2.05.5 Post-Mining Land Uses

The pre-mining and adjacent land use is rangeland and wildlife habitat. It is desired to provide final reclamation of the disturbed areas that is self-sustaining and provides habitat suitable for domestic livestock and wildlife.

As a result of concentrating the refuse disposal to as few acres as possible, only minimal impact will occur. The disposal areas will occupy a maximum of approximately 65 acres. Refuse disposal will occupy less than one percent of the total life-of-mine plan area (see Exhibits 50, 51 and 52). Post-mining topography of the affected area is indicated on Map 58 and Map 59. Except within the landslide area (if the upper refuse disposal site is constructed) and the lower refuse disposal site described in Exhibit 51, the reclaimed slopes will be similar to the pre-mining topography or less, if necessary, to assure a 1.3 factor of safety after reclamation. Cut-and-fill terraces are not anticipated nor proposed at this time.

Rangeland and wildlife habitat was selected as the post-mining land use for the refuse disposal areas because of the pre-mining conditions in the area. Reclamation at the West Elk Mine will provide grazing for livestock as well as develop cover, food, and nesting areas for wildlife. The surrounding heavily shrubbed areas and clusters of planted shrubs will provide adequate edge effect to assure a diverse wildlife habitat within a rangeland meadow plant community.

2.05.6 Mitigation of Surface Coal Mining Operation Impacts

Air Pollution Control Plan - 2.05.6(1)

Air quality protection will be provided by the following measures:

Conveyor Systems

All conveyors outside the mine portal are designed to prevent particulate dispersion of coal by wind. That portion of the loadout conveyor over the North Fork of the Gunnison River is totally enclosed to prevent discharge of coal dust to the river. Water sprays, using surfactant if appropriate, have been mounted at key transfer points to minimize dust generation from conveyors, if needed.

Loadout

The loadout uses a telescoping chute to load railroad cars, to help prevent dust generation and eliminate spillage.

Transfer Points

All transfer points between conveyors, screens, crusher, rotary breaker, and silo(s) are designed to control particulate emissions from these sources, if needed.

Fugitive Dust

Water is applied to any active unpaved roadways, parking areas, and refuse disposal area to control dust emissions from these areas, if required, on a seasonal basis.

Open Coal Stockpiles

The stockpiles are compacted and may be sprayed as necessary to eliminate particulate emissions created during coal handling.

Fish and Wildlife Plan - 2.05.6(2)

The baseline wildlife information collected on the property indicates that the mine facilities area is not of prime significance to major wildlife species. The affected area is not known to be critical habitat for big game, except small areas of critical winter range for elk and mule deer along the North Fork and Minnesota Creek. The North Fork corridor also provides winter concentration areas for federally listed (threatened) bald eagles, but no roost sites or other critical habitat features for bald eagles exist in the permit area. Fragmentary and relatively low-quality habitat for federally listed (threatened) Canada lynx is identified in the permit area, but lynx are not known to occur there and at best an occurrence or use would be peripheral to occupied range to the south. No identified critical habitat features exist in the permit area for other raptors, migratory birds, or other threatened or endangered species. Cliffs in the permit area are not known to provide important nesting or roosting habitat for raptors or other cliff-dependent wildlife. Water depletions to the Colorado River Basin, if they occur, could adversely affect populations and downstream critical habitat for four species of federally listed (endangered) Colorado River fish. Water depletions of less than 100 acre-feet per year are considered adequately mitigated by USFWS.

Using the best technology currently available and applying it to the extent reasonably feasible, disturbances and adverse impacts of mining and related operations on fish, wildlife, and related environmental impacts are minimized. Where practicable, enhancement of such resources is achieved. In so doing, MCC will report to the Colorado Division of Wildlife (CDOW) the presence of any threatened or endangered animal or plant species listed or proposed to be listed by the State or Secretary of the Interior; any critical habitat of any threatened or endangered animal or plant species listed or proposed to be listed by the State or Secretary of Interior; or any Bald or Golden Eagle, or nest thereof, of which MCC becomes aware and which was not previously reported to the CDOW. The electric power lines and other transmission facilities used for MCC’s underground coal mining operation on the permit area will be designed and constructed to prevent electrocution hazards to large birds.

In compliance with the USFWS's "Windy Gap Process" (a determination of effect of water depletions in the Colorado River Basin on four endangered fish species), MCC has calculated the net depletion of water from the North Fork as a result of West Elk Mine's current and projected operations, including production from the Jumbo Mountain and Box Canyon lease tracts and South of Divide area (Exhibit 67). This calculation is affected by any significant increase in production rates, but not by an increase in the areal extent of coal to be mined. Should the rate of production or other factors affecting the net depletion calculations change, the calculations would be revised.

MCC has taken the following factors into account to protect wildlife on the affected area:

1. Since the area is not a prime wildlife area, it is generally possible to operate and locate roads so as to avoid and minimize impacts on fish and wildlife species.

2. Since no major migration routes have been identified on the permit area, it is not necessary to guide migratory wildlife species by the means of fencing so as to direct their movement under roadways or other obstructions which might result from construction of the surface facilities.
3. There are no ponds containing toxic-forming materials; however, should such a facility be constructed, the pond will be fenced to exclude wildlife.
4. With regard to bald eagles and Canada lynx, the potential effects of surface-disturbing projects on populations and designated habitats (at the time specific surface disturbing projects are proposed) will be evaluated, and mitigation measures will be applied to avoid adverse impacts to these federally listed species, in compliance with the Endangered Species Act.
5. Aquatic communities existing in the North Fork will be protected by the use of 50-foot wide buffer zones of undisturbed land along stream channels.
6. The use of persistent pesticides is not anticipated.
7. Mountain Coal Company will, to the extent possible, prevent, control, and suppress range, forest, and coal fires that are not approved by CDOW as part of this or any other management plan.
8. Since wildlife habitat is to be the secondary post-mining land use, MCC has selected plant species to be used on reclaimed areas based on the following criteria:
    a. Their proven nutritional value for wildlife
    b. Their use for cover for wildlife species
    c. Their ability to support and enhance wildlife habitat after release of bond

These factors have been discussed in other portions of the permit document. As discussed, the intent of MCC is to distribute the plant species in clusters so as to maximize the benefit to wildlife. This will provide adequate edge effect, cover, and forage benefits for the wildlife species occurring on and adjacent to the site.

Protection of Hydrologic Balance – 2.05.6(3)

The hydrologic balance and probable hydrologic consequences are discussed after the Subsidence Survey, Subsidence Monitoring and Subsidence Control Plan in section 2.05.6. The surface effects of mining on the hydrologic balance in the SOD, Apache Rocks West, the Southern Panels and Sunset Trail Mining areas are anticipated to be minimal. Section 2.05.6 (6) in this document describes at length the anticipated impacts to the ground surface resulting from mining activities in these areas. It is acknowledged throughout this permit that numerous landslides and slumps are present throughout the MCC permit area and these features generally move in response to saturation by precipitation events. Monitoring plans included in 2.05.6 (6) describe how MCC will observe these features for effects due to mining related activities. Protection of the Hydrologic Balance and Probable Hydrologic Consequences are discussed as they relate to the effects of subsidence and follow the Subsidence Section of 2.05.6 (6).

Protection of Public Parks and Historic Places - 2.05.6(4)

Operations at the West Elk Mine are not located near public parks or historic places; therefore, this section does not apply.

Surface Mining Near Underground Mining - 2.05.6 (5)

There are no surface mining operations proposed near the West Elk Mine.

Subsidence Survey, Subsidence Monitoring- and Subsidence Control Plan - 2.05.6 (6) (a-f)

The extraction of coal from the B and E Seams in the SOD, Apache Rocks West, the Southern Panels and Sunset Trail Mining areas has and will be completed using longwall mining methods. The resulting disequilibrium due to longwall mining may result in surface subsidence, dependent on a number of inter-related factors. As stated by Peng in *Surface Subsidence Engineering* (1992), "When total extraction is used, it produces a large void in the coal seam and disturbs the equilibrium conditions of the surrounding rock strata. The rock strata bend downward while the floor heaves. When the excavated area (gob) expands to a sufficient size, the roof strata will cave. As a result, the overlying strata continue to bend and break until the piles of the fallen rock fragments are sufficiently high to support the overhanging strata. At this time, the overlying strata no longer cave, but bend and rest on the underlying strata. Strata bending in subsidence develop upward until reaching the surface and forming a subsidence basin. The whole overburden strata and the surface subsidence basin will further go through a period of compaction and gradually become stabilized."

The purpose of this section and the Exhibit 60 through 60 E series of documents is to describe on a site-specific basis, and to quantify to the extent feasible, the various phenomena that are embodied in this definition. These exhibits describe subsidence processes that have been observed from studies above longwall panels mined in the West Elk Mine and from other similar operations and studies. The subsidence information obtained from mining to date in the West Elk Mine has been used to project subsidence processes, amounts, and effects to the SOD, Southern Panels, Apache Rocks West, and Sunset Trail mining areas within MCC's permit and affected area boundaries. Also included in this section is an inventory of structures and renewable resource lands in the current permit area.The focus of Exhibit 60 was to address subsidence in the Apache Rocks and Box Canyon mining areas, Exhibit 60B and 60D was on the South of Divide Mining Area and Exhibit 60C in the West Flatiron mining areas. Since mining activities have been concluded in the Apache Rocks, Box Canyon, and West flatiron mining areas these Exhibits are replaced by the subsidence evaluations found in the most current version of Exhibit 60E for the SOD, Southern Panels, Apache Rocks West, and Sunset Trail mining areas, but retained in the permit for historic reference.

MCC continues its commitment to thoroughly understanding and describing the nature of subsidence that will occur in the West Elk Mine. MCC retained Wright Water Engineers, Inc. (WWE) of Denver several years ago to evaluate subsidence and probable hydrologic consequences. WWE worked closely with Mr. C. Richard Dunrud for many years on this project. Mr. Dunrud was employed by the U.S. Geological Survey (USGS) throughout his career and is a recognized authority on subsidence. Of particular note with respect to the Exhibit 60E document, is the report prepared by Mr. Dunrud entitled, *Some Engineering Factors Controlling Coal Mine Subsidence in Utah and Colorado* (Dunrud 1976). In that report, Mr. Dunrud evaluated subsidence in the Mesaverde Formation at the Somerset Mine, less than two miles from the West Elk Mine.

Working closely with Mr. Dunrud, WWE has adopted the following multi-faceted approach to quantifying subsidence in the permit area:

1. The mined longwall panels at the mine site have been extensively monitored and WWE has evaluated the relevant data. These data provide the basis for Mr. Dunrud's conceptual model, which is described later in this permit text and in Exhibits 60 and 60B. Please note that Exhibit 60 addresses the Apache Rocks and Box Canyon mining areas and Exhibit 60B specifically addresses the South of Divide mining area. (Exhibit 60C addresses the subsidence and geologic hazards for the West Flatiron lease tract). Exhibit 60D addresses Geologic Hazard Field Observations for the South of Divide Mining Area. Exhibit 60E, completed by TetraTech, Inc., addresses the extensions of Panel E1 through E 6 into the Dry Fork Lease.

2. WWE has utilized a computer model to quantify subsidence, and this model has been calibrated using the data collected at West Elk Mine. The model was developed by Dr. Syd Peng and Dr. Yi Luo at West Virginia University and is referred to as the "Comprehensive and Integrated Subsidence Prediction Model (CISPM)."

3. WWE has thoroughly reviewed the literature regarding subsidence and associated hydrologic consequences. We have checked the findings associated with Mr. Dunrud's conceptual model and the CISPM model with findings from case studies as described in the literature, and we have concluded that the results are consistent.

