of these maps is provided as Figure 2.3. Working copies of these maps should be made and marked with a" hi-liter" to indicate roadway locations potentially underlain by abandoned underground mines for which the DGS has available mapping. The District may also acquire county maps from DGS which are composite maps of the individual abandoned Underground Mine Map Series maps at a scale of 1" = 1 mile.

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Field Report

Name:____Date:________________

Office Location:____

Telephone Number:____________________Best time to call:__________________

As a part of establishing a listing of sites to be evaluated by the abandoned underground mine inventory, the District is gathering information regarding past or present maintenance or construction problems which may have been, or are, related to the presence of mines beneath the roadway.

Please report any unusual grade settlements or drainage conditions which you observed or upon which you have performed work either during maintenance or construction operations with the District. Please report any information, even if the condition/problem and related construction or maintenance occurred years ago. All known conditions/problems within the right of way should be reported. Significant conditions immediately beyond the right of way may also be indicators of conditions evolving beneath the roadway.

LOCATION (C-R-S)	CONDITION / PROBLEM / MAINTENANCE	APPROXIMATE DATE

Please return this completed form to__________ at the District __________ Office. If you have any questions about the completion of this form, or wish to discuss information you are reporting on this form, please contact (District Contact Person) at (Telephone number).

For District Office Use: Field Report No. ________

Figure 2.1: Field Report Form

Ohio Department of Transportation

Action Required:
1)
2)
3)

Abandoned Underground Mine Inventory and Risk Assessment

Office Investigation of Field Report

Person Filing Original Field Report:________________________Field Report No.__________
Location of Person Filing Original Field Report::____________________________________
Telephone Number:________________________Best time to call:______________________
Investigator's Name:____________________________________ Date:____________________

Note to Investigator:
Please contact the person providing the field report and make a record of the conditions which were observed or upon which work was performed either during maintenance or construction operations within the District. Use a new copy of this form for each separate roadway location. Be sure to make a record of any information, even if the condition/problem and related construction /maintenance occurred years ago. All known conditions/problems within the right of way should be reported. Significant conditions immediately beyond the right of way may also be indicators of conditions evolving beneath the roadway.

Location of Condition/Problem (C-R-S)____
Date(s) Observed:____

Check Appropriate Box(es):
_______Observed/encountered during Maintenance operations
_______Observed/encountered during Construction operations
_______Other____

Surface Grade Problems:

1. Subsidence features such as sinkholes/potholes, irregular grade settlement:
   Surface shape and depth of features:____
   Number of surface features:____
   Location of features relative to the referenced roadway:___________________________
   ____
   Construction/Maintenance action taken to correct condition:________________________
   ____
   ____

2. Areas of pavement requiring several overlays of patching material due to settlement:
   Shape of surface feature(s):____
   Number of areas____

Figure 2.2: Office Investigation of Field Report Form
Page 1 of 2

Location of features within the referenced roadway: ______________________________

____

Construction/Maintenance action taken to correct condition. ______________________

____

3. Areas of pavement with unusual crack patterns unrelated to known joints or repairs:

Shape of crack patterns: ______________________________

Number of areas with cracks: ______________________________

Location of cracked area(s) within the referenced roadway: ______________________

____

Construction/Maintenance action taken to correct condition: ______________________

____

____

Drainage Problems/Irregularities (Check all appropriate items):

1. ______Loss in volume of drainage at some midpoint of ditchline with smooth flowline
2. ______Gain in volume of drainage at some midpoint of ditchline with smooth flowline
3. ______Loss in volume of drainage in ditchline at some unexplainable low spot
4. ______Gain in volume of drainage in ditchline at some unexplainable low spot

Are these drainage conditions seasonal or year-round: ______________________________

Construction/Maintenance action(s) taken to correct condition: ______________________

____

____

____

General Information:

Is the person who completed the field report aware of any underground mines reported to exist in the vicinity of the roadway area? If so, please provide the name of the mine(s) here: ___________

____

____

____

Names of other contact person(s) (ODOT or private sector) which may be able to provide additional information regarding this site: ______________________________

____

____

Other information which may be pertinent: ______________________________

____

____

____

PLEASE ATTACH A MAP OR SITE SKETCH OF THE FIELD REPORT AREA

Figure 2.2: Office Investigation of Field Report Form

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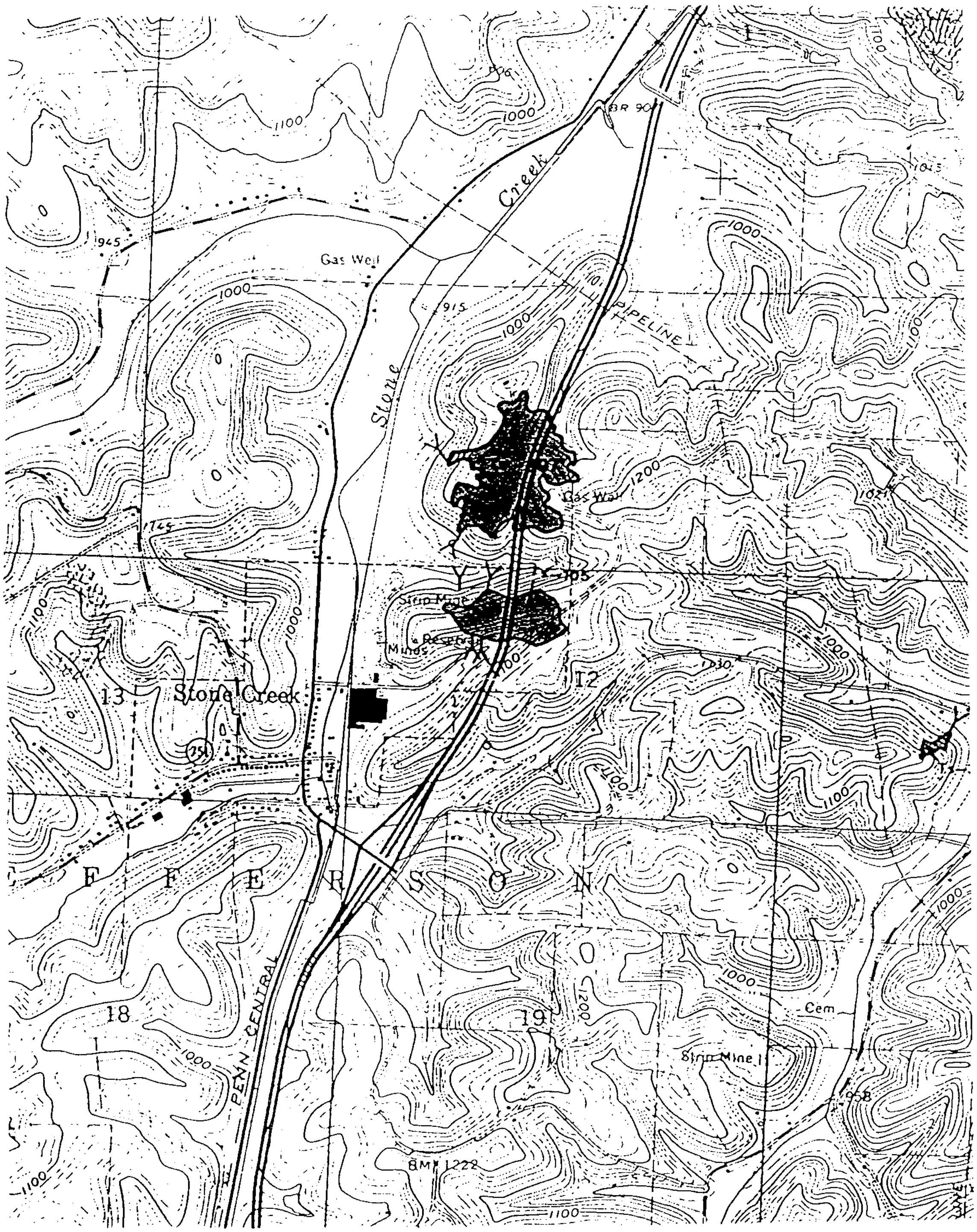

Figure 2.3: Sample Portion of ODNR, DGS Abandoned Underground Mine Map Series

ODNR, DGS has designated a contact person for members of the ODOT Abandoned Underground Mine Inventory and Risk Assessment technical team (See Appendix D: Contacts). The DGS has provided the following information regarding the Abandoned Underground Mine Map Series maps available from its office:

A.) These maps represent the locations of as many of the 4600 available Division of Mines abandonment maps as could be accurately located by DGS. Some small percentage of the available abandonment maps are not shown on the Abandoned Underground Mine Map Series maps because they do not contain enough information to be accurately located.

B.) The DGS has recently acquired annual underground mine maps originally filed with the former Division of Mines between 1874 and 1995. Some of these maps may represent underground mines for which there are no abandonment maps on record. Others may contain information as to the extent of some mines which the corresponding abandonment maps do not contain. The DGS estimates there are between 5,000 and 10,000 of these maps. The DGS still needs to review these maps and add any new information they contain to the currently available Abandoned Underground Mine Map Series maps.

C.) Other potential sources of abandoned underground mine maps include the Recorders Office at each county courthouse and the U.S. Dept. of Interior, Office of Surface Mining (OSM), Appalachian Regional Center's underground mine map repository located in Pittsburgh, Pennsylvania. An OSM comparison of their mine map collection versus the ODNR, DGS map collection suggested the possibility of up to 845 mine maps in the OSM collection which are not in the ODNR, DGS collection. DGS and OSM are currently working to resolve this situation so that both agencies will each have the same comprehensive collection of maps available.

A cooperative effort is currently underway by ODNR and ODOT to develop a plan to digitally scan all available abandoned underground mine maps, and develop a mutually accessible GIS database for these maps and associated attribute file information. ODNR is already digitizing the Abandoned Underground Mine Map Series maps.

Each district should acquire and review the appropriate Abandoned Underground Mine Map Series maps and related county composite maps for their District. Each shaded area on these maps represents an individual abandoned underground mine map which can be obtained from the ODNR, DGS. This will give each District an indication of the number and distribution of abandoned underground mines within its geographic area.

The following guidelines should be reviewed before the use of these maps to compile the initial inventory site listing:

A) Become VERY FAMILIAR with the symbols in the legend of the Abandoned Underground Mine Map Series maps.

B) The accuracy for any given mine location indicated on these maps is not always high. The ODNR, DGS took painstaking efforts to accurately locate the mines as displayed on these maps. However, the accuracy, quantity, and quality of the information contained on the original abandonment maps filed by the miner or mining company can be highly variable. Past ODOT work with these maps has revealed the actual mine locations to be up to one-half township section away from the locations as shown on the Abandoned Underground Mine Map Series maps.

C) The Abandoned Underground Mine Map Series maps may not show a mine beneath the roadway. But a mine map location adjacent to the roadway may be shown with cross-hatching in the direction of the roadway. The cross-hatching indicates that the map has notations of adjacent underground mining. These mine maps should be acquired as they represent the best and nearest documentation of past underground mining activities in the vicinity of the roadway. The cross-hatching on the margins of these maps indicates the possibility of unmapped mines in the vicinity of the roadway. This fact should be considered in determining sites for the initial site inventory. Unmapped mines may be present even if cross-hatching is not indicated.

2.4 OTHER OUTSIDE AGENCY REPORTS OF SUBSIDENCE ACTIVITY:

Each District shall obtain and review any available information from other state and federal agencies which document mine subsidence events in close proximity to roadways under the State's jurisdiction. These state and federal agencies include: 1) the ODNR, DMR, Abandoned Mine Lands Program; 2) the U.S.D.I., Office of Surface Mining Regulation and Enforcement, Ohio Field Office, and: 3) the Ohio Mine Subsidence Insurance Program. Refer to Appendix D: Contacts for further information.

This information may be critical in evaluating inventory sites. It may represent the only documentation of unmapped, abandoned underground mines which lie beneath the roadway.

The coordinating District engineer should notify the ODNR, DMR when a field report indicates a potential subsidence problem, especially those events which ODOT would eliminate because the event does not threaten the traveling public.

2.5 INITIAL INVENTORY SITE LISTING:

Each District should compile an initial inventory site listing utilizing the three above-described sources of information. The first step toward establishing this initial site listing should be to compile a listing of the roadway sites "hi-lighted" on the working set of the Abandoned Underground Mine Map Series quadrangle maps. This compiled listing should be in the form of a Quattro Pro spreadsheet file. An example of this spread sheet is provided as Figure 2.4. The spreadsheet should have columns for : county; route; section; site length; lane miles; site evaluation status; risk assessment rating (site group and site evaluation rating); ODNR, DGS mine map index number; U.S.G.S. quadrangle name; GPS coordinates; state plane coordinates; site elevation; township and section; and comments (mine

ODOT ABANDONED UNDERGROUND MINE INVENTORY AND RISK ASSESSMENT

INVENTORY SITE LISTING

DISTRICT:

DATE: 02/23/98

COUNTY	ROUTE.	SECTION	SITE LENGTH	LANE MILES	SITE EVAL. STATUS	RISK ASSESS. RATING: SITE GROUP	RISK ASSESS. RATING: SITE EVAL. RATING	ODNR MINE MAP#	U.S.G.S. QUAD. NAME	G.P.S. COORDINATES: LATITUDE	G.P.S. COORDINATES: LONGITUDE	STATE PLANE COORDINATES: ZONE	STATE PLANE COORDINATES: NORTHING	STATE PLANE COORDINATES: EASTING	SITE ELEVATION	TOWNSHIP / SECTION	COMMENTS/ MINE NAME / FIELD REPORT NUMBER
COS	SRO83	00.18–00.73	0.55	1.1	Detailed	Sur. Defor.	885	Cn-095	Wills Creek							Union 25	Mason # 3
COS	SRO83	00.80–01.03	0.23	0.46	Initial	Low Rating	150	Cn-169	Wills Creek							Union25/Franklin 21	Peabody # 3
COS	SRO83	01.22–01.27	0.05	0.1	Initial	Shaft	740	Cn-169	Wills Creek							Franklin 21	Field Report No. COS5
COS	SRO83	06.33–06.39	0.06	0.12	Initial	High Rating	700	Cn-033	Wills Creek							Franklin 2	
COS	SRO83	05.56–05.66	0.1	0.2	Initial	Low Rating	300	Cn-084	Wills Creek							Franklin 2	Powers Coal Mine
GUE	US040	13.12–13.33	0.22	0.44	Initial	Low Rating	325	Gy-029	Old Washington							Center 10	
GUE	IRO77	1.28–1.99	0.7	2.8	Initial	High Rating	810	Gy-044	Byesville							Valley 3, 4	Field Report No. GUE9
PER	SR013	04.93–05.30	0.37	0.74	Initial	Low Rating	400	Py-132	Corning							Monroe 10	Sunday Creek Coal CO. # 9

Figure 2.4: Example of Inventory Site Listing

name, field report number, etc.). The electronic spreadsheet file for this document is available from the Office of Materials Management, Geotechnical Design Section. The use of this one spreadsheet by all districts is crucial to creating the ability of the Department to compile and analyze statewide information regarding the problem of abandoned underground mines beneath state roadways.

Field reports, subsidence event reports, and research reports from other State and Federal government agencies should be compared to the above listing. These reports should be recorded for the related site listed on the established spreadsheet, or otherwise should be entered as additional sites on the initial inventory site listing.

SECTION 3:

Initial Site Investigation

3.1 GENERAL DISCUSSION:

The Initial Site Investigation fulfills several purposes in the overall inventory and risk assessment process. First, it familiarizes District personnel with inventory site locations. Second, it provides field verification of site characteristics and conditions. Third, it produces a permanent record of site characteristics and conditions which will be utilized for Initial and Detailed Site Evaluation. Last, it may produce field information which could ultimately result in sites being added to or eliminated from the initial inventory of sites.

3.2 AVAILABLE INFORMATION:

The Initial Site Investigation process is performed by utilizing two forms of information. The first form of information is the Initial Site Listing as described in Section *2*. The other form of available information is obtained from outside sources and ODOT records .

3.2.1 Initial Site Listing: The initial inventory site listing is the end product of the initial informational review as described in Section *2*.

3.2.2 Available Information*:* Information in addition to that recovered during the development of the initial site listing should be obtained. Sources for this information include: 1)) the Ohio Department of Natural Resources (ODNR), Division of Geological Survey (DGS); 2) the ODNR, Division of Mines and Reclamation (DMR); 3) the U. S. Department of Interior (USDI.),Office of Surface Mining (OSM); 4) the Ohio Mine Subsidence Insurance Underwriting Association (OMSIUA), and; 5) ODOT.

3.2.2.1 Individual Mine Maps: The first step in the Initial Site Investigation process is to obtain copies of maps for all the individual abandoned underground mines for roadway locations on the established site listing. Individual mine maps are available through ODNR, DGS. They are ordered by the county-number designation displayed on the Abandoned Underground Mine Map Series. A sample copy of one of these individual mine maps is provided as Figure 3.1. The ODNR, DGS "data form" associated with each individual mine map should also be obtained and reviewed. A sample copy of one of these forms is provided as Figure 3.2.

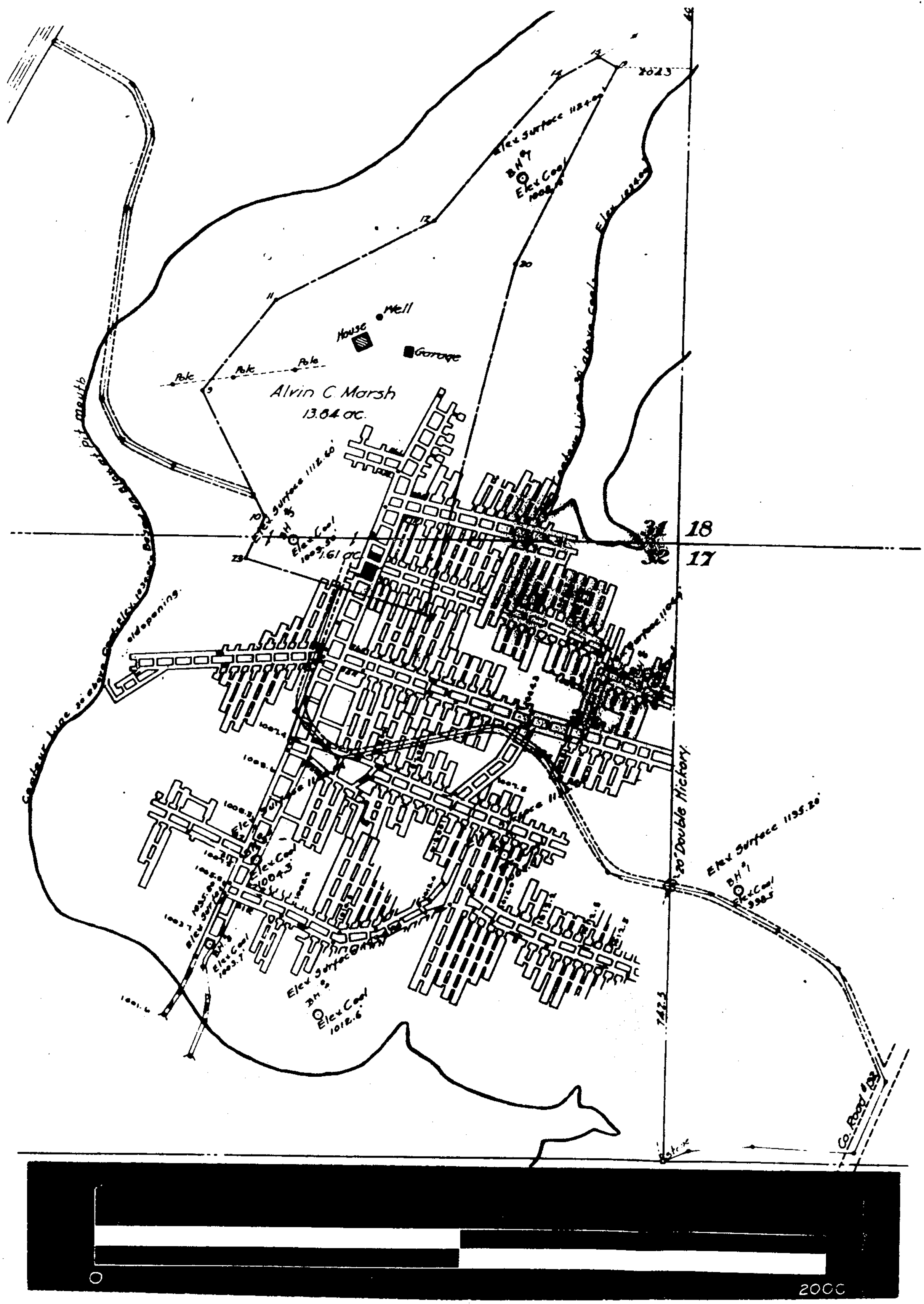

Figure 3.1: Sample Copy of a ODNR, DGS Individual Mine Map

DATA SHEET FOR MINE MAP REPOSITORY

Card	Questions	Answers
10	Mine Name	Stone Creek
10	Mine Type (underground, open pit, etc.)	UG
61	Commodities	coal
10	State and County	OH, Tuscarawas
50	Present Operating Company	Stone Creek Brick Co.
50	Previous Operating Company (ies)	
10	UTM, or Latitude and Longitude	
60	Land Survey (if applicable)	Lots 31, 32 Jefferson Twp
60	Quadrangle Name	Stone Creek
63	Name of Seam (if coal)	Middle Kittanning
60	Is map confidential; if so, for how long?	No

70 Remarks:

drift
el. 1002-1010

OGS 5492
30-32" MK coal
el. 1002

Abandoned 1933

NOTES: 1. Please draw north arrow on map if direction has not been indicated.
2. To enable us to correctly match this data sheet with its corresponding map, please provide an identifying map number in the place below, and write the same number on the back of the map.

Map No. 397

Figure 3.2: Sample Copy of a ODNR, DGS Mine Map Data Sheet

These maps, along with all corresponding roadway drawings, should be reviewed for each site. In cases where mine maps and roadway drawings do exist, a preliminary composite plan view of the roadway drawings and mine map(s) should be manually compiled. This information should then be reviewed in preparation for individual site visits.

3.2.2.2 Other ODNR, DGS Information : Other forms of ODNR, DGS information which should be reviewed at this time include: measured geologic sections and geologic structure maps.

3.2.2.3 ODNR, DMR Information: ODNR, DMR historic information regarding subsidence events should be reviewed for events near individual roadway sites.

3.2.2.4 USDI, OSM Information: OSM historic information regarding subsidence events should be reviewed for events near individual roadway sites.

3.2.2.5 OMSIUA Information: OMSIUA historic information regarding subsidence events should be reviewed for events near individual roadway sites..

3.2.2.6 ODOT Information: Roadway and right of way plans, subsurface investigations, centerline survey plat, and county maintenance records should be reviewed.

3.3 INDIVIDUAL SITE VISITS:

The next step in the Initial Site Investigation is to perform individual site visits. These site visits will serve two purposes. The primary purpose is to gather the necessary field data for the site. The secondary purpose is to eliminate sites from the initial site listing if they can be documented to have no potential for a current or future threat to the safety of the traveling public.

3.3.1 Priority Order for Site Visits: These visits shall be conducted on sites in the following priority order of classification of roadway: 1) Interstate; 2) NHS other than Interstate; 3) Arterial, and; 4) Collector.

3.3.2 Preparation for Individual Site Visits: Prior to traveling to the field to conduct an individual site visit, the coordinating District engineer should prepare for this work as outlined on the Pre-Inspection Checklist (Figure 3.3). This form outlines the information which should be office reviewed, the composite overlay plan view of the abandoned underground mine maps over the roadway , notification of the County Manager, and suggested equipment and field gear.

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Pre-Inspection Checklist

A. Review Existing Information

1) Abandoned Underground Mine Map Series (U.S.G.S. Based) - Obtain from ODNR. DGS and review.

2) Individual Underground Mine Abandonment Map and associated Data Form from ODNR, DGS - Obtain and Review

3) Roadway and Right of Way Plans - Review

4) Subsurface Investigation

5 Centerline Survey Plat - to help locate mine map (section lines, property lines, etc.)

6) ODNR Historic Information Regarding Subsidence Events - review for events near site

7) OSM Historic Information Regarding Subsidence Events - review for events near site

8) OMSIUA Historic Information Regarding Subsidence Events - review for events near site

9) Abandoned Underground Mine Inventory Field Data Sheets From Counties - review for reports near site

10) County Maintenance Records - review for unusual grade and drainage conditions/maintenance near site

11) Measured Geologic Sections - Obtain from ODNR, DGS and Review

12) Geologic Structure Maps - Obtain from ODNR, DGS and Review

B. Compile Overlay:

1) Scale Adjustment - use plan scale and modify mine map *(if necessary)* to fit

2) Manually produce composite plan view by overlaying mine map on roadway drawings.

Figure 3.3: Pre-Inspection Checklist Form
Page 1 of 2

C. Notify County Manager:

1) Inform of intent to visit site and invite to participate in site visit

2) Ask about any known records of unusual maintenance or construction at site.

D. Equipment:

shovel	permanent marker	DMI equipment
tape	hammer	measuring wheel
camera	rock hammer	climbing rope
notebook - with grid paper for sketching	machete	binoculars
locking hand level	folding rule	clipboard
altimeter (+/- 5 ft.)	level rod, telescoping	calculator
soil probe	sounding rope (cord with weight)	scale
mirror	hiking compass	straight edge
flashlight	spray paint	protractor
survey lath	safety strobe light for vehicle	
handheld GPS unit		

Figure 3.3: Pre-Inspection Checklist Form
Page 2 of 2

3.3.3 Collection of Required Field Data: The goal for the field site visit is to collect the required field observational information which will be necessary to complete an Initial Site Evaluation and Detailed Site Evaluation. Most ODNR, DMR, Abandoned Mine Land (AML) District Project Officers have many years of experience in reviewing underground mine maps and related field conditions in the development of AML projects. They can provide assistance in reviewing and interpreting sites.

County Garage personnel should be canvassed for local knowledge of underground mining information, including past or present roadway construction or maintenance problems. These employees may also know of local private individuals who might have information regarding past underground mining. Local individuals who might be of help may include mine employees (present day and retired), local historians, etc.

3.3.3.1 Field Visit Form: The final product of the individual site visits should be a completed Site Data Form (Figure 3.4). This form establishes a record of all site information needed to complete the evaluation of a given site through Initial and Detailed Site Evaluations. This information will become part of the body of data which will comprise a Geographic Information System (GIS) site attribute file.

3.3.3.1.1 Site Investigations: These investigations should be conducted while accompanied by the County Manager, or their representative, if possible.

3.3.3.1.1.1 Evidence of Past Mining Activities: A number of observable site features may be evidence of past mining activity in the site vicinity. These features include: mine openings, mine-related structures, coal refuse ("gob") piles, abandoned surface ("strip") mining pits, railroad spurs, and surface water, seeps, or springs having an orange color. While conducting the site visit, the coordinating District engineer should contact local individuals previously identified as possible sources of past mining information.

3.3.3.1.1.2 Surface Deformation Features: A number of observable features may be evidence of mine-related surface deformation in the site vicinity. These features include, but are not limited to: crack patterns or dips in the roadway; damaged or displaced drainage structures; effects on bridges, structures, poles, culverts, etc; unusual vegetation; drag patches; dips in guardrail; dips in flowline of ditches; low spots in grade which retain water; ponds (unusual water formations on surface, impoundments); surface topography anomalies; and level of groundwater.

3.3.3.1.2 Recording Information: The third page of the Site Data Form is used for recording needed site information. The more complete this work is performed on-site, the more likely that the needed information will not be lost or go unrecorded. The following is an outline of on-site activities to accomplish:

1) Record Mining and Geologic Information:

- Mark features with ribbon, paint, etc.
- Record type and apparent minimum overburden thickness to top of mined interval, if possible. Estimate minimum overburden thickness as one of the following:
  < 25 feet , 25 to 50 feet , 50 to 100 feet , > 100 feet .
- Record maximum mined interval (seam(s)) thickness. If outcrop is observable in the site vicinity, estimate its thickness as one of the following: > 6 feet , 3 feet to 6 feet , < 3 feet
- Record number of subsidences.
- Record mine opening information:
  - Type(s) and number(s) of opening(s). Types Include: Drift (Horizontal), Slope, or Shaft(Vertical).
  - Mine opening location(s) relative to the roadway.
    1) Between the Two Outer-Most Edge of Shoulders
    2) Less than 50' Feet From Edge of Shoulder
    3) Between 50' and 100' From Edge of Shoulder
    4) Within Sight From Edge of Shoulder
    5) Location not conclusively known
  - Method of mine opening closure, if observable.
    1) No Information
    2) Timber Decking
    3) Uncontrolled Random Backfill
    4) Concrete Cap
    5) Controlled Backfill
  - Type of mine opening cribbing, if observable.
    1) No Information
    2) Timbers
    3) Brick
    4) Concrete
  - Plan area of mine opening(s), if observable and safe to measure. Estimate area of mine opening as one of the following:
    1) Mine opening size unknown
    2) >750 Sq. Ft.
    3) From 500 to 750 Sq. Ft.
    4) From 250 to 500 Sq. Ft.
    5) From 150 to 250 Sq. Ft.
    6) <150 Sq. Ft.

- Record field observations of any other unique site features and describe the general site setting.
- Check information recorded against information reported on Field Data Sheet (if any).
- Record information provided by local contacts (if any).

2) Record Roadway Information:

- Record structures in the roadway, as a YES/NO record.
  - Then note type and condition of structure(s), including materials used in their construction.
- Record posted speed limit within site limits.
- Record type of pavement. Indicate either: 1)continuous reinforced concrete pavement, or: 2) other. In the case of asphalt surface, verify base pavement construction or reconstruction. Determine if rubblized, or broken and seated.
- Record evidence that the mine is not under the roadway.

3) Sketch Features on Map / Roadway Plans / Back of Site Data Form:

- Determine site limits, and sketch them on map/plans.
- Sketch in topographic anomalies.
- Sketch in all recorded features.
  - Record elevations relative to the roadway.
  - Measure and record dimensions of recorded features.
- Record bearing between features using a hand-held hiking compass.

4) Take Photographs:

- Reference the camera angle.
- Use "Data Back" film, or record and keep notes with film.
- Photograph multiple angles of significant features.

