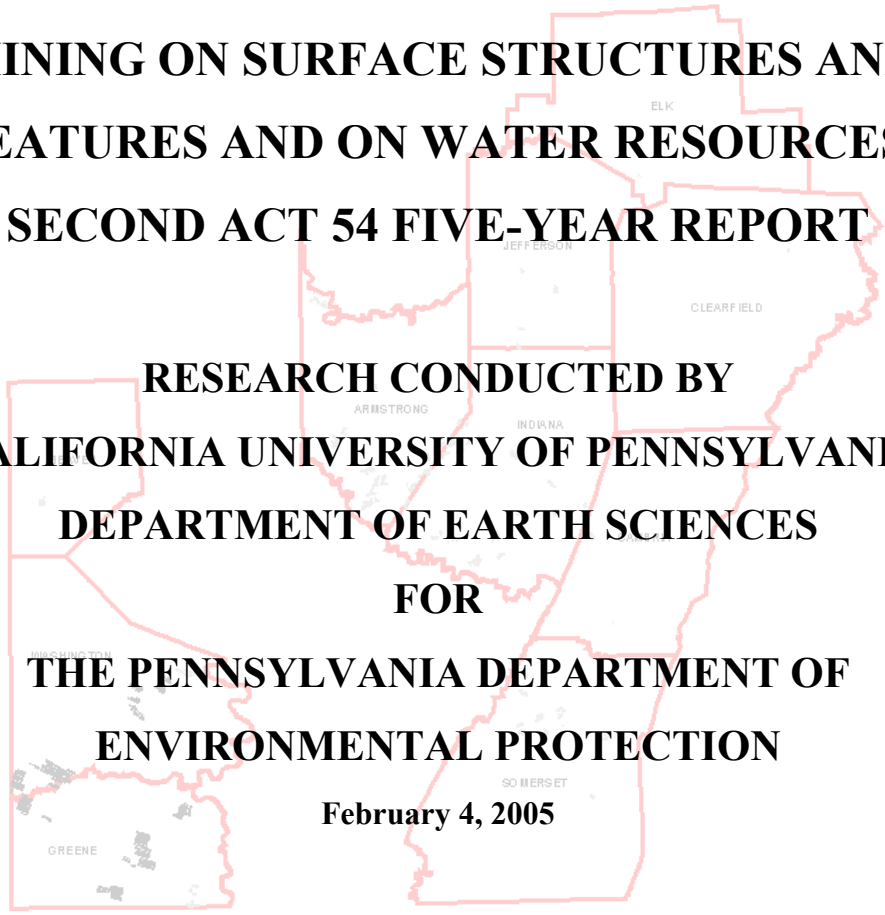
THE EFFECTS OF SUBSIDENCE RESULTING FROM UNDERGROUND BITUMINOUS COAL MINING ON SURFACE STRUCTURES AND FEATURES AND ON WATER RESOURCES: SECOND ACT 54 FIVE-YEAR REPORT



RESEARCH CONDUCTED BY

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DEPARTMENT OF EARTH SCIENCES

FOR

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CONTENTS

GUIDE TO PLATES FOUND IN THIS REPORT

A Guide to Understanding Section VI-Structures

- Plate 1 is a display of all structures with reported problems/claims.
- Individual plates show structures with problems/claims for particular mines.
- Structures are shown only for longwall mines.
- Shoemaker and High Quality mines had no structures with claims.
- All labeling is accurate for the time of collection.

Section VI: EFFECTS OF MINING ON STRUCTURES

VI.A. Overview

This section presents the total number of structures undermined, the total number of structures with reported problems, and the total number of structures with claims. The section also contains a table of damage magnitude for 70 structures that were impacted by subsidence during the assessment period. In addition, this section reveals the number and kinds of mitigation techniques applied pre-mining by longwall mine operators in an attempt to reduce or eliminate the potential impacts of subsidence.

VI.B. Data Sources

The University obtained data on undermined and impacted structures from five sources:

- Six-month mining maps submitted to the California District Mining Office by mine operators
- BUMIS reports
- Paper files in the California District Mining Office
- Damage reports faxed to the California District Mining Office by mine operators
- Interviews with professional staff at the California District Mining Office

The University's researchers believe the following information is germane to the collection of data on impacted structures for future Act 54 reports:

The University encountered some difficulties when its researchers first attempted to make an assessment of structure impacts. Initially, the researchers relied on reports from BUMIS, making the assumption that the details recorded there were representative of the universe of structures affected during the assessment period and instructive of the nature and solution to any structure damages. In BUMIS structures with claims are given an identification number preceded by the abbreviation "SA." Among the SA numbers for the assessment period, however, are non-structure entities, such as wells.

The University used the six-month mining maps to locate structures with problems and/or claims for the longwall mines. About nine structures for which there was either a problem or a problem and claim could not be precisely located within the property boundary. If a plat map or tax map were included in the information and if all structures had a GPS location, the mapping of structures would be facilitated.

Undermined structures generally had no recorded "distance to mining." Although the obvious observation would be that such structures overlie mines and their distance is, therefore, zero, the University's researchers, in an attempt to relate damage to structures and placement within the subsidence zone, needed such information. Also, no information was available that would enable the University to relate the time of mining to reported impacts. "Timing," a requirement of the MOU, was, therefore, impossible to ascertain.

There is no "presumptive zone of influence" for structures that lie beyond the immediate boundary of mining. A structure one inch off a line marking the surface boundary above an active mine must be treated on an individual basis. Investigators from the California District Mining Office who specialize in damage caused by subsidence assess each problem as it arises. Each such investigator or surface subsidence agent maintains a file of correspondence that includes letters to and from structure owners and mine operators. In numerous instances, the mediation of the surface subsidence agent prevents a problem from becoming a claim because of an amicable solution worked out between operator and owner (under the guidance of the surface subsidence agent). In such instances, no extensive record is necessarily kept beyond the initial faxed "problem."

VI.C. Number of Structures Undermined and Impacted

During the assessment period, 3,656 structures of various kinds on 3,033 properties were undermined (tables VI.1 and VI.2). Maple Creek Mine undermined more properties (348) and structures (446) than any other mine during the assessment period.

Table VI.1. Number of structures undermined during the assessment period.

Mine	Number of Structures Undermined
AMFIRE MINING CO/NOLO MINE	19
BAILEY DEEP MINE	197
BARBARA NO 1 DEEP MINE	2
BLACKSVILLE 2 MINE	208
BURRELL DEEP MINE	234
CLEMENTINE 1 DEEP MINE	49
CUMBERLAND MINE	202
DARMAC 2 MINE	19
DARMAC 3 MINE	15
DIANNE MINE (formerly DAVID DIANNE MINE)	4
DILWORTH DEEP MINE	280
DORA 8 DEEP MINE	2
DUNKARD DEEP MINE	8
DUTCH RUN MINE	25
EMERALD DEEP MINE	263
EMILIE 1 & 2 MINE	10
ENLOW FORK MINE	376
GENESIS INC/GENESIS NO 17	36
GERONIMO MINE	25
HIGH QUALITY MINE	14
JOSEPHINENO 3	13
LION MINING/GROVE #1 DEEP MINE	4
LONGVIEW DEEP MINE	10
LUCERNE 6E DEEP MINE	10
MAPLE CREEK MINE	446
MARSHALL RUN MINE	13
MATHIES MINE	136
MEADOW RUN DEEP MINE	2
MEARS ENTERPRISES/PENN RUN DEEP MINE	9
MILLER DEEP MINE	110
MINE 84	329
MINE NO 1	51
NO 3 DEEP MINE	9
ONDO MINE	17
PARKWOOD MINE	68
QUECREEK NO 1	11
RAMPSIDE 1 DEEP MINE	2
RAYNE NO 1 MINE	5
RIDGE MINE	31
ROARING RUN	150
ROSEBUD MINING CO/LOGANSPORT MINE	25
ROSEBUD MINING CO/STITT MINE	11
ROSEBUD MINING CO/TWIN ROCKS	6
SANDY LANDS MINE	2

SARAH MINE	53
SHOEMAKER MINE	1
SOLAR FUEL/SOLAR #10 DEEP MINE	1
SOLAR NO 7 DEEP MINE	9
TANOMA DEEP MINE	47
TJS 1 DEEP MINE	12
TRACY LYNNE MINE	57
TRIPLE K NO 1	14
URLING 1/3 DEEP MINE	4
Total	3656

Table VI.2 Number of properties undermined during the assessment period.