4. Finally, subsidence projections described herein were carefully reviewed by Mr. Dunrud for reasonableness. Mr. Dunrud has visited the West Elk Mine area on many occasions and he is familiar with key factors pertaining to subsidence as they relate to the South of Divide and other active mining areas. Consequently, Mr. Dunrud is well qualified to draw conclusions about the nature of subsidence that is likely to occur.

<u>Subsidence Survey – 2.05.6(6)(b)(iii)(A) & (6)(e)</u>

The following information documents subsidence processes that have been observed from studies above longwall mining panels in the current West Elk Mine permit area. The subsidence data obtained in the current West Elk Mine area have been used to project subsidence processes, amounts, and effects into the Apache Rocks, as well as Box Canyon in the B Seam, and South of Divide mining areas where only the E Seam coal is to be mined. These data have been used to calibrate the subsidence prediction models described above.

In addition to relying on actual subsidence data, WWE and TetraTech have concluded that many of the findings pertaining to subsidence and probable hydrologic consequences from previous permit revisions apply to the South of Divide with the Dry Fork Lease permit revision and mining area. The basis for this conclusion is as follows:

- Comparison of lithologic data from boreholes in the Jumbo Mountain, Apache Rocks and Box Canyon mining areas show consistency in the B Seam overburden materials, including those units immediately above and below the E Seam coal. While direct correlation of lithologic units, excluding coal beds, is generally difficult, comparison of lithologic logs shows very similar alternating sequences of shales, claystones, and sandstones. Based on the stratigraphic and lithologic information obtained from drill holes in the South of Divide mining area, the rocks consist of a greater proportion of shales, siltstones, and claystones than are present in the Apache Rocks and Box Canyon mining areas.

- The South of Divide and Dry Fork permit revision area is topographically similar to the Apache Rocks and Box Canyon mining areas although with a less extreme range of topographic relief. The elevation range across the South of Divide permit revision area is from about 7,000 feet to approximately 8,400 feet with fewer abrupt elevation changes than those seen in the Apache Rocks and Box Canyon permit areas, such as between the Sylvester Gulch drainages and West Flatiron. Like these two previously permitted areas, the South of Divide permit revision area contains gentle as well as steep slopes making it susceptible to rockfalls and landslides.

- Expected subsidence characteristics of the South of Divide permit revision area, based on lithology and topography, do not vary significantly from previous evaluations for B Seam mining according to Mr. Dunrud, with the obvious exception of the reduced overburden thicknesses associated with mining of the E Seam. Overburden thickness impacts will be discussed later in this section.

Based upon these similarities, much of the information contained within the documents pertaining to the Apache Rocks and Box Canyon permit revision area is applicable to the South of Divide permit revision area. Where differences occur, discussions of the resulting effects have been provided.

<u>Inventory of Structures and Renewable Resource Lands - 2.05.6 (6)(a)(i & ii)</u>

In order to ascertain the impacts that subsidence will cause on structures and renewable resource lands, an inventory of these features was conducted. Projected impacts to surface and ground water resources are presented later in Section 2.05.6(3). These water resources are shown on Map 37. MCC's hydrologic monitoring stations are shown on Maps 1 of Exhibit 71, 34, and 37. The many trails and U.S. Forest Service roads utilized to access these sites are shown on Maps 67 and 68.

Table 42A, below, shows an inventory of all structures and renewable resource lands which exist in the permit area and adjacent area. Water-bearing bedrock stratigraphic units are not considered to be aquifers in the permit and adjacent area (Section 2.04.7(1)); therefore, renewable resource lands are not associated with these units. More site-specific discussion of various areas follows the table.

Table 42A - Inventory of Structures & Renewable Resource Lands in the Permit & Adjacent Areas

Structure or Renewable Resource Land	Location	Description
Deep Creek Ditch Flume (raised culvert)	Adjacent to east side of permit area	
Deep Creek Ditch	Dry Fork Lease Area	Maps 66 and 67.
Minnesota Creek Ditch Rider's Cabin	Dry Fork Basin	Single-story, wood-framed building built in 1950s, 24 ft. 4 in. by 16 ft. 4 in.
Lower Cow Camp	Dry Fork Basin	Cabin and corrals. Seasonal living quarters for range cowboy. USFS-owned, leased to Dry Fork Cattle Pool. (Exhibits 60D and 73, Maps 66, 67, and 68). Wood-framed building on concrete slab, completed by landowner in 1994. Smaller wood-framed building and livestock enclosure, constructed November 1995 (Exhibit 73).
Monument Dam and Minnesota Reservoir	Dry Fork Minnesota Creek	Intermittent, seasonal use (Exhibit 74, Maps 66, 67, and 68).
Cabin	Sylvester Gulch	Deteriorated and collapsed (not usable).
Soil and stone foundations	Sylvester Gulch, overlooks	

	mine portal	
Remains of three log structures.	Lone Pine Gulch	Possibly a cabin, barn, and shed.
Remains of several abandoned structures	Jumbo Mountain lease area	Exhibits 10A and 10B.
Various abandoned structures	Various locations in permit area (none in West Flat Iron lease tract, COC-67011)	Cultural Resources Reports in Exhibits 10, 10A, 10B, 10C, 10D, and 10E.
Lazy H Cabin (formerly Mautz)	Jumbo Mountain lease	Wood-framed building. Apparently used as seasonal sleeping quarters for cattle operations and hunting. Constructed after 5NW longwall panel was developed. Maps 67 and 68.
State Highway 133	Northern edge of permit boundary	Asphalt-surfaced public highway. Maps 66, 67, and 68.
USFS Water Resources	Throughout permit area	Maps 68 and 73.
USFS Roads - 711 – Dry Fork Rd.; 711.A1 – West Flatiron Rd; 711.A3 – Upper Deep Creek Rd.; 711.2B – Horse Gulch Rd.	Dry Fork, West Flatiron, and Deep Creek	Maps 66, 67, and 68.
Alluvial aquifer of North Fork of the Gunnison River	Adjacent to north side of permit area	Map 66.
Alluvial aquifer of Minnesota Creek	Adjacent to west side of permit area	Map 66.

Man-made surface structures exist on the coal lease area and within the South of Divide (SOD) permit revision area (Exhibit 32B and Map 67). The only known man-made structures which are currently used (intermittent seasonal use) are Monument Dam - Minnesota Reservoir (Exhibit 74) and a cattle camp on the Dry Fork of Minnesota Creek with a wood-framed building on a concrete slab completed by the landowner in October 1994 and a smaller wood-framed building and livestock enclosure constructed in November, 1995 (see Exhibit 73). A deteriorated and collapsed cabin exists in Sylvester Gulch, and the remnants of soil and stone foundations of two buildings exist on a small bench overlooking the mine portal. The remains of three log structures, possibly a cabin, barn and shed, are located in Lone Pine Gulch. Several similar abandoned structures exist on the Jumbo Mountain lease tract (see Exhibit 10A and Exhibit 10B). Other abandoned structures in the permit area, are described in the Cultural Resources Reports in Exhibits 10, 10A, 10B, 10C, 10D, and 10E. Projected subsidence-related impacts to these "structures" are addressed under the permit section entitled “Effects of Subsidence and Mine-Induced Seismic Action on Man-Made Structures and Renewable Resources”.

Based on field evaluation of the West Flatiron lease area, there are no structures or renewable resource lands within the boundary of COC-67011. Known springs and renewable resource lands in the Raven Gulch drainage are not within the affected area associated with mining of the West Flatiron lease tract. The only notable man-made structure potentially influenced by mining activities within the least tract is Highway 133. The potential impact to this structure is indirect by reactivation of known landslides south of the highway and north of Longwall Panel 18A. Impacts from, and monitoring of, this potential reactivation are addressed under the worst possible consequences discussion associated with mine-induced subsidence under (*Landslides*) below.

Description of Possible Subsidence Consequences – 2.05.6(6)(b)(I)

Pre- and Post-mining Land Uses -2.05.6 (6)(b)(i)(A)

As indicated in the Mountain Coal Company Coal Methane Drainage Project EA (February 2002), North Fork Coal EIS (2000), and Environmental Analysis U-94-37 (November 1994), prepared by the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), in cooperation with the U.S. Office of Surface Mining (OSM) and other jurisdictional agencies, the permit area lands support wildlife use, dispersed recreation, and livestock grazing.

The *Forest Service Amended Land Resource Management Plan* prescribed land use designations of the Box Canyon lease tract, South of Divide permit revision area, and surrounding USFS lands as “5A”, "6B," and “9A” which emphasize riparian, wildlife habitat, and livestock grazing, respectively, and may provide recreational opportunities for semi-primitive non-motorized, semi-primitive motorized and roaded natural settings. The Gunnison National Forest prohibits cross-country travel in motorized vehicles.

It is anticipated that little or no impacts to wildlife and domestic livestock uses, and their respective habitat will occur as a consequence of mining-induced subsidence on the permit area. In the unlikely event that subsidence effects adversely impact wildlife or domestic livestock uses associated mitigation measures will focus on returned disturbed areas to a capability and land use(s) which existed prior to mining. These mitigation measures are discussed in detail in Section 2.05.6(6)(f)(iv)(A-D) – Detailed Description of Mitigating Measures.

Effects of Mining on Surficial Geologic Features

The most current evaluations of subsidence impacts can be found in the quarterly subsidence monitoring reports each year. In past years, when evaluating the effects of mining in the permit revision area, the present land use, the post-mining land use and the effects of previous mining in the area should be considered. Present land uses primarily include wildlife habitat, recreational hunting, and livestock grazing. Post-mining land uses will be essentially the same.

Evaluation of the effects of past and current longwall mining on surface features indicates that surface cracks and visible surface effects are relatively rare (see Map 67) and have been documented as follows:

1. Numerous cracks occurred in the meadow above and south of the West Elk Mine surface facilities. Some question exists as to whether these represented subsidence cracks or resulted from slight movement of the large landslide complex. Even if they were subsidence cracks, the cracks resulted from room-and-pillar mining, not longwall mining, as the cracks occurred above the F Seam room-and-pillar areas shortly after they were mined, and north of the area of influence of longwall mining.

2. Cracks occurred on the point of a high ridge immediately north of the forks of Lone Pine Gulch near the center of the south line of Section 17. Cursory surface investigation found no evidence that the cracks extended into the shales below a prominent sandstone ledge. Assessing the subsidence cause and relationships of these unique cracks is difficult. These cracks occurred along the south boundary of room-and-pillar B and C Seam mining by Bear Coal Company, along the north boundary of MCC F Seam room-and-pillar mining and 700 feet north and east of the boundaries of MCC's B Seam longwall panels. The cracks occur above the narrow, rigid boundary pillar. The cracks may be the result of any or a combination of all of the above activities. According to C. R. Dunrud, these cracks are larger than any he saw in his previous extensive subsidence research in the entire North Fork Valley.

3. In the fall of 1994, a series of cracks appeared along an unimproved road south of Lone Pine Gulch near the center of the NW1/4 of Section 20. The cracks occurred near the center of the north half of the 5NW longwall panel and above the western boundary of previous room-and-pillar mining of the F Seam. Careful study by Mr. Dunrud indicated that the most likely, but not conclusive, explanation of the cracks was that subsidence had reinitiated slight movement in old landslide deposits.

4. A limited set of cracks occurred above the barrier pillar on the east boundary of 1NW longwall panel, along the east line of Section 20. Again, this area was also affected by room-and-pillar mining in the F Seam.