3.3.3.2 Elimination of Sites: Some sites will be eliminated from further evaluation through the verification that the abandoned underground mine in question in fact does not lie beneath the highway right-of-way. This possibility could result from; 1) field review and concurrence with plan view composites suggesting this situation or 2) the field determination (visual verification) that the abandoned underground mine was excavated and removed from the site location when excavations were performed to construct the roadway. If the latter is the case for a given site, the danger of subsidence has been eliminated in the roadway, but the possibility of dangerous mine openings in cut slopes should be considered. A separate listing of such sites should be compiled.

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Site Data Form

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No. ______________________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.: ____________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: ____________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: ____________ (If known.)

Name of Site Evaluator: ______________________________ Evaluation Date: ____________

NOTE: Circle applicable items, and provide comments and sketch. Use back of forms or attach additional sheets as required.

I. Site Investigations

A. Evidence of Past Mining Activities

1) Mine Openings
2) Mine Structures (ruins/foundations of tipples, fanhouses, scalehouses, wash houses,etc.)
3) Gob Piles
4) Strip Pits
5) Railroad Spurs
6) Orange water/seeps/springs
7) Contact Local Residents

B. Surface Deformation Features

1) Crack Patterns and Dips in Roadway
2) Damaged or Displaced Drainage Structures
3) Effects on Bridges, Structures, Poles, Culverts, etc.
4) Unusual Vegetation
5) Drag Patches
6) Dips in Guard Rail
7) Dips in Flowline of Ditches
8) Low Spots Holding Water
9) Ponds (unusual water formations on surface, impoundments)
10) SurfaceTopography Anomalies
11) Level of Groundwater

Figure 3.4: Site Data Form

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Figure 3.4: Site Data Form
Page 2 of 4

II. Recording Information

1) Record Mining and Geologic Information:

- Mark Features with Ribbon, Paint,

- Record Type and Apparent Minimum Overburden Thickness to Top of Mined Interval (if visible)
  - Estimate as one of the following:
    < 25'   25' - 50'   50' - 100'   > 100'

- Record Maximum Mined Interval (seam(s)) Thickness, if outcrop is observable in site vicinity
    >6'   3' - 6'   0' - 3'

- Record Number of Subsidences

- Record Mine Opening Information:
  - Type(s) and Number(s) of Mine Opening(s). Types include: Drift (Horizontal), Slope, and Shaft (Vertical)
    Drift (Horizontal)________Slope________Shaft (Vertical) ________

  - Mine Opening Location(s) Relative to Roadway:

Location Not Conclusively Known	Between The Two Outer-Most Edge of Shoulders	Less Than 50 Feet From Edge of Shoulder	Between 50' and 100' From Edge of Shoulder	Within Sight From Edge of Shoulder

  - Method of Mine Opening Closure, if Observable.

No Information	Timber Decking	Random Backfill	Concrete Cap	Controlled Backfill

  - Type of Mine Opening Cribbing, if Observable

No Information	Timbers	Brick	Concrete

  - Plan Area of Mine Opening(s), if observable and safe to measure.

Size Is Unknown	>750 S. F.	From 500 to 750 S. F.	From 250 to 500 S. F.	From 150 to 250 S. F.	<150 S. F.

- Record Field Observations of any other unique site features and describe the general site setting.

- Check Information Recorded Against Information Reported on Field Data Sheet (if any).

- Record Information Provided by Local Contacts (if any), including any information about secondary mining or problems reported during mining.

2) Record Roadway Information:

- Record Structures in Roadway site? (YES/NO)
  - Note type and condition of structure(s), including materials used in their construction.,

- Record Posted Speed Limit Within Site Limits

- Record Type of Pavement. In the case of asphalt surface, verify base pavement construction or reconstruction. Determine if rubblized. Indicate one of the following:

    Continuously Reinforced   Other

- Record Evidence That The Mine Is Not Under The Roadway

3) Sketch Features on Map / Roadway Plans/ Back of This Form

- Determine Site Limits -Sketch on Map /Plans

- Sketch in Topographic Anomalies

- Sketch in All Recorded Features
  - Record elevations relative to the roadway
  - Measure and record dimensions of recorded features.

- Record Bearing Between Features using a hand-held hiking compass

4) Take Photographs:

- Reference the Camera Position if Possible,

- Use "Data Back" Film, or Record and Keep Notes with Film.

- Photograph Multiple Angles of Significant Features

Figure 3.4: Site Data Form
Page 3 of 4

Figure 3.4: Site Data Form

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SECTION 4:

Initial Site Evaluation

4.1 GENERAL DISCUSSION

The Initial Site Evaluation process is the first level of risk assessment for the established inventory of sites. The Initial Site Evaluation applies established, weighted criteria to gathered existing information and information from one site visit. The Initial Site Evaluation will result in the subdivision of sites into five risk assessment site groups.

The Initial Site Evaluation process is begun with three forms of information being available. The first form of information is the list of all roadway sites apparently overlying abandoned underground mines. The second form is the Site Visit Form and all information gathered in its completion. The third form is the Initial Site Evaluation Criteria provided in this section.

4.2 INITIAL SITE EVALUATION CRITERIA

The Initial Site Evaluation Criteria are utilized to evaluate site conditions and the public's exposure to those conditions.

4.2.1 Evidence of Surface Deformation: This criterion is utilized to give an indication of current, or past, subsidence observed in the right-of-way or within view of the right- of-way. Some examples might include: evidence of fill placement, localized differences in vegetation, puddles and standing water, wet spots, sags in roadway profiles evidenced by oil spot areas in center of lanes, patches in the roadway surface, etc.

Site Condition:	Rating Value:
Yes	Confirmation of this site condition automatically places a given site in the Surface Deformation Site Group, which is the highest priority Detailed Site Evaluation group.
No	A "No" response to this condition will result in the site being placed in one of the site groups other than the Surface Deformation Group.

4.2.2 Presence of Mine Opening(s): This criterion is utilized to report that a mine opening(s) is (are) observed or recorded as being in the right-of-way or within view of the right- of-way. Primary sources of mine opening information at this level of site evaluation will probably be ODNR Abandoned Underground Mine Map Series, individual mine maps, ODOT field reports, roadway drawings, County Managers, local contacts, etc. Some examples of field indicators of such conditions might include: defined, geometric depressions in the existing grade; and remnants of head frame, hoist foundations, mine waste on surface, point source(s) of groundwater expression, etc.

Site Condition:	Rating Value:
Yes	Confirmation of this site condition automatically places a given site in the Mine Opening Site Group, which is the second highest priority Detailed Site Evaluation group after the Surface Deformation Group.
No	A "No" response to this condition will result in the site being placed in one of the site groups other than the Mine Opening Site Group.

4.2.3 Ratio of Unconsolidated Materials to Bedrock in The Overburden Interval: This criterion is utilized as an indicator of subsidence potential. For the use of this criterion, overburden is considered as being composed of only two types of material: 1) unconsolidated material, or; 2) intact bedrock. The subsidence potential will be relatively greater for sites where a larger portion of the overburden is comprised of unconsolidated materials.

Three elevations must be estimated to rate this criterion for a given site. These elevations are for: 1) the roadway surface; 2) the top of the mined interval, and; 3) the bedrock topographic surface within the overburden interval existing between the roadway and the top of the mined interval. The roadway surface elevation may be estimated through review of existing ODOT roadway drawings and U.S.G.S. Quadrangle maps. The top of the mined interval may be estimated through review of several ODNR; DGS forms of information, including individual abandoned underground mine maps and their associated data sheets, bedrock topography maps, geological structure maps, measured geological sections, on-site geological field observations, and other sources of mining/coal information. The elevation of the bedrock topographic surface in the overburden interval may be estimated through review of the ODNR, DGS bedrock topography maps.

The more commonly available forms of surface topographic and bedrock topographic information are larger scaled maps which utilize coarse incremental values. Therefore, the elevations used to calculate the ratio defining the site condition for this criterion will be only approximate. This fact will only allow for an informed "best guess" estimation of the ratio of unconsolidated materials to bedrock in the overburden interval. However, sites which have an overburden interval comprised of a larger portion of unconsolidated materials can be screening for higher risk of subsidence through the use of this criteria. If the apparent unconsolidated material to bedrock estimated ratio appears from available information to be approximately equal to one, the site condition will be rated the same as if the ratio was greater than one.

Site Condition:	Rating Value:
Ratio ≥1	10 Points
Ratio <1	1 Point

Example of Site Evaluation: Review of the above described information has revealed the following information for a given site: elevation of roadway is 760, elevation of mine floor (from ODNR, DGS mine map) is 725, thickness of mined interval is 5 feet (from ODNR, DGS mine map data sheets, geological structure maps, measured geological sections, and/or on-site geological field observations), and the elevation of the bedrock topographic surface is 740. The site condition for this criterion would be thus determined:

1) Top of Mined interval = mine floor + thickness of mined interval = 725+5 =730
2) Full depth of Overburden = 760-730 = 30 feet
3) Thickness of Unconsolidated Materials in Overburden = 760-740 = 20 feet
4) Thickness of Bedrock in Overburden = 740-730 = 10
5) Site Condition = Ratio of Unconsolidated Materials to Bedrock
   = 20 feet / 10 feet = 2
6) Rating Value = 10 points

4.2.4 Average Daily Volume of Traffic (ADT): This criterion is utilized as a measure of the traveling public's exposure to the site. The site condition is the total average 24-hour traffic volume of traffic for a given site as determined by the most recent Traffic Survey Report, plus a 3% per year calculated increase to date for the time elapsed since the issuance of the Traffic Survey Report.

Site Condition:	Rating Value:
>30,000 Vehicles	10 Points
20,000 to 30,000 Vehicles	8 Points
10,000 to 20,000 Vehicles	6 Points
5,000 to 10,000 Vehicles	4 Points
<5,000 Vehicles	2 Points

4.2.5 Hydrogeologic Setting: This criterion is utilized to give an indication of current and historic groundwater conditions in the abandoned underground mine within the area of the right-of-way. The general site conditions of "Dewatered", "Flooded" and "Not Flooded" are used to estimate the probable impact of groundwater conditions on the stability of the abandoned underground mine. "Dewatered" indicates the existence of a confirmed report of current, or past, dewatering of the abandoned underground mine voids, either through natural processes or human activities. "Flooded" indicates that the water level in the abandoned underground mine is assumed to be at the mine roof elevation in an upland setting, or assumed to be totally inundated as the result of being at an elevation below the shallowest aquifer on the site. "Not Flooded" indicates the mine may have some minimal amount of groundwater storage and movement within it. If the site has a history of being dewatered and then recharged, then the site should be rated as "Dewatered".

Site Condition:	Rating Value:
Dewatered	10 Points
Flooded	8 Points
Not Flooded	1 Point

4.2.6 Minimum Overburden Thickness (Approx.): This criterion is utilized to give an indication of the potential for subsidence. The site condition is the minimum vertical interval of overburden between the roadway surface elevation and the top of the abandoned underground mine void existing below the roadway. Possible sources of information would include: ODNR, Division Geological Survey information, such as individual abandoned underground mine maps, coal outcrop elevation from topographic information or structure maps, measured geologic sections, etc.; ODNR, Division of Mining and Reclamation information, such as limits of nearby, active surface mine operations ; and contacts with individuals knowledgeable of local, historical mining operations.

Site Condition:	Rating Value:
< 25 Feet	10 Points
25 Feet to 50 Feet	8 Points
50 Feet to 100 Feet	5 Points
>100 Feet	1 Point

4.2.7 Maximum Mined Interval Thickness (Approx.): Thicker seams would be expected to have a higher likelihood of surface deformation. The approximate maximum mined interval (void height) of the abandoned underground mine will probably be determined through review of; 1) individual mine maps; 2) information from the ODNR, Division of Geological Survey and 3) information obtained from local individuals who are, or have been, involved in the mining of the mineral seam.

Site Condition:	Rating Value:
>6 Feet	10 Points
3 Feet to 6 Feet	5 Points
0 Feet to 3 Feet	1 Point

4.2.8 Ratio of Minimum Overburden Thickness to Maximum Mined Interval Thickness (Approx.): This criterion is utilized to give an indication of the potential for highly differential subsidence features at the surface. These subsidence features are also commonly referred to as "sinkholes." The site condition is the estimated ratio of overburden thickness (h) to mining height (m), or "h/m" (Matheson and Eckert-Clift, 1986 ; Peng, 1992).

The overburden thickness (h) is the minimum vertical interval between the roadway surface elevation and the top of the abandoned underground mine void existing below the roadway. The thickness of mined interval (m) is the approximate maximum void height of the abandoned underground mine. Possible sources of information include: ODNR, Division Geological Survey information, such as individual abandoned underground mine maps, coal outcrop elevation from topographic information or structure maps, measured geologic sections, etc.; ODNR, Division of Mining and Reclamation information, such as limits of nearby, active surface mine operations; and contacts with individuals knowledgeable of local, historical mining operations.

Site Condition:	Rating Value:
Ratio < 5	10 Points
Ratio = 5 to 11	5 Points
Ratio > 11	1 Point

4.2.9 Secondary Mining: This criterion is utilized as an indicator of the probability of the existence of large areas of unsupported mine roof. Evidence of the secondary removal of supporting blocks or pillars left by the original mining operation for roof support may be obtained for some sites. This information will probably be determined primarily through review of: 1) individual mine maps; 2) information from the ODNR, Division of Geological Survey and 3) information obtained from local individuals who are, or have been, involved in the mining of the mineral seam.

Site Condition:	Rating Value:
Yes	10 Points
No	1 Point

.3 SITE EVALUATION CRITERIA WEIGHTING FACTORS:

The weighting factors for the Initial Site Evaluation criteria are listed below. The weighting factors eflect the importance of the different criteria as related to one another.

Criteria	Criteria Weighting Factor
1) Evidence of Surface Deformation	Automatic placement in the Surface Deformation Group for Detailed Site Evaluation.
2) Presence of Mine Opening(s)	Automatic placement in the Mine Opening Group for Detailed Site Evaluation.
3) Ratio of Unconsolidated Materials to Bedrock In the Overburden Interval	9

Criteria	Criteria Weighting Factor
4) Average Daily Volume of Traffic (ADT)	9
5) Hydrogeologic Setting	8
6) Minimum Overburden Thickness (Approx.)	4
7) Maximum Mined Interval Thickness (Approx.)	4
8) Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6
9) Secondary Mining	4

4.4 INITIAL SITE EVALUATION FORM

An Initial Site Evaluation Form (Figure 4.1) shall be completed for all inventory sites. This form is structured with a beginning section of site information, an Eliminated Sites Screening section, and then the section listing the Site Evaluation Criteria. A sample completed form is provided as Figure 4.2

4.4.1 Eliminated Sites Screening: The Initial Site Evaluation process will most likely result in the screening of a small percentage of sites into the Eliminated Sites Group. The initial portion of the Initial Site Evaluation form pertains to the documentation of a site being designated as an eliminated site. The most likely reason to eliminate a site from the abandoned underground mine inventory would be conclusive proof that the mine , in fact does not lie beneath, or nearby, the roadway.

One pitfall to avoid in this part of the Initial Site Evaluation process is the elimination of sites without conclusive information indicating that the abandoned underground mine does not pose a threat to the roadway, and therefore the traveling public. If the available information for a given site does not provide conclusive proof that the mine is of no threat to the roadway, and therefore the traveling public, then the site should not be placed in the Eliminated Sites Group.

Two examples of sites which could be eliminated would be those where the mine appeared to be under or nearby the roadway during the initial informational review performed to establish the initial inventory listing of sites, but upon Initial Site Evaluation it was determined that:

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Initial Site Evaluation

C/R/S/ (Mile Marker): ____________________ Field Report / Office Investigation No. ____________

Site Description: ____________________

____

U.S.G.S. Topographic Quadrangle ODOT No.: __________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: __________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: __________ (If known.)

Name of Site Evaluator: ____________________ Evaluation Date: __________

ELIMINATED SITES SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not beneath the roadway ?

Yes____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No_____

	Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1)	Evidence of Surface Deformation	Automatic Placement in Surface Deformation Group For Detailed Site Evaluation	yes	no				If "Yes", Proceed to Detailed Site Evaluation
2)	Presence of Mine Opening(s)	Automatic Placement in Mine Opening Group For Detailed Site Evaluation	yes	no				If "Yes", Proceed to Detailed Site Evaluation
3)	Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	9	Ratio = 1 or > 1 10	Ratio <1 1				
4)	Average Daily Volume of Traffic (ADT)	9	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	< 5K 2	
5)	Hydrogeologic Setting	8	Dewatered 10	Flooded 8	Not Flooded 1			
6)	Minimum Overburden Thickness (Approx.)	4	< 25' 10	25' - 50' 8	50' - 100' 5	>100' 1		
7)	Maximum Mined Interval Thickness (Approx.)	4	>6' 10	3' - 6' 5	0 - 3' 1			
8)	Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6	Ratio < 5 10	Ratio = 5 to 11 5	Ratio >11 1			
9)	Secondary Mining	4	yes 10	no 1				

Overall (Total) Site Evaluation Rating: ______

COMMENTS (Attach additional sheets if necessary):

Figure 4.1: Initial Site Evaluation Form

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Initial Site Evaluation

C/R/S/ (Mile Marker): GUE-000-00.00 Field Report / Office Investigation No. N/A

Site Description: STATE ROUTE 000, APPROXIMATELY 2 MILES EAST OF OHIOVILLE

U.S.G.S. Topographic Quadrangle ODOT No.: 0-W-00 O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: OHIOVILLE O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: GY-00 (If known.)

Name of Site Evaluator: J. DOE Evaluation Date: 5/15/98

ELIMINATED SITES SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not beneath the roadway? Yes____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING) No X

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Evidence of Surface Deformation	Automatic Placement in Surface Deformation Group For Detailed Site Evaluation	yes	(no)			If "Yes", Proceed to Detailed Site Evaluation	
2) Presence of Mine Opening(s)	Automatic Placement in Mine Opening Group For Detailed Site Evaluation	yes	(no)			If "Yes", Proceed to Detailed Site Evaluation	
3) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	9	Ratio = 1 or > 1 10	Ratio <1 (1)				9
4) Average Daily Volume of Traffic (ADT)	9	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K (4)	< 5K 2	36
5) Hydrogeologic Setting	8	Dewatered 10	Flooded (8)	Not Flooded 1			64
6) Minimum Overburden Thickness (Approx.)	4	< 25' 10	25' - 50' (8)	50' - 100' 5	>100' 1		32
7) Maximum Mined Interval Thickness (Approx.)	4	>6' 10	3' - 6' (5)	0 - 3' 1			20
8) Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6	Ratio < 5 10	Ratio = 5 to 11 (5)	Ratio >11 1			30
9) Secondary Mining	4	yes (10)	no 1				40

Overall (Total) Site Evaluation Rating: 231

COMMENTS (Attach additional sheets if necessary):

Figure 4.2: Example of a Completed Initial Site Evaluation Form

1) Excavation for the roadway construction has eliminated ("Daylighted") the mined interval, or;

2) Roadway drawings, mine abandonment maps, field measurements and observations, and /or other data upon careful review reveals that the mine is actually documented to be somewhere other than beneath the roadway.

4.4.2 Surface Deformation and Mine Opening Site Screening: The first two listed Site Evaluation Criteria, Evidence of Surface Deformation and Presence of Mine Opening(s) are utilized to screen certain sites into two site groups. Sites for which there is evidence of surface deformation or the presence of mine openings will be documented as such and automatically be placed in the Surface Deformation Group or the Mine Opening Group for Detailed Site Evaluation. Mine Opening sites should also be evaluated as non-mine opening, general sites.

4.4.3 Rating of General Sites: This form is designed to develop an overall Initial Site Evaluation rating for the balance of the inventory sites which are not screened as Eliminated sites, Surface Deformation Sites, or Mine Opening(s) Sites. The site risk assessment rating is based on the totaling of rating values for all of the criteria. Each of the individual criterion rating values are calculated by multiplying a criterion weighting factor times a rating value which represents a site condition or characteristic. The weighting factors reflect the importance of the different criteria as related to one another.

A numerical site risk assessment rating will thus be established for each non-screened general site by the completion of a Initial Site Evaluation form. This work will provide a risk assessment for each site relative to all other sites within this given site group. These relative risk assessments of all sites not included in the Surface Deformation, Mine Opening, or Eliminated Sites Group will allow for the remaining general sites to be divided into the High Rating and Low Rating Site Groups. This division of sites is accomplished by listing the general sites in order of their overall total risk assessment rating.

4.5 RISK ASSESSMENT GROUPS:

The completion of Initial Site Evaluation forms for all sites will result in the sorting of the entire inventory of sites into five prioritized risk assessment site groups. These subgroupings of sites will be based on five categories of risk determined by the completed Initial Site Evaluation forms. These Initial Site Evaluation risk assessment group categories in order of priority are:

Priority	Group Designation	Group Description
1	Surface Deformation Group	Sites with evidence of surface deformation, such as areas of surface settlement, subsidence or irregular

Priority	Group Designation	Group Description
		drainage conditions which may be mine-related, and may exist or may have historically been observed in the right-of-way or within view of the right-of-way.
2	Mine Opening Group	Sites with evidence that mine opening(s) exist or have historically been observed or recorded as being in the right-of-way or within view of the right-of-way.
3	High Rating Group	The ten sites having the highest level of risk to the traveling public or damage to the roadway resulting from abandoned underground mines.
4	Low Rating Group	All other sites having a relatively lower level of risk as compared to those sites in the High Rating Group.
5	Eliminated Sites	Sites eliminated (screened) from further evaluation through the verification that the abandoned underground mine in question in fact does not lie beneath the highway right-of-way.

Sites in the Surface Deformation Group , the Mine Opening Group and High Rating Group will proceed to be further studied through the Detailed Site Evaluation process. Initial Site Evaluation information for the sites in the Low Rating Group will be maintained as active permanent files. The highest individually ranked sites in the Low Rating Group will automatically move up into the High Rating Group. This movement will occur as sites initially in the High Rating Group are individually evaluated and site recommendations implemented. All Mine Opening Group sites will also be evaluated and monitored as non-mine opening sites. Therefore, all Mine Opening Group Sites will also appear as sites in either the High Rating Group or the Low Rating Group.

The fifth group of sites determined through the completion of Initial Site Evaluation is the Eliminated Sites group. Although no further investigations will be conducted on these sites, a permanent, inactive record file should be made and maintained of the Initial Site Evaluation for each of these sites. This file should contain copies or documentation of all information considered in the site evaluation.

4.6 SITE MONITORING:

Periodic monitoring of all sites will be conducted in order to detect any changed site conditions. This monitoring may indicate a need to take immediate action or to perform a site reevaluation. A reevaluation of a site with changed conditions may move the site to a risk assessment group having a higher rating.

SECTION 5:

Site Monitoring

5.1 GENERAL DISCUSSION

The site visit conducted during the Initial Site Evaluation is, in effect, the first site monitoring visit. All sites not eliminated from the inventory as a result of the Initial Site Evaluation process will require continuing periodic monitoring on a permanent basis. The physical site conditions and the exposure of the traveling public to the site will determine the monitoring frequency for each particular site. The nature and frequency of monitoring for a given site may change as the result of changed field conditions either observed during site monitoring, or reported and confirmed by ODOT staff or other persons. Some sites will require reevaluation and possible placement into a different risk assessment site group as the result of these changed conditions detected during site monitoring.

5.2 DIFFERENT STAGES REQUIRING MONITORING

5.2.1 Monitoring Before Priority Site Evaluations: The forms of monitoring and frequencies of monitoring will depend on the field information and existing information reviewed for the given site at this point in the Abandoned Underground Mine Inventory and Risk Assessment process. Based on this information, the Initial Site Evaluation site group into which the site apparently will be placed will determine the forms and corresponding frequencies of site monitoring which will be appropriate.

Frequencies of the different forms of monitoring should be based on best available information and past field experiences by ODOT.

Suspected Surface Deformation Group Sites should be identified during the initial site visit by the location and documentation of particular features discovered as a result of the site visit. These sites should be assigned the highest level of monitoring. Site specific monitoring, as determined to be appropriate for the observed field conditions, should be undertaken. Detailed Site Evaluations and Priority Site Investigations should be given the highest priority for these sites. The initial monitoring visit should be performed as soon as possible after the initial site visit.

Suspected Mine Opening Group Sites should also be identified during the initial site visit. These sites should be assigned the second highest level of monitoring. Site specific monitoring, as determined to be appropriate for observed field conditions, should also be undertaken.

The balance of the sites visited will form one general group of sites which will be subdivided through the Initial Site Evaluation into the High Rating and Low Rating Groups of sites. These sites should be correspondingly assigned the third and fourth highest level of monitoring. Site specific monitoring as determined to be appropriate for the observed field conditions should be undertaken for these sites.

Once periodic monitoring of sites is initially established, a monitoring file should be established for each site. This file should be reviewed before each succeeding site visit. This effort will familiarize the site monitoring person with particular site features to be observed. Any changed conditions related to previously identified particular features can then be noted.

5.2.2 Monitoring After Priority Site Evaluations: After Initial and Detailed Site Evaluations, Priority Site Investigations and Recommendations will be undertaken. The Priority Site Investigation should either result in a Priority Site Recommendation to defer remediation or to perform remedial construction. If remedial construction is recommended, separate forms and frequencies of monitoring may be recommended during: 1) construction contract document development; 2) remediation construction and; 3) post remediation construction.

Frequencies of the different forms of monitoring are based on best available information and past field experiences by ODOT.

5.2.2.1 Remediation Deferred: If the Priority Site Recommendation is to defer remediation, the site still represents a location which at some time in the future may develop conditions which would warrant remediation. Therefore, these sites should remain on the active inventory site listing and should be monitored.

5.2.2.2 During Construction Document Development: Site conditions may change during the development of construction contract documents. For this reason, site monitoring should be maintained during this period so as to make adjustments to the construction contract documents and to protect the safety of the traveling public in locations where the roadway is remaining open.

5.2.2.3 During Remediation Construction: Site conditions may change during the remediation construction. This situation may occur due to the progressive nature of the conditions identified for remediation or as the result of conditions induced by the remediation construction itself. In either case, it is essential to be aware of, and vigilant for, the possibility of such changing surface and subsurface site conditions. Such conditions could have a significant impact on the scope of work required to complete remediation construction. They could also present a threat to the safety of persons working in the project area and to the traveling public if traffic is being maintained.

Provisions for site monitoring should be incorporated into remediation construction contract documents. See Section 9: Remediation for further information regarding this subject.

5.2.2.4 Post-Remediation Construction: Post construction monitoring should be conducted to insure that the remediation was successful and that all areas requiring remediation were included in the completed work. This monitoring should typically be initiated with a relatively short time period between individual site monitoring visits. If no problems evidence themselves over time, this time period will continue to lengthen.

5.3 FORMS OF MONITORING

Table 5.1 summarizes the various forms of site monitoring, including applications and limitations. Refer to Appendix E: Forms of Monitoring for a detailed discussion of the forms of monitoring..

TABLE 5.1
FORMS OF MONITORING
SUMMARY

Forms of Monitoring	Applications	Limitations
I. Visual:		
- Driving	All sites.	None.
- On the Ground		
- Particular features	Utilized to detect physical changes of identifiable site features. Features may include mine-related structures or surface deformation features.	None.
- Ground Photography	Utilized to record particular features, such as surface	None.

TABLE 5.1 (Continued)

Forms of Monitoring	Applications	Limitations
- Ground Photograghy (Cont'd.)	deformation, drainage irregularities, etc.	
II. Non- Intrusive		
- Ground Survey Techniques	Utilized to detect vertical settlements or heave related to underground mine subsidence. Point elevations to be monitored may include mine structures, roadway centerline station hubs, P-K nails driven into surface of driving lanes, etc. This work can be performed by ODOT personnel and equipment.	Lane closure/ traffic control required
- Aerial Photography		
- Conventional (B/W & Color)	Utilized to detect surface subsidence features and drainage irregularities which otherwise might not be noticeable from the ground. This work can be performed by ODOT personnel and equipment.	Two optimal times: Late Fall and early Spring.
- Infrared (B/W & Color)	Utilized to detect subsidence features, drainage irregularities, and possibly near surface voids or unconsolidated conditions not otherwise noticeable from ground reconnaissance. This detection is possible due to the variations in surface temperature, soil moisture and/or related variations in surface vegetation. This work can be performed by ODOT personnel and equipment.	Optimal Times: Days when higher solar heating is occurring.

TABLE 5.1 (Continued)

Forms of Monitoring	Applications	Limitations
- Profilometer	Creates a record of horizontal lane profiles through the site. No traffic control is normally required. This work can performed by ODOT personnel and equipment	None.
- Surface Seismic Methods - Refraction	Detects depth and thickness of geologic strata and depth to bedrock and water table.	Both refraction and reflection require an extensive array of geophones. If study area is large, reflection may not be practical for general studies. Lane closure/traffic control probably required.
- Reflection	Detects depth and thickness of geologic strata and possibly voids.	
- Dynaflect	Detects unconsolidated subgrade conditions through the use of a lower energy impulse. This work can be performed by ODOT personnel and equipment.	Lane closure/ traffic control required
- Falling Weight Deflectometer (FWD)	Detects unconsolidated subgrade conditions through the use of a higher energy impulse. This work can be performed by ODOT personnel and equipment.	Lane closure/ traffic control required
- Heavy Weight Deflectometer (HWD)	Detects unconsolidated subgrade conditions through the use of a higher energy impulse.	Lane closure/traffic control required. Heavier weights may damage pavements.

TABLE 5.1 (Continued)

Forms of Monitoring	Applications	Limitations
- Electrical Methods - Surface GPR	Detects subsurface voids or anomalous conditions. Longer wavelengths (25 to 50 MHZ) are utilized for deeper penetration of the subgrade in shoulders or other areas where no reinforcing steel exists. Shorter wavelengths (100 MHZ to 1 GHz) are utilized to penetrate pavements containing reinforcing steel. These shorter wavelengths are only effective at providing information on subgrade conditions immediately below the pavement.	This monitoring currently requires the contracting of external technical services. Success of this technique is highly dependent on the characteristics of the soils, bedrock, and groundwater. Traffic control is required.
- Resistivity Studies	Produce lateral or vertical electrical profiling of anomalous conditions of subsurface materials. Can detect voids and buried metals.	Standard methods require metal stakes driven into ground or pavement. Success depends upon electrical interference on site and size of target.
- Electromagnetic Induction (EM)	This form of monitoring may be in the form of Frequency-Domain EM or Time-Domain EM. This monitoring is used to obtain horizontal profiles and depth soundings of conductive layers, especially buried metals, such as abandoned rails in mines.	This monitoring technique is sensitive to above-ground metallic objects, such as guardrails, traffic, etc.