Mine	Number of Properties Undermined
AGUSTUS MINE	5
B & M 2 DEEP MINE	1
BAILEY DEEP MINE	189
BARBARA NO 1 DEEP MINE	8
BLACKSVILLE 2 MINE	138
BURRELL DEEP MINE	150
CLEMENTINE 1 DEEP MINE	72
CUMBERLAND MINE	114
DARMAC 2 MINE	30
DARMAC 3 MINE	23
DIANNE MINE (formerly DAVID DIANNE MINE)	9
DILWORTH DEEP MINE	341
DLR MINING INC/NOLO MINE	25
DOOLEY RUN MINE (FMLY TARGET #1 DEEP MINE)	6
DORA 6 DEEP MINE	2
DORA 8 DEEP MINE	4
DUNKARD DEEP MINE	11
DUTCH RUN MINE	29
EBERHART COAL/TITUS DEEP MINE	7
EMERALD DEEP MINE	161
EMILIE 1 & 2 MINE	31
ENLOW FORK MINE	182
GENESIS INC/GENESIS NO 17	14
GERONIMO MINE	21
HIGH QUALITY MINE	14
HUMPHREY 7 MINE	3
JOSEPHINENO 3	19
LAUREL RUN	4
LION MINING/GROVE #1 DEEP MINE	12
LONGVIEW DEEP MINE	25
LUCERNE 6E DEEP MINE	24
MANOR 44 DEEP MINE	4
MAPLE CREEK MINE	348
MARSHALL RUN MINE	30

MATHIES MINE	46
MEADOW RUN DEEP MINE	5
MEARS ENTERPRISES/PENN RUN DEEP MINE	16
MILLER DEEP MINE	54
MINE 84	230
MINE NO 1	35
NO 3 DEEP MINE	19
ONDO MINE	23
PARKWOOD MINE	43
PENN VIEW MINE	5
PLUMCREEK NO 1	20
QUECREEK NO 1	17
RAMPSIDE 1 DEEP MINE	4
RAMSAYTOWN DEEP MINE	6
RAYNE NO 1 MINE	9
RIDGE MINE	29
ROARING RUN	89
ROSEBUD MINING CO/LITTLE TOBY MINE	1
ROSEBUD MINING CO/LOGANSPORT MINE	9
ROSEBUD MINING CO/STITT MINE	11
ROSEBUD MINING CO/TWIN ROCKS	9
ROSEBUD MINING/#2 DEEP MINE	6
SANDY LANDS MINE	12
SARAH MINE	72
SHOEMAKER MINE	12
SOLAR FUEL/SOLAR #10 DEEP MINE	3
SOLAR NO 7 DEEP MINE	14
TANOMA DEEP MINE	46
TJS 1 DEEP MINE	24
TJS NO 4 DEEP MINE	11
TRACY LYNNE MINE	45
TRIPLE K NO 1	24
URLING 1/3 DEEP MINE	28
Total	3033

Table VI.3 shows the number of structures for which the California District Mining Office received faxed messages (348) from mine operators that indicated a notification of a structure "problem." Of these faxed problems eventually 141 became claims. This number of claims represents only 3.8% of the total undermined structures.

Table VI.3. Structures with "problems" and "problems with claims." Not all problems result in the filing of a claim. When a claim is filed, the California District Mining Office assigns an identification number that begins with the designator "SA."

Mine	Problems With Claims	Problems Without Claims	Total Problems
BAILEY DEEP MINE	6	35	41
BLACKSVILLE 2 MINE	8	30	38
BURRELL DEEP MINE	2	1	3
CUMBERLAND MINE	5	11	16
DIANNE MINE (formerly DAVID DIANNE MINE	8	1	9
DILWORTH DEEP MINE	10	8	18
EMERALD DEEP MINE	9	16	25
EMILIE 1 & 2 MINE	1	1	2
EMILIE 4 DEEP MINE	1	0	1
ENLOW FORK MINE	7	27	34
HIGH QUALITY MINE	0	1	1
HUMPHREY 7 MINE	0	9	9
LION MINING/GROVE #1 DEEP MINE	2	0	2
LUCERNE 6E DEEP MINE	1	0	1
LUCERNE NO 6 DEEP MINE	0	1	1
MAPLE CREEK MINE	43	24	67
MATHIES MINE	6	0	6
MINE 84	17	32	49
QUECREEK NO 1	2	0	2
ROARING RUN	1	0	1
SARAH MINE	1	0	1
SOLAR NO 7 DEEP MINE	0	1	1
TANOMA DEEP MINE	7	9	16
URLING 1/3 DEEP MINE	2	0	2
WARWICK DEEP MINE 3	2	0	2
Total	**141**	**207**	**348**

Table VI.4. Magnitude of impact that is known for 70 structures undermined during the assessment period. For the PA DEP a structure has suffered irreparable damage when its repair costs equal the current value of the structure. The designators "slight damage," "moderate damage," and "severe damage" are derived from the estimates made by agents of the California District Mining Office who have personal experience with each of the 70 structure claims.

Structures by Type of Construction	**Slight Damage***	**Moderate Damage****	**Severe Damage*****
All Masonry	1	2	2
Block Foundation, Aluminum Siding	1	2	3
Block Foundation	0	2	2
Block Foundation, Brick Veneer	1	3	9
Block Foundation and Modular	0	1	0
Block Foundation, Stone Veneer	0	1	2
Block Foundation, Wood Siding	0	2	3
Block Foundation, Vinyl Siding	1	0	3
Poured Concrete, Log	1	0	0
Chimney	1	0	0
Mobile Home	3	0	0
Wood Foundation, Wood Siding	1	0	0
Wood Siding	2	3	0
Poured Concrete, Wood Siding	0	0	1
Stone Foundation, Wood Siding	0	1	2
Stone Foundation, Brick Veneer	0	1	0
Greenhouse	0	0	1
Brick Veneer	0	1	1
No Data	2	3	5
Totals	14	22	34
* Slight Damage-Cosmetic Repairs			
** Moderate Damage-Partial Replacement			
*** Severe Damage-Foundation Replacement or High Repair Cost			

VI.D. Determination of Impact Magnitude

The University could not find data on costs for repairs to structures with claims. Without such information, the University could not make an assessment of damage magnitude. However, the surface subsidence agents of the California District Mining Office had the knowledge of their investigations into purported damages, and it was only through their assistance that the University was able to meet one of the requirements of the MOU: to determine the magnitude of effects. Using information provided by the California District Mining Office, the University has established a table of magnitude on 70 structures that were impacted during the assessment period (Table VI.4).

VI.E. Mitigation

Mine operators, in an effort to minimize potential damages, have applied a number of mitigation techniques to structures prior to undermining (fig. VI.5). These mitigation techniques include trenching around a structure to prevent damage by a compression wave that precedes the advance of a longwall panel. Mitigation can also include roping or banding around the walls of a structure and the use of angles and cables to secure the framework.

The faxed reports from mine operators sent to the California District Mining Office contain a line item designated "Mitigation." The University examined the faxes from each of the longwall mines for the assessment period to cull information from this line item. In some instances, the line contained for the entry a single word: **"Yes."** The University could assume only that mitigation of some kind had taken place. Also, in some instances, the mine operator and the structure owner came to a pre-mining agreement, and the line for mitigation contained the word **"agreement."** The number of such agreements is reflected in the graphs for each mine (below).