5. While mining was occurring in 8NW longwall panel, MCC received a complaint from the landowner regarding cracks on his property. As a result of the complaint, CDRMS conducted an inspection of the surface cracks on the owner's property and wrote an inspection report summarizing their observations (CDRMS, 1996). Since WWE was denied access to the site by the land owner, and therefore limited to low-elevation aerial reconnaissance, the discussion of the mechanism behind the formation of these cracks relies mostly on the CDRMS inspection report.

   These cracks were observed in the vicinity of a relatively large, historic, episodically active landslide (Dames and Moore 1993). Extensive recent landsliding was observed in the SW1/4 of Section 24 in the spring of 1996. The landslide activity created numerous cracks and "graben-like extensional troughs up to ten feet wide and five feet deep." These cracks were parallel to the fall line, which is typical of the translation of the sliding debris as shown in Figure 19. According to Dr. Pendleton of DMG, the observed features are typical of large landslide masses in the Williams Fork Formation (geological equivalent of the Mesaverde Formation) and they occur prolifically throughout the North Fork Valley on slopes of varying gradient and aspect. Based on his experience in the Forth Fork Valley, Dr. Pendleton concluded that subsidence does not appear to be a significant determinant in the reactivation or initiation of landslide activity. CDRMS concluded that "there is no evidence with which to definitively verify or discount a connection between subsidence of the MCC mine workings and this active landslide."

   Eight crack locations were visited during the CDRMS inspection. While most of the surface cracks were attributable to rejuvenated landslide movement, three minor cracks were reported to be the result of mining subsidence (Nos. 2, 3, and 8 on Figure 19A). These cracks were three to four inches wide and less than one foot deep. Field observations by MCC personnel indicated that these cracks were already healing shortly after mining had occurred. Two of these cracks (Nos. 3 and 8) are typical of the dynamic subsidence process. As mining occurs, the overburden above the mined portion subsides, and differential movement results between the mined and unmined areas. Surface cracking can occur at the location of the differential subsidence. As mining continues, the adjacent overburden subsides and the surface cracks will usually close completely (DeGraff and Romesburg 1981). These cracks healed significantly as evident in the late summer of 1997. Additionally, the overburden thickness under the areas where the cracks occurred was less than 500 feet—one of the few locations within the permit area where the overburden is this shallow.

6. Within the Apache Rocks mining area Mr. Dunrud has observed several additional surface cracks (see report titled "Subsidence Observations, West Elk Mine, July 22-24, 2003. These include the following:

   - Location 13 — located in the NW 1/4 , Section 28, T 13 S, R 90 W
   - Location 3 — bluff located above the eastern part of longwall panel 14, above the eastern end of longwall panel 14, in NE ¼, Section 27.
   - Location 1 — located in massive sandstones of the Ohio Creek Formation, above the approximate middle part of longwall panel 14, in the NE ¼, Section 27.

- Location 12 — located on friable sandstones of the Barren Member of the Mesaverde Formation above the middle part of longwall panel 13, in NE ¼, Section 29.
- Location 10 — located in sandstones of the Barren Member above longwall panel 13, about 2,000 feet east of location 12 in E½, Section 27.

7. Within the Box Canyon mining area all cracks observed were deemed to have been caused by mass-gravity movement (lateral spreading along ridges) or by the desiccation process (no longwall mining had occurred in this area at the last time the area was visited). These features were observed above projected longwall mining panels 18-22 in Section 14 and 23, T 13 S, R 90 W, (See Map 67 and Annual Subsidence Reports for general locations of historical subsidence cracks).

Given the long and extensive history of mining in the area, it is surprising the small number of subsidence related features that have been identified. It cannot be proved that these represent the only cracks associated with the mine, but given the regular survey activity, inspection of the subsidence profiles, and seasonal landowner, hunter, and U.S. Forest Service (USFS) personnel activity, additional cracks would have been noted if they existed. This lack of evidence of surface cracking would lend strong validation to the premise that longwall mining in the B-Seam has had minimal surface impacts at West Elk Mine.

Landslides

The most current evaluations of subsidence impacts can be found in the quarterly subsidence monitoring reports each year. In past years, it could be expected that the changes in stress and strain of the near-surface strata and possible near-surface fractures associated with the predicted subsidence could reactivate or initiate landslides. The landslides listed below are all naturally occurring features, which become unstable during periods of increase precipitation. A review of aerial photographs that were taken in 1963 show that the slides listed below were more stable at that time than they are now. Mr. Dunrud observed that many of the existing landslides, including the landslides north and south of Minnesota Reservoir became unstable and moved during the period of high precipitation in the mid 1980s. The landslides on the southeast side of West Flatiron and on the west side of Deep Creek in the Apache Rocks area appear to have been unaffected by longwall mining beneath the areas. It therefore appears apparent that wet seasons affect landslides more than does longwall mining. During very wet periods, however, landslides that are already unstable may locally be triggered by mine subsidence. Panel 25 in Sylvester Gulch is not expected to increase the potential of landslides in that area, as the east side of Sylvester Gulch is in an up-dip area not prone to landsliding.

There are four known locations within the permit area where the reactivation of a landslide could be potentially linked to past or current mining. The first area, in Lone Pine Gulch (Section 20, T13S, R90W, 6th P.M.), contains numerous old landslide features, including steep, hummocky topography with many smaller surficial slumps. Cracking and slumping occurred on one section of a jeep trail in this area in early October 1994. The cracks appeared during mining of the 5NW longwall panel in the B-Seam. Location of the cracks coincides with the boundary of earlier F-Seam room-and-pillar panels. The second area, discussed previously, is above the 8NW longwall panel. This landslide activity, which could not be definitively linked to longwall mining, is described in considerable detail in CDRMS's inspection report (CDRMS 1996). The third area is above the 9NW longwall panel. Another known landslide area is south of Highway 133 near Box Canyon within the Box Canyon

Permit revision area. These landslides are outside the projected longwall mining subsidence effects (i.e., 16 degree angle of draw) by more than 600 feet as described in Exhibit 60C, 60D and 60E.

A small portion of the development mining area along the northwest side longwall panel 18A underlies a known area of landslide disturbance south of Highway 133 as shown on Map 1 of Exhibit 60C. As a result, the worst possible consequence associated with mining-induced subsidence in the West Flatiron lease area is that this landslide will be reactivated during mining activities causing a potential crossing of Highway 133 and an obstruction to traffic.

Based on observations made in the field both of active and inactive landslide areas before and after mining activities, MCC and it's consultant (WWE) concludes that the greatest potential for the worst possible consequence would occur during a very wet precipitation period. Such periods have been observed in the North Fork Valley as recently as the mid-1990s causing initiation or reactivation of numerous natural landslides.

With few exceptions, most landslides along the North Fork Valley are relatively shallow in depth and move relatively slowly downhill (gravity creep) providing an opportunity for monitoring and evaluation. Monitoring of the landslide toe south of Highway 133 will provide an opportunity to assess whether reactivation of the landslide has occurred and to what extent this reactivation may have on the highway. Such monitoring will be accomplished by vertically driving steel rods into the landslide area south of Highway 133 at locations potentially subject to reactivation. These are then monitored by surveying to assess changes. Should movement be noted on these metal stakes, additional studies and surveys can be undertaken to assess where reactivation is occurring, the rate of movement, the area extent and depth of the materials that are moving, and the potential for impact to the highway.

It should be noted that the portion of longwall panel 18A that is closest to the highway (approximately 600 feet horizontal distance) includes development entries, which have the smallest subsidence potential because of the room-and-pillar mining techniques used. This development mining will occur before any longwall mining activities. When longwall mining occurs in panel 18A, it will be further south (about 250 feet) with an angle of draw that will not influence the landslide area. As a result, monitoring of the landslide during development mining will serve to assess the most likely potential reactivation period, particularly during spring runoff.

Material damages created by the activation of the landslide, should they occur, are expected to be limited to the physical obstruction of traffic on Highway 133. As previously stated, it is anticipated that monitoring will assist in evaluating the potential for this occurrence and minimize the health threat to individuals driving on Highway 133. Should the landslide reactivate and threaten or cross Highway 133, MCC will provide available assistance in the clearing of the highway and mitigation of the effects. WWE finds the likelihood of this occurrence to be extremely small except in abnormally wet conditions, which will have a similar effect on numerous landslides throughout the North Fork Valley.

The following are known locations within the present permit area, the South of Divide and Dry Fork permit revision areas where the reactivation of a landslide could occur as a result of current or future mining:

1. Apache Rocks mining area

a. North of Minnesota Reservoir dam in the SW¼ of Section 29
b. Above Panels 14 and 15 in the SW¼ of Section 26
c. On the west side of Deep Creek, above the southeastern part of Panel 17

2. Box Canyon mining area
   a. Above projected Panels 18 and 19 on the east side of Box Canyon in the N½ of Section 14
   b. Two landslides above projected Panels 19 and 20 on the west side of Box Canyon in the W½ of Section 14
   c. Above the barrier pillars between the Box Canyon and Apache Rocks longwall mining panels in the SE¼ of Section 22

3. South of Divide mining area:
   a. An extensive landslide located south of Minnesota Reservoir above the northern part of projected Panel E9 in the NW¼ of Section 32.

4. Dry Fork mining area:

   a. There are three slides identified on the Deep Creek Ditch in Section 2, of Township 14 South, Range 90 West, 6th P.M., one that warrants concern, this slide is located above the bleeder entries along the south side of Panel E 6 the other two land slides are outside the influence of mining. The slide will be monitored both visually and by survey methods.

A discussion regarding the monitoring plans for the landslide located on the south abutment of the Monument Dam are included in Section 2.05.6 (6)(e)(i)(D) - Detailed Description of Predicted Subsidence Phenomena, Subsection “Effects Of Subsidence And Mine-Induced Seismic Activity On Man-Made Structures And Renewable Resources”, Monument Dam - Minnesota Reservoir. A discussion concerning the preventative measures to be employed to protect Monument Dam from mining induced impacts is contained in Section 2.05.6(6)(f)(iv)(A-D) - Detailed Description of Mitigating Measures. Technical Revision No. 108 shows the plans in detail.

Rockfall

The most current evaluations of subsidence impacts can be found in the quarterly subsidence monitoring reports each year. In past years, as discussed in Section 2.04.6, *Geology Description*, there are exposed rock faces on steep slopes where the potential for rockfall exists within the permit area. Theoretically, mining-induced changes in stress and strain and fracturing could trigger additional rockfall from the many sandstone cliffs. Areas of rockfall potential, such as the flanks of West Flatiron within the Apache Rocks and Box Canyon permit areas are currently monitored for rockfall whether it is naturally occurring or mining-induced. As with landslides, due to the scarcity of structures and limited human activity within the permit area, present and future land uses will not be significantly impacted. The area above Panel 25 in Sylvester Gulch has two small areas of high potential for rockfall and are depicted on Map 53B. Mining of Panel 25 could trigger rockfalls on the east side of Sylvester Gulch in these two small areas which could result in boulders rolling downhill to the light-use roads (2) on the east side of Sylvester Gulch in Section 15, however, MCC controls all access to these roads.

There are no identified rockfall areas within the West Flatiron lease area, as shown on Map 1 of Exhibit 60C. Therefore, any possible subsidence-induced rockfall in the West Flatiron lease area should be of insignificant consequence.