TABLE 5.1 (Continued)

Forms of Monitoring	Applications	Limitations
- Spontaneous-Potential (SP)	Measures distortions created by local changes in the underlying electrical conductivity of the earth.	This technique requires groundwater flow in mines or voids.
- Very Low Frequency (VLF)	Measures distortions created by local changes in the underlying electrical conductivity of the earth.	Data resulting from this technique has a relatively low resolution.
- Potential Field Methods	These methods may be in the form of microgravity studies or magnetic studies. Near surface anomalies in the strengths of these two fields, in some settings, may be useful in locating subsurface voids.	Gravity studies require precise elevation surveys. Magnetic studies are sensitive to ferrous metals.
III. Intrusive (Borings Required)		
- Electrical Methods		
- Borehole GPR	This method is utilized to detect subsurface anomalies and/or voids. A radar signal is transmitted from one hole to an adjacent hole.	Maximum borehole spacing for this technique may be limited to 10 to 12 feet. May require a larger amount of data processing time.

TABLE 5.1 (Continued)

Forms of Monitoring	Applications	Limitations
- Time Domain Reflectometer (TDR)	Utilized to detect lateral (shear) and vertical (subsidence) movements. This form of monitoring is relatively inexpensive, particularly when drilling is performed for other purposes. Data collection can be performed by one person. Data can be easily interpreted and is usable at the time of collection on the site.	Rental of a grout pump, with operator, is required for cable installation. The roadway authority will need to purchase a TDR meter for the data collection from installed cables.
-Slope Inclinometer	Utilized to detect lateral subsurface movement (shear). This form of monitoring may have application in detection of "side-draw" related to adjacent subsidence activity.	Relatively expensive as compared to the costs of TDR monitoring. Requires sophisticated data gathering equipment, time consuming data collection, and extensive data analysis to produce usable information.
- Borehole Camera	Utilized to view soil and bedrock overburden conditions, also the nature and condition of subsurface voids, etc. Creation of a video record of viewed conditions. This work can be performed by ODOT personnel and equipment.	Requires stable overburden conditions. Otherwise, camera will be at risk when lowered in the borehole. Quality of video imagery below the groundwater table is usually of a lesser quality. Traffic control may be required.
- Seismic Studies - Borehole Seismic Studies	Utilized to detect subsurface anomalies, including voids, between adjacent boreholes.	Pairs of boreholes required. Currently requires contracting of external technical services. May require a larger amount of data processing time.

TABLE 5.1 (Continued)

Forms of Monitoring	**Applications**	**Limitations**
- Groundwater Studies - Piezometers	Utilized to detect and monitor ground water static head within a particular aquifer. This form of monitoring is relatively inexpensive, particularly if a drilling program is to be performed. Data collection can be performed quickly by one person. Data is easily interpreted and usable at the time of collection on the site.	Requires stable overburden condition to allow for installation of well casing, slotted at a particular aquifer's elevation, complete with the appropriate sealing(s) of the annular space, so as to only allow water from one particular aquifer to enter and rise in the casing. Location of piezometers must not interfere with the safety of the traveling public.
- Observation Wells	Utilized to detect combined static groundwater head for a given borehole location. This form of groundwater monitoring has application in areas where fractured overburden conditions allow for co-mingling of originally separate aquifers.	Requires stable overburden condition to allow for the installation of a well casing. Location of observation wells must not interfere with the safety of the traveling public.

5.4 SITE MONITORING GUIDELINES

The Site Monitoring Guidelines for the four active risk assessment site groups resulting from Initial Site Evaluation are provided as Figures 5.1, 5.2, 5.3 and 5.4 on the following pages. These guidelines indicate forms of monitoring applicable to the different stages of site monitoring. They are general monitoring guidelines for each of the site groups. They do not necessarily define the exact monitoring needs for each specific site.

Each site will be found to be unique. Many sites may require adjustment of actual monitoring undertaken depending on site configuration, surface and subsurface constraints, availability of equipment, etc.

5.4.1 Notes: The lower portion of the Site Monitoring Guidelines includes a "Notes" section. These notations are discussed below:

5.4.1.1 "M" Notation: The "M" on the Site Monitoring Guidelines indicates that the particular form of monitoring is applicable for a typical site within the given Site Group.

5.4.1.2 "T" Notation: The "T" refers to sites where traffic is maintained on or adjacent to the roadway during construction. The maintenance of traffic in close proximity to the remedial construction activity adds additional responsibility to protect the safety of the traveling public.

5.4.1.3 "S" Notation: The "S" on the Site Monitoring Guidelines forms indicates that the particular form of monitoring may be applicable depending on specific site conditions and constraints. Refer to the preceding portions of this section of the manual for descriptions of forms and applications of individual types of monitoring.

Example: Some forms of monitoring may have site-specific applications on Mine Opening Group sites having drift (horizontal) and slope mine entries. In these settings, certain forms of monitoring such as ground penetrating radar (GPR), time domain reflectometery (TDR), and borehole camera observation may be applicable. Determinations of the site-specific need for such forms of monitoring on such a site would be largely based on: 1) the mine opening location relative to the vertical and horizontal alignment of the roadway; 2) the known geometry of the mine opening itself, and: 3) the nature of the soil and rock strata comprising the overburden interval between the roadway and mine opening.

Site Monitoring Guidelines
For The
Surface Deformation Group

Forms of Monitoring	Different Stages of Site Monitoring				
	Before Priority Site Investigations	After Priority Site Investigations			
			During Construction Document Development	During Remediation Construction	Post - Remediation Construction
I. **Visual**					
- Driving	M		M	S	M
- On the Ground:					
- Particular Features	M		M	M	M
- Ground Photography	M		S	S	S
II. **Non - Intrusive**					
- Profilometer	M		M	S,T	M
- Dynaflect					
- FWD	M		S	S,T	M
- HWD					
- Ground Survey Techniques	M		M	S	M
- Aerial Photography					
- Conventional (B/W & Color)	M				M
- Infared (B/W & Color)	M				M
- Surface GPR	S		S		S
- Other **					
III. **Intrusive (Borings Required)**					
- Borehole GPR				S	
- TDR			S	S	S
- Slope Inclinometer					
- Borehole Seismic					
- Borehole Camera			S	S	
- Piezometers			S	S	S
- Observation wells			S	S	S

Notes:

"M" indicates a general monitoring guideline for the site group

"T" indicates where traffic is maintained during construction

"S" indicates determined on a site specific basis

** Other forms of monitoring may be specified on a site-by-site basis as needed.
See Table 5.2 for Listing of "Other forms of Monitoring."

Figure 5.1

Site Monitoring Guidelines
For The
Mine Opening Group

Forms of Monitoring	Different Stages of Site Monitoring				
	Before Priority Site Investigations	After Priority Site Investigations			
		Remediation Deferred	During Construction Document Development	During Remediation Construction	Post - Remediation Construction
I. Visual					
- Driving	M	M	M		M
- On the Ground:					
- Particular Features	M	M	M	M	M
- Ground Photography	S	S	S	M	S
II. Non - Intrusive					
- Profilometer	S	S	S	S,T	S
- Dynaflect					
- FWD	S	S	S	S,T	S
- HWD					
- Ground Survey Techniques	M	M	M	S	M
- Aerial Photography					
- Conventional (B/W & Color)	S				
- Infared (B/W & Color)	S				
- Surface GPR	S		S	S	S
- Other **					
III. Intrusive (Borings Required)					
- Borehole GPR					
- TDR	S	S	S	S	S
- Slope Inclinometer					
- Borehole Seismic					
- Borehole Camera	S	S	S	S	
- Piezometers					
- Observation wells					

Notes:

"M" indicates a general monitoring guideline for the site group.

"T" indicates where traffic is maintained during construction

"S" indicates determined on a site specific basis

** Other forms of monitoring may be specified on a site-by-site basis as needed. See Table 5.2 for Listing of "Other forms of Monitoring."

Figure 5.2

Site Monitoring Guidelines
For The
High Rating Group

Forms of Monitoring	Different Stages of Site Monitoring				
	Before Priority Site Investigations	After Priority Site Investigations			
		Remediation Deferred	During Construction Document Development	During Remediation Construction	Post - Remediation Construction
I. Visual					
- Driving	M		M	M	M
- On the Ground:					
- Particular Features	M	M	M	M	M
- Ground Photography	S	S	S	M	S
II. Non - Intrusive					
- Profilometer	M	M	M	S,T	M
- Dynaflect					
- FWD	M	M	S	S,T	M
- HWD					
- Ground Survey Techniques	M	S	S	S	M
- Aerial Photography					
- Conventional (B/W & Color)	S				M
- Infared (B/W & Color)	S				M
- Surface GPR	S				
- Other **					
III. Intrusive (Borings Required)					
- Borehole GPR				S	
- TDR	S	M	S	S	M
- Slope Inclinometer					
- Borehole Seismic					
- Borehole Camera	S		S	S	
- Piezometers	S	S	S	S	S
- Observation wells	S	S	S	S	S

Notes:

"M" indicates a general monitoring guideline for the site group

"T" indicates where traffic is maintained during construction

"S" indicates determined on a site specific basis

** Other forms of monitoring may be specified on a site-by-site basis as needed.
See Table 5.2 for Listing of "Other forms of Monitoring."

Figure 5.3

Site Monitoring Guidelines
For The
Low Rating Group

Forms of Monitoring	Different Stages of Site Monitoring				
	Before Priority Site Investigations	After Priority Site Investigations			
		Remediation Deferred	During Construction Document Development	During Remediation Construction	Post - Remediation Construction
I. **Visual**					
- Driving	M				
- On the Ground:					
- Particular Features	S				
- Ground Photography	S				
II. **Non - Intrusive**					
- Profilometer	M				
- Dynaflect					
- FWD	S				
- HWD					
- Ground Survey Techniques	S				
- Aerial Photography					
- Conventional (B/W & Color)	S				
- Infared (B/W & Color)	S				
- Surface GPR	S				
- Other **					
III. **Intrusive (Borings Required)**					
- Borehole GPR					
- TDR					
- Slope Inclinometer					
- Borehole Seismic					
- Borehole Camera					
- Piezometers					
- Observation wells					

Notes:

"M" indicates a general monitoring guideline for the site group

"T" indicates where traffic is maintained during construction

"S" indicates determined on a site specific basis

** Other forms of monitoring may be specified on a site-by-site basis as needed. See Table 5.2 for Listing of "Other forms of Monitoring."

Figure 5.4

TABLE 5.2
OTHER FORMS OF MONITORING GUIDELINES

Form of Monitoring	Applications	Limitations
Surface Seismic Methods	Site-specific.	Site-specific
Resistivity Studies	Site-specific.	Site-specific.
Electromagnetic Induction (EM)	Site-specific.	Site-specific.
Spontaneous Potential (SP)	Site-specific.	Site-specific.
Very Low Frequency (VLF)	Site-specific.	Site-specific.
Potential Field Methods		
- Gravity Studies	Site-specific.	Site-specific.
- Magnetic Studies	Site-specific.	Site-specific.

5.5 FREQUENCY OF MONITORING

The exact frequency for the forms of monitoring indicated on the preceding Site Monitoring Guidelines tables will be unique to each individual site. This reflects the fact that no two sites will be identical. Conditions and constraints, at grade and below grade, as well as availability of personnel and equipment, will in many cases dictate the frequency of monitoring. The final decision on monitoring forms and frequencies for each inventory site will be based on the best judgement of the District engineer designated to coordinate the monitoring process. The following text discusses the range of frequencies for the various forms of site monitoring.

5.5.1 Visual Forms of Monitoring:

5.5.1.1 Driving: The frequency for this form of monitoring can range from daily, in the case of some high risk Surface Deformation Group sites, to two years, in the case of some Low Rating Group sites. This monitoring can often be easily performed by roadway authority personnel traversing the site either to and from work, or during the course of their daily work.

5.5.1.2 On the Ground:

5.5.1.2.1 Particular Features: The frequency for this form of monitoring can range from daily, in the case of some high risk Surface Deformation Group sites, to two years, in the case of some Low Rating Group sites. This monitoring can often be easily performed by roadway authority personnel traversing the site either to and from work, or during the course of their daily work.

5.5.1.2.2 Ground Photography: The frequency for this form of monitoring can range from daily, during certain remedial construction operations on some high risk Surface Deformation Group sites or Mine Opening Group sites, to two years, in the case of some Low Rating Group sites. This monitoring can often be easily performed by roadway authority personnel traversing the site either to and from work, or during the course of their daily work.

5.5.2 Non-Intrusive Forms of Monitoring:

5.5.2.1 Ground Survey Techniques: The frequency for this form of monitoring can range from every week, during some stages of monitoring on Surface Deformation Group sites, Mine Opening Group sites, and High Rating Group sites during certain remedial construction operations if traffic is being maintained, to three years, in the case of some Low Rating Group sites. This form of monitoring can be performed by ODOT personnel and equipment.

5.5.2.2 Aerial Photography:

5.5.2.2.1 Conventional (B/W and Color): The frequency for this form of monitoring can range from yearly, before priority site investigations and immediately following remediation construction on some high risk Surface Deformation Group sites or Mine Opening Group sites, to three years, in the case of some Low Rating Group sites. This form of monitoring can be performed by ODOT personnel and equipment.

5.5.2.2.2 Infrared (B/W and Color): The frequency for this form of monitoring can range from yearly, before priority site investigations and immediately following remediation construction on some high risk Surface Deformation Group sites or Mine Opening Group sites, to three years, in the case of some Low Rating Group sites. This form of monitoring can be performed by ODOT personnel and equipment.

5.5.2.3 Profilometer: The frequency for this form of monitoring can range from every two weeks, on Surface Deformation Group sites, Mine Opening Group sites, and High Rating Sites during certain remedial construction operations if traffic is being maintained, to three years, in the case of some Low Rating Group sites. This form of monitoring can be performed by ODOT personnel and equipment.

5.5.2.4 Surface Seismic Methods:

5.5.2.4.1 Dynaflect

5.5.2.4.2 Falling Weight Deflectometer (FWD): The frequency for this form of monitoring can range from: 1) every two weeks, on Surface Deformation Group sites, Mine Opening Group sites,, and High Rating Sites during certain remedial construction operations if traffic is being maintained, to; 2) three years, in the case of some Low Rating Group sites. This form of monitoring can be performed by ODOT personnel and equipment.

5.5.2.4.3 Heavy Weight Deflectometer (HWD)

5.5.2.5 Electrical Methods:

5.5.2.5.1 Surface Ground Penetrating Radar (GPR): The frequency for this form of monitoring may range from: 1) every six months, before priority site investigations and immediately following remediation construction on some high risk Surface Deformation Group sites, Mine Opening Group sites or High Rating sites, to; 2) two years, in the case of these same sites if remediation is deferred or remedial construction took place several years in the past with no apparent occurrence of further mine-related problems.

5.5.2.5.2 Resistivity Studies

5.5.2.5.3 Electromagnetic Induction (EM)

5.5.2.5.4 Spontaneous Potential (SP)

5.5.2.5.5 Very Low Frequency (VLF)

5.5.2.6 Potential Field Methods

5.5.3 Intrusive Forms of Monitoring:

5.5.3.1 Electrical Methods:

5.5.3.1.1 Borehole Ground Penetrating Radar: The frequency for this form of monitoring can range from weekly to monthly, during certain remedial construction operations on some Surface Deformation Group sites and High Rating Sites during certain remedial construction operations.

5.5.3.1.2 Time Domain Reflectometer: The frequency for this form of monitoring can range from continuous to three months on Surface Deformation Group sites, Mine Opening Group sites, and High Rating Sites, depending on the particular risk assessment stage being monitored. This form of monitoring can be performed by ODOT personnel and equipment (one TDR meter is currently available).

5.5.3.1.3 Slope Inclinometer: The frequency of this form of monitoring is site specific.

5.5.3.1.4 Borehole Camera: The frequency of this form of monitoring is site specific.

5.5.3.2 Borehole Seismic Studies

5.5.3.3 Groundwater Studies:

5.5.3.3.1 Piezometers: The frequency for this form of monitoring can range from instrumented, continuous (hourly at worst) monitoring, on some Surface Deformation Group sites, Mine Opening Group sites, and High Rating Sites during certain remedial construction operations; to three months, in the case of some High Rating sites where remediation is deferred.

5.5.3.3.2 Observation Wells: The frequency for this form of monitoring can range from instrumented, continuous (hourly at worst) monitoring, on some Surface Deformation Group sites, Mine Opening Group sites, and High Rating Sites during certain remedial construction operations, to three months, in the case of some High Rating sites where remediation is deferred.

5.6 SITE REEVALUATION

5.6.1 General: Permanent site monitoring will provide a feedback loop in the process to allow for the detection of changed site conditions. This aspect of the inventory and risk assessment process makes it a dynamic, responsive system. This process feature is necessary because the age of the abandoned underground mines beneath the roadways is continuing to increase. The stability of those mines and the associated overburden strata, at least in many cases, will continue to deteriorate.

5.6.2 Changed Conditions: Changed conditions may be detected during site monitoring as: 1) observed changes to previously documented site features, or; 2) new site features not noted during previous site monitoring. Site reevaluation may also be required as the result of new information developed during Detailed Site Evaluations or Priority Site Investigations.

5.6.2.1 Examples: Some examples of information which would document the need to reevaluate a site may include:

5.6.2.1.1 New or Changed Surface Deformation Features: These types of surface features may be observed on a given site during a routine periodic site monitoring visit, or they may be reported by others and confirmed by inventory personnel

5.6.1.1.2 Changed Site Characteristics Documented Through Development of New Information: Detailed Site Evaluation and Priority Site Investigations work may reveal a previously unidentified mine shaft location nearby the roadway

5.6.3 Reevaluation Method: When new changed conditions or information is obtained for a given site, site reevaluation should be performed. This reevaluation should be accomplished by first completing a new Initial Site Evaluation form for the site. The site may be placed in a different risk assessment site group as the result of this reevaluation. Whether or not this occurs, the site should next be further reevaluated by completing a new Detailed Site Evaluation form for the appropriate site group. This work should determine the site's adjusted risk assessment priority in the appropriate site group.

SECTION 6:

Detailed Site Evaluation

6.1 GENERAL DISCUSSION

The Detailed Site Evaluation process is begun by evaluating the Site Deformation, Mine Opening, and High Rating Site Groups in order of their Initial Site Evaluation risk assessment. This second level of site evaluation will reconsider, in some cases, some of the criteria considered during the Initial Site Evaluation, along with additional criteria related to the nature of the particular site group. Separate Detailed Site Evaluation Forms are provided for the Surface Deformation Group, Mine Opening Group, and High Rating Group. Each group of sites, in order of risk level, will proceed through the complete Abandoned Underground Mine Inventory process before the subsequent group is subjected to Detailed Site Evaluation. Some sites may require reevaluation and possible placement into a different risk assessment site group as the result of site information reviewed during the Detailed Site Evaluation.

6.2 DETAILED SITE EVALUATION CRITERIA

The Detailed Site Evaluation Criteria are utilized to evaluate site conditions and the public's exposure to those conditions.

6.2.1 Number of Subsidences: This criterion is an indicator of the likelihood of current, or past, subsidence activity on the site. The rating value shall be the number of areas of surface settlement, subsidence, or irregular drainage conditions, which may be mine-related, and exist or have historically been observed in the right-of-way or within view of the right-of-way.

Site Condition:	Rating Value:
"Yes" for all sites in the Detailed Site Evaluation Surface Deformation Group.	Number of subsidence features on site

6.2.2 Recent Dewatering: This criterion is an indicator of recent and historic fluctuations in groundwater conditions within the abandoned underground mine. Dewatering of the abandoned underground mine voids, and subsequent groundwater movements and possible recharging, either through natural processes or human activities, can have a very detrimental effect on the stability of natural and man-made supporting structures within the abandoned underground mine. These fluctuations in groundwater conditions can also affect the stability and integrity of the soil and rock units comprising the overburden interval between the roadway surface and the top of the abandoned mine void. The site condition is the length of time since each report or incidence of dewatering. The total rating value for a given site will be the sum of all rating values of all dewatering events.

Site Condition:	Rating Value:
< 1 Year	10 Points
1 to 3 Years	9 Points
4 to 6 Years	4 Points
7 to 9 Years	2 Points
> 9 Years, unknown, or dry mine	1 Point

Example: A site was dewatered five years ago and again in the past year. The total site rating value for this criteria would be equal to 4 + 10 , or 14.

6.2.3 Average Daily Volume of Traffic (ADT): This criterion is a measure of the traveling public's exposure to the site. The site condition is the total average 24-hour volume of traffic for a given site as determined by the most recent Traffic Survey Report, plus a 3% per year calculated increase to date for the time elapsed since the issuance of the Traffic Survey Report.

Site Condition:	Rating Value:
>30,000 Vehicles	10 Points
20,000 to 30,000 Vehicles	8 Points
10,000 to 20,000 Vehicles	6 Points
5,000 to 10,000 Vehicles	4 Points
<5,000 Vehicles	2 Points

6.2.4 Classification of Roadway: This criterion is an indicator of the strategic significance of the roadway site to the state and interstate highway transportation systems. The site condition for this criterion is defined as four classifications of roadway. The "NHS Other Than Interstate" site condition should be utilized for National Highway System routes other than the Interstate highway system. In the case of intersecting roadways, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the intersecting roadways.

Site Condition:	Rating Value:
Interstate (I.R.)	10 Points
NHS Other Than Interstate	7 Points
Arterial	5 Points
Collector	1 Points

Examples: 1) Given: An intersection of an interstate roadway and an arterial roadway is within the site area. The total site rating value for this criteria would be equal to 10 + 5 , or 15.

2) Given: An intersection of two arterial roadways is within the site area. The total site rating value for this criteria would be equal to 5 + 5 , or 10.

6.2.5 Average Daily Volume of Truck Traffic (ADTT): This criterion is a measure of a possible sudden collapse of the pavement due to impact loading. The site condition is the average 24-hour total volume of "B"and "C" commercial traffic for a given site as determined by the most recent Traffic Survey Report.

Site Condition:	Rating Value:
>6,000 Vehicles	10 Points
4,000 to 6,000 Vehicles	8 Points
2,000 to 4,000 Vehicles	6 Points
1,000 to 2,000 Vehicles	4 Points
<1,000 Vehicles	2 Points

6.2.6 Traffic Speed: This criterion is an indicator of a driver's ability to perceive and avoid a roadway subsidence area. The site condition is the maximum legal speed limit within the section of roadway defining the site.

Site Condition:	Rating Value:
>35 MPH	10 Points
0 to 35 MPH	1 Point

6.2.7 Type of Pavement: This criterion is an indicator of the pavement's ability to bridge a subsidence or to survive deformation caused by subsidence. The site condition is the type of pavement existing on the site.

Site Condition:	Rating Value:
All forms of pavement other than continuous	10 Points
Continuously Reinforced Pavement	1 Point

6.2.8 Ratio of Unconsolidated Materials to Bedrock in The Overburden Interval: This criterion is utilized as an indicator of subsidence potential. For the use of this criterion, overburden is considered as being composed of only two types of material: 1) unconsolidated material, or; 2) intact bedrock. The subsidence potential will be relatively greater for sites where a larger portion of the overburden is comprised of unconsolidated materials.

Three elevations must be estimated to rate this criterion for a given site. These elevations are for: 1) the roadway surface; 2) the top of the mined interval, and; 3) the bedrock topographic surface within the overburden interval existing between the roadway and the top of the mined interval. The roadway surface elevation may be estimated through review of existing ODOT roadway drawings and U.S.G.S. Quadrangle maps. The top of the mined interval may be estimated through review of several ODNR, DGS forms of information, including individual abandoned underground mine maps and their associated data sheets, bedrock topography maps, geological structure maps, measured geological sections, on-site geological field observations, and other sources of mining/coal information. The elevation of the bedrock topographic surface in the overburden interval may be estimated through review of the ODNR, DGS bedrock topography maps.

The more commonly available forms of surface topographic and bedrock topographic information are larger scaled maps which utilize coarse incremental values. Therefore, the elevations used to calculate the ratio defining the site condition for this criterion will be only approximate. This fact will only allow for an informed "best guess" estimation of the ratio of unconsolidated materials to bedrock in the overburden interval. However, sites which have an overburden interval comprised of a larger portion of unconsolidated materials can be screening for higher risk of subsidence through the use of this criteria. If the apparent unconsolidated material to bedrock estimated ratio appears from available information to be approximately equal to one, the site condition will be rated the same as if the ratio was greater than one.

Site Condition:	Rating Value:
Ratio ≥ 1	10 Points
Ratio <1	1 Point

Example of Site Evaluation: Review of the above described information has revealed the following information for a given site: elevation of roadway is 760, elevation of mine floor (from ODNR, DGS mine map) is 725, thickness of mined interval is 5 feet (from ODNR, DGS mine map data sheets, geological structure maps, measured geological sections, and/or on-site geological field observations), and the elevation of the bedrock topographic surface is 740. The site condition for this criterion would be thus determined:

1) Top of Mined interval = mine floor + thickness of mined interval = 725+5 =730
2) Full depth of Overburden = 760-730 = 30 feet
3) Thickness of Unconsolidated Materials in Overburden = 760-740 = 20 feet
4) Thickness of Bedrock in Overburden = 740-730 = 10

5) Site Condition = Unconsolidated Material to Bedrock Estimated Ratio
= 20 feet / 10 feet = 2
6) Rating Value = 10 points

6.2.9 Availability of Reasonable Detour Routes: This criterion is an indicator of the strategic significance that lost use of the roadway site would have on the local flow of traffic. The rating of this criteria is a judgment call. The decision should be based on the need for a three month required road closure in the case of a sudden, unplanned road collapse.

Site Condition:	Rating Value:
None	10 Points
Yes (Available)	0 Point

6.2.10 Structures in Roadway: This criterion is an indicator of the presence of structures, as defined by the ODOT Bridge Inventory Manual and Appraisal Coding Guide, which could be affected by a subsidence event. The definition of "structure", as defined in these referenced publications, states :

> "For the purposes of this inventory, a bridge is defined as: any structure, including supports, of 10 feet or more clear span or 10 feet or more (clear opening) in diameter on, above, or below a highway. The span of all bridges, except culverts regarded as bridges, shall be measured along the centerline of the highway. Culvert span(s) shall be measured normal to the axis of the culvert." .

Worst case conditions should be assumed in determining if a structure will be affected by a subsidence event. This information is considered significant because structures sensitive to differential settlement, if they were to become unstable, would pose a threat to the safety of the traveling public and a significant financial loss to the State if damaged.

Site Condition:	Rating Value:
Yes	10 Points
No	0 Points

6.2.11 Minimum Overburden Thickness (Approx.): This criterion is an indicator of the potential for subsidence. The site condition is the vertical interval of overburden between the roadway surface elevation and the top of the abandoned underground mine void existing below the roadway. Possible sources of information would include: ODNR, Division Geological Survey information, such as individual abandoned underground mine maps, coal outcrop elevation from topographic information or structure maps, measured geologic sections, etc.; ODNR, Division of Mining and Reclamation information, such as limits of nearby, active surface mine operations ; and contacts with individuals knowledgeable of local, historical mining operations.

Site Condition:	Rating Value:
< 25 Feet	10 Points
25 Feet to 50 Feet	8 Points
50 Feet to 100 Feet	5 Points
>100 Feet	1 Point

6.2.12 Mine Opening Location: This criterion is an indicator of the relative risk to the safety of the traveling public. The site condition is the location of the mine opening relative to the roadway. In the case of multiple mine openings, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the mine openings on the site. The highest potential rating value should be used when a mine opening's location is not conclusively known.

Site Condition:	Rating Value:
Location not Conclusively Known	10 Points
Between the Two Outer-Most Edge of Shoulders	10 Points
Less than 50' Feet From Edge of Shoulder	8 Points
Between 50' and 100' From Edge of Shoulder	2 Points
Within Sight From Edge of Shoulder	1 Point

6.2.13 Method of Mine Closure: This criterion is an indicator of the current stability of any materials originally placed to seal the mine opening. In the case of multiple mine openings, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the mine openings on the site.

Site Condition:	Rating Value:
No Information	10 Points
Timber Decking	10 Points
Uncontrolled Random Backfill	6 Points
Concrete Cap	4 Points
Controlled Backfill	2 Point

6.2.14 Type of Cribbing: This criterion is an indicator of the current stability of materials originally placed to provide vertical or lateral support of the mine opening. In the case of multiple mine mine openings, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the mine openings on the site.

Site Condition:	Rating Value:
No Information	10 Points
Timbers	10 Points
Brick	7 Points
Concrete	4 Points

6.2.15 Minimum Overburden Above Mine Opening: This criterion is an indicator of the potential for subsidence. The site condition is the minimum vertical interval of overburden between the elevation of roadway surface and flowlines of drainage structures, and the top of the abandoned underground mine opening existing below the roadway.

Site Condition:	Rating Value:
Shaft / Cover = 0 Feet	10 Points
Slope/Drift: Cover < 25 Feet	9 Points
Slope/Drift: Cover = 25 Feet to 50 Feet	8 Points
Slope/Drift: Cover = 50 Feet to 100 Feet	5 Points
Slope/Drift: Cover >100 Feet	1 Point

6.2.16 Type of Mine Opening: This criterion is an indicator of the relative danger posed to the safety of the traveling public by the original type of mine opening. In the case of multiple mine openings, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the mine openings on the site.

Site Condition:	Rating Value:
Shaft (Vertical) Entry	10 Points
Slope Entry	8 Points
Drift (Horizontal) Entry	6 Points

6.2.17 Plan Area of Mine Opening (Approx.): This criterion is an indicator of the potential size of surface feature which could occur and the volume of material which could be drawn into the mine opening in the case of a catastrophic collapse. Such a collapse might occur due to failure of the existing backfill, cribbing, and/or closure at the mine opening entrance. The site condition is the plan area of the original mine opening. In the case of multiple mine openings, the overall site condition rating value should be calculated as the sum of the individual site condition rating values for each of the mine openings on the site.

Site Condition:	Rating Value:
>750 Sq. Ft.	10 Points
From 500 to 750 Sq. Ft.	8 Points
From 250 to 500 Sq. Ft.	6 Points
Mine Opening size unknown	5 Points
From 150 to 250 Sq. Ft.	4 Points
<150 Sq. Ft.	2 Points

6.2.18 Age of Mining: This criterion is an indicator of the mining methods utilized and the condition of the mine due to length of time elapsed since abandonment. The site condition is the year of abandonment. This criteria reflects relative differences in: mining methods, probable deterioration due to age: and the possibility of unrecorded mining.