The following figures present the overview of mitigation for longwall mines from the type of mitigation listed in the reports faxed to the California District Mining Office. As the reader can see, in some instances the faxed message simply states that a plan of some unspecified sort was implemented ("plan implemented"). The University made a

concerted effort to relate the type of mitigation, the type of structure, the type of subsidence pattern, the distance to mining, and the timing of the mining. However, the University *could not* find a pathway that links these parameters. Avenues of research included delving into the BUMIS files and the paper files on structures and attempting to cross-reference the BUMIS files, the faxed reports, the six-month mining maps, the structure claims files, and the personal knowledge of the surface subsidence agents of the California District Mining Office. At the outset of the research, the University hoped to relate mitigation to damage to assess the effectiveness of a pre-mining action. Because no cross-referencing could be established and because some mitigation actions are vaguely defined at best, the University could not determine whether, for example, an all-masonry structure survived subsidence impacts better than a type-5 building of concrete and wood during the assessment period.

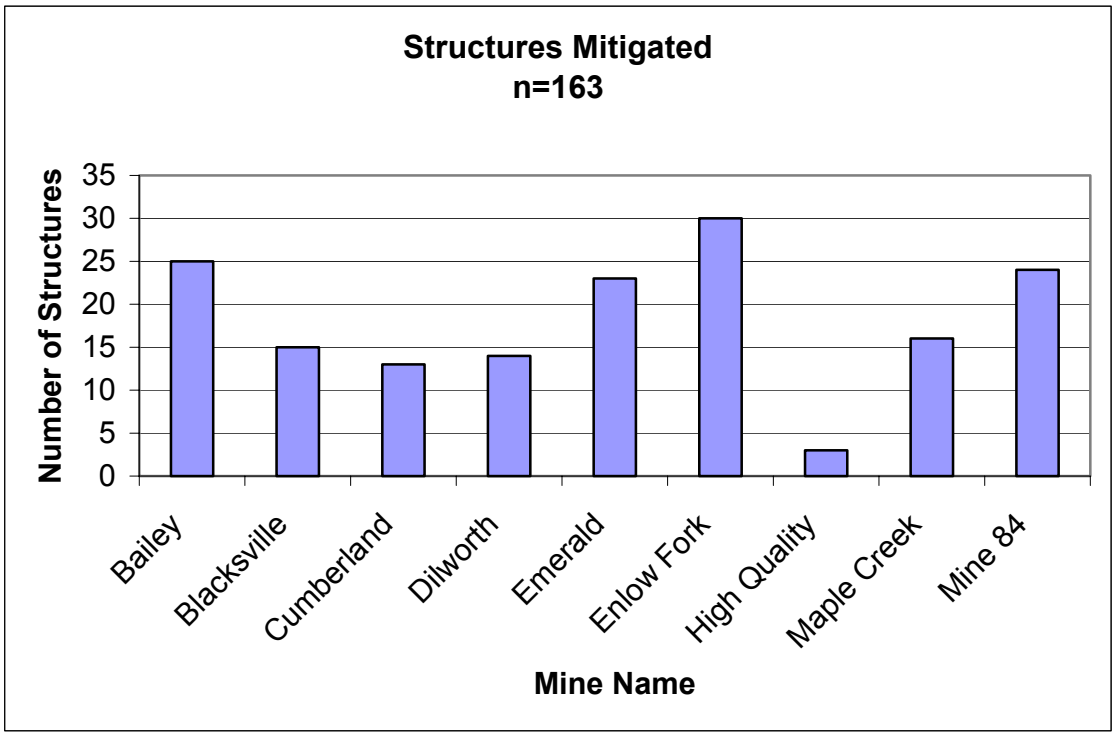

Figure VI.1. Number of structures for which the reports faxed by mine operators to the California District Mining Office had an entry on the line marked "Mitigation." This represents all longwall mines except Shoemaker, whose mining was conducted only partially within Pennsylvania during the assessment period.

Not all mitigation actions occurred pre-mining, and some actions appear to involve only "monitoring." Other actions appear to be combinations, such as "supported and monitoring."

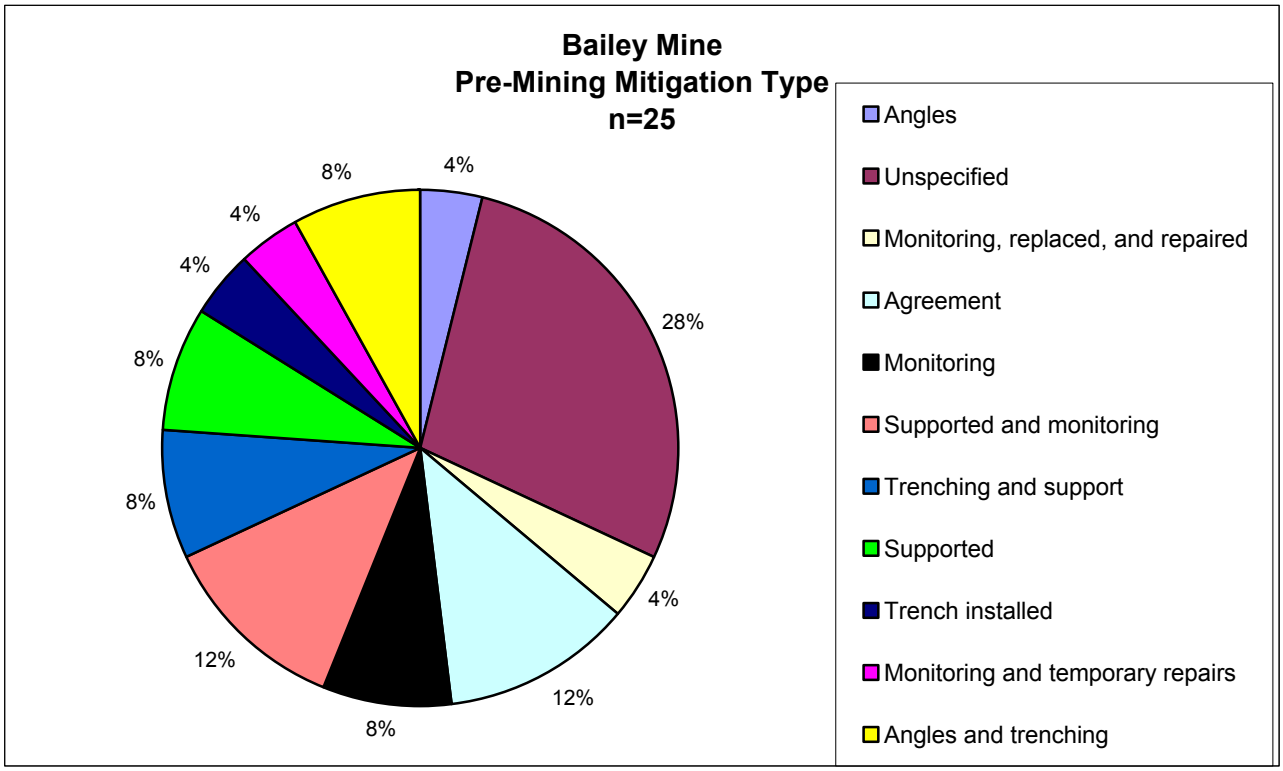

Figure VI.2 Bailey Mine mitigation actions. Twenty-eight percent of the actions are "unspecified" on the faxed reports.

The variation in reporting practices can be seen by comparing figure VI.2 and figure VI.3. Blacksville has fewer categories of mitigation types than Bailey. The University does not conclude, however, that types of mitigation used over Bailey were not used over Blacksville nor does it conclude that one mine operator has a more successful strategy for mitigation than the other. Rather, the differences between the two relate only to the reporting of mitigation on the faxed sheets.