Figure 19, Typical Surface Cracking Due to Landslide Movement

Figure 19A, Observed Crack Locations Above 8NW Longwall Panel

Predicted Subsidence-Related Phenomena and Material Damage Which Would Occur as a Result of Subsidence - 2.05.6 (6)(b)(i)(B&C)

Predicted subsidence impacts for the mining area have been described in detail in the following section entitled "Subsidence Prediction" 2.05.6 (6)(e)(i). Also refer to the most current versions of Exhibit 60 E and 55 B. Given the magnitude of the subsidence projected in the above referenced section, the following outlines the material damage which could result as a consequence of the projected subsidence. Structures in the permit area are described in Section 2.05.6 (6)(a)(i & ii). The discussions in Section 2.05-6(6)(e)(ii)(A-C) and Section 2.05.6(6)(f)(iv)(A-D) include the "worse possible consequence" to these structures, as well as mitigation commitments. There are no buildings located in the Apache Rocks and Box Canyon permit revision areas, one building in the South of Divide area and one outside the influence of mining in the Dry Fork Lease area.

There are 13 stock ponds in or near the Apache Rocks permit revision area and only one stock pond in the Box Canyon permit revision area. There are 24 stock ponds within the South of Divide permit revision area. The stock pond embankments are not expected to be impacted, however, the ponds will be monitored and any subsidence impacts mitigated by MCC per the USFS agreement letter in Exhibit 19C.

The most significant surface impacts are expected to occur along the precipitous slopes and cliffs immediately north of the Minnesota Reservoir and in those areas within the influence of longwall mining. See the current Exhibit 60E for additional information on longwall panel overburden depths and the modeling results to project subsidence at varying mining heights and overburden depths. In all of these areas, the most severe hydrologic scenarios are as follows:

- As discussed in Section 2.05.6, *Maximum Depth of Surface Cracks*, development of cracks as much as 100 feet deep above the chain and barrier pillars could divert intermittent surface and/or spring flow into the more impermeable rocks in the overburden. The probability of such surface cracks occurring is very small. For example, based upon MCC mining of longwall panels to date, only a few surface cracks have been observed that are considered to be solely related to B Seam mining. As discussed later, there are many "healing" and "sealing" mechanisms that act to close surface cracks. In the event that a surface crack opens and stays open, surface and spring flows that encounter relatively permeable zones in the overburden will move downgradient and likely reemerge as springs with subsequent discharge into the Dry Fork.

  WWE and Mr. Dunrud have determined that there is virtually no potential for a surface crack in the permit area to be deep enough to connect with a mine fracture zone. In the *extremely* unlikely scenario in which this occurs, however, the implications would be minor. If this scenario were to happen in the Dry Fork basin, surface and/or spring flows could be discharged into the mine workings. Waters collected within the mine workings would be treated, if necessary, to comply with the National Pollution Discharge Elimination System (NPDES) permit requirements and pumped through a drill hole back into the Dry Fork basin. Losses within the mine would be minor – ie: less than 5 percent of total inflows. The magnitude of replacement water provided by MCC in the Dry Fork/Minnesota Creek basin is orders of magnitude more than will be required, based upon the subsidence evaluation conducted by WWE with Mr. Dunrud.

- There is a very small risk (WWE has calculated the risk to be less than one percent) that one or more of the stock ponds in the permit area could be adversely affected via surface cracks. Pond water could be diverted into locally permeable zones within the overburden where it could: (1) Migrate down-dip toward the North Fork or Dry Fork to become part of the tributary alluvial/colluvial contribution of baseflow to the stream system, (2) Reappear as an ephemeral seep or spring, or (3) Become trapped as storage in an isolated zone within the overburden. If any of these circumstances were to occur, they would render the affected stock pond temporarily useless for retaining surface water. However, the lost water would eventually return to the Dry Fork and/or North Fork. The stock pond embankments could conceivably be affected by surface cracking; although, the probability of this occurring is insignificant.

It is important to note that the overburden materials in the permit area contain numerous shale and claystones layers and lenses which tend to undergo plastic deformation under compression, thereby sealing fractures that develop. In addition, the sediment load within surface flows (especially during spring runoff) will tend to fill surface cracks which may develop, thus further reducing the potential to transmit water downward.

The most severe potential subsurface hydrologic consequences include:

- Formation of interconnected fractures in the fracture zone with local water-bearing units of the overburden, thereby inducing either: (1) The movement of groundwater from one formation to another or (2) Loss of water to the mine workings. Should diversion to the mine occur, this water will be collected, treated, and discharged into the North Fork or the Dry Fork (see discussion above regarding the implications of surface water discharges to the North Fork and Dry Fork).

  As discussed extensively within this permit document, there are no regional aquifers within the Mesaverde Formation in the vicinity of West Elk Mine, nor is there demonstrated formation groundwater use at the mine or in the general area. Consequently, there are no aquifers which could be damaged as a result of subsidence. While there has been a sizeable amount of groundwater inflow observed from recently encountered fault systems (BEM and 14HG) there is no evidence to indicate any use of that water regionally. In addition, the observed inflows from these fault systems have decreased over time to a small percentage of the initial inflows, similar to other groundwater encounters in the mine.

- Interconnection of fractures filled with water and methane (as reported in the Oliver No. 2 Mine) with the mine workings via the B or E Seam fracture zone. This subject is discussed later in this section and in Exhibit 60.

As discussed in Section 2.05.6(6)(e)(i) *Potential Impacts from Local Seismic Activity*, subsidence could accelerate the naturally-occurring rockfall and landslide propensities that are already evident in the permit area, but this will not constitute a hazard to either people or property nor would this measurably impact the surface or ground water hydrology of the area.

Cracking of the earth along or across the trails or unimproved roads of the coal lease area already naturally occurs, but in the "worse case" could be accelerated by, or additional cracks created by, subsidence. As the trails and roads are unimproved, typically only all-terrain or four-wheel drive vehicles are utilized and rough terrain is expected, so the hazards created by any additional subsidence (rather than natural) cracking would be minimal. MCC will conduct visual inspections of primary public access to the USFS lands on a monthly basis, weather and ground conditions allowing, when these roads could be potentially impacted by undermining. MCC will mitigate all roads that may have been impacted due to subsidence and provide signage, particularly on public roads, warning of potential hazards.

Subsidence Prediction – 2.05.6 (6)(e)(i)

Brief Description of Mining Method - 2.05.6 (6)(e)(i)(A)

Apache Rocks and Box Canyon Mining Areas - The longwall mining method was utilized in the Apache Rocks and the Box Canyon mining areas. The panel design was similar to the current West Elk Mine longwall panels. An average of 12 feet of coal will be extracted from the B Seam in both areas and an average of 11 feet will be extracted from the E Seam in the western panels of the Apache Rocks mining area. The E Seam was not mined in the Box Canyon permit revision area. In the Apache Rocks mining area, E Seam mining occurred in Sections 28, 29, and 30. Top coal and bottom coal was left in place in these areas to improve roof and floor stability.

Southern Panels Mining Area (South of Divide and Dry Fork Mining Area) - The longwall mining method was and will be utilized in the Southern Panels mining area. Refer to Exhibit 60E for the most current panel designs and subsidence modelling parameters.

Geologic Factors Influencing Subsidence - 2.05.6 (6)(e)(i)(B)

As is also discussed in the most current version of Exhibit 60E, subsidence is influenced by the local geology in the following ways:

Geologic Structure

Attitude of the bedrock, faulting, and jointing may control mine layout and mining method. In steeply dipping, faulted coal beds, for example, a certain mine layout and method, such as room-and-pillar or limited panel-pillar may be required. Joints often control the way in which the roof rocks break, cave, and fracture, both underground and at the surface during mining and subsidence. In relatively flat-lying, unfaulted coal seams like the South of Divide and current mining area, there is latitude to develop the most efficient layout and method to recover a maximum amount of the coal resource with a minimum of impact.

Strength and behavioral properties of the rocks

These properties may control the amount and rate of subsidence. Strong, brittle sandstones and siltstones tend to break and cave in large blocks on the mine floor. The bulking factor is greater for strong rocks than it is for soft, weak rocks. The greater bulking factor of strong, caved material commonly reduces the height of caving and the subsidence factor over soft, weak rocks. Conversely, the height of fracturing often is greater for strong, brittle rocks than it is for soft, weak rocks.

Stratigraphic sequence

The stratigraphic distribution of rock units (stratigraphic sequence) influences the effects of mining and subsidence. For example, strong and brittle sandstones in the mine roof, as discussed above, can reduce the height of caving compared to shales, whereas sandstones in the fractured zone above the caved zone may increase the height of fracturing compared to shales.

In addition, the lithology of the overburden rock may control the subsidence factor. The subsidence factor may be less where the overburden contains a greater proportion of thick, strong sandstones, and greater where the overburden contains thin, weak shales. In the current mining area, a unit that may reduce the subsidence factor is the locally thick Lower and Upper Marine Sandstones that underlie the D and E Seams. These sandstones are about 100 feet thick in the eastern panel area and the eastern part of the western panels of the Apache Rocks mining area; they are approximately 100 to 125 feet thick in the Box Canyon mining area and the northwestern part of the current West Elk Mine area. In the South of Divide mining area, the first 200 to 300 feet of rocks above the E Seam consist primarily of siltstones, shales, claystones, local lenticular sands, and coal seams.

Moisture content

Wet or saturated conditions in the mine roof and overburden tend to reduce the bulking factor of the caved roof rocks. Therefore, the subsidence factor commonly is greater under wet conditions than it is in dry conditions. In general, the greater the saturation of the mine roof and overburden rocks, the greater the subsidence factor.

Field Recognition of Subsidence and Non-subsidence Features in the West Elk Mine Area

There are four different types of features that have been observed in the West Elk mining area: (1) Subsidence cracks and bulges, (2) Construction cracks, (3) Desiccation cracks, and (4) Gravity-induced tension cracks. They can be distinguished easily in some areas where, for example, no mining has occurred in that area. In other areas they may be difficult to distinguish, such as in areas that have been mined, but where conditions are also favorable for construction, desiccation, or gravity-induced tension cracks to occur.

Subsidence Cracks and Compression Features

Subsidence cracks are open cracks that most likely occur in areas where the ground surface has undergone extension during subsidence processes. Cracks as much as 3.5 inches wide, for example, have been observed in sandstone outcrops at Apache Rocks where zones of maximum extension (or tension in rock mechanics terminology) occur. As discussed in Exhibit 60B, cracks close—and the underlying rocks become compressive—below the neutral surface (the boundary between tensile and compressive strain) of the rocks downwarping as a single unit. Therefore, any water located in cracks above the neutral surface is blocked from traveling downward into rocks in compression below the neutral surface.

Cracks in the zone of maximum tension occur approximately perpendicular to the orientation of the longwall mining faces (transverse cracks) and parallel to the orientation of the longwall mining panels (longitudinal cracks). The cracks commonly do not conform to a precise pattern and as with other deformational processes in nature, crack orientation may be quite variable.

The transverse tension cracks that locally occur above the longwall mining face often have a dynamic history. They open when the longwall face moves beneath a particular area, and they close again when the longwall face moves out of the area of mining influence.

Longitudinal cracks occur above, and roughly parallel to the edges of the longwall mining panel above the gate road pillars and the haulageway (or beltway) pillars. Longitudinal tension cracks commonly remain open, particularly in areas above gate roads with a rigid-pillar configuration. The cracks may stay open or close in areas above gate roads with a combination rigid-pillar/yield-pillar configuration. However, as discussed in Exhibit 60B, it is unlikely that cracks will occur in colluvium and alluvium in the stream valleys of the South of Divide mining area.

Compression features (bulges and warps) also occur above the longwall mining panels in areas where the ground surface undergoes compression in the subsidence process. The compression features occur toward the center of the mining panel in zones of maximum compression, and are usually more difficult to recognize. They often are masked, or absorbed, by soil and colluvium, or are hidden in the brush and grass. They also may be indistinguishable from natural humps and mounds in the soil and colluvium.