Site Condition:	Rating Value:
<1900, or unknown	10 Points
1900 to 1930	9 Points
1931 to 1945	7 Points
1946 to 1968	5 Points
>1968	1 Point

6.2.19 Extraction: This criterion is an indicator of the amount of mine roof support which remains in the mine. Evidence of the rate of mineral extraction and secondary removal of supporting blocks or pillars left by the original mining operation for roof support may be obtained for some sites. This information will probably be determined primarily through review of: 1) individual mine maps; 2) information from the ODNR, Division of Geological Survey and 3) information obtained from local individuals who are, or have been, involved in the mining of the mineral seam.

Site Condition:	Rating Value:
Evidence of Secondary Mining	10 Points
Rate of Mineral Extraction > 50%	7 Points
Unknown	5 Points
Rate of Mineral Extraction < 50%	1 Point

6.2.20 Maximum Mined Interval Thickness (Approx.): Thicker seams would be expected to have a higher likelihood of surface deformation. The approximate maximum mined interval (void height) of the abandoned underground mine will probably be determined through review of; 1) individual mine maps; 2) information from the ODNR, Division of Geological Survey and 3) information obtained from local individuals who are, or have been, involved in the mining of the mineral seam.

Site Condition:	Rating Value:
>6 Feet	10 Points
3 Feet to 6 Feet	5 Points
0 Feet to 3 Feet	1 Point

6.2.21 Special Mine Features: This criterion is an indicator of the presence of larger unsupported mine roof areas that are more likely to collapse beneath the right-of way. The source of this information will primarily be individual mine maps. The site condition is the feature beneath the roadway having the highest rating value.

Site Condition:	Rating Value:
Intersecting Haulways	10 Points
Entry	5 Points
Large Room	5 Points
None	0 Points

6.2.22 Problems Reported During Active Mining: This criterion is a measure of potential abandoned underground mine instability related to geological conditions. Some of these conditions may include the vertical movement of groundwater down through the overburden, horizontal groundwater movements through the coal seam and unstable mine conditions indicating inherent or induced instability in the mined strata and associated geologic units overlying the mined interval. The condition is any confirmed report of mine instability or significant groundwater problems during active mining.

Site Condition:	Rating Value:
Yes	10 Points
No/Not Known	0 Points

6.2.23 Ratio of Minimum Overburden Thickness to Maximum Mined Interval Thickness (Approx.): This criterion is utilized to give an indication of the potential for highly differential subsidence features at the surface. These subsidence features are also commonly referred to as "sinkholes." The site condition is the estimated ratio of overburden thickness (h) to mining height (m), or "h/m" (Matheson and Eckert-Clift, 1986; Peng, 1992).

The overburden thickness (h) is the minimum vertical interval between the roadway surface elevation and the top of the abandoned underground mine void existing below the roadway. The thickness of mined interval (m) is the approximate maximum void height of the abandoned underground mine. Possible sources of information include: ODNR, Division Geological Survey information, such as individual abandoned underground mine maps, coal outcrop elevation from topographic information or structure maps, measured geologic sections, etc.; ODNR, Division of Mining and Reclamation information, such as limits of nearby, active surface mine operations; and contacts with individuals knowledgeable of local, historical mining operations.

Site Condition:	Rating Value:
Ratio < 5	10 Points
Ratio = 5 to 11	5 Points
Ratio > 11	1 Point

6.3 DETAILED SITE EVALUATION WEIGHTING FACTORS

The weighting factors for each site group are indicated in Table 6.1. The numbers appearing in the boxes following given site criteria indicate the weighting factor values utilized for the particular site groups.

Table 6.1

Detailed Site Evaluation Criteria and Weighting Factors By Site Group

Criterion	Surface Deformation Group	Mine Opening Group	High Rating Group
Number of Subsidences	30		
Recent Dewatering	21	8	10
Average Daily Traffic (ADT)	15	10	9
Classification of Roadway	12	9	9
Average Daily Truck Traffic (ADTT)	9	6	5
Traffic Speed	6	5	3
Type of Pavement	6	6	5
Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	6		8

Table 6.1 (Continued)

Criterion	Surface Deformation Group	Mine Opening Group	High Rating Group
Availability of Reasonable Detour Routes	6	2	3
Structures in Roadway	3	6	3
Minimum Overburden Thickness (Approx.)	2		4
Method of Mine Closure		10	
Type of Cribbing		10	
Mine Opening Location		9	
Minimum Overburden above Mine Opening		8	
Type of Mine Opening		5	
Plan Area of Mine Opening (Approx.)		4	
Age of Mining		4	8
Extraction			8
Maximum Mined Interval Thickness (Approx.)			8
Special Mine Features			2

Table 6.1 (Continued)

Problems Reported During Active Mining			2
Ratio Of Minimum Overburden Thickness to Maximum Mined Interval Thickness (Approx.)			6

6.4 DETAILED SITE EVALUATION FORMS

A Detailed Site Evaluation Form shall be completed for each site determined to be in either the Surface Deformation Group, Mine Opening Group, or the High Rating Group. A blank Detailed Site Evaluation form is provided for each of these three site groups as Figures 6.1, 6.3, and 6.5 . These forms are structured with a beginning section of site information, an Eliminated Sites Screening section, and then the main section listing the site evaluation criteria pertinent to the nature of the site. Corresponding examples of completed forms are provided as Figures 6.2, 6.4, and 6.6.

These forms are designed to develop an overall Detailed Site Evaluation rating based on the totaling of rating values for each listed individual site evaluation criterion. Each individual criterion rating value is calculated by multiplying a weighting factor times a rating value which represents a site condition. The weighting factors reflect the importance of the different criteria as related to one another for the given type of site. The completion of these forms will produce a prioritized site listing for each site group

6.4.1 Eliminated Sites Screening: The Surface Deformation Group Site Evaluation may result in the elimination of a small percentage of sites from this site group. The initial portion of the Surface Deformation Group Site Evaluation form pertains to the documentation of a site being designated as an eliminated surface deformation site. The decision to eliminate a site from the Surface Deformation Group indicates that site investigations and/or interviews have conclusively proven that the surface deformation at this site is not an apparent threat to the safety of the roadway. The exact location , orientation and limits of influence should be verified in the field and a determination should be made that any further surface settlement would not affect the roadway or roadside development.

Similarly, the Detailed Mine Opening Group Site Evaluation process may result in the elimination of a small percentage of mine opening sites from this site group. The initial portion of the Detailed Mine Opening Group Site Evaluation form pertains to the documentation of a site being designated as an eliminated mine opening site. The decision to eliminate a site from the Mine Opening Group indicates that site investigations and/or interviews have conclusively proven that the identified mine opening(s) at this site is (are) not an apparent threat to the safety of the roadway. The exact location , orientation, and limits of influence should be verified in the field. The coordinating District engineer should make a determination that the collapse of the located mine opening or mine closure would not affect the roadway or roadside development.

One pitfall to avoid in this part of the Detailed Site Evaluation of Surface Deformation and Mine Opening Sites is the elimination of sites without conclusive information indicating that the surface deformation activity or abandoned underground mine opening does not pose a threat to the roadway, and therefore the traveling public. If the available information for a given site does not provide conclusive proof that the surface deformation or mine opening is of no threat to the roadway, and therefore the traveling public, then the site should not be eliminated from the site group into which it has been placed

All sites which are eliminated from the Surface Deformation Group Site Evaluation will be separately considered as non-surface deformation Abandoned Underground Mine Inventory sites. Similarly, all sites which are eliminated from the Detailed Mine Opening Group Site Evaluation will be separately considered as non-mine opening Abandoned Underground Mine Inventory sites.

Ohio Department of Transportation

Abandoned Underground Mine Inventory
and Risk Assessment

Detailed Surface Deformation Site Evaluation

C/R/S/ (Mile Marker): ____________________ Field Report / Office Investigation No ____________________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.: __________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: __________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: __________ (If known.)

Name of Site Evaluator: ____________________ Evaluation Date: ____________________

ELIMINATED SURFACE DEFORMATION SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes_____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No______

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Number of Subsidences	30	Number of Subsidence Features on Site					
2) Recent Dewatering	21	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1	
3) Average Daily Traffic (ADT)	15	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	< 5K 2	
4) Classification of Roadway (NOTE: For Intersecting Roads, See Implementation Manual)	12	I.R. 10	NHS Other Than IR 7	Arterial 5	Collector 1		
5) Average Daily Truck Traffic (ADTT)	9	>6K 10	4K to 6K 8	2K to 4K 6	1K to 2K 4	< 1K 2	
6) Traffic Speed	6	>35 MPH 10	0 to 35 MPH 1				
7) Type of Pavement	6	Other 10	Continuously Reinforced 1				
8) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	6	Ratio = 1 or > 1 10	Ratio <1 1				
9) Availability of Reasonable Detour Routes	6	None 10	Yes 0				
10) Structures in Roadway	3	Yes 10	No 0				
11) Minimum Overburden Thickness (Approx.)	2	< 25' 10	25' - 50' 8	50' - 100' 5	>100' 1		
						Overall (Total) Site Evaluation Rating:	

COMMENTS (Attach additional sheets if necessary):

Figure 6.1: Detailed Surface Deformation Site Evaluation Form

Ohio Department of Transportation

Abandoned Underground Mine Inventory
and Risk Assessment

Detailed Surface Deformation Site Evaluation

C/R/S/ (Mile Marker) GUE-000-00.00 Field Report / Office Investigation No N/A

Site Description STATE ROUTE 000, APPROXIMATELY 2 MILES EAST OF OHIOVILLE

U.S.G.S. Topographic Quadrangle ODOT No. 0-W-00 O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: OHIOVILLE O.D.N.R. DGS Individual Abandoned Underground Mine Map Index No.: (if known) GY-00

Name of Site Evaluator J. DOE Evaluation Date 5/15/98

ELIMINATED SURFACE DEFORMATION SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not an apparent threat to the safety of the roadway? Yes____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING) No X

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Number of Subsidences	30	Number of Subsidence Features on Site: (6)					180
2) Recent Dewatering	21	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine (1)	21
3) Average Daily Traffic (ADT)	15	>30K 10	20K to 30K 8	10K to 20K (6)	5K to 10K 4	< 5K 2	90
4) Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	12	I.R. 10	NHS Other Than IR 7	Arterial (5)	Collector 1		60
5) Average Daily Truck Traffic (ADTT)	9	>6K 10	4K to 6K 8	2K to 4K (6)	1K to 2K 4	< 1K 2	54
6) Traffic Speed	6	>35 MPH (10)	0 to 35 MPH 1				60
7) Type of Pavement	6	Other (10)	Continuously Reinforced 1				60
8) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	6	Ratio = 1 or > 1 (10)	Ratio <1 1				60
9) Availability of Reasonable Detour Routes	6	None 10	Yes (0)				0
10) Structures in Roadway	3	Yes (10)	No 0				30
11) Minimum Overburden Thickness (Approx.)	2	< 25' 10	25' - 50' (8)	50' - 100' 5	>100' 1		16
					Overall (Total) Site Evaluation Rating:		631

COMMENTS (Attach additional sheets if necessary):

Figure 6.2: Example of a Completed Detailed Surface Deformation Site Evaluation Form

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed Mine Opening Site Evaluation

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No ______________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.: __________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: __________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No __________

Name of Site Evaluator ______________________ Evaluation Date: __________

ELIMINATED MINE OPENING SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine opening(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes_____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No______

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

	Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1)	Method of Mine Closure (NOTE: For Multiple Mine Openings See Implementation Manual)	10	No Information 10	Timber Decking 10	Random Backfill 6	Concrete Cap 4	Controlled Backfill 2	
2)	Type of Cribbing (NOTE: For Multiple Mine Openings and/or Multiple Forms of Cribbing See Implementation Manual)	10	No Information 10	Timbers 10	Brick 7	Concrete 4		
3)	Average Daily Traffic (ADT)	10	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	< 5K 2	
4)	Mine Opening Location (NOTE: For Multiple Mine Openings See Implementation Manual)	9	Location Not Conclusively Known 10	Between The Two Outer-Most Edge of Shoulders 10	Less Than 50 Feet From Edge of Shoulder 8	Between 50' and 100' From Edge of Shoulder 2	Within Sight From Edge of Shoulder 1	
5)	Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR 7	Arterial 5	Collector 1		
6)	Minimum Overburden above Mine Opening	8	Shaft or Cover = 0' 10	Slope/Drift Cover < 25' 9	Slope/Drift Cover = 25' - 50' 8	Slope/Drift Cover = 50' - 100' 5	Slope/Drift Cover >100' 1	
7)	Recent Dewatering	8	<1 Yr. 10	1 to 3 Yrs 9	4 to 6 Yrs 4	7 to 9 Yrs 2	>9 Yrs , Unknown, or Dry Mine 1	

Figure 6.3: Detailed Mine Opening Site Evaluation Form

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Criterion	Criterion Weighting Factor	Site Condition / Rating Value						Individual Criterion Rating
8) Average Daily Truck Traffic (ADTT)	6	>6K 10	4K to 6K 8	2K to 4K 6		1K to 2K 4	< 1K 2	
9) Type of Pavement	6	Other 10	Continuously Reinforced 1					
10) Structures in Roadway	6	Yes 10	No 0					
11) Traffic Speed	5	>35 MPH 10	0 to 35 MPH 1					
12) Type of Mine Opening (NOTE: For Multiple Mine Openings) See Implementation Manual)	5	Shaft (Vertical) 10	Slope 8	Drift (Horizontal) 6				
13) Plan Area of Mine Opening (Approx.) (NOTE: For Multiple Mine Openings) See Implementation Manual)	4	>750 Sq. Ft. 10	From 500 to 750 Sq. Ft. 8	From 250 to 500 Sq. Ft. 6	Mine Opening Size Unknown 5	From 150 to 250 Sq. Ft. 4	<150 Sq. Ft. 2	
14) Age of Mining	4	<1900, or Unknown 10	1900-1930 9	1931-1945 7		1946-1968 5	> 1968 1	
15) Availability of Reasonable Detour Routes	2	None 10	Yes 0					
				Overall (Total) Site Evaluation Rating:				

COMMENTS (Attach additional sheets if necessary):

Figure 6.3: Detailed Mine Opening Site Evaluation Form
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Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed Mine Opening Site Evaluation

C/R/S/ (Mile Marker): GUE - 000 - 00.00 Field Report / Office Investigation No N/A

Site Description: STATE ROUTE 000, APPROXIMATELY 2 MILES EAST OF OHIOVILLE

U.S.G.S. Topographic Quadrangle ODOT No.: O-W-00 O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: OHIOVILLE O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: GY-00

Name of Site Evaluator: J. DOE Evaluation Date: 5/15/98

ELIMINATED MINE OPENING SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine opening(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)
No X

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Method of Mine Closure (NOTE: For Multiple Mine Openings See Implementation Manual)	10	No Information 10 (circled)	Timber Decking 10	Random Backfill 6	Concrete Cap 4	Controlled Backfill 2	100
2) Type of Cribbing (NOTE: For Multiple Mine Openings and/or Multiple Forms of Cribbing See Implementation Manual)	10	No Information 10	Timbers 10	Brick 7	Concrete 4 (circled)		40
3) Average Daily Traffic (ADT)	10	>30K 10	20K to 30K 8	10K to 20K 6 (circled)	5K to 10K 4	< 5K 2	60
4) Mine Opening Location (NOTE: For Multiple Mine Openings See Implementation Manual)	9	Location Not Conclusively Known 10	Between The Two Outer-Most Edge of Shoulders 10	Less Than 50 Feet From Edge of Shoulder 8 (circled)	Between 50' and 100' From Edge of Shoulder 2	Within Sight From Edge of Shoulder 1	72
5) Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR 7 (circled)	Arterial 5	Collector 1		63
6) Minimum Overburden above Mine Opening	8	Shaft or Cover = 0' 10 (circled)	Slope/Drift Cover < 25' 9	Slope/Drift Cover = 25' - 50' 8	Slope/Drift Cover = 50' - 100' 5	Slope/Drift Cover >100' 1	80
7) Recent Dewatering	8	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1 (circled)	8

Figure 6.4: Example of a Completed Detailed Mine Opening Site Evaluation Form

Page 1 of 2

Criterion	Criterion Weighting Factor	Site Condition / Rating Value						Individual Criterion Rating
8) Average Daily Truck Traffic (ADTT)	6	>6K 10	4K to 6K 8	2K to 4K 6	1K to 2K 4	< 1K 2		36
9) Type of Pavement	6	Other 10	Continuously Reinforced 1					60
10) Structures in Roadway	6	Yes 10	No 0					0
11) Traffic Speed	5	>35 MPH 10	0 to 35 MPH 1					50
12) Type of Mine Opening (NOTE: For Multiple Mine Openings) See Implementation Manual)	5	Shaft (Vertical) 10	Slope 8	Drift (Horizontal) 6				50
13) Plan Area of Mine Opening (Approx.) (NOTE: For Multiple Mine Openings) See Implementation Manual)	4	>750 Sq. Ft. 10	From 500 to 750 Sq. Ft. 8	From 250 to 500 Sq. Ft. 6	Mine Opening Size Unknown 5	From 150 to 250 Sq. Ft. 4	<150 Sq. Ft. 2	8
14) Age of Mining	4	<1900, or Unknown 10	1900-1930 9	1931-1945 7	1946-1968 5	> 1968 1		28
15) Availability of Reasonable Detour Routes	2	None 10	Yes 0					20
				Overall (Total) Site Evaluation Rating:				675

COMMENTS (Attach additional sheets if necessary):

Figure 6.4: Example of a Completed Detailed Mine Opening Site Evaluation Form
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Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed Mine Opening Site Evaluation

C/R/S/ (Mile Marker): GUE - 000 - 00.00 Field Report / Office Investigation No N/A

Site Description: STATE ROUTE 000, APPROXIMATELY 2 MILES EAST OF OHIOVILLE

U.S.G.S. Topographic Quadrangle ODOT No.: 0-W-00 O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: OHIOVILLE O.D.N.R., DGS Individual Abandoned Underground Mine Map Index No.: GY-00

Name of Site Evaluator: J. DOE Evaluation Date: 5/15/98

ELIMINATED MINE OPENING SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine opening(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)
No X

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Method of Mine Closure (NOTE: For Multiple Mine Openings See Implementation Manual)	10	No Information 10 (circled)	Timber Decking 10	Random Backfill 6	Concrete Cap 4	Controlled Backfill 2	100
2) Type of Cribbing (NOTE: For Multiple Mine Openings and/or Multiple Forms of Cribbing See Implementation Manual)	10	No Information 10	Timbers 10	Brick 7	Concrete 4 (circled)		40
3) Average Daily Traffic (ADT)	10	>30K 10	20K to 30K 8	10K to 20K 6 (circled)	5K to 10K 4	< 5K 2	60
4) Mine Opening Location (NOTE: For Multiple Mine Openings See Implementation Manual)	9	Location Not Conclusively Known 10	Between The Two Outer-Most Edge of Shoulders 10	Less Than 50 Feet From Edge of Shoulder 8 (circled)	Between 50' and 100' From Edge of Shoulder 2	Within Sight From Edge of Shoulder 1	72
5) Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR 7 (circled)	Arterial 5	Collector 1		63
6) Minimum Overburden above Mine Opening	8	Shaft or Cover = 0' 10 (circled)	Slope/Drift Cover < 25' 9	Slope/Drift Cover = 25' - 50' 8	Slope/Drift Cover = 50' - 100' 5	Slope/Drift Cover >100' 1	80
7) Recent Dewatering	8	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1 (circled)	8

Figure 6.4: Example of a Completed Detailed Mine Opening Site Evaluation Form

Page 1 of 2

Criteria	Criteria Weighting Factor	Site Condition / Rating Value				Individual Criteria Rating
12) Structures in Roadway	3	Yes 10	No 0			
13) Traffic Speed	3	>35 MPH 10	0 to 35 MPH 1			
14) Availability of Reasonable Detour Routes	3	None 10	Yes 0			
15) Special Mine Features	2	Intersecting Haulways 10	Entry 5	Large Room 5	None 0	
16) Problems Reported During Active Mining	2	Yes 10	No/Not Known 0			
				Overall (Total) Site Evaluation Rating:		

COMMENTS (Attach additional sheets if necessary):

Figure 6.5: Detailed High Rating Site Evaluation Form

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Ohio Department of Transportation

Abandoned Underground Mine Inventory
and Risk Assessment

Detailed High Rating Site Evaluation

C/R/S/ (Mile Marker): GUE-000-00.00 Field Report / Office Investigation No: N/A

Site Description: STATE ROUTE 000, APPROXIMATELY 2 MILES EAST OF OHIOVILLE

U S G S Topographic Quadrangle ODOT No: 0-W-00 O D N.R. Abandoned Underground Mine Series (U S G S) Map: OHIOVILLE O.D.N.R., DGS Individual Abandoned Underground Mine Map Index No. (If known): GY-00

Name of Site Evaluator: J. DOE Evaluation Date: 5/15/98

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Minimum Overburden Thickness (Approx.)	4	< 25' 10	25' - 50' (8)	50' - 100' 5	>100' 1		32
2) Recent Dewatering	10	<1 Yr. 10	1 to 3 Yrs. (9)	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1	90
3) Average Daily Traffic (ADT)	9	>30K 10	20K to 30K (8)	10K to 20K 6	5K to 10K 4	< 5K 2	72
4) Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR (7)	Arterial 5	Collector 1		63
5) Extraction	8	Secondary (10)	>50% 7	Unknown 5	<50% 1		80
6) Maximum Mined Interval Thickness (Approx.)	8	>6' 10	3' - 6' (5)	0' - 3' 1			40
7) Age of Mining	8	<1900, or Unknown 10	1900-1930 (9)	1931-1945 7	1946-1968 5	> 1968 1	72
8) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	8	Ratio= 1 or > 1 10	Ratio <1 (1)				8
9) Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6	Ratio < 5 10	Ratio = 5 to 11 (5)	Ratio >11 1			30
10) Average Daily Truck Traffic (ADTT)	5	>6K 10	4K to 6K (8)	2K to 4K 6	1K to 2K 4	< 1K 2	40
11) Type of Pavement	5	Other (10)	Continuously Reinforced 1				50

Figure 6.6: Example of a Completed Detailed High Rating Site Evaluation Form

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Criteria	Criteria Weighting Factor	Site Condition / Rating Value				Individual Criteria Rating
12) Structures in Roadway	3	Yes 10 (circled)	No 0			30
13) Traffic Speed	3	>35 MPH 10 (circled)	0 to 35 MPH 1			30
14) Availability of Reasonable Detour Routes	3	None 10	Yes 0 (circled)			0
15) Special Mine Features	2	Intersecting Haulways 10 (circled)	Entry 5	Large Room 5	None 0	20
16) Problems Reported During Active Mining	2	Yes 10	No/Not Known 0 (circled)			0
					Overall (Total) Site Evaluation Rating:	657

COMMENTS (Attach additional sheets if necessary):

Figure 6.6: Example of a Completed Detailed High Rating Site Evaluation Form

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SECTION 7:

Priority Site Investigation

7.1 GENERAL DISCUSSION

The purpose of the Priority Site Investigation is to develop a comprehensive body of information to which the evaluation criteria in Section 8 should be applied to develop Priority Site Recommendations. This body of information should include gathered existing information, information from the site visit and site monitoring, and information gathered from newly conducted site investigations as described in this manual section. The coordinating District engineer should be aware that unmapped portions of the subject mine(s) and/or other unmapped mines may be present in the immediate vicinity. These mines may be more prone to failure than the identified, mapped mine(s). The Priority Site Investigation should include limited field work in adjacent, suspect areas to determine the existence, condition and extent of any adjacent unmapped mines.

Priority Site Investigations should be performed in the order of the prioritized listing of the sites for each of the Detailed Site Evaluation risk assessment site groups. All sites within the particular Detailed Site Evaluation risk assessment group should be individually investigated before this work proceeds to sites in the next lower Detailed Site Evaluation group.

For an individual site to be the subject of this step in the risk assessment portion of the process, it should be the uninvestigated site with the highest risk assessment rating in the District. This site priority should have been documented by the prioritized site listing for the Detailed Site Evaluation Group in which the site is included.

7.2 NOTIFICATIONS

The coordinating District engineer should notify the appropriate highway authority staff and outside agencies of the intent to conduct investigations on the priority site. The appropriate staff to be notified should include: 1) the District Deputy Director; 2) the District Highway Management Administrator; 3) the District Public Information Officer; 4) the County Manager; 5) the Administrator of the Office of Highway Management in the Central Office; 6) the Ohio Highway Patrol, and; 7) the Ohio Department of Natural Resources, Division of Mining and Reclamation and the Division of Geological Survey.

The coordinating District engineer should remain in close communication with the County Manager throughout the site investigation. The engineer should review past maintenance records for the site with the County Manager. The coordinating District engineer should keep the County Manager informed of new site information as it becomes available as the result of the site investigations. This channel of communication is very important.

WARNING:

The District and the county need to be prepared to manage the worst case conditions that might be revealed during Priority Site Investigations. Investigations may indicate the need for immediate road closure and/or emergency remediation. The availability and identification of reasonable detour routes, as documented in the Detailed Site Evaluation, should be reviewed with the District Roadway Services Manager and the County Manager. If Emergency Action/ Road Closure is considered, refer to Section 10.

7.3 REVIEW OF ALL AVAILABLE INFORMATION

All available information should be acquired and reviewed before on-site investigations are planned and initiated in the field. Additional information which should be acquired at this time includes: 1) roadway construction diaries; 2) historic and new aerial photography (conventional and infrared if available or needing to be ordered), 3) satellite imagery (if available), and ; 4) ODNR, DGS Quaternary Geology Maps. This information should be added to the site information gathered during the inventory and risk assessment process through Detailed Site Evaluation. (See Appendix C).

Most of the available geological and historic mining information will be acquired from the ODNR, Division of Geological Survey. Other valuable ODNR information may also be acquired by contacting the ODNR, Division of Mining and Reclamation District Abandoned Mine Land (AML) Project Officer. The coordinating District engineer should contact the appropriate ODNR, DMR Project Officer to inform them of the impending ODOT priority site investigation and to request local AML information and/or assistance in site investigations.

The District should develop a composite plan view of the priority site by overlaying the best available roadway drawings and the acquired ODNR, DGS mine map(s). This plan view should be digitally compiled, if possible, for the best accuracy. Accuracy of this overlaying process is critical for the best interpretation of other existing information and the information which will result from the impending site investigations.

A copy, or copies, of the above-described composite plan view should be utilized to indicate points on the site where existing information has been acquired and reviewed. The actual information for these points should also be added to the composite plan view if practical.

This work should allow the District to be as informed as possible before beginning the decision making process of planning and initiating site investigations in the field. This informational review is important because the District will be committing its limited inventory and risk assessment resources to this one particular site. The more efficient such a field operation can be, the more sites the District will be able to afford to investigate in the interest of the public safety.

7.4 FIELD INVESTIGATIONS

7.4.1 Area of Investigations: The purpose of these site investigations is to determine if the existing roadway, including shoulders, is supported by stable subgrade materials. The minimum width of the investigation area should eliminate any roadway areas from remaining in the surface area which could be influenced by the subsidence of mines directly beneath, or adjacent to, the roadway. Investigations data may verify the existence of stable conditions or provide information in support of the recommendation to stabilize a portion, or portions, of the known abandoned underground mine(s) so as to effectively guarantee the future stability of the roadway site.

The coordinating District engineer should designate an investigations area including the roadway and adjacent areas. This work should be done prior to the layout of the ground survey baseline and initiation of field investigations. The width of this investigations area perpendicular to the roadway centerline should be defined by the area from the outside edge of paved shoulder to outside edge of paved shoulder, plus an additional distance beyond the edge of each paved shoulder to allow for surface subsidence related to adjacent mines. This additional distance beyond the edge of the paved shoulder should be equal to the depth of the overburden at the edge of the paved shoulder times the trigonometric tangent value for the angle of draw. If a specific angle of draw is not known for the particular site geology, an angle of draw value of 35 degrees should be considered for use as a rough rule of thumb (Figure 7.1).

7.4.2 Forms of Investigative Techniques: Based on the earlier performed review of all available information, the District should select the forms of investigative techniques to be conducted on the priority site. These investigative techniques should either be of a non-intrusive or intrusive nature.

Non-intrusive investigations are defined as those techniques which are conducted on the roadway without any resulting physical affect or damage. Intrusive investigations are defined as those techniques which affect the roadway site at, and possibly below, grade. Non-intrusive investigations should be conducted first so that the data acquired can be utilized to direct the intrusive investigations for maximum efficiency, with minimum roadway damage.

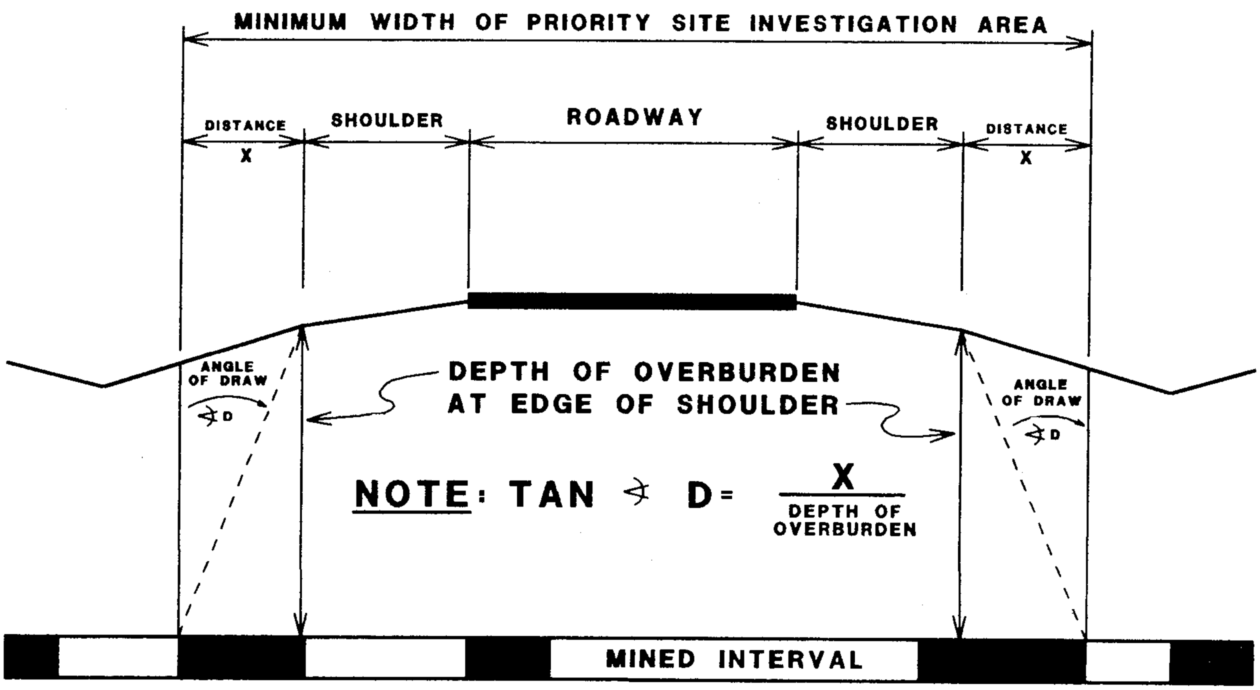

Figure 7.1 : Minimum Width of Priority Site Investigation Area
N.T.S.