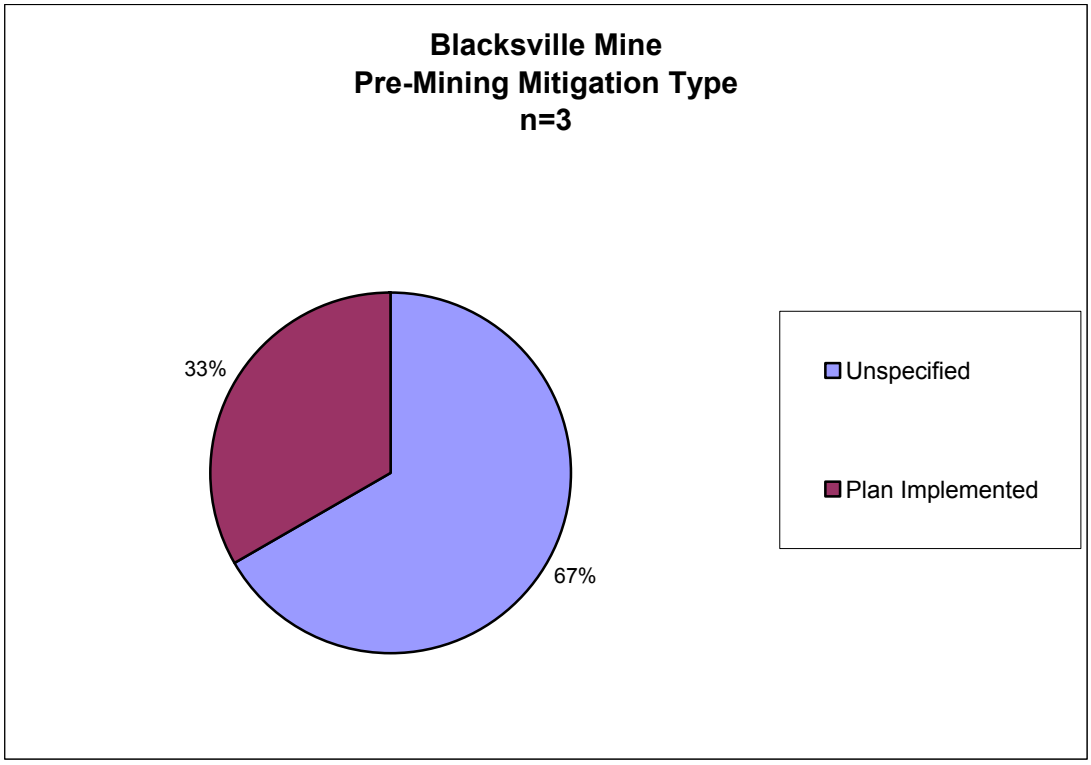

Figure VI.3. Mitigation of three structures over Blacksville Mine.

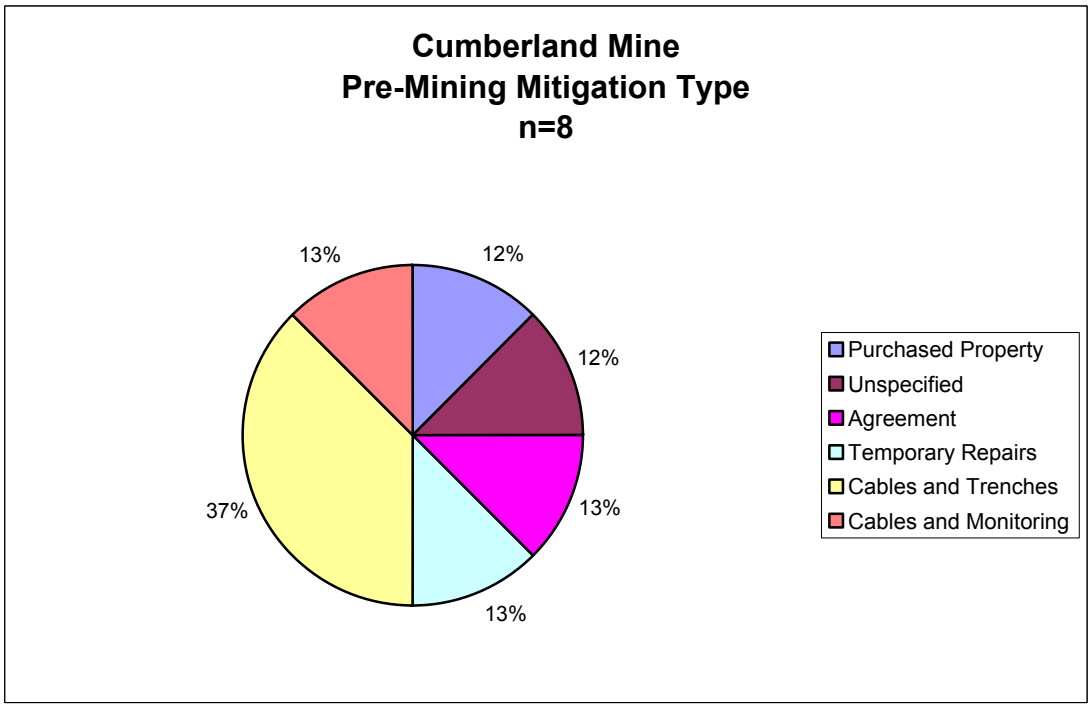

Figure VI.4. Mitigation of eight structures over Cumberland Mine.

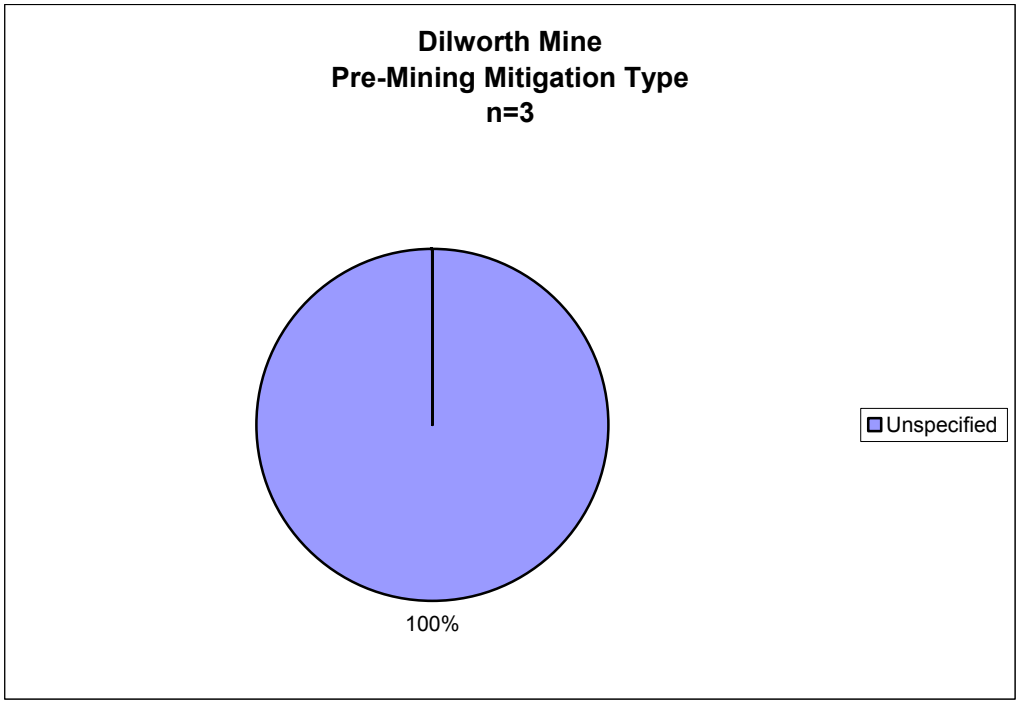

Figure VI.5. All three structures for which there was a line-item entry for mitigation on the faxed report had no specific type of mitigation defined.