Pseudo Subsidence Features (Gravity-Induced Tension Cracks)

Cracks have been observed on high, steep ridges, near cliffs, and in landslides, in the Box Canyon and Apache Rocks mining areas. These cracks look very much like subsidence cracks, but cannot be, since no mining occurred in the area where they were observed. A good example of a gravity-induced crack is the extensive crack that Mr. Dunrud observed on the narrow ridge of West Flatiron in August 2002. This crack was as much as 3.5 in wide and 150 ft long. This was not a mining-related crack because no mining had occurred in the area. The possibility of gravity-induced cracking in the rugged country above planned mining activities at the West Elk mining areas is a good reason to perform baseline studies of the area prior to mining so that these features can be documented prior to any mining.

Cracks and bulges caused by landslides are other types of gravity-induced features that may appear to be related to subsidence, particularly in areas that have been, or are being, undermined. However, landslide-induced features are related to the geometry of the landslide rather than the mine geometry. For example, cracks are most common in the upper area of a landslide, whereas, bulges are most common in the lower area of the slide. This spatial and geometric relationship to a landslide footprint on steep, unstable slopes, rather than the mine geometry can usually be used to differentiate between gravity-induced and mine-induced surface features.

Subsidence Prediction Based on Local Mining Experience - 2.05.6 (6)(e)(i)(C)

As is also discussed in the most current version of Exhibit 60E, much information has been gathered regarding subsidence at West Elk Mine due to local mining of the F Seam (room-and-pillar method), B Seam and E seam (longwall method). Subsidence monitoring of a grid network has been conducted since 1985, and has provided considerable data regarding the effects of varying overburden thicknesses, mining heights, and mining methods on the subsidence network. The grid has also verified MCC's predicted subsidence, and established when subsidence occurs, where it occurs, and when it is complete. The grid demonstrated, in regard to longwall mining, that the majority of the subsidence was seen within the first year after mining, and in most cases subsidence was completed within 12 to 18 months. This monitoring ceased in 1997. This information and its usefulness in predicting subsidence parameters in the current and Southern Panels mining areas is detailed in the following section. In addition, some general observations obtained from West Elk Mine and neighboring mining operations are described below.

Detailed Description of Predicted Subsidence Phenomena – 2.05.6 (6)(e)(i)(D)

As is also discussed in the most current version of Exhibit 60E, subsidence, as it relates to mining, is defined as the local downward displacement of the surface and the overburden rock in response to mining under the influence of gravity. The following text includes a general discussion of the various zones defined within the subsidence area; predicted maximum vertical and horizontal displacements, tilt, curvature and horizontal strain; predicted zones of tensile strain related to mine geometry; predicted rates and duration of subsidence; the effects of topography on subsidence; and the predicted angle of draw. A summary of these values as determined from the present mining area subsidence monitoring data is presented in the Exhibit 60 series (Table 1). Table 2 and Table 3 in Exhibit 60 series summarize the projected values of these parameters for the Apache Rocks and Box Canyon mining areas. Table 2 of Exhibit 60B summarizes the projected values of these parameters for the South of Divide mining areas as described in the following subsidence discussion.

Subsidence Zone Description

For purposes of describing subsidence effects on overburden material and the ground surface, subsidence can be divided into four zones (see the Exhibit 60 series for details): (1) Caved zone, (2) Fractured zone, (3) Continuous deformation zone, and (4) Near-surface zone.

Caved Zone

As coal is extracted and a void is produced, the roof rocks break along bedding planes, joints, and fractures and fall to the mine floor. Rotation of the caved debris occurs during the fall so that the caved fragments tend to pile up in a random fashion. This caved zone, according to Peng (1992), occurs for the first 2 to 8 mining thicknesses (2 to 8t) in the roof rocks. In the current West Elk Mine longwall panels, the caved zone is estimated to be 2.5 mining thicknesses (2.5t) based on roof rock observations from directly behind the current longwall equipment. Any water present in this zone will drain into the mine almost immediately after caving occurs.

The B and E-Seam roof rocks commonly consist of thinly bedded carbonaceous shales, sandy shales, claystones, and sandstones. A soft shale that is susceptible to air slaking forms the immediate roof of the B-Seam in most areas. Thick sandstones locally form the immediate roof of the E-Seam, in addition to the shales and sandstones.

The ratios of shale to sandstone are quite similar in the first 20 feet of roof in the B and E-Seams. The shale to sandstone ratio of the first 20 feet of B-Seam roof averages about 2:3, the shale to sandstone ratio of the first 5 feet averages 3:2. The shale to sandstone ratio of the first 20 feet of the E-Seam roof is 3:2; the shale to sandstone ratio of the first 5 feet is also 3:2. Although the percentages of shale to sandstone are similar in the B-Seam and E-Seam roof rocks, a much higher degree of local variability occurs above the E-Seam.

The B and E-Seam roof rocks above the first 20 feet consist of shale, siltstone, lenticular sandstones, and thin coal beds. A marine sandstone, locally consisting of a lower and upper tongue and ranging from about 30 to 125 feet thick, underlies the D and E-Seams; the D-Seam occurs a foot, to as much as 50 feet below the E-Seam.

Mr. Dunrud estimates that the caved zone in the Apache Rocks and Box Canyon mining areas will range from 2 to 4 extraction thicknesses. Caved zone heights closer to 2 times the mining thickness (t) are expected in dry mining conditions, whereas wetter conditions will produce caved zone heights closer to 4t. An acceptable average value for the Apache Rocks and Box Canyon mining areas is 2.5t.

Based on the stratigraphic and lithologic information obtained from drill holes in the South of Divide mining area, the rocks consist of a greater amount of shales, siltstones, and claystones than are present in the Apache Rocks and Box Canyon mining areas. It is therefore estimated that the caved zone will range from 2t to 5t, depending on water conditions encountered and on specific roof lithology. In a dry environment, where lenticular sandstones comprise the E Seam roof, the caved zone will be closer to 2t. In a wet environment where soft shales and claystones occur in the roof, however, the caved zone will likely be closer to 5t.

Fractured Zone

A zone of fracturing and local separation along rock bedding planes and joints occurs above the zone of caving. In this zone, which is transitional to the underlying caved zone, lateral and vertical constraints in the adjacent overburden strata and the caved rocks below minimize further displacement or rotation of the fractured rock. Displacements in the fractured zone and severity of fracturing tend to decrease upward as lateral and vertical confining stresses increase.

Based on width and conductivity of fractures Peng (1992, p. 143) states that the upper one-third of the fractured zone (in terms of height) has only minor fractures with little potential for water conductivity. In the lower two-thirds of the fractured zone, water conductivity increases progressively downward.

Compression arches (arcuate zones of compressive stress) commonly develop, or partially develop, above the mining panels. These arches temporarily transfer overburden stresses to the panel barrier or chain pillars and also to the caved zone and the mining face (Dunrud 1976). The arches in a given area commonly move upward and disperse as longwall mining is completed in the area. Compression arches may not disperse where the room-and-pillar mining method is used, because pillars and stumps left after mining may prevent dissipation of the arches. The rocks affected by the arches temporarily are subjected to increased stress and strain as the arches move upward. However, in the longwall mining area, this increased stress and strain commonly is less than it is in room-and-pillar mining areas because stresses are relieved as the arches move upward and dissipate.

Peng (1992) reports that the combined height of the zone of caving and fracturing ranges from 20 to 30 extraction thicknesses (20 to 30t), and that the height of the fractured zone is greater for hard, strong rocks than it is for soft, weak rocks.

The height of the zone of fracturing is a function of lithology and layer thickness, according to Peng (1992). For example, the zone of fracturing commonly is higher for strong, thickly-bedded, brittle sandstones than it is for thinly layered, soft, plastic shales and claystones. Liu (1981), reports ranges of heights of the zone of fracturing for various rock types as follows:

- Heights of 20 to 30 times coal extraction thickness (20 to 30t) are reported in strong brittle rocks, such as siliceous sandstones and limestones; a value of 28t was reported for overburden containing 70 percent sandstone. Also, because of hardness, fractures do not close as readily in brittle rocks as they do in soft rocks during recompression.

- Heights of 9 to 11 times the coal extraction thickness (9 to 11t) are reported where all the rocks consist of soft, plastic shales and claystones. The fractures also commonly close again under lateral vertical compression associated with static conditions, and become impermeable again.

Within the Southern Panels mining area, fracturing will likely become discontinuous with increasing height because of the alternating sequence of harder and brittle and softer and yielding rocks. Due to the stratigraphic position of the E Seam, above the 170’ to 250’ thick Bowie Sandstone, the proportion of soft yielding strata as compared to the hard brittle strata in the fractured zone is higher than for the B Seam mining. The absence of the Bowie Sandstone in the fractured stratum and the high percentage of softer rocks is best illustrated in the Cross-Sections A-A’ through F-F’. The height of the fracture zone, therefore, will likely be less, by possibly 10 to 20 percent, than the height predicted in the Apache Rocks and Box Canyon mining areas because of the presence of more shale. Steeply dipping fractures near the top of the caved zone, therefore, will likely become less continuous with increasing height in the zone of fracturing.

The maximum height of fracturing above longwall panels in the Southern Panels mining areas was estimated to range from about 10 to 20 times the extraction thickness. This is near the mid-range of 9 to 30 times coal extraction thickness as reported by Peng (1992, p. 7). This estimate may be conservative for rocks above the E Seam.

Also, with increasing height in this zone, and as lateral and vertical constraints increase, fracturing that could impact water-bearing zones will tend to occur more in zones of convex upward curvature, along separated bedding planes toward the center of the panel, and along local cracks in zones of convex downward curvature (Figure 2, Exhibit 60B). Fracturing within the expected zone of fracture may cease completely where soft shales and claystones occur as alternating sequences with sandstones.

Mr. Dunrud has concluded that the maximum height of fracturing above longwall panels in the B-Seam in the Apache Rocks mining area is estimated to range from about 15 to 20 times the extraction thickness (t) (for example, if t = 12 feet, the maximum fracture height would be 240 feet at 20t) near the mid-range of 9 to 30 times coal extraction thickness. This estimate is viewed as conservative by Mr. Dunrud because rocks above the B Seam and below the Marine Sandstone, that underlies the D Seam, consist of about 150 to 200 feet of laminated sandstone and shale and sandy shale and sandstone.

Drainage, however, may cease after mining is complete and any water-bearing zones present may be restored. This is particularly likely in the upper part of the fractured zone in shale sequences between sandstone layers, once subsidence is completed and the separated beds recompress and close in response to overburden load (see Exhibit 60B, Figure 2). Evidence of restored water levels has been measured and reported in at least one well (SOM 38-H-1) in the West Elk Mine subsidence monitoring area after mining and subsidence were complete.

Continuous Deformation Zone and Near-Surface Zone

These two zones are discussed together because the ground surface is where nearly all measurements are made that monitor subsidence processes active in the zone of continuous deformation. The near-surface zone, which typically consists of weathered bedrock, colluviums, and soil ranging in depth from a few feet to a few tens of feet, may deform differently than the underlying bedrock, especially on steep slopes. The zone of continuous deformation, which is transitional to the underlying zone of fracturing, consists of differential vertical lowering and flexure of the overburden rocks above the zone of caving and fracturing.