The two forms of investigations are discussed in the following text. The District should choose which of these investigative techniques is applicable for the priority site. Site location, anticipated soil and rock conditions in the overburden, groundwater conditions and chemical constituents, and above and below ground constraints should define which investigative techniques are appropriate for the priority site.

As priority site investigations are conducted, copies of the earlier described composite plan view should serve as working drawings to display new information and/or data. All information resulting from non-intrusive and intrusive investigations should be referenced to the established, ground surveyed baseline.

A detailed discussion of the nature, applications, and limitations of the individual forms of investigations is presented in Section 5: Site Monitoring. The following text discusses the use of the available techniques for Priority Site Investigations.

7.4.2.1 Non-Intrusive Investigations:

7.4.2.1.1 Ground Survey Techniques: The very first on-the-ground activity for a priority site investigation should be the establishment of a surveyed, stationed baseline throughout the site. This stationing will allow for the different forms of site data to be commonly indexed for comparative analysis.

All point elevations to be monitored, as they are known at this time, should be identified and their elevation accurately recorded through ground survey.

7.4.2.1.2 Aerial Photography: The District should request, from the Office of Aerial Engineering , a listing of the available historic aerial photography for the site. The District should review this list, determine the aerial photography which would be of interest to the site investigation, and order that photography from the Office of Aerial Engineering. Depending on the date and type of film exposed for the most recent aerial photography, new aerial photography, if needed, should be requested from the Office of Aerial Engineering.

Older historic photography may show above-ground abandoned underground mine structures, previous roadway alignments, and/or original stream bed locations which may also appear on the individual abandoned underground mine map(s).

Conventional aerial photography should be useful in detecting particular features, including subsidence features, drainage irregularities, and abandoned mine-related structures .

The particular advantage of infrared photography over conventional photography is that in some cases it can detect localized variations in ground vegetation or areas of differential surface temperatures. These forms of information may be key indicators of either surface subsidence, irregular drainage features, near-surface voids or unconsolidated conditions not otherwise notable during ground reconnaissance.

Aerial photography should be reviewed in the office, and particular features to be verified or investigated on the site should be marked with a grease pencil.

7.4.2.1.3 Visual Observations: The District should perform a walking reconnaissance of the entire roadway site. Particular features grease penciled on aerial photography should be investigated during this work. This reconnaissance should be conducted as the first on-the-ground activity by the District and should involve a visual inspection of the full width of the right-of-way. The County Manager, or their chosen representative should be invited to attend this reconnaissance for the purpose of identifying any areas where unusual maintenance problems may have occurred on the site.

7.4.2.1.4 Measurements of Particular Features: Features previously noted on original site data sheets and/or noted during succeeding site monitoring should be physically measured. New measurements should be compared to any previous ones. This comparison of current and past measurements of the same features may provide information on the occurrence and severity of subsidence activity in the site area.

7.4.2.1.5 Falling Weight Deflectometer (FWD): If applicable for the nature of the priority site, the FWD should be run in all lanes and all shoulders where possible. FWD data should be analyzed for points of outlying data as an indicator of areas having shallow, anomalous subsurface conditions. FWD data will be in the form of numerical values indexed to each of the seven FWD sensors. These sensors are designated as DF1 through DF7. The DF1 sensor is the closest geophone to the falling weight, and therefore collects the shallowest subgrade data. The DF7 sensor is the farthest geophone from the falling weight, and therefore collects the deepest subgrade data.

The following are general rules of thumb for analyzing FWD raw data:

1) High DF1's and average DF7's probably indicate weak pavement conditions.

2) Average DF1's and high DF7's probably indicate weak subgrade conditions.

3) High DF1's and high DF7's could indicate a problem area.

4) Significantly different values for DF1 through DF7 other than what appears to be the average range of values typical for the site may indicate areas of subsurface anomalies

7.4.2.1.6 Heavy Weight Deflectometer (HWD): If applicable for the nature of the priority site, the HWD should be run in all lanes and all shoulders where possible. HWD data should be analyzed for points of outlying data as an indicator of areas having shallow, anomalous subsurface conditions. The District should exercise caution in choosing the amount of weight to be dropped by the HWD. Excessive weight dropped on the pavement may damage some travel lanes and/or shoulders. If this damage occurs, the HWD becomes an intrusive, rather than non-intrusive, form of site testing.

7.4.2.1.7 Profilometer: The profilometer should be run in all driving lanes and shoulders where possible for the purpose of detecting settlements (troughing) or heave of the pavement. Any troughing locations detected within a site should be further investigated as possible points where pavement could be bridging shallow, anomalous subsurface conditions or voids. Areas of heave may be detected adjacent to areas of subsidence.

7.4.2.1.8 Dynaflect: If applicable for the nature of the priority site, the Dynaflect should be run in all lanes and all shoulders where possible. Dynaflect data should be analyzed for points of outlying data as an indicator of areas having shallow, anomalous subsurface conditions.

7.4.2.1.9 Surface Ground Penetrating Radar (GPR): The GPR should be run in all lanes to look for anomalies and/or voids in the subgrade immediately below the reinforced pavement. GPR may detect pavement bridging over unconsolidated soil conditions and/or voids. GPR data collected in non-reinforced, paved shoulder areas may detect deeper subsurface soils anomalies. The depth of GPR penetration is highly site-specific, based on soil, bedrock, and groundwater characteristics.

7.4.2.1.10 Microgravity: This form of testing is very time consuming and requires all traffic removed from the roadway. Resulting data may show reduced gravity values in the presence of voids or disturbed subsurface materials. This testing technique should be utilized as a secondary non-intrusive form of investigation. Its best application may be for smaller areas where other forms of non-intrusive testing, such as FWD, profilometer, etc., have recorded anomalous data.

7.4.2.1.11 Surface Seismic Studies: Surface seismic studies may be conducted to create a profile of the below-grade bedrock surface. This information can be utilized to determine the soil-to-rock ratio of the overburden lying between the roadway grade and the top of the abandoned underground mine voids. Surface seismic studies may also be utilized to record the bedrock structure below the roadway. These studies may be able to detect unconsolidated bedrock conditions indicating lower lying mine voids or subsidence activity.

7.4.2.1.12 Resistivity: Resistivity studies may provide data indicating the subsurface location of soil anomalies and/or voids. Success of this investigative technique is site-specific, based on soil, bedrock, and groundwater characteristics.

7.4.2.1.13 Electromagnetic Scanning: This technique should be considered as a possible means to find mine haulage way rails and concentrations of roof bolts, etc. However, it is sensitive to adjacent traffic and/or other metallic objects. Electromagnetic scanning should still be considered on sites where the equipment can be operated well away from passing vehicles. One example of such a location would be at the edge of the right-of- way in rural settings.

7.4.2.1.14 Comparative Analysis of Non-Intrusive Data: Past ODOT experience in utilizing several forms of non-intrusive data on study areas has not revealed one particular form of geophysical testing that will alone provide well-defined locational information for evidence of subsurface soils anomalies and/or voids. Correlation between areas of anomalous data recorded by several different non-intrusive types of investigations has been found on some past sites. These areas were then targeted for further investigated during later intrusive site investigations.

The coordinating District engineer should perform a comparative analysis of the data resulting from the various chosen non-intrusive forms of investigations. This effort should basically involve a unified compilation of the of anomalous data locations detected by all the chosen non-intrusive forms of investigations. This compilation should be performed on a copy of the composite plan view.

Once this data compilation has been performed, the resulting plan view displaying the information should be studied for: 1) concentrations (common areas) of data anomaly occurrence, and; 2) patterns of data anomalies which might suggest verification of, or adjustment needing to be made to, the abandoned underground mine location as displayed on the composite plan view.

This new information, and the previously collected existing information, should be considered, as a whole, in specifying and directing forms of intrusive investigations to be performed as a next phase of priority site investigations.

7.4.2.2 Intrusive Investigations:

7.4.2.2.1 WARNINGS:

1) BE CERTAIN NOT TO CREATE A MINE DEWATERING EVENT.

2) CALL THE OHIO UTILITY PROTECTION SERVICE (OUPS) 48 HRS BEFORE DRILLING OR EXCAVATING

7.4.2.2.2 Drilling Program: The coordinating District engineer should formulate a subsurface investigations program. This program should be tailored to the individual site and should only involve drilling enough boreholes to define the extent of the abandoned underground mine and the conditions in and above that mine in areas of higher concern. Examples of areas of higher concern would include those locations where surface subsidence has been detected, or where various forms of non-intrusive investigations have commonly recorded anomalous data. Other areas of higher concern would include locations where a main haulage way, main mine entry, large mine room, intersecting haulage ways, or areas of low cover or changed cover are suspected of being located beneath the roadway.

Maps for several different abandoned underground mines may exist for the priority site being investigated. A gap between the available underground mine maps , or a lack of information within or along the edge of, one of the available maps, may exist for portions of the site. These roadway areas should be the subject of limited subsurface investigations for the purpose of determining if unmapped underground mines do exist in these areas, and if so, what the conditions are within the mine. Boreholes executed within these areas should be limited and staggered at uneven intervals. Once mines are encountered in these areas and the conditions within these mines are determined, drilling of the unmapped area should be terminated and the subsurface explorations should move on to the next area.

The potential danger of vertical or horizontal surface subsidence or collapse is possible in and around abandoned mine openings. This subsidence may occur as the result of settlement related to existing, unstable mine opening backfill material. Another cause of such subsidence may be the failure of existing mine opening cribbing. Any work proposed and performed in the vicinity of such a potential mine opening site should address the necessary safety considerations for such potential occurrences of collapse. Such events of collapse or surface subsidence may be induced by the physical disturbance or vibration induced by surface activities. The surcharge of surface loading, such as the weight of equipment and any materials stockpiled on the site, may also induce a subsurface failure of mine cribbing.

Initial intrusive investigations at potential shaft locations should involve angle drilling to define the shaft location and condition(s). The coordinating District engineer should designate a danger zone surrounding the potential shaft location prior to any investigations. This danger zone should be defined by the expected shaft dimensions plus an additional distance away from the shaft equivalent to the overburden depth at the mine shaft multiplied by the trigonometric tangent value for the angle of draw. If a specific angle of draw is not known for the particular site geology, an angle of draw value of 35 degrees should be considered for use as a rough rule of thumb (Figure 7.2). Initial drilling locations should lie outside of this shaft danger zone.

The drilling program should specify: 1) number, location and angle (if applicable) of proposed boreholes; 2) recovery of boxed cores and/or soil samples as required; 3) receipt of written borehole logs, and; 4) the type and frequency of testing to be conducted on recovered cores and/or samples. Boreholes should be located in shoulder and berm areas when possible. All boreholes should be sealed in accordance with the current <u>ODOT Specifications for Subsurface Investigations</u>.

All boreholes should be cased upon completion if the borehole location permits the temporary extension of the casing above grade. These cased holes can serve at a minimum as groundwater observation wells during investigations. They would provide an opportunity for groundwater sampling and flow monitoring. They may also be utilized for remedial construction purposes in the case where subsurface conditions require immediate placement of stable materials in encountered voids beneath the roadway. Boreholes which cannot be temporarily cased should be sealed.

At the conclusion of priority site investigations or any resulting remedial construction, some cased boreholes may either be modified to remain as

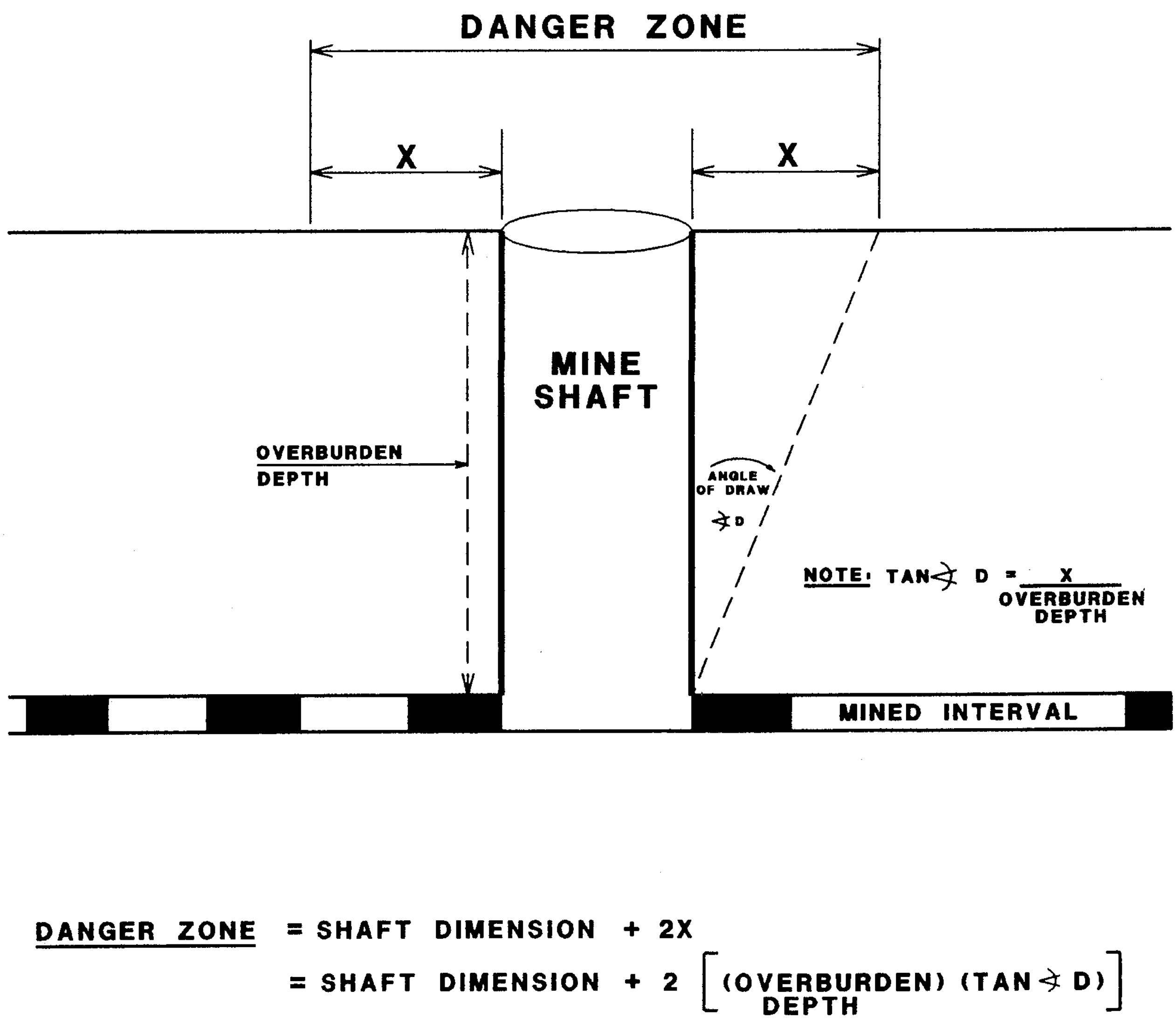

Figure 7.2 : Shaft Danger Zone
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permanent piezometers or observation wells utilized for groundwater monitoring. The casings should be removed from all other remaining boreholes and the boreholes should be sealed by tremie grouting. The use of tremie grouting is important to construct continuous grout columns in boreholes through consolidated materials, and to increase the likelihood for lateral placement of grout in mine voids encountered by some boreholes.

Even if the conditions within a mine at the location of one of these boreholes has been judged to be reasonably stable, it is still important to consider tremie grouting the mine void(s) at these borehole locations. The reason for this is that the drilling of the borehole itself may have created a weakened point in the mine roof by shattering the structure of the bedrock. Lateral placement of grout at these borehole locations would construct a pillow of grout which would provide support to the mine roof.

Boreholes which are to be sealed by tremie grouting may also be considered for their potential value as post-investigations time domain reflectometry (TDR) monitoring locations.

Analysis of rock cores should, as a minimum, include determination of Rock Quality Designation (RQD) for each borehole location. Testing of rock cores for unconfined compressive strength should also be considered depending on availability of laboratory services and time required for such core testing.

Soil samples, as a rule of thumb, should be taken at five foot intervals. Samples should be tested for Standard Penetration, gradation, Atterburg limits, and moisture content. ODNR, DGS Quaternary Geology maps should be consulted when recording the nature of the different unconsolidated materials recovered in the soil samples.

7.4.2.2.3 Borehole Monitoring: As mentioned briefly above, a borehole has utility beyond providing physical samples and a log of the in-situe soils and bedrock. There are a number of forms of site monitoring which should be considered for utilization if a subsurface investigations program is to be performed.

7.4.2.2.3.1 Borehole Ground Penetrating Radar (GPR): Borehole GPR data collected between closely spaced boreholes may provide information related to areas of subsurface anomalies and/or voids. This subsurface investigative technique will be more applicable if other forms of intrusive testing have already isolated a relatively small area in which the borehole GPR might then be utilized.

7.4.2.2.3.2 Time Domain Reflectometery (TDR): Some boreholes which are to be sealed by tremie grouting may also be considered for their potential value as post- investigations time domain reflectometry (TDR) monitoring locations. TDR coaxial cables properly tremie grouted into boreholes can provide ongoing, low cost earth movement monitoring information or can alternately be installed to function as a piezometer or observation well .

7.4.2.2.3.3 Slope Inclinometer: A slope inclinometer may provide subsurface, lateral earth movement ("sidedraw") data in areas adjacent to subsidence areas. However, TDR monitoring points may provide the needed information for a lesser cost.

7.4.2.2.3.4 Borehole Seismic Studies: Borehole seismic studies may provide very good location information for subsurface soil anomalies and/or voids. Pairs of boreholes, one on each side of the area to be analyzed, are required to conduct this work.

7.4.2.2.3.5 Borehole Video Camera: This form of borehole monitoring can provide real time viewing of subsurface conditions in the borehole. This information can help with interpretation of drilling results immediately following removal of the drill tools from the borehole. Borehole camera viewing of the entire section of overburden requires a stable, uncased borehole. If the overburden is unstable, the camera can be lowered through hollow stemmed augers or casing. The video tape of this information can immediately be available for presentation to management in the case of high risk conditions being encountered.

7.4.2.2.3.6 Piezometers: Piezometers can provide valuable short-term and long-term data. This information is valuable in assessing the affects that ground water may play in the hydrogeological environment of which the abandoned underground mine is a part. Piezometers should first be installed into the abandoned underground mine well upslope of any areas where future excavations into the coal mine or coal seam are anticipated. These piezometers will provide information on the static head of any mine pool existing in the portion of the mine to be studied.

The ground elevation of initially installed piezometers should be greater than the maximum head possible within the mined mineral seam. This elevation can be estimated by first determining the highest elevation of the base of the mineral seam within the mine. This work can be accomplished usually by: 1) finding the highest mine floor elevations displayed on the furthest up-dip extent of the available abandoned underground mine map, or; 2) finding the highest base elevations of the mined mineral seam for the furthest up-dip extent of the mined mineral utilizing structural geological information obtained from the ODNR, Division of Geological Survey (DGS). The suggested approximate elevation of initially installed piezometers would then be calculated by adding the maximum reported mined mineral seam thickness to the maximum, up-dip elevation of the base of the mineral seam within the mine. If geologic units above and below the mined mineral seam are hydraulically "connected" with the mined unit, then the above-described simplistic calculation of hydostatic head in the abandoned mine may not apply.

Particular attention should be given to the possibility of an interconnection between the mine(s) under the roadway and other adjacent mines. All available maps should be reviewed in light of this possibility. It is possible that an abandoned underground mine beneath a roadway may be interconnected to one or more similar mines having a slightly higher elevation and lying beyond the right- of -way If such an interconnection may exist, the highest mine floor elevation found in the interconnected mine(s) should be used for the above calculation of the initial piezometer elevation.

7.4.2.2.3.7 Observation Wells: Observation wells provide valuable information particularly if remediation may follow priority site investigations. A loosely cased borehole with no annular sealing most likely represents the type of casing that would be utilized if drilling and grouting operations were performed. Groundwater levels recorded in these wells will provide a good indication of the conditions which would need to be overcome by any proposed remediation. The elevation of initially installed piezometers should be determined as described above for piezometers.

7.4.2.2.4 Exploratory Excavation:

7.4.2.2.4.1 WARNINGS:

1) MINE POOL CONDITIONS SHOULD BE DETERMINED BEFORE EXCAVATION IS INITIATED.

2) MINES WILL "BREATH" AS THE RESULT OF CHANGING BAROMETRIC PRESSURE. OUTSIDE AIR WILL BE DRAWN INTO THE MINE VOID(S) ON DAYS WHEN THE BAROMETRIC PRESSURE IS RISING. AIR, INCLUDING ANY EXISTING GASES, WILL BE EXPELLED FROM THE MINE VOID(S) ON DAYS WHEN THE BAROMETRIC PRESSURE IS DROPPING. EXPELLED GASES MAY BE OF AN EXPLOSIVE AND/OR LETHAL NATURE.

3) GAS MONITORING EQUIPMENT SHOULD BE ON-SITE AND IN OPERATION DURING ANY EXCAVATIONS INTO POSSIBLE MINE VOIDS. THIS EQUIPMENT SHOULD BE USED TO DETECT ANY GASES WHICH MAY BE EXPELLED FROM ENCOUNTERED MINE VOIDS.

4) UNDER NO CIRCUMSTANCES SHOULD ANYONE ENTER ANY EXPOSED MINE WORKS.

5) MINE WORKS EXPOSED DURING EXCAVATIONS SHOULD BE SEALED BEFORE THE SITE IS LEFT UNATTENDED. THIS SEALING WILL PREVENT PERSONS FROM ACCESSING THE SITE AND ENTERING DANGEROUS MINE WORKS.

7.4.2.2.4.2 General Discussion: Exploratory excavation is a tempting option when surface features suggest limited excavation required to reveal conditions in a suspected mine subsidence feature or collapsed mine entry. Though it is true that in some cases such excavation might be accomplished relatively quickly, the consequences could be serious and substantial. A sudden release (hydraulic "blow-out") of a mine pool or the release of gases from within an excavated mine could instantaneously be upon the personnel performing the excavations, as well as the general public traveling the roadway and living in the surrounding area. A hydraulic "blow out" may occur when excavation removes the stabilizing barrier of the mined mineral seam which is resisting the hydraulic head within an adjacent, flooded mine (Figure 7.3).

An example of this situation would be if a priority site investigations coordinating engineer decided to order a backhoe to excavate along an apparent coal seam cropline where an iron/sulfate bearing seepage

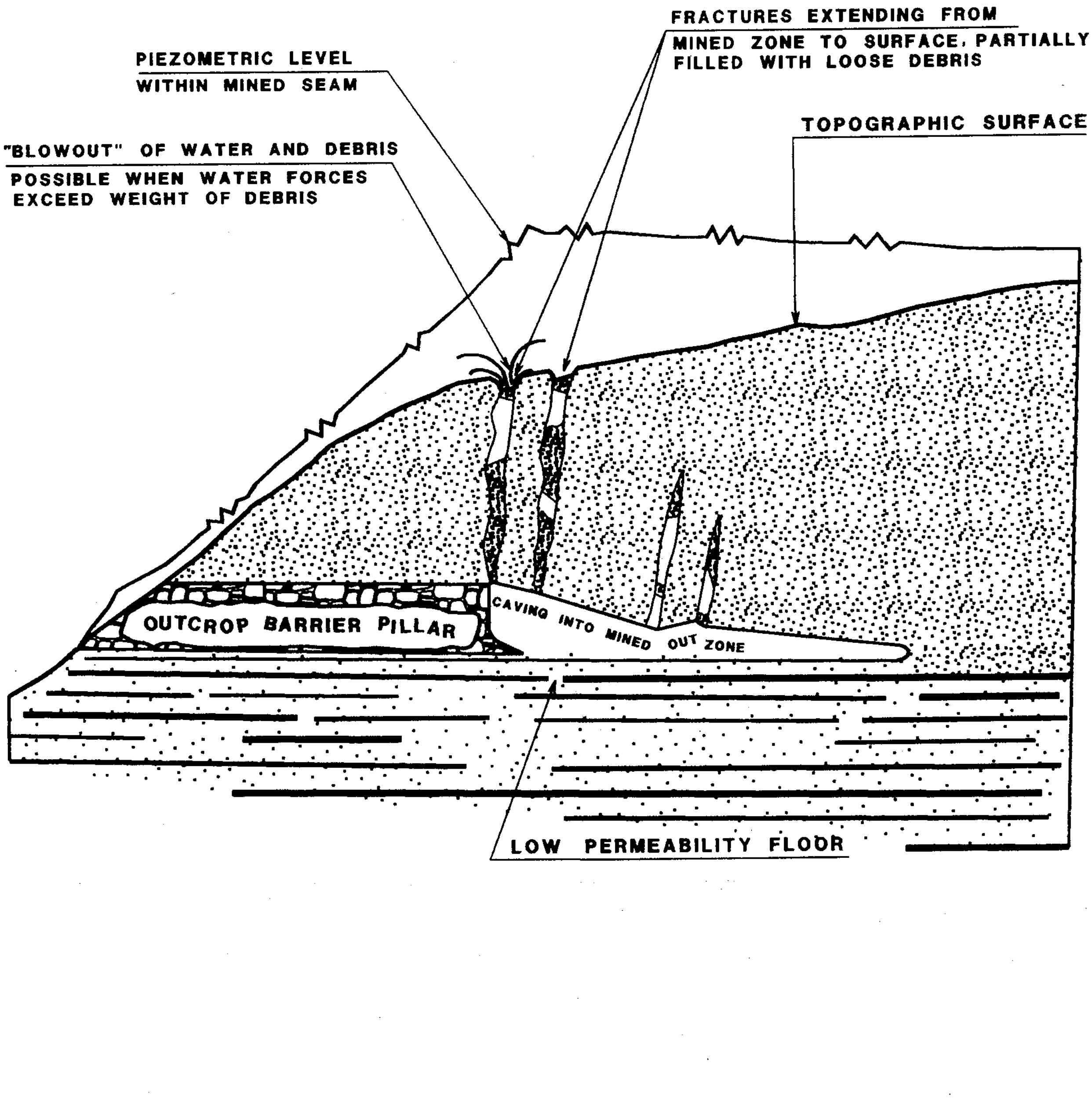

Figure 7.3 : Potential Hydraulic "Blowout" Location

Source : U.S.D.I., Office of Surface Mining

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zone suggested the possibility of an entry into an abandoned underground mine. If excavation operations were to encounter a water-filled void, a rapid uncontrollable release of mine water would occur.

The dewatering of an abandoned underground mine void can have a destabilizing effect on conditions within the particular mine intercepted. Such a dewatering event can also cause the dewatering and destabilizing of adjacent, interconnected mines. Surface subsidence activity in areas overlying such dewatered mines may be induced or accelerated by dewatering.

The coordinating District engineer should review elevations shown on the available abandoned underground mine map(s) and be certain there is no possibility of mine pool dewatering before considering excavation. Piezometers and/or observation wells should be established to provide information on the static hydraulic head of any existing mine pool(s) in the area to be excavated. Monitoring equipment for methane, carbon monoxide, hydrogen sulfide and oxygen should be utilized in areas of excavation. This monitoring is particularly critical in low-lying, or below-grade, areas of excavation.

Any excavations having a vertical aspect (a downward or partially downward direction) may induce further collapse of the materials upon which the excavation equipment and personnel are located. Small surface subsidence features can sometimes be associated with much larger voids below grade.

7.4.2.2.4.3 Surface Features in Shallow Overburden Areas: Excavation of such features can still have the danger of sudden mine dewatering, releases of deadly and/or explosive mine gases, and the possibility of induced further collapse. As mentioned above, such features can often be associated with a much larger existing void below grade.

7.4.2.2.4.4 Mine Openings: Excavation of these features can have all the dangers described in the early excavation discussions. Prior to any excavation, shaft and slope entry location and conditions should be determined through angle drilling from surface locations outside of the potential shaft danger zone. Please refer to the related discussions in the earlier 7.4.2.2.2. Drilling Program text and to Figure 7.2.

As discussed in the above-referenced text, the potential danger of vertical or horizontal surface subsidence or collapse is possible in and around abandoned mine openings. This subsidence may occur as the result of settlement related to existing, unstable mine opening backfill material. Another cause of such subsidence may be the failure of existing mine opening cribbing. Any work proposed and performed in the vicinity of such a potential mine opening site should address the necessary safety considerations for such potential occurrences of collapse. Such events of collapse or surface subsidence may be induced by the physical disturbance or vibration induced by surface activities. The surcharge of surface loading, such as the weight of equipment and any materials stockpiled on the site, may also induce a subsurface failure of mine cribbing.

Excavation of such sites is often most safely performed utilizing a crane with clam-shell bucket. The crane should be located outside of the shaft danger zone.

7.4.2.2.5 Compilation of Intrusive Investigations Data: Data from the different forms of intrusive investigations should be compiled on a copy of the composite plan view so as to create a comprehensive view of this data. This compilation should include detailed notations of actual information if practical.

7.4.2.2.5.1 Cross-sectional Plotting of Data: A cross section of all the developed data should be plotted to display, in profile, the existing mine and conditions, as determined by the various investigative techniques. Data should be displayed at the appropriate stations, with left or right of centerline off-set notations. Separate profiles, both left and right, should be alternatately developed for divided roadways.

If left and right cross sectional profiles are developed, information for a common mine panel (room), haulage way, etc. may appear at approximately the same elevation on the left and right profiles. However, these same features may appear at different horizontal stations on left and right profiles unless the common feature runs exactly perpendicular to the roadway centerline.