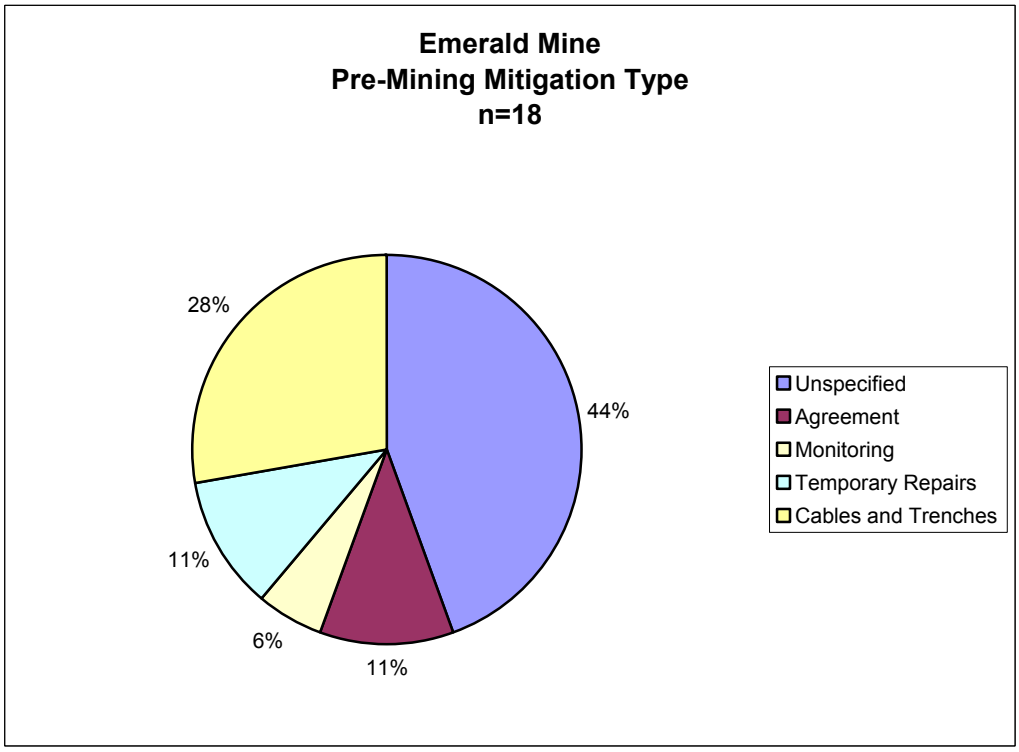

Figure VI.6. Mitigation of 18 structures undermined by Emerald Mine during the assessment period.

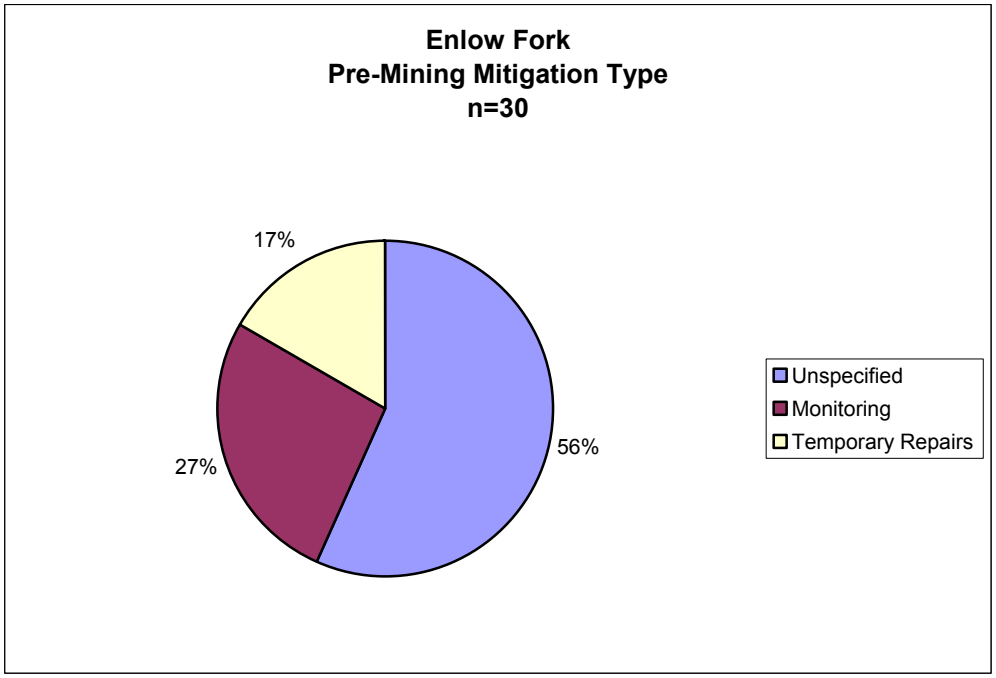

Figure VI.7. Enlow Fork Mine operator took mitigation actions on 30 structures during the assessment period.

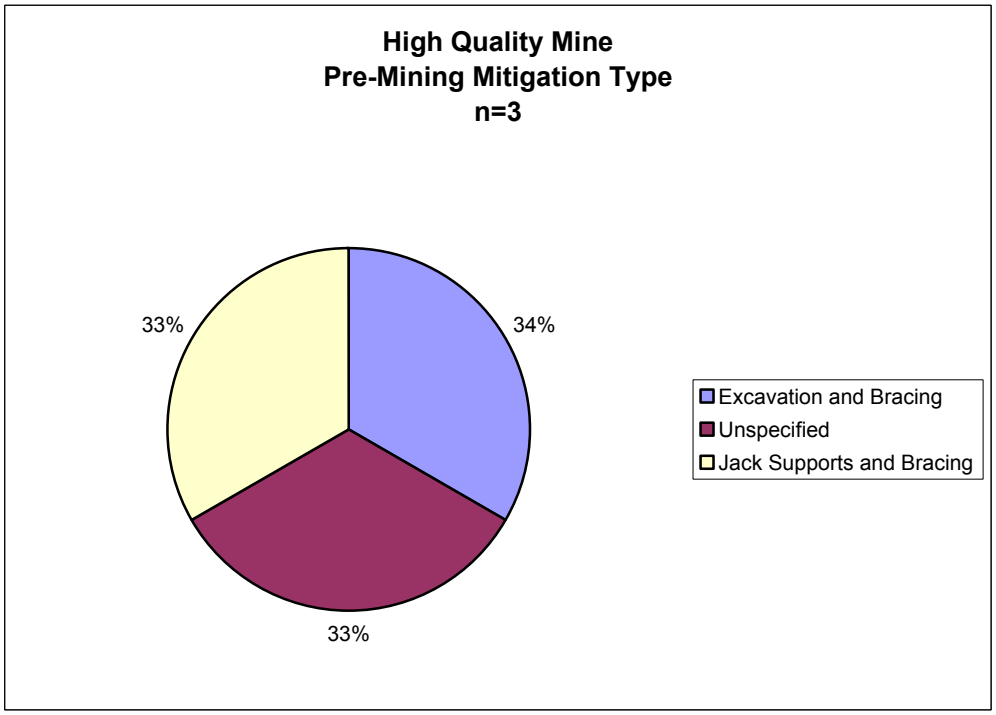

Figure VI.8. High Quality Mine took action on three structures pre-mining to mitigate potential damage from subsidence.