Near-Surface Zone

Field studies by Mr. Dunrud indicate that near-surface colluvium and alluvium, which consist of predominantly clay and silt, can undergo significantly more extension without rupturing than can the underlying material. In both the Somerset, Colorado and Sheridan, Wyoming areas colluvium and alluvium 5 to 10 feet thick were observed to cover cracks as much as 10 to 14 inches wide so that there was no indication of the underlying ruptures. Mr. Dunrud's observations in the Bear Creek area in 1976 are discussed in the Final Environmental Impact Statement for the Iron Point Coal Lease Tract and Elk Creek Coal Lease Tract (2000).

The zone of continuous deformation, which is transitional to the overlying near-surface zone and to the underlying zone of fracturing, undergoes differential vertical lowering and flexure as laterally-constrained plates (in three dimensions) or beams (in two dimensions). With flexure, shear occurs at the boundaries of rock units with different strength and stiffness, characteristics, such as sandstones and shales. Zones of tension above the neutral surfaces of a rock unit, for example, become compressive above the boundary with another rock unit and below its neutral surface (Figure 2, Enlargement 2 of Exhibits 60B and 60E). Any cracks, therefore, which occur in the tension zone of a rock unit, terminate at the neutral surface, because the unit is in compression below this point.

Maximum Vertical Displacement, Tilt, Horizontal Strain, and Depth of Surface Cracks

Differential vertical lowering of the continuous deformation and near surface zones causes vertical displacement (S), horizontal displacement (S_h), tilt (M), and horizontal strain (E). Each of these parameters is graphically illustrated in Figure 2, Exhibit 60B. In flat or gently sloping terrain (slopes less than about 30 percent), surface profiles of subsidence depressions are similar to flexure of fixed-end, laterally constrained beams. Tensile stresses are present in areas of positive curvature decreasing to zero at the neutral surface before which they reverse to become compressive stresses (see Figure 1, Exhibit 60B).

In flat or gently sloping terrain, vertical displacement typically increases inward from the limit of the subsidence depression, is half the maximum value at the point of inflection, and is at its maximum in the middle of the depression (also called subsidence basin or subsidence trough). Horizontal displacement and tilt increase inward from the margin of the depression to a maximum at the point of inflection and become zero again at the point of maximum vertical displacement (Exhibit 60B, Figure 3). Maximum values of tilt, curvature, and strain, discussed herein, apply only to slopes less than about 30 percent; values may be greater on slopes steeper than 30 percent.

Positive curvature (convex upward) and horizontal tensile strain increase inward from the margin of the depression to a maximum about midway between the depression margin and the point of inflection and decrease to zero again at the point of inflection. Negative curvature (concave upward) and compressive horizontal strain increase inward from the point of inflection to a maximum about midway between the point of inflection and the point of maximum vertical displacement and decrease to zero again at the point of maximum vertical displacement.

Maximum Vertical Displacement (Subsidence)

Longwall mining panels are defined by their panel width to overburden depth ratio as subcritical, critical, or supercritical. The subsidence literature indicates that a panel width to overburden depth ratio between 1.0 and 1.4 (average of 1.2) generally defines the critical longwall panels. Those panels with panel width to overburden depth ratios exceeding this value are defined as supercritical, and those which are less are defined as subcritical.

- ***Apache Rocks West Mining Area*** ***Apache West Panels E Seam Mining*** – As is also discussed in the most current version of Exhibit 60E, for E Seam mining, all three western panels will be of supercritical width (i.e., mining width greater than critical; critical width is the mining width needed to cause maximum subsidence) in areas near the head of Pond Gulch, in the Horse Gulch area, and the two unnamed draws east of Horse Gulch. Only in areas of the higher ridges adjacent to these draws will the panels be of subcritical width (mining width less than critical). With a projected longwall panel width of 950 feet, assuming an 11-foot coal-extraction thickness and chain pillar dimensions and geometry similar to the current West Elk mining area, maximum subsidence is projected to range from 6.6 to 8.8 feet (0.6t to 0.8t).

Maximum subsidence is expected to be closer to 6.6 feet (0.6t) beneath the ridges and closer to 8.8 feet (0.8t) beneath the draws. Maximum subsidence above the chain pillars (S_{cp}) is predicted to range from 0.6 feet (0.05t) where the overburden is thinnest (in the draws) to about 3.6 feet (0.3t) beneath the ridge areas. Maximum subsidence may be less in the northeastern part of the panel area where the Marine Sandstone beneath the D-Seam is about 100 feet thick.

- ***Western Panels-Combined E and B-Seam Mining*** – For E Seam mining and B Seam mining, the three mining panels will range from supercritical to critical in the draw areas, previously mentioned in the E Seam mining section, to subcritical in the ridge areas adjacent to these draws. Because the total extraction thickness will average 23 feet (E Seam, 11 feet; B Seam, 12 feet), the total maximum subsidence (vertical displacement) after mining both seams is projected to range from about 13.8 to 18.4 feet (-0.6t to 0.8t).

Southern Panels Mining Area (South of Divide and Dry Fork Lease Mining Area) –

The following range of vertical displacements (subsidence values) are projected for the Southern Panels mining area based on the baseline data obtained from subsidence measurements above the 1NW, 2NW, and 3NW longwall panels at West Elk Mine (see Figure 3 and Table 1, Exhibit 60B) and the proposed E Seam mining configuration (Map 51). The projected range of maximum vertical displacements, for the South of Divide mining area is shown in Table 2 of Exhibit 60B.

As is also discussed in the most current version of Exhibit 60E, overburden depth to the E Seam above the longwall panel centers within the Southern Panels mining area ranged from approximately 400 to 1,425 feet. With a projected longwall panel width of 1,080 feet, and assuming that the chain pillars (gate road pillars) are similar to those in longwall Panel 17 of the Apache Rocks Mining Area, maximum subsidence (vertical displacement S_m =at) is predicted as follows (Table 2 of Exhibit 60B and 60E):

- ***Panels E1 to E8.*** These panels, that trended roughly N80ºW, will range in width from subcritical to supercritical (width-to depth ratio (W/d) ranges from 0.76 to 2.7).

    1. Maximum vertical displacement above the chain pillars (Scp) ranged from 0.8 to 2.4 feet (0.1 to 0.3t) where the extraction thickness is 8 feet, 1.2 to 3.6 feet (0.1 to 0.3t), where the extraction thickness is 12 feet, and from 1.4 to 4.2 feet (0.1 to 0.3t), where the extraction thickness is 14 feet.

    2. Maximum vertical displacement (subsidence, S_m =at) ranged from 4.8 to 6.4 feet (0.6 to 0.8t) where the extraction thickness is 8 feet, from 7.2 to 9.6 feet, where the extraction thickness is 12 feet, and from 8.4 to 11.2 feet (0.6 to 0.8t), where the extraction thickness is 14 feet.

- ***Panel E9.*** This panel trends about N10ºE and is of supercritical width.

    1. Maximum vertical displacement above the chain pillars in this shallow overburden is expected to range from 1.2 feet (0.1t), where the extraction thickness is 12 feet and from 1.4 feet (0.1t), where the extraction thickness is 14 feet.

    2. Maximum subsidence is projected to range from 8.4 to 9.6 feet (0.7 to 0.8t), where extraction thickness is 12 feet, and 9.8 to 11.2 feet (0.7 to 0.8t), where the extraction thickness is 14 feet.

Maximum Tilt

Maximum tilt (M_m) was calculated from differential vertical displacements at the West Elk Mine monitoring network in terms of the ratio of maximum vertical displacement to overburden depth (S_m/d in dimensionless units L/L). Tilt values at West Elk Mine range from 0.014 to 0.021 dimensionless units (L/L). Maximum tilt in four different mining areas of the Western United States ranges from 2.5 to 5·(S_m/d).

Southern Panels Mining Area (South of Divide Mining and Dry Fork Lease Mining Areas) **-** Tilt above the nine longwall panels (panels E1-E9) within the South of Divide mining area ranged between 2.2 and 2.3 Sm/d for coal extraction thickness ranging between 8 and 14 feet. These values are based on subsidence measurements at West Elk Mine (Table 1, and Figure 5 of

Exhibit 60B). As represented in Table 2 of Exhibit 60B, the overburden depth above the longwall panel centers ranges from 400 to 1,425 feet.

- *Panels E1 to E8*. Maximum tilt in these panels ranged from 0.007 to 0.037 (0.7 to 3.7 percent) where 8 feet of coal is extracted, from 0.013 to 0.044 (1.3 to 4.4 percent) where 12 feet of coal is mined, and from 0.013 to 0.064 (1.3 to 6.4 percent) where a 14-foot thickness of coal is mined.

- *Panel E9.* Maximum tilt in this panel is predicted to range from 0.034 to 0.044 (3.4 and 4.4 percent), where 12 feet of coal is mined and from 0.039 to 0.052 (3.9 to 5.2 percent) where 14 feet of coal is produced.

Maximum Curvature

Curvature, i.e., subscript (C_m) which is the reciprocal of radius of curvature (and thus expressed in radians/foot [rad/ft]), is calculated from differential tilt. Maximum positive (convex upward) curvature in the West Elk Mine monitoring network is as much as 50 percent more over chain pillars than it is above longwall panel boundaries. Maximum positive curvature at the current West Elk Mine ranges from 14.4 to $18 \cdot (S_m/d^2)$ with a numeric range of 0.000060 to 0.000065 rad/ft above longwall panel boundaries to an average of $24 \cdot (S_m/d^2)$ with a numeric range of 0.000144 to 0.00022 rad/ft above the chain pillars.

Maximum negative (concave upward) curvature averaged about the same when measured above the chain pillars as it did above the panel boundaries. Maximum negative curvature ranges from about –20 to $-25 \cdot (S_m/d^2)$ (-0.000111 to –0.000066 rad/ft) above longwall panel boundaries and has an average value of $-24 \cdot (S_m/d^2)$ (-0.00012 to –0.00025 rad/ft) in the panel centers between the chain pillars. Maximum positive and negative curvature in four different areas of the Western United States ranges from 9 to $45 \cdot (S_m/d^2)$. Maximum curvature ranges are given below for the eastern and western panels of the Apache Rocks and the Box Canyon mining areas.

Maximum Horizontal Strain

Maximum positive horizontal strain (E_m) measured in the West Elk Mine monitoring network ranges from 1.1 to $1.4 \cdot (S_m/d)$ (0.0058 to 0.0102, that is 0.58 and 1.0 percent); maximum negative strain between -0.20 and -4.0 times (S_m/d) (or 0.0009 and 0.0307, that is 0.09 to 3.0 percent) (Table 1 of Exhibit 60B). The range of horizontal tensile strain in four different mine areas of the Western United States studied by Mr. Dunrud is 0.45 to $3 \cdot (S_m/d)$.

Maximum tensile and compressive strain is significantly greater above large barrier pillars and rigid chain pillars and mine boundaries than it is above longwall mining faces. This is because tensile strains caused by mining the two adjacent panels are additive above the common rigid chain pillars or unyielding mine panel boundary pillars. Cracks tend to be wider and deeper above barrier pillars or lease boundary barrier pillars than chain pillars because of their greater rigidity.

The tensile strains presented in Exhibit 60B (Figure 4) were believed to be conservative for the South of Divide mining area. Maximum horizontal tensile strains, measured by Mr. Dunrud in bedrock during annual observations in the Apache Rocks area (in hard brittle sandstone, where the only strain is revealed by cracks), were 0.0031 to 0.0062 (0.31 to 0.62 percent). The tensile strain is considered to be close to a maximum value for those observed by Mr. Dunrud in the Apache rocks area because (1) the features are located above the area if influence of a large solid coal pillar and (2) no greater strain was observed in the Apache Rocks mining area.