7.4.2.2.5.2 Comparative Analysis: As with the non-intrusive data, the resulting intrusive data compilation should be studied for: 1) concentrations (common areas) of anomalous data or void detections, and; 2) patterns of anomalous data or void detections which might suggest verification of, or adjustment needing to be made to, the abandoned underground mine map location(s) as displayed on the existing composite plan view. Adjustments of the composite plan should be made where judged appropriate by the coordinating District engineer. Comparative analysis may reveal data from different intrusive studies that clearly document, or strongly suggest, similar or different subgrade conditions.

7.5 COMPREHENSIVE REVIEW AND INTERPRETATIVE SUMMARY OF ALL SITE INFORMATION

The coordinating District engineer should collect all investigations data and all previously gathered information. This information can be used to synthesize the best evaluation of the site conditions as related to the abandoned underground mine lying beneath or nearby the roadway. This effort should include an effort to develop correlations between data anomalies, void detections, surface deformations, etc. in the site investigations information. It should also define locations, areas and/or zones of particular subsurface conditions in relation to the roadway.

This work should provide clearly defined information to which the evaluation criteria in Section 8 can be applied to develop Priority Site Recommendations.

7.6 SITE REEVALUATION

The site may be reevaluated for possible placement in a different risk assessment site group as the result of site information gathered for, or developed during, the Priority Site Investigation. This reevaluation should be conducted as described at the conclusion of Section 5: Site Monitoring.

SECTION 8:

Priority Site Recommendations

8.1 GENERAL DISCUSSION

The purpose of this section of the manual is to establish guidelines for making Priority Site Recommendations. These recommendations should be formulated by considering the site evaluation criteria discussed in this section of the manual when reviewing the summarized information produced as the result of the Section 7: Priority Site Investigations. All Surface Deformation Group or Mine Opening Group sites should be remediated unless they can be clearly documented to not be a threat to the roadway.

8.2 PRIORITY SITE EVALUATION CRITERIA

The overburden in a priority site area is in effect functioning as a "bridging" structure of soil and bedrock over subsurface voids related to abandoned underground mines. The coordinating District engineer in formulating Priority Site Recommendations should determine whether there is a current requirement to repair or replace this existing bridging structure of soil and bedrock.

The following criteria are guidelines for formulating Priority Site Recommendations. Most of these criteria would not singlely determine if remediation is warranted for a given site. Several are too interrelated to be considered separately. Of course, in extreme cases such as detection of voids at extremely shallow depths, a single criterion such as "Minimum Overburden Thickness" would alone be a deciding factor for a recommendation to remediate a given site. However, for most sites, all the listed criteria should be considered as a whole to determine the overall risk to the traveling public which the site represents.

The following is a discussion of the individual priority site recommendation criteria:

8.2.1 Minimum Overburden Thickness: This criterion may be utilized as a means to evaluate the configuration of the existing bridging structure of overburden materials. It is a measure of the minimum vertical soil and bedrock interval between the roadway surface and the top of detected voids. This interval in site areas not exhibiting mine subsidence will be the vertical distance from the roadway surface down to top of the originally mined mineral seam.

A site's known "worst case" areas for this criterion should commonly be those where the top of the apparently failed bedrock structure or void(s) related to mine subsidence has progressed upward toward the roadway surface. The configuration of the existing bridging structure of overburden materials which remains supporting the roadway is reduced in these areas. This depth of intact overburden may be significantly less than the overburden depth to the original mine voids.

An abandoned mine opening could be a less common example of a "worst case" area for this criterion. An abandoned mine opening in its originally constructed form was, in effect, an excavated void extending from existing grade to the mineral seam to be extracted. These mine openings were horizontal, vertical or sloping as originally constructed. Methods of abandonment were highly variable depending on the age of the mine. A given priority site may be found to be generally safe for the traveling public, while having a smaller portion of the site considered high risk due to the presence of an abandoned mine opening(s).

8.2.2 Rock Quality Designation (RQD) of Minimum Overburden Overlying the Mine Void, Top of Apparent Failed Bedrock Structure, or Void(s) Related to Mine Subsidence: This criterion may be utilized to evaluate the structural integrity of the existing bridging structure of overburden materials. It is determined for a given borehole location through studies performed on the recovered core samples. The RQD value is the percentage of the length of core run which is made up of continuous pieces of core sample which are four (4) inches in length or greater.

8.2.3 Ratio of Unconsolidated Materials to Bedrock in The Overburden Interval: This criterion may be utilized to evaluate the load versus available supporting structure which the overburden, taken as a whole, represents. The ratio is determined by dividing the total depth of unconsolidated materials above the bedrock topographic surface by the thickness of intact bedrock in the overburden. This thickness of bedrock should be from that bedrock topographic surface down to the top of apparent failed bedrock structure or voids related to mine subsidence.

This ratio is a good indicator of the relative amount of the vertical overburden interval between the roadway surface and the top of the apparent mine void which is comprised of bedrock having structural value. The unconsolidated materials should be considered as a dead load on the structure represented by the underlying intact bedrock. Locations of "worst case" overburden conditions would typically be those where the thickness of unconsolidated materials is equal to , or greater than the thickness of intact bedrock between the bedrock topographic surface and the shallowest failed bedrock structure, or voids related to mine subsidence.

8.2.4 Type of Bedrock in Overburden: This criterion may be utilized to evaluate the structural ability of the bedrock to span voids or unconsolidated materials potentially underlying the roadway. This structural ability is related to the strengths of the various lithologic types of bedrock present.

8.2.5 Unconfined Compressive Strength of Bedrock in Overburden: This criterion may be utilized as a laboratory measurement of the inherent material strength of the different types of bedrock in the overburden interval. This information, when combined with the bedding and fracture information, may be utilized to physically characterize the supporting bedrock "beam" of overburden spanning potential subsidence areas.

8.2.6 Bedding and Fractures of Bedrock in Overburden: This criterion may be utilized to evaluate the structural integrity of the bedrock overburden. The vertical thickness and horizontal dimension of intact rock occurring within each of the types of bedrock present in the overburden interval should be reviewed. In the case of progressive structural failure and resulting subsidence, each intact portion of bedrock spanning the subsiding area is called upon to function as a beam spanning the subsiding area. The length, width and depth of this beam, as represented by the portions of intact bedrock in the overburden directly reflect the likelihood of subsidence progressing ultimately to the roadway surface.

Stress fractures in the recovered bedrock core samples may be observed. These fractures are characteristically oriented approximately 45 degrees to the vertical axis of bedrock core material. If these fractures are of a greater age, their surfaces are usually moderately to heavily stained as the result of long term groundwater flow. If stress fractures which are not heavily stained by groundwater are present in the recovered core samples, they are a good indication of relatively recent structural failure of the affected bedrock. Such recent structural failure may be attributable to the subsidence of an abandoned underground mine and associated overburden. It is a general indication of the loss of supporting structural bedrock integrity at the borehole location.

8.2.7 Detection of Surface Subsidence Activity / Mine Opening(s): This criterion may be utilized to evaluate how active subsidence mechanisms are in the site area. Information developed through Priority Site Investigation may or may not document evidence of surface deformation. If no surface deformation activity is detected, this would be one positive factor in the consideration to defer remediation. Another factor which might further strengthen the argument for non-remediation of a site evidencing no surface deformation activity would be the applicability and availability of Time Domain Reflectometry (TDR) and/or other acceptable forms of site monitoring. Such monitoring could be placed on the site as a condition of Priority Site Recommendations.

If surface deformation is detected and cannot be attributed to other factors such as failed drainage structures, etc., then it should be interpreted as documenting the occurrence of surface subsidence related to the abandoned underground mine(s) underlying the roadway. If such information is developed for a priority site, the coordinating District engineer should realize that surface and subsurface subsidence is active in the priority site area. The question then to be answered is whether or not the subsidence activity has affected, or will affect in the near future, the roadway and thereby the safety of the traveling public. It is intended that if surface deformation has occurred, or a mine opening(s) exists on the site, remediation should be required.

Correlation of data anomalies between the various forms of Priority Site Investigation information should be considered a strong indicator of subsidence activity. Some of the forms of this information which might independently contain or contribute to a combined form of documentation of surface deformation may include: 1) ground survey data; 2) profilometer data; 3) FWD data; 4) visual observations; 5) measurement of features data; 6) ground and aerial photography, and; 7) borehole camera observations.

8.2.8 Hydrology and Piping Potential: Various forms of information gathered during the Detailed Site Evaluation and Priority Site Investigation should be considered in evaluating the hydrology and related soil piping potential of the priority site. Some of the forms of this information which should be considered in evaluating the hydrology and related soil piping potential include: 1) Number of Subsidence Events; 2) Recent Dewatering; 3) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval; 4) Minimum Overburden Thickness (Approx.), and 5) Problems Reported During Active Mining.

The existence of localized, high volume groundwater flows within abandoned underground mines should be verified. If such flows exist, remediation techniques should, if possible, allow for the continuation of such groundwater movements. This should prevent the interruption of the stable state of the groundwater regime beneath the site. If interruption of such groundwater flows is required for the chosen form(s) of remediation, the coordinating District engineer should analyze the possible resulting impacts on the groundwater regime beneath the roadway, as well as in up gradient and down gradient locations adjacent to the roadway.

8.2.9 Risk to the Traveling Public: Various forms of information gathered during the Detailed Site Evaluation and Priority Site Investigation should be considered in evaluating the risk to the traveling public which the priority site represents. Some of the forms of this information which should be considered in evaluating the risk to the traveling public include: 1) Average Daily Traffic (ADT); 2) Classification of Roadway; 3) Average Daily Truck Traffic (ADTT); 4) Traffic Speed; 5) Type of Pavement; 6) Availability of Reasonable Detour Routes, and; 7) Structures in Roadway.

8.3 RECOMMENDATIONS

Priority Site Recommendations should either specify remedial construction or deferral of remediation. Recommended remediation may involve the entire site, or only a portion (or portions) of the site. All sites will be unique and therefore requiring site-specific considerations. The coordinating District engineer should exercise his or her best judgement to formulate recommendations based on the following criteria and other site-specific considerations.

8.3.1 Factors Affecting the Selection of Remedial Techniques: If remediation is recommended, selection of the most appropriate alternative technique(s) is critical. A number of factors should be considered in evaluating which remediation technique, or combination of techniques, would be most appropriate for the conditions anticipated to be encountered during construction. These factors should include:

8.3.1.1 Hydrogeologic Setting: Some mined mineral seams, and particularly coal seams, are commonly found to also be confined aquifers. Some seams are more water-bearing than others. The amount of groundwater associated with the mined mineral seam at a particular site will depend on the occurrence and location of local and regional aquifers, the local strike and dip of the bedrock, interconnection of the mine(s) with other adjacent mines, and the seam's elevation at the site relative to the local and regional aquifers.

8.3.1.2 Geometry, Size and Condition of Mine Voids Requiring Remediation: The geometry of the mine voids will be a direct function of the mining method(s) utilized in the layout and operation of the mine. The dimensions of the mine voids will be the direct result of the height of the extracted mineral(s), the nature and condition of bedrock forming the mine roof and floor, and the method of roof support.

Present conditions within an abandoned underground mine may be highly variable. Varying degrees of roof rock failure, roof support pillar/post punching into the mine floor, mine floor heave, support pillar crushing, etc. may commonly be encountered. Other abandoned underground mines may be found to be in about the same condition as they were at abandonment. If a large amount of roof fall has occurred in the mine, random compartmentalization of the mine may have resulted.

All the above-described factors may greatly influence the effectiveness of the different forms of remediation. This situation may be especially true for remedial techniques employing the remote placement of stable backfill materials in mine voids.

8.3.1.3 Type and Condition of Overburden: The type of bedrock, its bedding and fracture patterns and its compressive strength should greatly affect the selection of remedial work to be undertaken. The coordinating District engineer should work closely with the project design staff to incorporate information about the existing structural strength of overburden materials into the design considerations for remedial construction.

This information should be integrated into the preliminary design investigations undertaken to determine the preferred method of site remediation. This decision making should typically consider how to: 1) incorporate the natural strength of the bedrock into remedial techniques which do not radically disturb the overburden; 2) physically increase the existing strength of the bedrock in the overburden, or; 3) physically remove and replace the overburden.

8.3.1.4 Site Constraints - Surface and Subsurface: Some site constraints which may affect the selection of a remedial technique could include: above and below ground utilities, above and below ground structures, right of way width, etc. These types of constraints may dictate which alternative form of remediation is the most practical to construct .

8.3.1.5 Type of Roadway: The type of roadway being remediated will have a large influence on the method of remediation to be undertaken. In the case of multi-lane highways with full width shoulders, the possibility of limited lane closures while maintaining traffic allows for increased flexibility in the chosen construction methods and sequencing of operations. The roadway as a structure also has a varying ability to bridge unconsolidated subgrade conditions. For example, an original slab pavement with asphalt overlay has much more structural value than rubblized pavement with an asphalt overlay.

8.3.1.6 Type and Volume of Traffic: The type and volume of traffic being serviced by the roadway may directly affect the choice of a remedial construction technique. This statement does not mean that a different level of safety is desired for different types of roadways. It means that some roadways carrying greater volumes of heavier vehicles must be made structurally stronger to ensure the same level of safety that may be achieved through less extensive efforts on roadways carrying lower volumes of lighter weight vehicles.

8.3.1.7 Presence of Traffic in or Nearby Remedial Construction Project Area: If an acceptable detour is available for the proposed remedial work area, traffic can be eliminated from the remedial construction area. In this case, almost any form of remedial construction operations which can be set up within the site can be performed.

If there is not an acceptable detour around the proposed remedial work area, then traffic must be maintained during remediation. If for a given site this is the case, the ongoing remedial construction operations must be conducted at all times well away from the traffic in a manner that will not create dangerous driving conditions for the traveling public.

8.3.1.8 Adjacent Land Use and Groundwater Utilization: These factors need to come under serious consideration when remedial options being considered may include affecting the groundwater table(s) associated with the mined mineral seam and the overlying overburden. The possible forms of remediation that could affect the local or regional groundwater may include remote placement of stable backfill materials into mine voids or undercutting excavation extending down through the mined mineral seam. The remote placement of stable backfill materials into subsurface voids is regulated by the Ohio EPA for the protection of the public drinking water resources. Roadway excavation may potentially result in a catastrophic dewatering event. A dewatering event within the right of way may induce new mine subsidence within or beyond the right of way, and/or well dewatering on adjacent lands beyond the right of way.

Please refer to the warnings and discussions provided in Section 7.4.2.2 Intrusive Investigations (including all subsections).

8.3.2 Remediation Alternatives:

8.3.2.1 Emergency Action / Road Closure: This alternative should be recommended for consideration by the District Deputy Director if conditions as revealed during the priority site investigations are considered by the coordinating District engineer to pose an imminent danger to the safety of the traveling public. See Section 10: Emergency Action / Road Closure for a detailed discussion of this subject.

8.3.2.2 Excavation and Controlled Backfill: This alternative is the most desirable because it unquestionably eliminates any voids within the remedial work area. Excavation of the roadway is performed down to the base of the mined interval. The positive aspect of this form of remediation is that the abandoned mine beneath the roadway is totally eliminated. The negative aspect of this form of remediation is that the existing roadway has been eliminated and must be completely replaced

The groundwater hydrology of the work area must be fully evaluated before recommending this alternative. Groundwater associated with the mined interval, and other upper lying aquifers may flood incised excavation areas. Excavation may result in mine dewatering. Intact barriers of the mined mineral sufficient to resist any potential hydraulic "blowout" from adjacent abandoned underground mines should be maintained between remedial construction excavations and any adjacent mine voids. Dangerous gases may also be released during excavation.

8.3.2.2.1 Mine Opening Stabilization: This alternative should be considered when a mine opening is found to be open or containing debris which can be removed by equipment. Back fill materials should typically be 601.07 dumped rock fill. All stabilized mine openings should be marked with a permanent monument located over the center of the shaft. These monuments should be located by ground survey and become a permanent record of soils information for the roadway site.

8.3.2.2.1.1 Shaft and Slope Entries: All initial operations should be performed with equipment and on-site storage of materials being located beyond the pre-determined Shaft Danger Zone (See Figure 7.2). Shaft and slope entries which are to be backfilled should be cleared of existing debris through excavation by a crane equipped with a clamshell bucket or other equipment. If shaft or slope entries cannot be completely cleared, the crane should then repeatedly drop a demolition ball on any debris remaining in the mine opening until compaction of debris has been achieved prior to commencing backfilling operations. Cleared shaft and slope entries should be backfilled with 601.07 dumped rock fill placed by conveyor. Initially placed dumped rock backfill materials should be typically 601.07 Type C.. Later backfill materials can grade into 601.07 Type D and then #1 and #2 aggregate. Filter fabric should be placed over backfilled shaft and slope entries to prevent soil piping downward through the dumped rock backfill.

8.3.2.2.1.2 Drift Entries: These horizontal mine openings can also be cleared of debris by excavation equipment and then similarly backfilled to a limited horizontal distance with 601.07 dumped rock backfill, followed by materials grading to #1 and #2 aggregate. Filter fabric should be placed over backfilled drift entries to prevent soil piping downward through the dumped rock backfill. A mine drain should be considered if the potential for the impounding of mine drainage behind placed materials is a possibility. A mine vent may also be appropriate if there is a chance of gas accumulating in the mine due to the placement of backfill materials. Pneumatic stowing can often be specified if backfill materials need to be placed at a greater horizontal distance back into the mine from its opening at grade (See 8.3.2.5.3 Pneumatic Stowing).

Please refer to the warnings and discussions provided in Section 7.4.2.2 Intrusive Investigations (including all subsections).

8.3.2.3 Dynamic Compaction: This alternative employs the dropping of a heavy weigh onto the surface in an effort to induce collapse of subsurface voids and/or consolidation of the subgrade. The weigh is dropped though the use of a crane. Site constraints may dictate whether this form of remediation can be considered for a given location. This form of remediation has not been performed or evaluated by ODOT at this time.

8.3.2.4 Implosion of Mine Voids Through The Use of Explosives: This alternative eliminates underground voids by inducing the collapse of the abandoned underground mine voids through the use of explosives. Explosives must be placed by an experienced blaster. Proper timing delays and explosive placement within the abandoned underground mine and associated overburden are critical to the successful use of this remedial alternative. A pre-blast survey should be performed, including a groundwater survey as required. Dynamic compaction and/or controlled backfill may also be used in association with this form of remediation depending on site characteristics. This form of remediation has not been performed or evaluated by ODOT at this time.

8.3.2.5 Remote Placement of Stable Backfill Materials in Voids and Unstable Subgrade Areas:

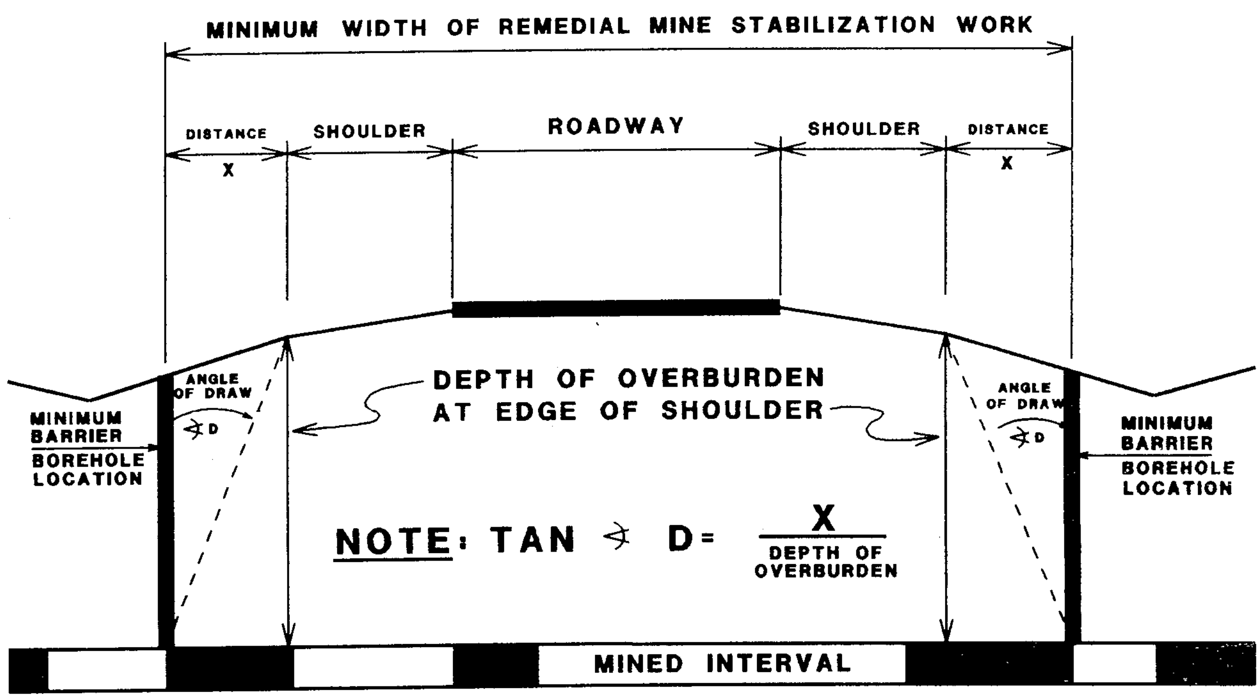
8.3.2.5.1 Notes:

A) All placed materials must be pre-approved by the Ohio EPA (OEPA).

B) All drilling and grouting work must conform to the OEPA waste injection well permit requirements. If industrial waste products such as flyash comprise 50% or more of the grout components by weight, an OEPA waste injection well permit must be applied for and received before construction. An OEPA permit fee will be required.

8.3.2.5.2 Drilling and Grouting Program: This alternative eliminates voids beneath the roadway through placement of cement grout in abandoned underground mine voids.

Low slump grout is first placed in barrier boreholes. The barrier boreholes are located externally to the roadway area to be stabilized. This method of barrier borehole location is performed so as to eliminate any roadway areas from remaining in the angle of draw area of influence from non-remediated mine voids beyond the roadway (See Figure 8.1). Barrier borehole drilling and grouting should effectively create an isolated portion of the abandoned mine works which should be stabilized so as to effectively guarantee the future stability of the roadway site.



MINIMUM BARRIER BOREHOLE DISTANCE FROM EDGE OF SHOULDER = DISTANCE X = [(DEPTH OF OVERBURDEN AT EDGE OF SHOULDER) (TAN ∡ D)]

Figure 8.1 : Barrier Borehole Location
N.T.S.

Higher slump grout is then placed in production boreholes located internally to the completed barrier borehole drilling and grouting. This higher slump grout placed in production boreholes acts to flood the abandoned mine voids in the area defined by the barrier boreholes. Production grouting should proceed from the geological "down-dip" end to the "up-dip"end of the isolated mine workings so as to "squeeze" any existing groundwater out of this portion of the void system , ahead of the production grout placement.

8.3.2.5.2.1 Shaft Stabilization: Some shafts will be found to contain unconsolidated random backfill materials. Such shafts can be stabilized by drilling and grouting operations which can fill voids in the uncontrolled, existing backfill. Shafts which are to be stabilized by drilling and grouting an unclassified fill should be angle drilled and grouted by equipment located beyond the Shaft Danger Zone.

Confirmation drilling atop the drilled and grouted shaft would be the final phase of such remedial construction. All stabilized shafts should be marked with a permanent monument located over the center of the shaft. These markers should be located by ground survey and become a permanent record of soils information for the roadway site.

8.3.2.5.3 Pneumatic Stowing: This alternative eliminates voids beneath the roadway by filling them with aggregate materials. These materials are placed by pneumatic transport down cased boreholes which intercept voids to be eliminated.

8.3.2.5.3.1 Drift Entry Stabilization: This alternative can be utilized to eliminate voids related to horizontal mine openings found to be extending beneath the roadway. Such drift mine entry voids can be filled with aggregate materials pneumatically placed horizontally through the mine entry located downslope of the roadway.

8.3.2.6 Bridging of Roadway over Subsidence Risk Area (Land Bridge): The maximum length of potential subgrade subsidence which a land bridge would be expected to span for the site under consideration should first be determined when considering this remediation alternative. Span lengths may be estimated utilizing available historic maps and other collected records regarding methods of mining. The accuracy of the original abandonment maps and records filed by the miner or mining company can be highly variable.

Some forms of land bridging structures to be considered may include:

8.3.2.6.1 Continuous Reinforced Concrete Pavement (CRCP): This alternative utilizes concrete pavement continuously reinforced in only the direction of travel as a structure to span potentially minor subsidence-related settlements.

8.3.2.6.2 Double Reinforced Pavement: This alternative utilizes concrete pavement continuously reinforced in both directions as a structure to span potential subsidence-related settlements. This structure is, in effect, acting as a bridge deck founded on the subgrade.

8.3.2.6.3 Pre-Cast Concrete Spans: This alternative utilizes pre-cast concrete sections such as box beams or bridge spans to form a structure to span isolated mine haulage ways acting as major conveyances of groundwater flow beneath the roadway. A fairly accurate location for placement of these box beams or bridge spans is required for this remediation effort to be effective. Precast sections should be founded on bedrock.

8.3.2.6.3.1 Mine Shafts: This alternative utilizes pre-cast concrete box beams or bridge spans to form a capping structure over a mine shaft (vertical) entry. The existing lateral support ("cribbing") within the mine shaft should be evaluated and found to be in a durable, stable condition before considering this form of remediation. In the case of shafts which cannot be backfilled or otherwise stabilized, soils should be removed to bedrock. Box beams or bridge spans should then be founded on footers formed on the exposed bedrock. Vertically cast end walls should be specified for end sections of pre-cast bridge spans. This specification would ensure that an enclosed shaft cap is created when all precast bridge spans are placed.

All capped shafts should be marked with a permanent monument located over the center of the shaft. These monuments should be located by ground survey and become a permanent record of soils information for the roadway site

8.3.2.7 Deferral of Remediation and Performance of Normal Post-Investigations Site Monitoring: This alternative should be chosen when information developed through Priority Site Investigations has documented that conditions related to the abandoned underground mine beneath the roadway do not currently appear to pose a threat to the safety of the traveling public.

8.3.2.8 Deferral of Remediation and Specification of Additional Studies or Site Monitoring: This alternative should be chosen when information developed through Priority Site Investigations has documented no apparent threat to the safety of the traveling public, but certain site areas or conditions warrant further long-term studies or specific forms of monitoring.

8.3.2.9 Combination of Techniques: A variety of conditions requiring remediation may be found on a given site. In such instances, a combination of the above-described techniques may be appropriate.

8.3.2.10 Other Site-Specific Alternatives: The above-described alternatives do not include all possible forms of remediation. They are some of the more commonly considered methods of remediation. The best alternative for remediation of a given site may be unique due to above and below ground constraints, condition and nature of soils and bedrock, hydrogeologic setting, etc. The coordinating District engineer should use his or her best judgement when recommending a unique remediation alternative.

8.4 SITE SPECIFIC MONITORING REQUIREMENTS

Monitoring requirements will be determined by the coordinating District engineer. This monitoring effort will be based on conditions documented during Priority Site Investigations.

SECTION 9:

Remediation

9.1 GENERAL DISCUSSION:

The purpose of this section of the manual is to provide general guidelines and advice for the remediation of priority sites. This remediation effort should consist of the development of remedial construction documents and the performance of the remedial construction.

9.2 DEVELOPMENT OF CONSTRUCTION DOCUMENTS:

This document is not a design manual. The purpose of this manual is to provide a means of site inventory and risk assessment. English units of measurement are utilized in this manual since a large part of this process involves review of historic documents using English units. Detailed design work and construction documents which might be undertaken as a result of the site inventory and risk assessment process documented in this manual should be prepared in metric units or dual units of measurement.

Information obtained during the Priority Site Investigation should be used to select the remediation technique and to develop construction documents. The design engineer should consult with the coordinating District engineer throughout the design process. Specific documents for the various remedial construction techniques are not provided in this inventory and risk assessment manual.

9.2.1 Flexibility of Contract Documents: All information developed through Priority Site Investigations and Recommendations is limited and does not necessarily define every possible condition which may be encountered throughout remedial construction work. Non-intrusive investigations do not precisely define subsurface conditions. Intrusive investigations precisely define conditions at specific locations.

The design engineer is faced with the task of making decisions and developing contract documents for the repair or replacement of the existing overburden structure. However, the design engineer is only given general information or limited detailed information (borehole logs, etc.) of the location, dimensions, and condition of the existing overburden structure. The designer should be aware that the mine maps, if available, may not be accurate regarding the location and extent of the mine. The extent of secondary mining, mine deterioration, and possible mine collapses will not be known.

Because of the limited site information available, design decisions should remain conservative and construction contract documents should be flexibly structured. This flexibility should allow for as many adjustments as can be foreseen prior to performing the work. Contingency items should be included for work which may or may not be needed. This flexibility should reduce or eliminate the need for negotiation of new items during construction.

9.2.2 Determination of Work Limits: Work limits should be extended beyond the expected area of roadway needing remediation. This guideline is recommended because the actual extent of the needed remediation will only be revealed through the execution of the work. An increased project work area cleared for construction activities should help in minimizing any complications related to the possible need during construction to expand project limits.

9.2.3 Progression of Project Work: The sequencing of construction operations should be tailored for each site. The following guidelines should be considered in the development of construction documents.

9.2.3.1 Excavation Operations, and Drilling and Grouting Operations: Work should generally be specified to progress from an unaffected area of roadway on one side of the remediation site, to a similar unaffected area of roadway on the other side. This guideline is intended to minimize the possibility of the project being completed without addressing all areas requiring remediation.

9.2.3.2 Shaft Stabilization: All initial operations should be performed with equipment and on-site storage of materials being located beyond the pre-determined Shaft Danger Zone, as described in 7.4.2.2.2 and shown in Figure 7.2. Shafts which are to be backfilled should be cleared by cranes or other equipment, and then backfilled. Shafts which are to be stabilized by drilling and grouting should be angle drilled and grouted by equipment located beyond the Shaft Danger Zone.

9.2.3.3 Other Forms of Remediation: Other sequencing of construction operations may be required due to unique site conditions or constraints.