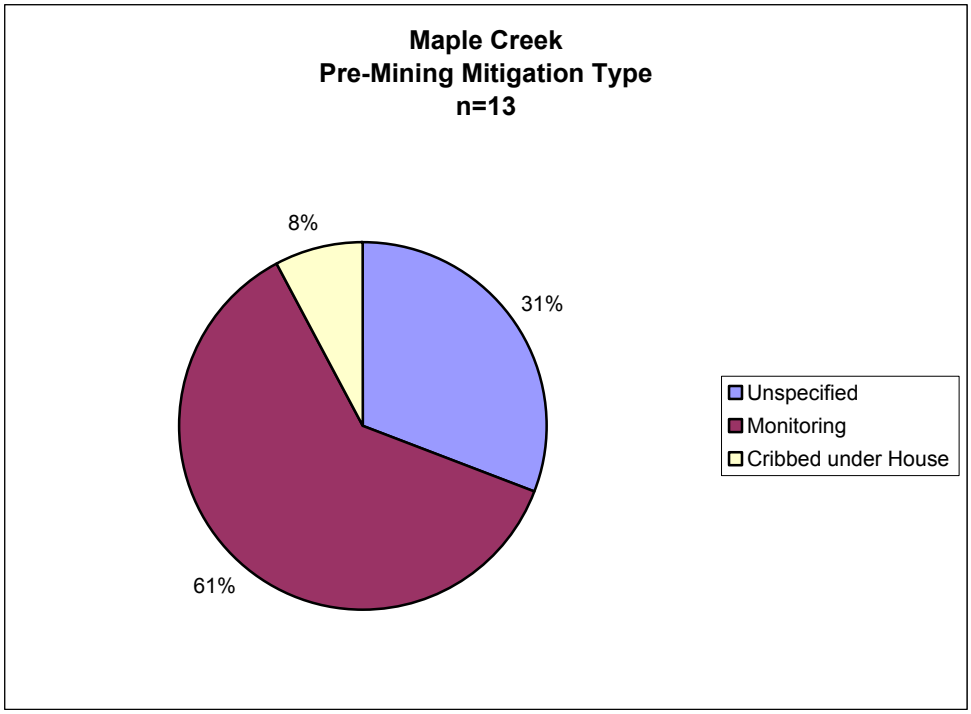

Figure VI.9. Mitigation over Maple Creek Mine during the assessment period.

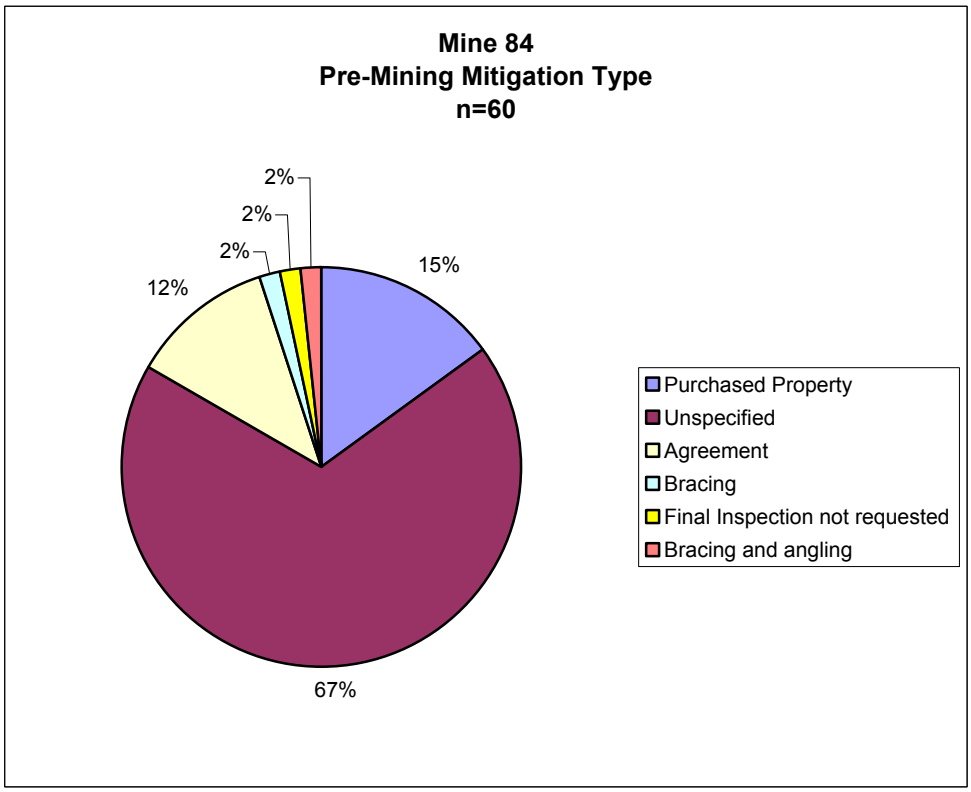

Figure VI.10. Mitigation over Mine 84 during the assessment period.

VI.F. Problems Associated with Time until Resolution and with Data

During the study period, the University initially assumed that it could establish a pattern of resolution for structure claims. The University subsequently discovered that the "date of first occurrence" as recorded in BUMIS is most likely the date of the receipt of a report faxed by the mine operator to the California District Mining Office. In conversations with the surface subsidence agents, the University's researchers also learned that the discovery of a supposed subsidence-related structure problem is not necessarily contemporaneous with the actual date of first occurrence. Some structure problems are insidious; some, immediate and catastrophic; and still others, variable, appearing to one degree then to another over a period of weeks or months.

Another problem with resolution lies in the assignment of the "SA" number to the supposed structure problem, elevating that problem to the level of a claim. In the instances of multiple structures and water sources on a single property, some water

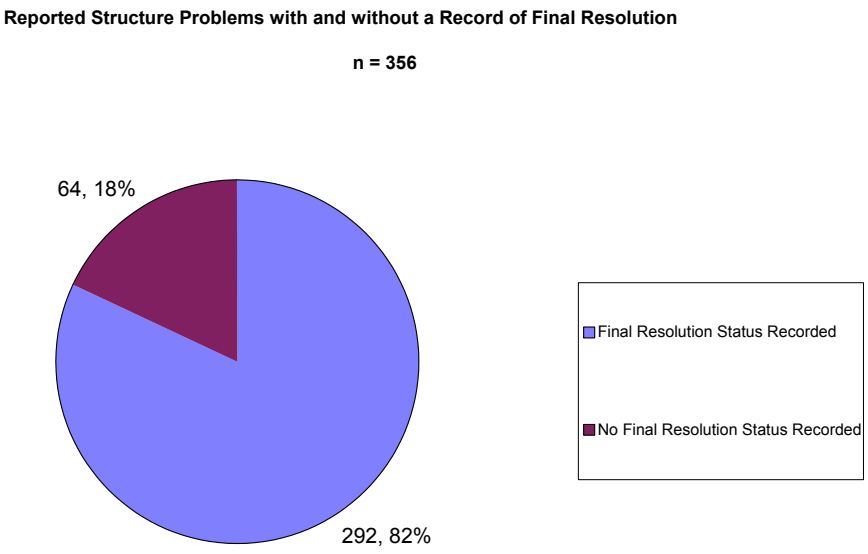

Figure VI.11. All problems that are "problems" or "problems with claims," and that have a record of final resolution recorded in BUMIS and those without such a record. These include, as explained in the accompanying text, some water sources erroneously assigned an "SA" number.

Sources have been assigned inappropriately an "SA" number in BUMIS. For all "SA" identification numbers and structure "problems" recorded during the assessment period, 18% (64) had no recorded resolution, as figure VI.11 shows. The graph in figure VI.11, however, reflects a number of total structures (problems plus problems with claims) found in BUMIS and differs from that number found in table VI.3 above. The University believes that table VI.3 is accurate and that it reflects the precise number of structures with claims.

Nevertheless, it might be instructive to examine how the BUMIS files record resolution for structure problems and problems with claims. Of the 356 structural impacts reported in BUMIS with SA numbers or as structure problems, 292 have a recorded "final resolution" status in the electronic files. Those without such a status were presumed to be "pending" at the end of the assessment period.

Of the 292 problems and problems with claims that have been resolved, not all are treated equally in the BUMIS records. Sixty of the problems have no date of occurrence, 15 have no record of a resolution date, 8 have the resolution date recorded before the occurrence of impact, and 209 have the dates in chronological sequence. The next graph looks at those 292 entities (see fig. VI.12).