South of Divide Mining Area **-** Maximum tensile and compressive horizontal strains were calculated for the South of Divide mining area, using the values obtained from the West Elk Mine area (see Exhibit 60B, Figure 5 and Table 2). These values were believed to be conservative, based on Mr. Dunrud's annual observations since 1998 in the Apache Rocks mining area.

- *Panels E1 to E8*: For these eight panels, projected horizontal tensile strain ranges from 0.004 to 0.022 (0.4 to 2.2 percent) where the planned coal extraction thickness is 8 feet; from 0.007 to 0.027 (0.7 to 2.7 percent) where the extraction thickness equals 12 feet; and from 0.007 to 0.039 (0.7 to 3.9 percent) where the extraction thickness equals 14 feet.

  Horizontal compressive strain ranges from -0.004 to -0.024 (-0.4 to -2.4 percent) where the extraction thickness equals 8 feet; -0.007 to -0.029 (-0.7 to -2.9 percent) where the thickness equals 12 feet; and -0.007 to -0.042 (-0.7 to -4.2 percent) where it equals 14 feet.

- *Panel E9*: Predicted horizontal tensile strain in this single panel ranges from 0.018 to 0.027 (1.8 to 2.7 percent) where the coal extraction thickness equals 12 feet and 0.021 to 0.031 (2.1 to 3.1 percent) where the extraction thickness equals 14 feet.

  Compressive strain this panel is predicted to range from -0.018 to -0.029 (-1.8 to -2.9 percent) where the extraction thickness equals 12 feet and -0.021 to-0.034 (-2.1 to -3.4 percent) where it equals 14 feet.

Maximum Depth of Surface Cracks

Curvature, or differential tilt (curvature is the second derivative of vertical displacement with respect to horizontal distance) of subsided rock layers causes horizontal strain. Comparison of calculated curvature values and horizontal tensile strain derived from horizontal displacement measurements, therefore, provides a means of calculating the depth of the neutral surface, and hence the maximum depth of tension cracks from the surface. The neutral surface is the boundary between tensile and compressive strain.

In terrains with slopes less than about 30 percent, the depth of the neutral surface can be estimated by dividing the maximum horizontal strain values by the maximum curvature values at a given location. The calculated depth of the possible tensile zone to the neutral surface, ie: the boundary between tension above and compression below—ranges from about 50 to 100 feet in the subsidence monitoring network at West Elk Mine. Crack depth may be much less than this projected 50 to 100 foot range of maximum values. An unpublished study for the U.S. Bureau of Mines (Engineers International) indicated that surface crack depth rarely is greater than about 50 feet. Cracks will also be less extensive or terminate where shale and claystone layers occur.

Based on annual field subsidence observations, maximum crack depth in bedrock in the South of Divide mining area was estimated to be (1) 5 to 15 feet in terrain sloping less than, or equal to, 30 percent (2) 10 to 35 in terrain sloping more than 30 percent, and (3) 40 to 50 feet in thick, brittle sandstones in ridges (Exhibit 60B, Table 2).

Crack depth is likely to be at a maximum value above massive coal barriers. Crack depth may therefore be greatest above the 700-foot-wide protective barrier system projected between longwall panels E4 and E5 (Exhibit 60B, Figure 1). The crack depth is projected to be less (probably 10 to 20 percent less) above the panel chain pillars, where even the rigid pillars are predicted to yield 10 to 30 percent of the coal extraction thickness (Exhibit 60B, Table 2).

Cracks that occur above the mine panel area also tend to close, once mining faces move out of the surface area of influence (DeGraff and Romesburg 1981). Any local bed separations during active subsidence between rocks of different strengths (Exhibit 60B, Figure 1) will likely close once equilibrium conditions occur. However, any cracks present above rigid chain pillars, barrier pillars, or mine boundaries may remain open where permanent tensile stresses remain after mining is completed due to the convex curvature of the subsidence profile.

During the nine years of annual observations in the West Elk mining area by Mr. Dunrud (from 1996 to 2004), particularly in the Apache Rocks mining area, no cracks were observed above mined-out longwall panels in colluvium more than an estimated ten feet thick. No cracks have been observed in alluvium above mined-out longwall panels.

No cracks were observed in the alluvium and colluvium of Sylvester Gulch and Deep Creek (estimated thickness range: 25 to 150 feet) during periodic field observations in the Apache Rocks and Box Canyon mining areas. The near-surface alluvial material consisted of primarily sand, silt, clay, and soil in the two areas mentioned, and was located above rigid pillars and panel boundaries where the overburden depth ranges from 800 to 1,050 feet. The alluvium and colluvium in Sylvester Gulch, Dry Fork, and Lick Creek drainages (estimated thickness range: 25 to 75 feet), on the average, contains more clay than does the Deep Creek alluvium. Therefore, it is very unlikely that cracks will occur in colluvium and alluvium in the stream valleys of Sylvester Gulch (Panel 25) or the South of Divide mining area even considering the shallow overburden.

The probable reason for the lack cracking in alluvium is that the fine sand- to clay-sized material and overlying soil can yield without cracking or bulging as it deforms as a discrete unit, or units during in the subsidence process. The alluvium observed by Mr. Dunrud during geologic mapping activities also varies in thickness from more than ten feet to many tens of feet in the West Elk mining area, including the South of Divide mining area. This same reasoning also applies to the colluvium in the area. Although subsidence cracks were locally observed in colluvium less than one foot to a few feet thick, no cracks were observed in colluvium more than about ten feet thick.

Cracks were also observed south of Lone Pine Gulch and north of the Mautz cabin. After extensive analysis by former Colorado State Geologist, John Rold, and Mr. Dunrud, it was concluded that the cracks were the result of both landslide movement and mining activities in the B-Seam.

Angle of Draw

The draw, or limit angle (ϕ, from a vertical reference) in the Somerset area ranges from about 8 to 21 degrees. See Exhibit 60E. The actual E-seam angle-of-draw has been conservatively estimated at 16.3 degrees (see appendix B of the Spring 2010 Subsidence Report.) The angle of draw is measured using the greatest verticle distance between the top of the E-seam at the nearest edge of each longwall panel and the ground surface elevation equal to the point of no discernable subsidence. As such, the conservative approximate limit of the maximum predicted E-seam angle-of-draw is 19 degrees.

Break Angle

The break angle, the angle (B, from a vertical reference) of a straight line projected from the zone of maximum horizontal tensile strain at the ground surface to the boundary of the mine workings, is more important than the draw angle for hydrologic analyses. The break angle provides a means of determining zones, in relation to underground mine workings, where surface water most likely may be impacted. The break angle generally averages 10 degrees less than the corresponding draw angle (Peng and Geng 1982).

The break angle ranges from 9 to 3 degrees in the West Elk Mine subsidence monitoring network area. Topography appears to control the location of the zone of maximum tensile strain and consequently the break angle. For example, the break angle is 3 degrees where tilt direction (caused by subsidence) is opposite to the direction of the slope of the ground surface (42 percent slope), but is 9 degrees where the tilt direction is in the same direction as the slope of the ground surface (32 percent slope).

Tensile strain caused by subsidence commonly reaches a maximum value in linear zones above mining panels. The location of these zones can be determined by the break angle (the angle of the break line from panel boundaries to the zone of high tensile strain). At panel boundaries with solid coal, subsidence data from the West Elk Mine monitoring network shows that the break angle for subcritical mining panels ranges from 9 to 3 degrees with an average expected value of about 0 degrees.

Information from the West Elk Mine subsidence monitoring network also indicates that the zone of increased horizontal tensile strain ranges from 100 to 150 feet wide above mine boundaries and from 100 to 250 feet wide above the chain pillars. This zone, is located approximately above the edges of the panels or slightly outside the panel boundaries and above the center of the chain pillars, unless a down-slope component of movement occurs on steep slopes in addition to the differential tilt component. Cracks tend to be more common and more permanent in zones above mine boundaries, barrier pillars, and unyielding chain pillars. Any surface or near-surface water that might be present in this zone has a higher probability of being impacted than that occurring in the centers of the panels.

Angle of Major Influence

The angle of major influence, β, (also called angle of influence of the point of evaluation) is defined by Peng (1992, p. 11) “. . . as the angle between the horizontal and the line connecting the inflection point and the edge of the radius of major influence.” The radius of major influence (r) is therefore the horizontal distance from the vertical projection of the inflection point to the point of maximum subsidence and the limit of subsidence (See Exhibit 60B, Figure 3). The angle of major influence is used for computer modeling by the influence function method. In the B Seam mining at West Elk Mine, the angle of major influence ranges (from a horizontal reference) from about 70 to 80 degrees. For E Seam mining in the South of Divide mining area, the angle of major influence is also expected to range from 70 to 80 degrees, which was used for the computer modeling described below.

The angle of major influence may also be referenced to the vertical, as has been done for the break angle and angle of draw. The angle of major influence (from a vertical reference) is roughly equal to the angle of draw, and is therefore predicted to range from 10 to 20 degrees.

Relation Between Dynamic and Final Subsidence Deformations

Maximum dynamic tilt (change of slope) and horizontal tensile and compressive strain are reportedly less above longwall mining panels than are the final tilt and strain values at panel boundaries. Dynamic tilt and strain decrease, relative to final tilt and strain, as the rate of face advance increases.

Dynamic tilt and strain reportedly decrease with increasing speed of longwall coal extraction (Peng 1992, p. 20-21). Based on observations in a West Virginia coal mine:

1. Maximum dynamic tilt decreased by an average of 42 percent (from 0.0024 to 0.0014) as the mining face rate of movement increased from 10 ft/day to 40 ft/day; dynamic tilt, therefore, decreased by 14 percent as the face rate of movement increased by 30 ft/day.

2. Maximum dynamic tensile strain decreased by an average of 22.5 percent (from 0.0031 to 0.0024) as the mining face velocity increased from 10 ft/day to 40 ft/ day; dynamic horizontal tensile strain decreased by 7.5 percent as the face increased by 30 ft/day.

3. Maximum dynamic compressive strain decreased by an average of 48 percent (0.0062 to 0.0032) as the face velocity increased from 10 ft/day to 40 ft/day; dynamic horizontal compressive strain decreased by 16 percent as the face increased by 30 ft/day.

Critical Extraction Width of Mining Panels

Critical extraction width (W) is the width of mining panels necessary for maximum subsidence to occur at a given overburden depth (d). Values for critical W/d typically range from about 1.0 to 1.4, with an average of about 1.2. Based on the subsidence development data for the 5^{th} NW longwall panel, the critical extraction width-to-depth ratio is estimated to be 1.0 in the Apache Rocks and Box Canyon mining areas and 1.2 in the South of Divide mining area (see Exhibits 60B 60E, Figure 4).

Zones of Tensile Strain in Relation to Mine Geometry

Tensile strain caused by subsidence commonly reaches a maximum value in linear zones above mining panels. The locations of these zones can be determined by the break angle. At panel boundaries with solid coal, subsidence data from the West Elk Mine monitoring network shows that the break angle for subcritical mining panels ranges from -8 to 3 degrees with an average value of about 0 degrees, or directly above the panel edges.

Information from the West Elk Mine subsidence monitoring network also indicates that the zone of high horizontal tensile strain ranges from 100 to 150 feet wide above mine boundaries and from 100 to 250 above the chain pillars. This zone is located approximately directly above or slightly outside the panel boundaries and above the center of the chain pillars, unless a downslope component of movement occurs on steep slopes in addition to the differential tilt component (see Map 51 and Map 52).