9.2.4 Compliance With Applicable Regulations: Any person performing work related to underground mines must note that significant legal consequences may stem from failure to comply with all relevant environmental laws. The coordinating District engineer should contact the appropriate Ohio EPA (OEPA) District Office contact person capable of advising ODOT on all areas of environmental compliance about which ODOT must be concerned. The coordinating District engineer should refer to Appendix D: Contacts for the appropriate OEPA District Office contact person for each project location. The coordinating District engineer should also process the projects through the District Environmental Coordinator for clearance through the Department's environmental process as documented in ODOT's Transportation Development Process (and implementing manuals).

If the remote placement of stable backfill materials in subsurface voids is the chosen form of remediation, boring locations and logs, and material placement records are critical to ODOT. They will also be required for compliance with reporting requirements of the OEPA injection well permit program described in the following paragraph.

Drilling and grouting programs must comply with the OEPA UIC Permit to Install / Permit To Operate A Class V -Injection Well Area Permit for Well Code 5X13. Compliance with this OEPA injection well permit program is a requirement for a drilling and grouting program, even if an actual permit is not required. Such a situation could occur for a given project if industrial waste materials, such as flyash, comprised less than 50% by weight of the components in the chosen grout mixes. If remote placement of stable backfill materials in subsurface voids is being considered for site remediation, the coordinating District engineer should contact the appropriate Ohio EPA UIC-specific contact person to assist with this permit program. This OEPA contact should be in addition to the OEPA District Office contact which should also be made. OEPA UIC-specific contact information is provided in Appendix D: Contacts.

9.2.5 Site Monitoring During Document Development: Provision should be made for continued site monitoring during development of construction contract documents. Existing conditions may change, or new conditions may develop on the site during this period. The coordinating District engineer should refer to Section 5: Site Monitoring for recommended guidelines on the forms and frequencies of monitoring which are applicable. Contract documents should alert the contractor to the requirement that he is to provide monitoring or allow access to ODOT for monitoring.

9.3 REMEDIAL CONSTRUCTION:

Since the actual limits and nature of all required project work may only be revealed through the completion of the work, the project engineer and inspection staff must remain well informed of work progress and changing conditions encountered. When most remediation projects are completed, the only picture of the final product will be the three-dimensional one in the mind's eye of the project engineer and inspection staff. The project engineer should be familiar with all facts obtained during the Priority Site Investigation and should be fully aware of the intent of the design.

9.3.1 Project Construction Inspection: Close inspection of work as it progresses should be maintained. Inspectors should report changed conditions revealed by the work immediately to the project engineer. The project engineer should advise the design engineer and coordinating District engineer of any unusual or unexpected conditions encountered during the work. If conditions are encountered which substantially change the overall scope of the project, the design engineer and coordinating District engineer should be consulted. If for any reason the project engineer proposes a significant deviation from contract requirements, the design engineer and coordinating District engineer should be consulted, so that the intent of the design is not compromised.

The project engineer and inspection staff should work closely with the contractor to anticipate points during the progress of the work where efficient and informed decision making will be required for the work to proceed efficiently and without delay. Any operational changes, phasing of work operations, or other adjustments required during a given day or shift should be documented. These adjustments should also be explained to all other staff which might be inspecting the work on the following days or shifts.

All construction staff should make an effort to stay informed of work progress and changing conditions. Shared information and good inspection records will be the only means the project engineer and inspection staff will have to review the completed work.

9.3.2 Construction Testing: If the remote placement of stable backfill materials in subsurface voids is the chosen form of remediation, confirmation boreholes should be performed and accurately logged. Any voids encountered by such confirmation boreholes should be filled with grout, as well as the boreholes themselves. Accurate drilling and grouting records of confirmation boreholes should be made part of the permanent project records.

Ground penetrating radar (GPR) or other forms of geophysical testing may also be considered as a means to verify the completion of remote placement of stable backfill materials.

Impact echo testing, selected borehole redrilling, and other forms of testing may be required for remedial work involving grouted boreholes

9.3.3 Project Construction Records: Accurate and thorough record keeping during project construction is essential. Most remediation work will involve construction below grade. Subsurface conditions may be highly variable throughout the work area. Accurate records should be kept of all work performed below grade. An accurate record of the actual work limits should be a part of this record keeping.

Subsidence events that occur during construction, as well as mine openings and other mine-related features or conditions encountered during construction, should be photographed. These photographs should be included in the permanent construction record.

Actual time and materials usage as compared to that anticipated in the construction documents should be monitored. This work will provide an indication of potential overruns of contract items, and/or subsurface conditions other than anticipated by the construction documents.

“As-built” drawings should be produced for all mine remediation projects when possible. These drawings should contain all modified or new information developed as the result of the project. This information should include the location of all new production boreholes, confirmation boreholes, adjacent mine workings, work performed under contingency items, and actual work limits.

The above described construction records are necessary for the future monitoring of the site. Post-construction inspection of completed work items, in the traditional sense, will not be possible due to the work being below final grade. Accurate construction records will be invaluable as a reference for post-construction monitoring and review of conditions adjacent to the project area.

Pertinent project records such as drilling and grouting summaries, photographs, "as-built" plans, etc. should be transferred to the coordinating District engineer after physical completion of the work.

9.3.4 Site Monitoring During Remedial Construction: The site should be monitored for possible changes during remedial construction. Existing conditions may change, or new conditions may develop on the site. Certain forms of remediation may unintentionally induce additional mine-related settlements. The potential impact of such settlements should be a consideration in the development of a construction monitoring program. The coordinating District engineer should refer to Section 5: Site Monitoring for recommended guidelines on the forms and frequencies which are applicable during project construction.

SECTION 10:

Emergency Action / Road Closure

10.1 GENERAL DISCUSSION:

The purpose of this section is to provide general guidelines for consideration of emergency remedial construction and/or closure of the roadway to traffic. Such roadway conditions may be discovered during the Initial Site Investigations, Site Monitoring, or Priority Site Investigations. They may also be reported at any time to the coordinating District engineer by ODOT staff or by the general public.

Regardless of the amount of investigative information available, it is impossible to determine exactly when a collapse of a roadway may occur. Geologic and hydrologic conditions may vary considerably over a site. In addition, conditions of materials may change dramatically following a collapse of supporting roof rock or pillars. It is impossible to fully investigate 100 % of a site and fully know present conditions. Consequently an attempt to predict future stability and safety of the supporting overburden and roadway is, at best, an informed guess.

Specific criteria to determine the safety of a roadway and whether a roadway should be closed cannot be given. Questions and factors to consider are offered in this section. The possible danger of a site should not be disregarded. Alternatively, undue alarm and extreme reaction should not be expressed at every site with a possible hazard. A thoughtful balanced decision should be made using all available information. This decision should balance the safety of the mine site, and the safety and mobility consequences of the detour route. It is expected that, since the decision is ultimately an informed guess, errors of judgement may occur.

10.2 INVESTIGATIONS

The coordinating District engineer should use his or her best judgement in the field management of such a site. Extreme conditions may only require visual inspection to make an initial determination of risk. Less extreme conditions may be impossible to evaluate without initiation of site investigations. Investigation should continue as far as necessary until enough information is available to make a reasonably informed decision Until such time as the safety of the traveling public is assured, such a site should be considered as a priority site requiring immediate investigation per Section 7. Once the existence of such a site is verified, the coordinating District engineer should notify the appropriate ODOT staff and outside agencies as discussed in Subsection 7.2.

WARNING:

The District and the county need to be prepared to manage the worst case conditions that might be revealed during the investigations. Investigations may indicate the need for immediate road closure and/or emergency remediation. The availability and identification of reasonable detour routes, as documented in the Detailed Site Evaluation, should be reviewed with the District Roadway Services Manager and the County Manager

10.3 FACTORS TO CONSIDER

Several aspects of the site conditions, and the public exposure to those conditions, should be considered:

A.) Can a sudden collapse occur in the roadway without warning? Some factors to consider include:

1.) Type and condition of pavement (CRCP should provide support with some deflection before failure)

2.) Number of subsidence features that have already occurred.

3.) Type and condition of overburden beneath the roadway. Fractured rock indicates that collapse and movement is already occurring.

4.) Granular soils can collapse abruptly.

5.) Deep soils overlying small amounts of mine roof rock can allow rapid upward movement of subsidence to the surface.

6.) Proximity (angle of draw) of adjacent collapses or shafts.

7.) Voids encountered under the roadway.

B.) What is the exposure of motorists to the possible danger in the event of a collapse? Some factors to consider include:

1.) Speed.

2.) Density of traffic.

3.) Type of Traffic (Number of heavy vehicles).

C.) Can motorists reasonably observe and avoid a potential collapse? Some factors to consider include:

1.) Speed of Traffic.

2.) Density of traffic.

3.) Type of traffic.

4.) Roadway geometrics.

5.) Roadway lighting.

D.) Would a detour provide a safer, or less safe, condition? Some factors to consider include:

1.) Underground mines under detour.

2.) Detour geometrics and capacity.

3.) Increased number of intersections and pedestrians on detour.

E.) Would you want your family to drive over this site?

10.4 ALTERNATIVE RESPONSES

The available options for the management of such a site can be defined by two levels of risk. These levels of risk and their associated alternatives are:

10.4.1 Site Conditions Represent No Perceivable Immediate Risk:

10.4.1.1 No Action: The site may be determined to not pose a threat to the safety of the traveling public. No action would be required in such cases. Monitoring would continue to follow normal procedures.

10.4.1.2 Increased Monitoring and Possible Site Reevaluation: The site may be determined not to pose an immediate threat to the safety of the traveling public, but to warrant increased monitoring. Forms of increased monitoring should be determined in the best judgement of the coordinating District engineer.

The coordinating engineer should also consider reevaluation of the site because of the changed conditions.

10.4.2 Site Conditions Warrant a Measured Response : If action is to be taken, the first decision to be made is whether the roadway can safely remain open while on-going Priority Site Investigations or emergency construction is undertaken. Action will be undertaken either while maintaining traffic or under road closure. If emergency construction is chosen, the coordinating District engineer should keep in mind that remediation may unintentionally induce additional or new settlements in adjacent lanes carrying traffic.

10.4.2.1 Maintaining Traffic: If the coordinating District engineer determines in his or her best judgement that the safety of the traveling public can be maintained while action is taken, then one of the following courses of action should be undertaken:

A.) Initiation of Priority Site Investigations

B.) Initiation of Emergency Construction

10.4.2.2 Road Closure: If the coordinating District engineer determines, in his or her best judgement, that site conditions represent a possible risk to the traveling public, the coordinating District engineer shall notify: 1) the District Deputy Director; 2) the District Highway Management Administrator; 3) the District Public Information Officer; 4) the County Manager, and; 5) the Administrator of the Office of Highway Management in the Central Office. The coordinating District engineer shall await the decision of the District Deputy Director as to the desired management of the site. If road closure occurs, one of the following actions should be undertaken:

A.) Initiation of Priority Site Investigations

B.) Initiation of Emergency Construction

10.5 SITE RECORDS

A record of all communications, site information, and actions taken should be maintained as a permanent file.

10.6 SITE MONITORING

Monitoring requirements will be determined by the coordinating District engineer on a site-by-site basis.

SECTION 11:

Preliminary and Final Development Applications

11.1 GENERAL DISCUSSION:

The purpose of this section is to provide general guidelines for the integration of the Abandoned Underground Mine Inventory and Risk Assessment process into the roadway planning and design processes. Abandoned underground mine information should be considered an additional soils and/or underground structure consideration for roadway development. The process can be integrated into both roadway planning and design without modification.

The Abandoned Underground Mine Inventory and Risk Assessment process should be utilized as a planning and design tool to identify subsurface conditions and possible risks related to the presence of underground mines lying beneath single and multiple corridors studies, and existing or new alignments. It should be made a part of the Preliminary Development Phase (PDP) as described in the Transportation Development Process manual and the Final Development Phase (FDP) design investigations. A Section 2: Initial Informational Review should be performed for any roadway PDP or FDP in historically mined portions of the state. If the presence of abandoned underground is documented through such a review, then the process should be followed for the given PDP corridor(s), or the FDP existing or new alignments. As discussed in Section 2, the presence of unmapped mines should be considered.

NOTE: This process may reveal significant mine-related subsurface conditions either beneath the existing or proposed roadway, or in proposed cut slope or embankment areas.

11.2 PRELIMINARY DEVELOPMENT PHASE

The process should be used to develop individual mine location and risk assessment information, and also to summarize the aggregate mine-related risks and associated costs for single or multiple corridor studies. The advanced knowledge of this information may also allow for avoidance if recognized in the Stage I Study Areas portion of the PDP.

The PDP can utilize the entire process. By utilizing the process, any geotechnical investigations undertaken should be effectively directed to the highest priority sites on each study corridor. Section 7: Priority Site Investigation and Section 8: Priority Site Recommendations can serve as guidelines for conducting such geotechnical investigations and resulting recommendations. These priority site investigations should be conducted as necessary to characterize the nature of the mine-related subsurface conditions so that accurate assessment of them could be made for single or multiple corridor studies.

Specific points of the PDP process where the Abandoned Underground Mine Inventory and Risk Assessment process should be considered are:

1) Stage I Study Area, A. Inventory, 8. Geological
(or Stage I Study Area, B. Special Instructions)

2) Stage II, B. Feasible Alternative Segment, 2. Alignment and Profile and Cost Estimate
(or Stage II, E. Special Instructions

3) Stage III Evaluation for Significance, E. Engineering
(or K. Special Instructions)

11.3 FINAL DEVELOPMENT PHASE

The FDP can utilize the entire Abandoned Underground Mine Inventory and Risk Assessment process. Utilization of the process will prioritize areas for consideration of investigation under a geotechnical investigation. Such geotechnical investigations can be undertaken effectively by directing them to the highest priority sites on each study corridor. Section 7: Priority Site Investigations and Section 8: Priority Site Recommendations can serve as guidelines for conducting such geotechnical investigations and evaluating the resulting data.

A large part of the Abandoned Underground Mine Inventory and Risk Assessment process should be integrated into the Part 1 Subgrade Stabilization (as required) and the Part 2 Subsurface Investigations.

APPENDIX A

Glossary of Terms

TERM	DEFINITION
angle of draw:	The angle subtended between the vertical and a line joining the extraction edge and limit of subsidence (Whittaker and Reddish, 1989)
bistatic:	A term used to describe a Ground Penetrating Radar (GPR) antennae arrangement in which separate transmit and receive antenna are used.
conductivity:	A measure of the amount of free charge (electrons) comprising a material. Under the influence of an applied electric field these electrons move, generating an electric current which in turn produces a secondary electric/magnetic field. This secondary field provides information regarding the conductivity of the anomaly. (Munk and Sheets, 1997).
cropline:	The general term "cropline", if not further defined, refers to the line along the ground surface where the mined mineral seam is exposed in the existing grade. The term "cropline ", with further definition, can also be utilized to define the structural contour of the top of the mined mineral seam which is covered by a uniform depth of overburden. Example: On some ODNR abandoned underground mine maps, the notation on a map line may read "30 foot cropline". This indicates the line on the top on the mined mineral seam which was covered by 30 feet of natural overburden.
drift entry:	A horizontal mine entry into the natural outcrop of the mined mineral seam.
electrical permittivity:	A measure of the polarizability of a material, or the extent to which the molecules comprising a material distort when subjected to an electric field. When a material comprised of molecules with bound charge is subjected to an electric field a slight displacement occurs between the negative and positive charges of the atom/molecule. This displacement results in a secondary electric/magnetic field which can then be measured (Kraus, 1992).

gob: Coal refuse commonly abandoned on the surface in piles at or near the mining operation.

haulage shaft: A mine shaft utilized for transport of the mined mineral to the surface.

manway: A mine opening utilized for worker access into and out of the underground mine. These shafts also can function at an integral part of the mine safety and mine ventilation plans. The term can refer to drift (horizontal), slope, or shaft (vertical) mine openings. This type of opening may also be referred to as a portal.

mine opening: A mine entry extending either vertically (shaft entry), horizontally (drift entry), or at an inclined angle (slope entry) to the mined interval.

monostatic: A term used to describe an antenna which is used to both transmit and receive GPR electromagnetic pulses.

portal: A mine opening utilized for worker access into and out of the underground mine. These shafts also can function at an integral part of the mine safety and mine ventilation plans. The term can refer to drift (horizontal), slope, or shaft (vertical) mine openings. This type of opening may also be referred to as a manway.

Rock Quality Designation: (RQD) The RQD value is the percentage of the length of core run which is made up of continuous pieces of core sample which are four (4) inches in length or greater.

shaft: A mine entry extending vertically from the ground surface down to the elevation of the mined interval.

slope entry: A mine entry which descends on an incline from the ground surface down to the elevation of the mined interval.

surface deformation: Areas of surface settlement, subsidence, or irregular drainage conditions.

troughing: Linear surface deformation extending for some distance and having a gentle curvilinear profile when viewed in section.

APPENDIX B

Abbreviations

ABBREVIATION	COMPLETE TERM
ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
CRCP	Continuous Reinforced Concrete Pavement
C-R-S	Project Designation (County-Route-Section)
DMI	Distance Measuring Instrumentation
EM	Electromagnetic Induction
EOP	Edge of Pavement
FHWA	Federal Highway Administration
FWD	Falling Weight Deflectometer
GPR	Ground Penetrating Radar
HWD	Heavy Weight Deflectometer
NHS	National Highway System
NTS	Not to Scale
ODNR, DMR	Ohio Department of Natural Resources, Division of Mining and Reclamation
ODNR, DGS	Ohio Department of Natural Resources, Division of Geological Survey

ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
OMSIUA	Ohio Mine Subsidence Insurance Underwriters Association
OSM	U.S. Department of the Interior Office of Surface Mining
SP	Spontaneous Potential
SPT	Standard Penetration Testing
TDR	Time Domain Reflectometry
USDI, OSM	U.S. Department of the Interior Office of Surface Mining
USGS	U. S. Geological Survey
VLF	Very Low Frequency

APPENDIX C

Informational Sources

AVAILABLE INFORMATION FOR ABANDONED UNDERGROUND MINES:	SOURCE
INITIAL SITE LISTING:	
1) Abandoned Underground Mine Map Series (U.S.G.S. Based)	ODNR, Division of Geological Survey (DGS)
2) ODNR Historic Information Regarding Subsidence Events (Including information from the Ohio Mine Subsidence Insurance Program.)	ODNR, Division of Mining and Reclamation (DMR)
3) OSM. Historic Information Regarding Subsidence Events	U.S.Department of Interior (USDI), Office of Surface Mining (OSM)
4) Abandoned Underground Mine Inventory Field Data Sheets	ODOT, Districts
5) Maintenance Records	ODOT, Districts and Office of Highway Management
6) ODOT Field Reports	ODOT, Districts and Counties
7) Individual Abandoned Underground Mine Maps	ODNR, DGS USDI, OSM County Recorders

INITIAL SITE EVALUATION:

1) Individual Abandoned Underground Mine Map Data Sheets	ODNR, DGS
2) Construction Plans / Microfilm including original soils investigations information	ODOT, Library
3) Measured Geological Section(s)	ODNR, DGS; and USGS
4) Geological Structure Maps and/or Information	ODNR, DGS; and USGS
5) Oil/Gas Well Logs	ODNR, Division of Water (DOW)
6) Water Well Logs	ODNR, DGS; and USGS

DETAILED SITE EVALUATION:

1) Mine Inspector Records (From 1874 to 1914)	ODNR, DGS

PRIORITY SITE INVESTIGATION:

1) Roadway Construction Diaries	ODOT, District Office Of Highway Management
2) Aerial Photography, Historic and New, B&W and Infrared	ODOT, Aerial Engineering
3) Satellite Imagery	ODOT, Aerial Engineering
4) Quaternary Geology Maps	ODNR, DGS

APPENDIX D

Contacts

STATE AGENCIES

ODOT

Office of Materials Management, Geotechnical Design Section

FAX: 614/275-1354

L. Rick Ruegsegger, P.E.

Special Projects Coordinator 614/275-1395

ADDRESS: ODOT
Office of Materials Management
1600 West Broad Street, Room 2033
Columbus, Ohio 43223

ODNR

Division of Geological Survey (DGS)

FAX: 614/447-1918

Doug Crowell - Supervisor, Coal Group 614/265-6594

Larry Wickstrom

ADDRESS: ODNR
Div. of Geological Survey
4383 Fountain Sq. Drive, Bldg. B-2
Columbus, Ohio 43224

Division of Mining and Reclamation (DMR)

FAX: 614/262-6546

Harry Payne, Liaison to ODOT 614/265-1076

ADDRESS: ODNR
Div. of Mining and Reclamation
1855 Fountain Sq. Ct., Bldg. H-3
Columbus, Ohio 43224

John Husted, Emergency Coordinator 614/265-7072

OEPA

The following individuals have been designated by the OEPA as District Office contact persons available for advising ODOT on all areas of environmental compliance about which ODOT must be concerned for individual mine remediation projects. The coordinating District engineer should contact the appropriate OEPA District contact person for each proposed mine remediation project. Please consult the provided state map indicating the geographic area of each OEPA district office. If remote placement of backfill materials in subsurface voids is the chosen form of remediation, the coordinating District engineer should also contact the OEPA, Underground Injection Control (UIC) unit for permitting requirements.

(Note: In addition to these requirements, the coordinating engineer should also process all projects through the District Environmental Coordinator for clearance through the Department's environmental process as documented in ODOT's Transportation Development Process (and implementing manuals).)

OEPA District Office Contact Persons:

Central District Office (CDO)
Rod Mehlhop
Assistant District Chief
3232 Alum Creek Drive
Columbus Ohio 43207
(614) 728-3778
FAX: (614) 728-3898

Northeast District Office (NEDO)
Robert Wysenski
Assistant District Chief
2110 East Aurora Rd.
Twinsburg, Ohio 44087
(330) 425-9171
FAX: (330) 487-0769

Northwest District Office (NWDO)
Jeff Steers
Assistant District Chief
347 Dunbridge Rd.
Bowling Green, Ohio 43402
(419) 352-8461
FAX: (419) 352-8468

Southeast District Office (SEDO)
Steve Skinner
Assistant District Chief
2195 Front Street
Logan. Ohio 43138
(740) 385-8501
FAX: (740) 385-6490

Southwest District Office (SWDO)
Jeff Hines
Assistant District Chief
401 East Fifth Avenue
Dayton, Ohio 45402-1911
(937) 285-6357
FAX: (937) 285-6249

OEPA Districts

Division of Drinking and Ground Water

FAX: 614/644-2909

ADDRESS: OEPA, Central Office
Division of Drinking and Ground Water
P.O. Box 1049
Columbus, Ohio 43216-1049

Thomas Allen - 614/644-2752	Assistant Chief
Mary Lou Rochette - 614/644-2752	Underground Injection Control (UIC) Unit Supervisor
Valerie Orr - 614/644-2752	UIC Unit - Class V Geologist

Ohio Mine Subsidence Insurance Underwriting Association

FAX: 614/847-1779
T.A. Brininger 614/ 436-4530

ADDRESS: 6230 Busch Blvd., Suite 303
Columbus, Ohio 43229

FEDERAL AGENCIES

Federal Highway Administration

Columbus Office
FAX: 614/280-6876
Thomas Lefchik, P.E.
Asst. Bridge Engineer 614/280-6845

ADDRESS: Federal Highway Administration
200 N. High Street
Columbus, Ohio 43215

U.S. Department of Interior, Office of Surface Mining

Columbus Office
FAX: 614/469-2506
Daniel Schrum 614/866-0578
Steve Koratich 614/866-0578

ADDRESS: U.S. Department of Interior
Office of Surface Mining
And Reclamation Enforcement
4480 Refugee Road
Columbus, Ohio 43232

U.S Geological Survey, Water Resources Division

FAX: 614/469-5626
Steven Hindall, District Chief
614/469-5553, Ext. 112

ADDRESS: U. S. Geological Survey
Water Resources Division
975 W. Third Avenue
Columbus, Ohio 43212

APPENDIX E

Forms of Monitoring

I. GENERAL DISCUSSION

The various forms of site monitoring are divided in this appendix into three types: visual, non-intrusive, and intrusive. Applicability and effectiveness of each of these forms of monitoring is site-specific. This appendix, in many areas, draws upon information included in the 1997 of the U.S.G.S. Water Resources Investigations Report 97-4221 entitled "Detection of Underground Voids in Ohio by Use of Geophysical Methods" by Jens Munk and Rodney A. Sheets. Please refer to this U.S.G.S. report for a more detailed discussion of many of the subjects discussed in this appendix.

II. Visual Forms of Monitoring:

A Driving: This form of monitoring involves driving the section of roadway, visually inspecting surface conditions within and beyond the right of way, and "feeling" the roadway profile. Visual information which should be noted would include changes in grade or drainage patterns which might reflect settlements or mine-related subsidence. Evidence of a possible swale/depression (troughing) of the pavement may include a combination of "feeling" the vehicle gently bounce as the trough is driven at roadway speed, and noting the presence of an increased area of oil deposition in the center of the lane at the end of the swale/depression (troughed) area. This oil is the result of lubricants being shaken off the vehicles as they bounce coming out of the swale/depression (troughed) area.

B. On the Ground:

1. Particular Features: This form of monitoring involves on-the-ground measurements of identifiable site features. These features may be structures related to past mining activities, such as an observable shaft cap. Or, they may be the result of past mining activities, such as a surface deformation feature in the form of a pothole subsidence. In either case, the feature is readily identifiable and periodic measurements of the same feature can be taken and compared to past measurements as a means of monitoring site conditions.

2. Ground Photography: This form of monitoring involves creating a photographic record of particular features as described in the above paragraph. Features such as suspected areas of surface deformation or drainage irregularities should be periodically photographed. The resulting photography is then compared to earlier photography of the same site features so as to detect any observable changes.

III. Non-Intrusive Forms of Monitoring:

A. Ground Survey Techniques: This monitoring involves the use of commonly employed surveying techniques to monitor point elevations in areas of suspected surface deformation and in remediation areas as a form of post-construction monitoring. Once the decision has made to perform any form of testing and data collection in the site area, stationing should be immediately established through ground survey. This stationing will allow for the different forms of data to be commonly indexed for comparative analysis.

B. Aerial Photography:

1. Conventional (B/W and Color): This form of monitoring is utilized to: 1) create a base photographic record of the site; 2) to detect particular features which may indicate past mining activities, and; 3) to detect particular features and later, changes to those same features. Particular features may include subsidence features and/or drainage irregularities.

2. Infrared (B/W and Color): This form of monitoring is utilized to: 1) create a base photographic record of the site; 2) to detect particular features which may indicate past mining activities, and; 3) to detect particular features and later, changes to those same features. Particular features may include subsidence features, drainage irregularities, and possibly near surface voids or unconsolidated conditions. The particular advantage of infrared photography over conventional photography is that it detects changes in vegetation and differential surface temperatures which may be key indicators to either surface subsidence, irregular drainage features, or possibly near-surface voids or unconsolidated conditions not otherwise noticeable during ground reconnaissance.

C. Profilometer: This form of monitoring utilizes instrumentation mounted internally in a van which is driven through the site at normal roadway speeds. This form of monitoring produces a record of the existing roadway profile through the site. This profile an then be compared to the roadway profile as constructed. This comparative study can point out areas of possible settlement or change in grade. There are no site limitations known regarding the use of this form of monitoring.

D. Surface Seismic Studies: Seismic studies employ an acoustic impulse, such as a hammer or explosive device, which generates a acoustic wave that travels into the earth and returns where sensitive vibration detectors are used to receive the response. The measured response results from reflections, refractions and diffractions of the generated impulse wave due mainly to differences in material seismic wave velocity.

In seismic surveying, an array of vibration detectors is placed in the ground at spacings defined by the required depth of penetration. Several impulses are generated in this configuration and then the entire array is moved, with some overlap of the first array.

The spacing of the arrays can vary from < 1-10 m for very shallow exploration(<100m) to >100m for deep exploration (>100m). Naturally occurring high energy sources such as volcanos and earthquakes have been utilized to infer the earth's inner structure.

1. Seismic Reflection: With the seismic reflection method the travel time of a wave from a source to a seismic velocity contrast and reflected back to the geophones located at the surface. This reflection results from differences in the seismic velocity of the different materials. By moving the relative positions of the geophone and source the nature of the anomaly can be determined.

Seismic reflection is primarily used for determining the depth and thickness of geologic strata. It is also effective in locating isolated bodies that may be either geological or cultural in origin. Some researchers have reported success in using the seismic reflection method to detect underground voids.

2. Seismic Refraction: The seismic refraction method utilizes geophones to measure the travel time of a wave traveling down to and along an interface of differing velocities and back up to the geophones. The refracted wave propagates along the so-called critical angle until it reaches a discontinuity where it travels horizontally along the interface separating the two materials. The critical angle is determined from the velocities v1 and v2 that a transverse acoustic wave will travel in the respective materials.

Seismic refraction is primarily used for determining the depth and thickness of geologic strata. For example it can be used for determining depth to water table and depth to bedrock in alluvial valleys. Seismic refraction is capable of resolving multiple layers if seismic velocities of these layers increase with depth.

This form of monitoring utilizes various means to impart an energy impulse into the ground. The rate of transmission and the reflection of this energy impulse is detected by an array of geophones. This method of subsurface testing is an excellent tool for defining the depth of the soil-bedrock interface and locating areas of anomalous subsurface conditions. The method of imparting the energy impulse into the ground can take several forms, ranging from firing of a shotgun shell into the surface to the "thumper trucks" commonly utilized for petroleum industry exploratory work.

3. Dynaflect: This form of monitoring involves the use of an oscillating 500 pound weight which is pulled through the roadway section, vibrating the pavement. The pavement response to this vibration is recorded. The resulting data, which is immediately available, records the subsurface conditions in the subgrade immediately below the pavement up to a maximum depth of approximately ten feet. Traffic control in the form of a lane closure is required for this work.

4. Falling Weight Deflectometer (FWD): This form of monitoring involves the use of a falling weight and an array of geophones which are trailer mounted. The weight can be adjusted from 1,500 to 24,000 lbs. The trailer stops at stationed intervals, and then raises and drops the weight on the pavement. The pavement response and associated subgrade response are recorded. The resulting data, which is immediately available, reflects the subsurface conditions in the subgrade below the pavement up to a depth of approximately 10 feet. Traffic control in the form of a lane closure is required for this work.

5. Heavy Weight Deflectometer (HWD): This form of monitoring is basically just another version of the falling weight deflectometer described in the previous paragraph. The only difference is that the HWD falling weight can be adjusted from 6,000 to 54,000 lbs. The HWD also has an optional 18 inch diameter load plate which allows for its use on unpaved areas.