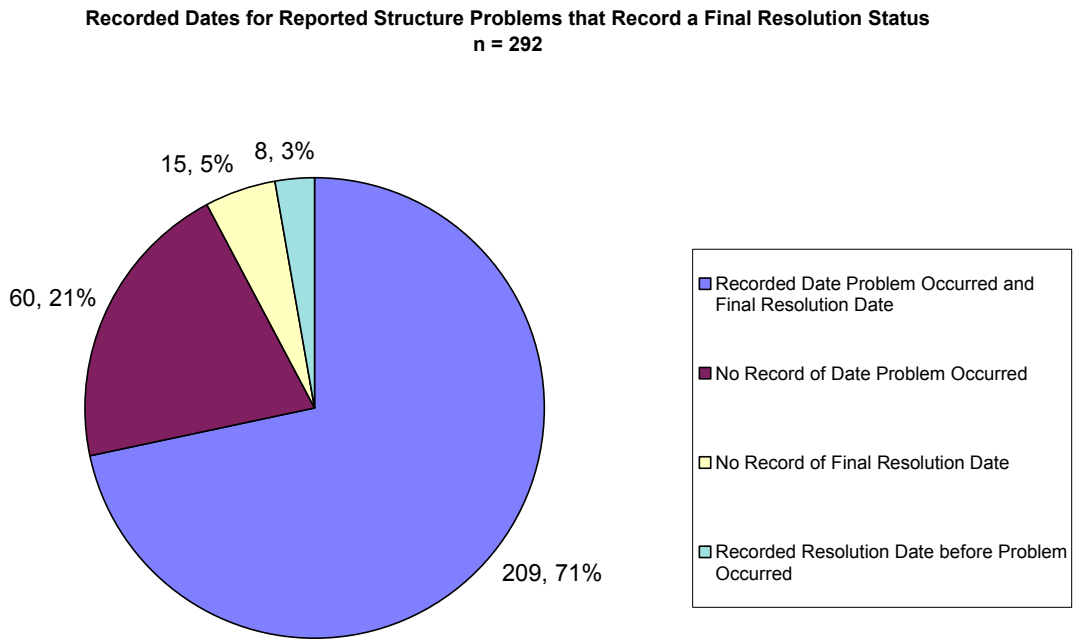

Figure VI.12. The 292 "structure problems" and "structure claims" with a date of "final resolution."

Seventy-one percent of the "structure problems" meet the following criteria: 1) a specified final resolution status; 2) a record of the date the problem occurred; 3) a record of the final date of resolution; and 4) the date the problem occurred had to precede the date of the final resolution. The resolution of the structure problems came about through various means, including pre-mining agreements between the coal operator and the property owner (4) and some unspecified agreements between operator and owner (95), as the following graph shows (see VI.14).

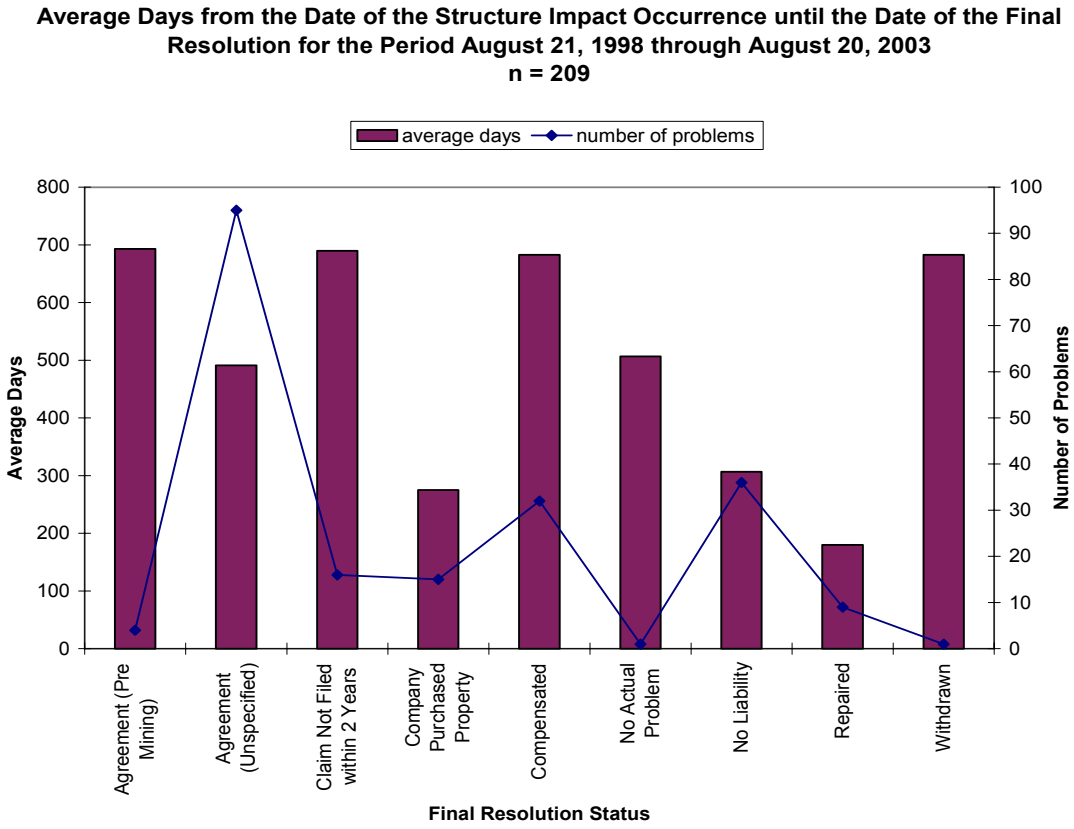

Figure VI.14. BUMIS records of average days for different types of resolution for "structure problems" arising from subsidence.

The date of problem occurrence and the date that the California District Mining Office receives notification of a problem often differ. The significance of the date of notification is that it is only after receipt of a faxed report that the California District Mining Office ordinarily becomes officially aware that an action must be taken, as noted elsewhere in this report. Out of the total 356 structure problems, 292 specify a final resolution status, as shown in figure VI.14 above. In figure VI.15 the BUMIS record is examined to see how many reported "structure problems" had not only a date of occurrence, but also a date when the California District Mining Office received notification plus a date of final resolution. Thus, there is a difference in the "time to resolution" between the occurrence date and the notification date. Of the 292 problems and problems with claims that specify a final resolution status, 15 have no record of a final resolution date, and 22 have a record of the final resolution date the precedes the

date that the California District Mining Office received notification that a problem existed. In all, 255 of the structure problems have a recorded date of notification and a chronologically correct date for a final resolution.

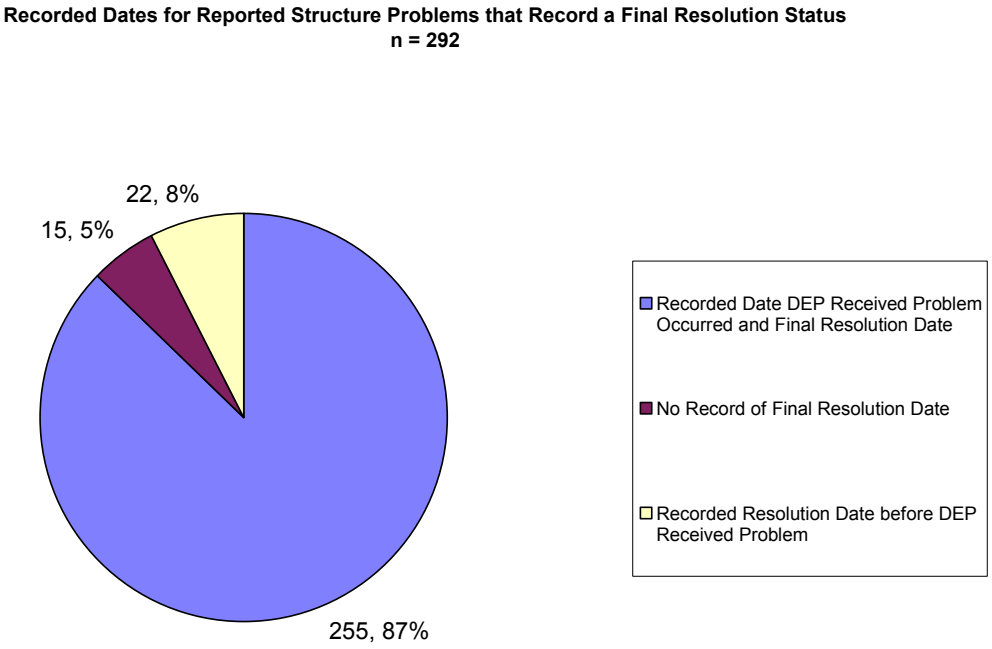

Figure VI.15. Of the reported structure problems, only 255 of the original 356 were properly recorded in BUMIS (compare fig. X.5). The diagram shows both the percentage and the absolute number.

In figure VI.16 the 255 structure problems identified as having a complete calendar record are examined for the average number of days between notification and all types of final resolutions. In certain instances, the claim was not filed within two years of the first occurrence of the problem. For 19 such structure impacts, the average resolution time was 640 days. For 52 reported problems, the PA DEP took an average of 218 days to reach a determination of "no liability."

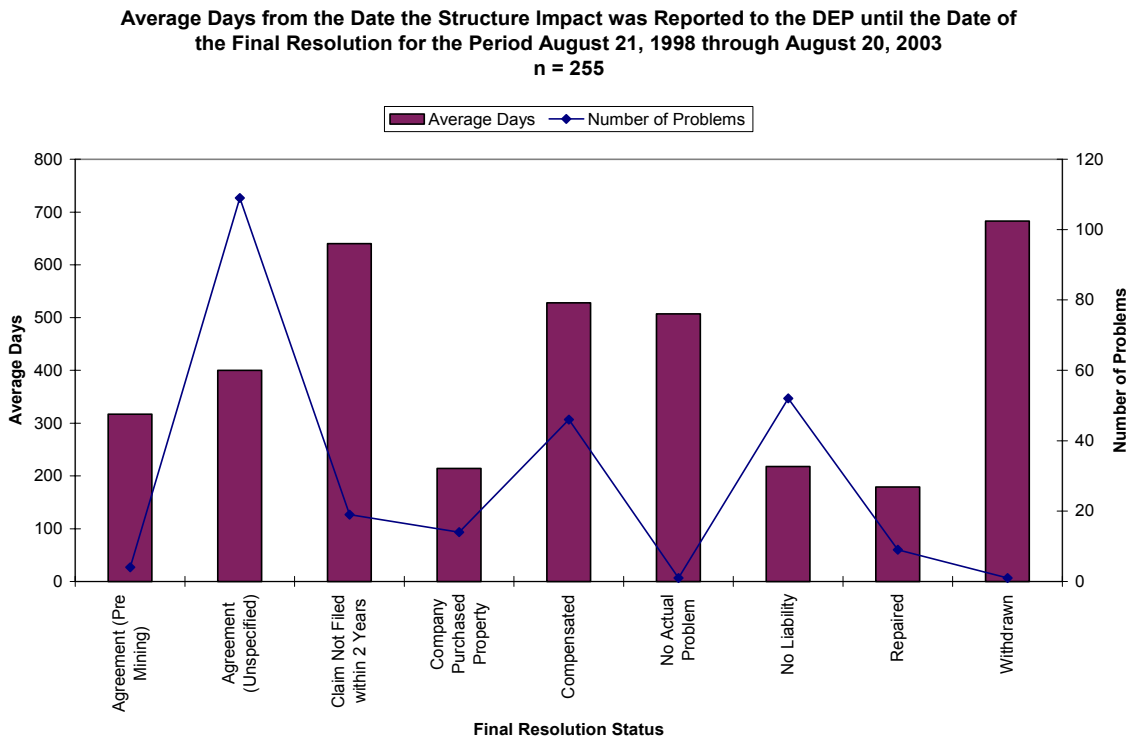

Figure VI.16. Average time to resolution in this graph depicts the period between notification of the California District Mining Office and the final resolution.

The qualifications of the graphs in section VI.F indicate the problems associated with the data recorded in BUMIS. The University recognizes that BUMIS was instituted during the assessment period and that many files from ACCESS were transferred along with paper files into BUMIS. The numerous data might have, on occasion, been erroneously entered. Also, some of the fields in the BUMIS spreadsheet have not been completed, most likely for lack of data. It is also true, however, that agents of the California District Mining Office do not collect certain data. The practicalities of their jobs in dealing with problems at hand do not preclude their recording other, peripheral data, but they do apparently absorb much, if not all, of their time. Thus, the University found lapses in information that, although not inimical to the daily procedures and effectiveness of the California District Mining Office, were obstacles in the performance of this analysis. The MOU under which this report was written required the analyses of certain data that the University found, upon investigation, to be incomplete, invalid, conflicting, illogical, or unrecorded.

VI.G. Findings

During the assessment period 3,656 structures on 3,033 properties were undermined.

Although owner's of 9.5% (348) of structures undermined during the assessment period initially reported problems, owners of only 3.8% (141) of all undermined structures filed structure claims during the assessment period.

Much of the information required by the MOU regarding structures is unavailable, incomplete, or inconsistent, making a thorough, quantified assessment of the effects of subsidence on structures impossible to achieve. Nevertheless, agents of the California District Mining Office appear to work effectively to achieve resolutions for problems and problems with claims associated with structure impacts.

Pre-mining mitigation techniques to prevent or lessen potential damage caused by subsidence are not thoroughly documented.

The discovery of a supposed subsidence-related structure problem is not necessarily contemporaneous with the actual date of first occurrence.

The record of "date of first occurrence" for a subsidence-related "problem" as recorded in the Bituminous Underground Mining Information System is not necessarily the actual date of the problem's occurrence, but is often the date that a report of a problem is faxed by the mine operator to the California District Mining Office. This variation in dates of first occurrence makes the determination of time to final resolution tenuous at best. In addition, owners of structures, for various reasons, apparently do not always discover a structure problem contemporaneously with its first occurrence.

Timing of mining with respect to structure damage is not readily determinable from the six-month mining maps.

Distance to mining for structures lying directly above mine workings is usually recorded as "0." Depth to mine is not recorded in the Bituminous Underground Mining Information System for all structures.

A record of distance to type of mine subsidence effect (i.e., tension, compression) would enhance the ability of investigators in their attempt to quantify the effects of subsidence on structures.

The architectural type of construction is not recorded uniformly in either the paper files or in the Bituminous Underground Mining Information System. The University had to obtain structure type descriptions from the personal memories and files of the surface subsidence agents of the California District Mining Office.

Agents of the California District Mining Office know specific information about type of damage and type of structure, and they are aware of agreements among structure owners

and mine operators. Agents also know the resolution status and the type of resolution for each structure claim.

The University finds that with the present available data, it cannot correlate among type of construction, mitigation technique, distance to mining, and timing of mining.

VI.F. RECOMMENDATIONS

Pre-mining mitigation techniques to prevent or lessen potential damage caused by subsidence should be thoroughly documented.

The record of "date of first occurrence" for a subsidence-related "problem" as recorded in the Bituminous Underground Mining Information System should be the actual date of the problem's occurrence, rather than the date that a report of a problem is faxed by the mine operator to the California District Mining Office. This would make an accurate determination of the time to resolution possible.

Timing of mining with respect to structure damage should be noted in the Bituminous Underground Mining Information System.

Depth to mine should be recorded for all undermined structures.

The California District Mining Office should record distance to type of mine subsidence effect (i.e., tension, compression) to enhance the ability of investigators to quantify the effects of subsidence on structures.

The California District Mining Office should record in the Bituminous Underground Mining Information System information on architectural type of construction.

To correlate among type of construction, mitigation technique, distance to mining, type and extent of damage, timing of mining, problem identification number, structure number, and claim number, the PA DEP should devise cross-referencing identification numbers for the Bituminous Underground Mining Information System.