E. Electrical Methods: The respective electrical methods vary greatly with respect to their methodology, and frequency of operation. In addition the source of electrical energy can be either naturally or artificially generated.

The effectiveness of a particular electric method is dependent on various factors, the most important being a significant difference in the electrical material properties between the anomaly and the surrounding medium. In electrical prospecting, the important physical properties are the electrical conductivity/resistivity and permittivity.

Conductivity is a measure of the amount of free charge (electrons) comprising a material. Under the influence of an applied electric field, these electrons move, generating an electric current which in turn produces a secondary electric/magnetic field. This secondary field provides information of regarding the conductivity of the anomaly.

The electrical permittivity is a measure of the polarizability of a material, or the extent to which the molecules comprising a material distort when subjected to an electric field. When a material comprised of molecules with bound charge is subjected to an electric field, a slight displacement occurs between the negative and positive charges of the atom/molecule. This displacement results in a secondary electric/magnetic field which can then be measured (Kraus, 1992).

1. Surface Ground Penetrating Radar (GPR): Ground penetrating radar (GPR) employs high frequency electromagnetic waves to produce a continuous profile of the subsurface. A transmit antenna is used to generate an electromagnetic pulse while a receive antenna measures the response. The response measured by the receive antenna are the electromagnetic reflections resulting from electrical discontinuities in the subsurface. These discontinuities are due to variations in the electrical conductivity and dielectric permittivity of the underlying media and determine the velocity and attenuation of the electromagnetic pulse.

Typical GPR systems accommodate various antennas ranging in frequency from 20MHz-2GHz, where the choice of antenna is dependent on the application. Generally the use high frequency antennae improves resolution of subsurface features, but depth penetration is limited. GPR surveys are conducted by moving the antenna(s) over the region of interest and measuring the response (voltage) at the receive antenna. The pulses are triggered using either a constant time or distance based mode. Applications include locating pipes, tunnels and voids (Lytle and others, 1976; Moran and Greenfield, 1993; Greenfield, 1988).

This form of monitoring, as it has been field tested, utilizes low frequency (longer wave length) radar signals to penetrate the ground to detect subsurface voids and/or anomalies. The success of this technique is highly dependent on the individual site's soils, bedrock and ground water characteristics. Greatest penetrations of GPR have typically been achieved in paved and unpaved shoulder areas where an absence of reinforcing steel exists. Longer wavelengths (25MHz to 50MHz) are utilized in these areas. Shorter wavelengths (100MHz to 1GHz) can be utilized to look for voids and/or anomalies below reinforced pavement . However, the shorter wavelengths utilized to penetrate the reinforced pavement are only able to provide information regarding conditions immediately below the pavement. In general, longer wavelengths penetrate deeper, but provide coarser data collection, than shorter wavelengths.

2. Resistivity Studies: The electrical resistivity method typically employs a direct current (DC) or a very low frequency (<10 Hz) current which is applied to the ground using electrodes in contact with the ground. The voltage potential is then measured between a second pair of electrodes. A number of possible patterns of electrodes can be used, depending upon the depth of penetration needed and the resolution desired. A mathematical combination of the current, potential, and electrode spacing yields the apparent resistivity of the subsurface.

Resistivity measurements are used to measure lateral or vertical changes in the resistivity of the subsurface. To investigate the variation of resistivity with depth, electrode spacings are gradually increased. A fixed electrode separation is maintained along a profile line to determine lateral variations.

Electrical resistivity is commonly used to map electrically-conductive ground-water (salt water; waste plumes), lateral changes in lithology, and depth to bedrock in valley-fill aquifers. The utility of the method is wholly dependent upon the size of the target and the differences between its electrical resistivity and the resistivity of the rock surrounding the target.

3. Electromagnetic Induction (EM): The electromagnetic induction method (EM) uses the variations measured in a secondary electromagnetic field produced when a primary field is generated by inducing a current through coils. Two EM methods, the time-domain and frequency-domain, are described below.

The EM method is typically used to obtain horizontal profiles and depth soundings of conductive layers. The effectiveness of the method is dependent upon the size of the target and the differences between its electrical resistivity and the resistivity of the rock surrounding the target.

a. Frequency-Domain EM: The frequency domain electromagnetic induction technique measures the magnitude and phase of an induced electromagnetic current which is altered by the conductivity of the underlying soil and rock. An electromagnetic field is generated by passing an alternating current at a frequency of 100-5000 Hz through a wire loop.

b. Time-Domain EM: The time-domain EM technique measures the conductivity of soil and rock by inducing pulsating currents into the ground by use of a transmitting coil and monitors their decay over time with a separate receiver coil.

This monitoring technique, when tested on an interstate roadway site was found to be too sensitive to the passing vehicles to be effective. However, this technique may still prove to be a valuable tool to detect abandoned underground mines on sites where the equipment can be removed from the nearby passing of vehicles. One example of such a site would be at the edge of the right of way in rural settings.

4. Spontaneous-Potential (SP): The spontaneous-potential or self-potential method utilizes two electrodes located on the ground to measure natural voltage differences. Natural voltage differences are typically associated with differences in conductivity that can result from geochemical reactions associated with mineral composition or flowing water.

SP anomalies are usually on the order of hundreds of millivolts in magnitude and are usually measured along profiles with electrode pairs maintained at uniform separation. Typically the gradients, as opposed to the actual potential differences are mapped.

Equipotential lines (contours with the same relative voltage) are sometimes mapped by maintaining one electrode in a fixed position and finding the contour along the surface for which no voltage difference between it and a movable probe is observed.

The method is typically used in locating ore bodies which may be in contact with solutions of different composition resulting in an electro-chemical reaction. The method has been responsible for the discovery of numerous sulfide ore bodies at shallow depths.

__5. Very Low Frequency (VLF):__ The VLF technique utilizes existing military radio transmissions operating in the 10-30Khz range and measures distortions created by local changes in the underlying conductivity of the earth. VLF transmitters are located throughout the world including 3 locations in the continental United States.

A VLF survey is typically performed in a traverse or grid with interval spacing based on the size and depth of the suspected anomalies. At each station, the VLF receiver measures the horizontal and vertical component of the electric field at a specified frequency. Variations in the ratio of the two electric (or magnetic) field components are then related to lateral variations in the underlying conductivity.

VLF measurements are primarily used in mapping the extent of sedimentary basins (limestones, sandstones) to define gross lithology and locating vertical faults containing water, clay or other conductive materials.

__F. Potential Field Methods:__ Potential fields are slowly varying naturally occurring force fields and include the gravitational field and the magnetic field. Local variations in the measured potential field can be due to subsurface rock or materials properties.

For near-surface anomalies, potential fields are typically measured in traverses or gridded surveys at the surface. For both the gravity and magnetic methods, depth to anomaly estimates can be made by performing the survey at several heights over the region of interest. Changes in the measured anomaly as a function of measurement elevation are then used to infer the depth of the anomaly.

__1. Gravity Studies:__ The gravity method utilizes precise measurements of the earth's local gravitational field to infer changes in the underlying rock and soil densities. The gravitational field varies with local changes in the density of the subsurface resulting from either geological or cultural features.

Measurement spacing of a gravity survey vary considerably depending on the size and depth of the anomaly under investigation. Typically ground based measurements are on the order of 10's to 1000's of feet, while data obtained from satellites are less dense. Small targets at shallow depths can require much smaller grid spacing often on the order of 1 foot.

Typical uses of gravity surveys are locating buried valleys and igneous intrusions in bedrock. However microgravity surveys can be used to locate voids. The method is most effective for relatively large anomalies with large density contrasts in relatively homogeneous host material.

This form of monitoring measures extremely small variations in the earth's gravitational field within a given study area. Since a void has no mass to create gravitational attraction, the gravitational field over it is reduced. This monitoring technique requires specialized equipment operated by a highly trained person. It is more applicable for studying areas of limited size , rather than larger areas.

2. Magnetic Studies: Magnetic measurements of the earths local magnetic field are used to infer ferrous properties of the subsurface material. The effectiveness of the method depends on the anomalies having sufficiently different magnetic susceptibilities with respect to the surrounding material. The susceptibility is a measure of a materials response to an external magnetic field.

Magnetic surveys are useful in locating ferrous materials that may be cultural or geologic in origin. Magnetic surveys have been used in locating man made objects such as an oil drums, utility pipes, and even locating regions of archeological interest where the station spacing is quite small (< 1 meter). Geological applications include locating ore and mineral deposits as well as mapping the extent of igneous contacts in bedrock. The spacing of measurements for these types of studies are on the order of 10's-100's of meters.

G. Other Methods:

1. Infrared Thermography (IT): Variations in the surface temperature can result from differences in the thermal conductivity and heat capacity of the underlying earth material, and can be measured through the use of a thermal infrared detector.

This method is typically employed to locate fractures, caves, tunnels and seeps and to map contaminants floating on water, and with limited success, in the detection of unexploded ordinances. For detection of unexploded ordinances, surface temperature measurements are made either at dusk or dawn when the higher heat capacity of a metallic unexploded ordinance produces either a source or sink of thermal energy.

IV. Intrusive Forms of Monitoring: The largest cost of performing most of the following intrusive forms of monitoring is the cost of the borehole itself. If a subsurface investigations program is to be undertaken, including a drilling program, the following forms of monitoring should be considered for utilization as applicable to the nature of the given site.

A. Electrical Methods:

1. Borehole Ground Penetrating Radar: This is a form of ground penetrating radar in which the transmitter and antenna elements are inserted into adjacent boreholes. A radar signal is transmitted from one borehole and received by an antenna in the other borehole. Data for the soils and/or rock between the two boreholes is recorded. Borehole spacing for this technique reportedly should not exceed approximately 10 to 12 feet. This fact will limit the use of this technique to very small areas of study to be practical.

2. Time Domain Reflectometer (TDR): The TDR equipment detects deformation of a coaxial cable grouted into the borehole. It can detect lateral (shear) and vertical (subsidence) subsurface movements in the vicinity of the borehole. Cables grouted into boreholes are periodically read and data collected. This data is then compared to preceding historic data for a given borehole to detect changed subsurface conditions.

One District's Special Projects personnel have successfully constructed the required coaxial cables grouted into boreholes which were drilled by the Test Lab. The only non-ODOT equipment required for this operation was a rental grout pump with operator which was required for tremie grouting the boreholes.

3. Slope Inclinometer: This form of monitoring measures lateral subsurface earth displacements. It requires installation of special casing having special grooves at 90 degree intervals. A data collection device with wheels at 180 degrees to each other is lowered down the casing. The wheels travel in the casing grooves which are 180 degrees from each other. This operation is performed twice so as to collect data when the data recorder is traveling down the borehole in each of the pairs of casing grooves which are 180 degrees to each other . The resulting data reports lateral earth movements in two vertical planes 90 degrees to one another.

This form of monitoring is relatively expensive as compared to TDR monitoring due to the special casing, equipment, and time required for data collection and interpretation.

4. Borehole Camera: This is a form of video reconnaissance of boreholes. It allows for the viewing of soil and bedrock conditions in the overburden. It also allows for the viewing of the condition, nature and extent of any voids encountered in the borehole. The borehole camera can provide a video record of the viewed conditions.

B. Borehole Seismic Studies: This is a form of seismic data collection in which the seismic impulse is introduced in a given borehole, and is detected and recorded by a geophone in an adjacent borehole. Data for the soils and/or rock between the two boreholes is then gathered.

C. Groundwater Studies:

1. Piezometers: This is a relatively inexpensive form of monitoring which can provide continuing groundwater data with no sophisticated instrumentation. The borehole is cased with slotted PVC pipe and the annulus is sealed with bentonite so as to isolate the aquifer which the piezometer is intended to monitor. A well screen mesh sock is placed around the slotted portion of the PVC pipe to prevent clogging. Data collection can be performed quickly by one person. Data is easily interpreted and is usable at the time of collection on site.

2. Observation Wells: This a simplified variation of a piezometer in which a borehole is drilled and is cased, with no effort made to isolate a specific aquifer to be monitored. This form of well allows for the monitoring of combined static groundwater head for a given borehole location. This form of groundwater monitoring has application in areas where fractured overburden conditions allow for commingling of originally separate aquifers.

APPENDIX F

References

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APPENDIX G

Forms

I. GENERAL DISCUSSION

The following forms are provided for manual users to conduct the Abandoned Underground Mine Inventory and Risk Assessment for their area.

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Field Report

Name:____Date:________________

Office Location:____

Telephone Number:____________________Best time to call:__________________

As a part of establishing a listing of sites to be evaluated by the abandoned underground mine inventory, the District is gathering information regarding past or present maintenance or construction problems which may have been, or are, related to the presence of mines beneath the roadway.

Please report any unusual grade settlements or drainage conditions which you observed or upon which you have performed work either during maintenance or construction operations with the District. Please report any information, even if the condition/problem and related construction or maintenance occurred years ago. All known conditions/problems within the right of way should be reported. Significant conditions immediately beyond the right of way may also be indicators of conditions evolving beneath the roadway.

LOCATION (C-R-S)	CONDITION / PROBLEM / MAINTENANCE	APPROXIMATE DATE

Please return this completed form to____________ at the District ____________ Office. If you have any questions about the completion of this form, or wish to discuss information you are reporting on this form, please contact (District Contact Person) at (Telephone number).

*For District Office Use: Field Report No.*__________

5/15/98

Ohio Department of Transportation

Action Required:
1)
2)
3)

Abandoned Underground Mine Inventory and Risk Assessment

Office Investigation of Field Report

Person Filing Original Field Report:________________________Field Report No.__________
Location of Person Filing Original Field Report::__________________________________
Telephone Number:________________________Best time to call:________________________
Investigator's Name:__________________________________ Date:__________________

Note to Investigator:
Please contact the person providing the field report and make a record of the conditions which were observed or upon which work was performed either during maintenance or construction operations within the District. Use a new copy of this form for each separate roadway location. Be sure to make a record of any information, even if the condition/problem and related construction /maintenance occurred years ago. All known conditions/problems within the right of way should be reported. Significant conditions immediately beyond the right of way may also be indicators of conditions evolving beneath the roadway.

Location of Condition/Problem (C-R-S)____
Date(s) Observed:____

Check Appropriate Box(es):
_______Observed/encountered during Maintenance operations
_______Observed/encountered during Construction operations
_______Other____

Surface Grade Problems:

1. Subsidence features such as sinkholes/potholes, irregular grade settlement:
   Surface shape and depth of features:____
   Number of surface features:____
   Location of features relative to the referenced roadway:____________________________
   ____
   Construction/Maintenance action taken to correct condition:__________________________
   ____
   ____

2. Areas of pavement requiring several overlays of patching material due to settlement:
   Shape of surface feature(s):____
   Number of areas____

Location of features within the referenced roadway:______________________________

____

Construction/Maintenance action taken to correct condition:____________________

____

3. Areas of pavement with unusual crack patterns unrelated to known joints or repairs:

Shape of crack patterns:____

Number of areas with cracks: ____

Location of cracked area(s) within the referenced roadway:______________________

____

Construction/Maintenance action taken to correct condition:____________________

____

____

Drainage Problems/Irregularities (Check all appropriate items):

1.______Loss in volume of drainage at some midpoint of ditchline with smooth flowline

2.______Gain in volume of drainage at some midpoint of ditchline with smooth flowline

3.______Loss in volume of drainage in ditchline at some unexplainable low spot

4.______Gain in volume of drainage in ditchline at some unexplainable low spot

Are these drainage conditions seasonal or year-round:____________________________

Construction/Maintenance action(s) taken to correct condition:____________________

____

____

____

General Information:

Is the person who completed the field report aware of any underground mines reported to exist in the vicinity of the roadway area? If so, please provide the name of the mine(s) here:__________

____

____

____

Names of other contact person(s) (ODOT or private sector) which may be able to provide additional information regarding this site:_________________________________

____

____

Other information which may be pertinent:____________________________________

____

____

____

PLEASE ATTACH A MAP OR SITE SKETCH OF THE FIELD REPORT AREA

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Pre-Inspection Checklist

A. Review Existing Information

1) Abandoned Underground Mine Map Series (U.S.G.S. Based) - Obtain from ODNR. DGS and review.

2) Individual Underground Mine Abandonment Map and associated Data Form from ODNR, DGS - Obtain and Review

3) Roadway and Right of Way Plans - Review

4) Subsurface Investigation

5 Centerline Survey Plat - to help locate mine map (section lines, property lines, etc.)

6) ODNR Historic Information Regarding Subsidence Events - review for events near site

7) OSM Historic Information Regarding Subsidence Events - review for events near site

8) OMSIUA Historic Information Regarding Subsidence Events - review for events near site

9) Abandoned Underground Mine Inventory Field Data Sheets From Counties - review for reports near site

10) County Maintenance Records - review for unusual grade and drainage conditions/maintenance near site

11) Measured Geologic Sections - Obtain from ODNR, DGS and Review

12) Geologic Structure Maps - Obtain from ODNR, DGS and Review

B. Compile Overlay:

1) Scale Adjustment - use plan scale and modify mine map *(if necessary)* to fit

2) Manually produce composite plan view by overlaying mine map on roadway drawings.

C. Notify County Superintendent:

1) Inform of intent to visit site and invite to participate in site visit

2) Ask about any known records of unusual maintenance or construction at site.

D. Equipment:

shovel	permanent marker	DMI equipment
tape	hammer	measuring wheel
camera	rock hammer	climbing rope
notebook - with grid paper for sketching	machete	binoculars
locking hand level	folding rule	clipboard
altimeter (+/- 5 ft.)	level rod, telescoping	calculator
soil probe	sounding rope (cord with weight)	scale
mirror	hiking compass	straight edge
flashlight	spray paint	protractor
survey lath	safety strobe light for vehicle	
handheld GPS unit		

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Site Data Form

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No.______________________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.:______________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map:______________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.:__________ (If known.)

Name of Site Evaluator:______________________________ Evaluation Date:______________

NOTE: Circle applicable items, and provide comments and sketch. Use back of forms or attach additional sheets as required.

I. Site Investigations

A. Evidence of Past Mining Activities

1) Mine Openings
2) Mine Structures (ruins/foundations of tipples, fanhouses, scalehouses, wash houses,etc.)
3) Gob Piles
4) Strip Pits
5) Railroad Spurs
6) Orange water/seeps/springs
7) Contact Local Residents

B. Surface Deformation Features

1) Crack Patterns and Dips In Roadway
2) Damaged or Displaced Drainage Structures
3) Effects on Bridges, Structures, Poles, Culverts, etc.
4) Unusual Vegetation
5) Drag Patches
6) Dips in Guard Rail
7) Dips in Flowline of Ditches
8) Low Spots Holding Water
9) Ponds (unusual water formations on surface, impoundments)
10) SurfaceTopography Anomalies
11) Level of Groundwater

II. Recording Information

1) Record Mining and Geologic Information:

- Mark Features with Ribbon, Paint,

- Record Type and Apparent Minimum Overburden Thickness to Top of Mined Interval (if visible).
  - Estimate as one of the following:

    < 25'   25' - 50'   50' - 100'   > 100'

- Record Maximum Mined Interval (seam(s)) Thickness, if outcrop is observable in site vicinity

    >6'   3' - 6'   0' - 3'

- Record Number of Subsidences

- Record Mine Opening Information:
  - Type(s) and Number(s) of Mine Opening(s). Types include: Drift (Horizontal), Slope, and Shaft (Vertical)

    Drift (Horizontal)_________Slope_________Shaft (Vertical) _________

  - Mine Opening Location(s) Relative to Roadway:

Location Not Conclusively Known	Between The Two Outer-Most Edge of Shoulders	Less Than 50 Feet From Edge of Shoulder	Between 50' and 100' From Edge of Shoulder	Within Sight From Edge of Shoulder

  - Method of Mine Opening Closure, if Observable.

No Information	Timber Decking	Random Backfill	Concrete Cap	Controlled Backfill

  - Type of Mine Opening Cribbing, if Observable

No Information	Timbers	Brick	Concrete

  - Plan Area of Mine Opening(s), if observable and safe to measure.

Size Is Unknown	>750 S. F.	From 500 to 750 S. F.	From 250 to 500 S. F.	From 150 to 250 S. F.	<150 S. F.

- Record Field Observations of any other unique site features and describe the general site setting.

- Check Information Recorded Against Information Reported on Field Data Sheet (if any).

- Record Information Provided by Local Contacts (if any), including any information about secondary mining or problems reported during mining.

2) Record Roadway Information:

- Record Structures in Roadway site? (YES/NO)
  - Note type and condition of structure(s), including materials used in their construction.,

- Record Posted Speed Limit Within Site Limits

- Record Type of Pavement . In the case of asphalt surface, verify base pavement construction or reconstruction. Determine if rubblized. Indicate one of the following:

    Continuously Reinforced   Other

- Record Evidence That The Mine Is Not Under The Roadway

3) Sketch Features on Map / Roadway Plans/ Back of This Form

- Determine Site Limits -Sketch on Map /Plans

- Sketch in Topographic Anomalies

- Sketch in All Recorded Features
  - Record elevations relative to the roadway
  - Measure and record dimensions of recorded features.

- Record Bearing Between Features using a hand-held hiking compass

4) Take Photographs:

- Reference the Camera Position if Possible,

- Use "Data Back" Film, or Record and Keep Notes with Film.

- Photograph Multiple Angles of Significant Features

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Initial Site Evaluation

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No. ____________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.: __________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: __________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: __________ (If known.)

Name of Site Evaluator: ______________________ Evaluation Date: __________

ELIMINATED SITES SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not beneath the roadway ?

Yes_____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No_____

	Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1)	Evidence of Surface Deformation	Automatic Placement in Surface Deformation Group For Detailed Site Evaluation	yes	no				If "Yes", Proceed to Detailed Site Evaluation
2)	Presence of Mine Opening(s)	Automatic Placement in Mine Opening Group For Detailed Site Evaluation	yes	no				If "Yes", Proceed to Detailed Site Evaluation
3)	Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	9	Ratio = 1 or > 1 10	Ratio <1 1				
4)	Average Daily Volume of Traffic (ADT)	9	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	≤ 5K 2	
5)	Hydrogeologic Setting	8	Dewatered 10	Flooded 8	Not Flooded 1			
6)	Minimum Overburden Thickness (Approx.)	4	≤ 25' 10	25' - 50' 8	50' - 100' 5	>100' 1		
7)	Maximum Mined Interval Thickness (Approx.)	4	>6' 10	3' - 6' 5	0 - 3' 1			
8)	Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6	Ratio < 5 10	Ratio = 5 to 11 5	Ratio >11 1			
9)	Secondary Mining	4	yes 10	no 1				

Overall (Total) Site Evaluation Rating: ______

COMMENTS (Attach additional sheets if necessary):

5/15/98

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed Surface Deformation Site Evaluation

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No.______________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.:____________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map:____________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.:____________ (If known.)

Name of Site Evaluator:______________________ Evaluation Date:______________

ELIMINATED SURFACE DEFORMATION SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes_____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No______

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1) Number of Subsidences	30	Number of Subsidence Features on Site					
2) Recent Dewatering	21	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1	
3) Average Daily Traffic (ADT)	15	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	< 5K 2	
4) Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	12	I.R. 10	NHS Other Than IR 7	Arterial 5	Collector 1		
5) Average Daily Truck Traffic (ADTT)	9	>6K 10	4K to 6K 8	2K to 4K 6	1K to 2K 4	< 1K 2	
6) Traffic Speed	6	>35 MPH 10	0 to 35 MPH 1				
7) Type of Pavement	6	Other 10	Continuously Reinforced 1				
8) Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	6	Ratio = 1 or > 1 10	Ratio <1 1				
9) Availability of Reasonable Detour Routes	6	None 10	Yes 0				
10) Structures in Roadway	3	Yes 10	No 0				
11) Minimum Overburden Thickness (Approx.)	2	< 25' 10	25' - 50' 8	50' - 100' 5	>100' 1		

Overall (Total) Site Evaluation Rating: ______

COMMENTS (Attach additional sheets if necessary):

5/15/98

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed Mine Opening Site Evaluation

C/R/S/ (Mile Marker): ______________________________ Field Report / Office Investigation No. ______________________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.: ____________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map: ______________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.: ____________

Name of Site Evaluator: ______________________________ Evaluation Date: ______________

ELIMINATED MINE OPENING SITE SCREENING

NOTE: Have site investigations and /or interviews conclusively proven that the identified mine opening(s) at this site is (are) not an apparent threat to the safety of the roadway ?

Yes_____ (SEE COMMENTS BELOW FOR BASIS OF THIS FINDING)

No______

NOTE: Checking "Yes" to this question indicates that exact location, orientation and limits of influence have been verified in the field and a determination made that collapse of the opening or the closure would not affect the roadway or roadside development.

	Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1)	Method of Mine Closure (NOTE: For Multiple Mine Openings See Implementation Manual)	10	No Information 10	Timber Decking 10	Random Backfill 6	Concrete Cap 4	Controlled Backfill 2	
2)	Type of Cribbing (NOTE: For Multiple Mine Openings and/or Multiple Forms of Cribbing See Implementation Manual)	10	No Information 10	Timbers 10	Brick 7	Concrete 4		
3)	Average Daily Traffic (ADT)	10	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	< 5K 2	
4)	Mine Opening Location (NOTE: For Multiple Mine Openings See Implementation Manual)	9	Location Not Conclusively Known 10	Between The Two Outer-Most Edge of Shoulders 10	Less Than 50 Feet From Edge of Shoulder 8	Between 50' and 100' From Edge of Shoulder 2	Within Sight From Edge of Shoulder 1	
5)	Classification of Roadway (NOTE: For Intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR 7	Arterial 5	Collector 1		
6)	Minimum Overburden above Mine Opening	8	Shaft or Cover = 0 ' 10	Slope/Drift Cover < 25' 9	Slope/Drift Cover = 25' - 50' 8	Slope/Drift Cover = 50' - 100' 5	Slope/Drift Cover >100' 1	
7)	Recent Dewatering	8	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1	

(Over)

Criterion	Criterion Weighting Factor	Site Condition / Rating Value						Individual Criterion Rating
8) Average Daily Truck Traffic (ADTT)	6	>6K 10	4K to 6K 8	2K to 4K 6	1K to 2K 4	< 1K 2		
9) Type of Pavement	6	Other 10	Continuously Reinforced 1					
10) Structures in Roadway	6	Yes 10	No 0					
11) Traffic Speed	5	>35 MPH 10	0 to 35 MPH 1					
12) Type of Mine Opening (NOTE: For Multiple Mine Openings) See Implementation Manual)	5	Shaft (Vertical) 10	Slope 8	Drift (Horizontal) 6				
13) Plan Area of Mine Opening (Approx.) (NOTE: For Multiple Mine Openings) See Implementation Manual)	4	>750 Sq. Ft. 10	From 500 to 750 Sq. Ft. 8	From 250 to 500 Sq. Ft. 6	Mine Opening Size Unknown 5	From 150 to 250 Sq. Ft. 4	<150 Sq. Ft. 2	
14) Age of Mining	4	<1900, or Unknown 10	1900-1930 9	1931-1945 7	1946-1968 5	> 1968 1		
15) Availability of Reasonable Detour Routes	2	None 10	Yes 0					
				Overall (Total) Site Evaluation Rating:				

COMMENTS (Attach additional sheets if necessary):

5/15/98

Ohio Department of Transportation

Abandoned Underground Mine Inventory and Risk Assessment

Detailed High Rating Site Evaluation

C/R/S/ (Mile Marker): ______________________ Field Report / Office Investigation No.______________

Site Description: ____

____

U.S.G.S. Topographic Quadrangle ODOT No.:______________ O.D.N.R. Abandoned Underground Mine Series (U.S.G.S.) Map:______________ O.D.N.R.,DGS Individual Abandoned Underground Mine Map Index No.:__________ (If known.)

Name of Site Evaluator:______________________________ Evaluation Date:______________

	Criterion	Criterion Weighting Factor	Site Condition / Rating Value					Individual Criterion Rating
1)	Minimum Overburden Thickness (Approx.)	4	≤ 25' 10	25' - 50' 8	50' - 100' 5	>100' 1		
2)	Recent Dewatering	10	<1 Yr. 10	1 to 3 Yrs. 9	4 to 6 Yrs. 4	7 to 9 Yrs. 2	>9 Yrs., Unknown, or Dry Mine 1	
3)	Average Daily Traffic (ADT)	9	>30K 10	20K to 30K 8	10K to 20K 6	5K to 10K 4	≤ 5K 2	
4)	Classification of Roadway (NOTE: For intersecting Roads, See Implementation Manual)	9	I.R. 10	NHS Other Than IR 7	Arterial 5	Collector 1		
5)	Extraction	8	Secondary 10	>50% 7	Unknown 5	<50% 1		
6)	Maximum Mined Interval Thickness (Approx.)	8	>6' 10	3' - 6' 5	0' - 3' 1			
7)	Age of Mining	8	<1900, or Unknown 10	1900-1930 9	1931-1945 7	1946-1968 5	> 1968 1	
8)	Ratio of Unconsolidated Materials to Bedrock in the Overburden Interval	8	Ratio= 1 or > 1 10	Ratio <1 1				
9)	Ratio of Minimum Overburden Thickness To Maximum Mined Interval Thickness (Approx.)	6	Ratio < 5 10	Ratio = 5 to 11 5	Ratio >11 1			
10)	Average Daily Truck Traffic (ADTT)	5	>6K 10	4K to 6K 8	2K to 4K 6	1K to 2K 4	≤ 1K 2	
11)	Type of Pavement	5	Other 10	Continuously Reinforced 1				

(Over)

Criteria	Criteria Weighting Factor	Site Condition / Rating Value				Individual Criteria Rating
12) Structures in Roadway	3	Yes 10	No 0			
13) Traffic Speed	3	>35 MPH 10	0 to 35 MPH 1			
14) Availability of Reasonable Detour Routes	3	None 10	Yes 0			
15) Special Mine Features	2	Intersecting Haulways 10	Entry 5	Large Room 5	None 0	
16) Problems Reported During Active Mining	2	Yes 10	No/Not Known 0			
				Overall (Total) Site Evaluation Rating:		

COMMENTS (Attach additional sheets if necessary):

5/15/98

APPENDIX H

Log of Revisions and Updates

To Manual Holders:

The form below is provided for users of the manual to maintain a log of revisions and updates. In this section, users should also file summaries of revisions that accompany transmittals.

LOG OF REVISIONS AND UPDATES

DATE	SUBJECT/ SECTION	COMMENTS

LOG OF REVISIONS AND UPDATES (Continued)

DATE	SUBJECT/ SECTION	COMMENTS

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