The zone of maximum tensile strain above the chain pillars between the longwall panels is approximately twice the strain values measured above mine boundaries. Cracks tend to be more common and more permanent in zones above mine boundaries, barrier pillars, or rigid chain pillars. Any surface water or near-surface water that might be present in these zones is potentially more subject to impact than in the centers of the panels. This was found by Werner and Hempel who state in their paper, *Effects of Coal Mine Subsidence on Shallow Ridge - Top Aquifers in Northern West Virginia* (1992), "Analysis of water level and spring flow records indicates that the effects are greatest at the edges of the longwall panels, in the tensional regime," and by Leavitt and Gibbens (1992) who stated, "Well response was found to be correlated to the location of the well above the mining with greater effects observed in zones of surface tension and compression, and fewer effects in zones which are stress neutral."

<u>Rate and Duration of Subsidence</u>

A point on the surface begins to be affected when the longwall mining face is within 0.1d to 0.6d (d = overburden depth) of the point and is near maximum downward velocity. Subsidence is 50 percent complete when the face is 0.2d to 0.5d beyond the point, and is more than 90 percent complete when the face is 1.0d to 1.4d (average about 1.2d) beyond the point if longwall mining is done. Data obtained above the 5th NW longwall panel at West Elk Mine plot between the National Coal Board (NCB) and Somerset curves (Figure 9, Exhibit 60B). The data also show that subsidence is more than 95 percent complete when the longwall face has moved 1.0d beyond the points of measurement. Critical extraction width, therefore, is approximately 1.0d for the B Seam panels at West Elk Mine, and is projected to range from 1.0d to 1.2d for the South of Divide mining area.

Rate and duration of subsidence above longwall mining panels, therefore, are a function of mining rate. The faster and more uniformly the longwall mining occurs, the less time any surface cracks present will be open to potentially impact surface or ground water. Therefore, rapid, uniform mining beneath streams and other sensitive features causes minimum mining impact.

The duration of subsidence above room-and-pillar mines; however, is less predictable because not all pillars are removed. For example, in Figure 9 of Exhibit 60B, subsidence at a given point (p) was only about 60 percent complete after mining was completed within the area of influence of the point.

<u>Results of Computer Modeling</u>

As is also discussed in the most current version of Exhibit 60E, a computer software package was used to model the results of subsidence measurements at West Elk Mine. The package that was used waa entitled "Comprehensive and Integrated Subsidence Prediction Model (CISPM)," Version 2.0, by Syd S. Peng and Yi Luo, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV. This program performed an influence function analysis and best fit of the West Elk Mine subsidence data. The fit between the data points and the influence function output from the model are shown in Figure 6, Exhibit 60B. See the most current version in Exhibit 60E.

Baseline subsidence measurements in the current West Elk Mine subsidence monitoring area were selected such that subsidence parameters from longwall mining in the B Seam were obtained with as little influence from prior room-and-pillar mining as possible. In this way, the longwall mining subsidence parameters from the monitoring area could be used to most accurately project longwall mining subsidence parameters into the SOD mining area. The baseline subsidence measurements selected for both conceptual modeling and computer modeling were October 1991, which was before B Seam longwall mining began and after F Seam room-and-pillar mining was completed in the subsidence monitoring network area.

Once the computer program was calibrated to the West Elk Mine subsidence data, subsidence was projected into the SOD mining areas using representative coal extraction thicknesses and overburden depths for the respective panels in order to obtain an independent check on the subsidence projections based on the conceptual model (Table 1 and Figure 7, Exhibit 60B).

Southern Panels Mining Area **-** Comparison of Mr. Dunrud's conceptual model calculations and the influence function computer model of Peng and Luo (which were done by the WWEs staff in Figures 7 and 8, Exhibit 60B) showed the following:

1. Maximum vertical displacement (subsidence) above the chain pillars in the transverse profile (Figure 7, Exhibit 60B) is close to the maximum values predicted in the conceptual model calculations (0.8 to 4.2 feet). Maximum vertical displacement above the longwall panel centers, however, is about equal to the median values projected in the conceptual model calculations (4.8 to 11.2 feet).

2. The ranges calculated for vertical displacement in the conceptual model are conservative. The ranges account for changing rapidly changing overburden thickness in the local rugged terrain of the South of Divide mining area and for changing lithology such as lenticular sandstones, coal seams, and shales in the overburden rocks.

Effects of Topography and Structure on Subsidence Processes

In contrast to subsidence of rock units behaving as fixed-end, laterally constrained, multiple plates, subsidence in steep topography will typically occur as non-fixed end, laterally unconstrained multiple plates (rock units). This lack of lateral confinement may locally cause reversals of horizontal displacement and excessive tensile strain on steep slopes. Peng and Hsuing (1986) found that horizontal displacement is affected by slopes greater than 20 percent. Displacements on steep slopes and cliffs can cause cracks to open more along faults, fractures, and joints than would occur in subdued topography where the rock units are laterally constrained. Therefore, steep slopes and cliffs, which commonly are susceptible to rockfalls and landslides anyway, may become less stable when undermined.

Stresses are concentrated within the overburden and coal beds beneath ridges and peaks. Abnormally high stresses may have led to the closure and abandonment of the Oliver No. 2 Mine in October 1953, after methane gas and water were encountered in quantities too costly to control at that time. Overburden thicknesses in the area of the Oliver No. 2 Mine increase from about 325 to

1,250 feet within a distance of about 1,500 feet beneath the ridge north of the first east-trending side canyon off Sylvester Gulch (Dunrud 1976). Large volumes of methane and water apparently flowed from cracks in the mine floor in the top entry of 6 East after only limited mining. Water flow in the east side canyon was reduced shortly after the mine was closed (Bear 1972).

The topography is less rugged in the SOD mining area than in the Box Canyon mining area. However, there are steep slopes and local cliffs and ledges. Therefore, these steeper slopes and cliffs may become less stable when they are undermined.

Effects of Topography on Subsidence Cracks

Cracks are commonly wider, deeper, and may remain open longer above rigid chain pillars or mine boundaries on steep slopes where there is little or no lateral constraint. In addition, the direction of mining relative to slope direction may control crack width, depth, and abundance. For example, tension cracks were wider, deeper, and more abundant on steep canyon slopes that faced in the direction of mining than they were on slopes facing in directions opposite the mining direction (Dunrud and Osterwald 1980, p. 26-29; Gentry and Abel 1978, p. 203-204).

Cracks are projected to be locally wider and deeper on the steep slopes and cliffs flanking West Flatiron. In the Apache Rocks mining area, maximum crack depth on steep slopes and cliffs (in isolated locations) is conservatively estimated to reach a maximum depth of 150 feet deep, and as much as 200 feet deep in the Box Canyon mining area. These cracks may remain open until they are filled by processes of mass wasting and sedimentation. However, their location on steep slopes and cliffs relative to hydrologic resources is such, that these cracks will cause minimal impacts.

Cracks are projected to be widest and deepest on the steep slopes, cliffs and ridges adjacent to and on either side of Minnesota Creek and its tributaries, as well as Lick Creek. Maximum crack depth on these steep slopes and cliffs is estimated to locally be from 15 to as much as 35 feet deep. Due to the lack of lateral constraint, these cracks may remain open until they are filled by processes such as sheet wash and sedimentation.

Fracture-Controlled Drainages

Based on mapping by Mr. Dunrud in the Somerset area and on recent field work, Mr. Dunrud believes that there is reasonably good, but certainly not conclusive, evidence that some drainages are controlled by fractures and/or joints. The Dry Fork of Minnesota Creek and some of its tributaries exhibit linear trends on satellite images and on high-altitude photographs that indicate, or at least suggest, fracture control (Dunrud, 1976, p. 14-15). These fractures have been caused in part by stresses generated by the West Elk Mountain intrusive bodies, particularly Mt. Gunnison. Section 2.04.6 (Geology Description) includes additional discussion and references relating to the nature and continuity of fractures.

The conservative approach may be to assume that the drainage system is fracture controlled. But even if fractures control the present drainage system, they may not extend downward as continuous joints of fractures to the E Seam located several hundreds of feet below. Even if the fractures were present in the more brittle sandstone units, it would be very unlikely that these fractures would occur in the softer siltstone and shale units. Even under the conservative approach that the drainages of Sylvester Gulch (Panel 25) and in the South of Divide and Dry Fork permit revision areas are fracture controlled, it is extremely unlikely that they extend downward to the E Seam through multiple shale and siltstone units. Using this conservative evaluation, it is now important to evaluate the potential impact that subsidence may have on any pre-mining fractures.

Evaluation of subsidence due to downwarping of laterally-constrained strata shows that rock strata with different deformation and strength characteristics deform as discrete units. For example, strata of shale and siltstone behave as units discrete from sandstone. Above the fractured zone and within the continuous deformation zone these units undergo continuous flexure (Figure 2, enlargement 2 of Exhibits 60B and 60E). Above the neutral surfaces, in zones of convex-upward curvature, the material is in tension and below them, the material is in compression.

Consequently, stresses change across neutral surfaces from tension to compression with each successive rock unit that deforms as a plate. Fractures already present would thus tend to open more in the zones of tension and close more in the zones of compression, which would close these fractures more than they were prior to mining and subsidence.

After longwall mining is completed in the area and static conditions are attained, the zones of tension and compression commonly cease, and any fractures present will likely resume the pre-mining condition. Therefore, the impacts on surface flow in the drainage of the South of Divide mining revision area are likely to be minimal or non-existent under even the most conservative assumptions.

Water and Methane

Observations of the north and west flanks of Mt. Gunnison during an October 1996 field trip, revealed numerous talus and rock glacier deposits that occur in the valleys and lower part of this intrusive body. Snow melt and rain can easily infiltrate these deposits, which may eventually enter any permeable rocks, faults, fractures, and joints near the mountain. Coal beds and rocks in the deformed zone around Mt. Gunnison might also contain increased methane where the coal is metamorphosed to a higher rank by the intrusive body. Great quantities of water and methane may therefore be expected as coal is mined closer to Mt. Gunnison.

Potential Impacts of Subsidence and Mine-Induced Seismic Activity on Landslides and Rockfalls

Landslides

Southern Panels Mining Area -An extensive landslide area is located above the northern part of longwall panel E9 in the South of Divide mining area (N½, Sec 32, T 13 S, R 90 W) (Dunrud, 1989). Overburden depth to the E Seam in that area varies from 500 to 550 feet. The landslide surface contains cracks, bulges, and depressions. Movement likely has occurred during the last decade or so, but began many centuries ago.

Based on a stereographic review of July 2004 vertical aerial photographs, renewed activity occurred locally in western part of the landslide areas north and south of Dry Fork during wet periods in the 1980s (1984 to 1987) and the mid 1990s (1994 to 1996). The Dry Fork road was taken out one half-mile west of the Minnesota Reservoir dam by this renewed movement in 1987 (Map 1 of Exhibit 60).

Landslide located near the north shore of Minnesota Reservoir in the SW¼ of Sec 29. This slide is located on the border between the Apache Rocks and South of Divide mining areas.

Landslide area located on the Dry Fork road in the approximate center of Sec 31, T 13 S, R 90 W. Two small landslides are located to the southeast in the SE¼ of Sec 31 and the SW¼ of Sec 32.

Landslide located near the southwest corner of un-mined longwall panel 8 in the N½ of Sec 8 and the S½ of Sec 5, T 14 S, R 90 W.

Some of the most important information regarding mine subsidence and mine-induced seismicity was obtained from observations of active landslides on Jumbo Mountain above longwall panels 8 and 9, which were mined during the mid 1990s. Landslide movement occurred during unusually wet periods before mining, during mining, and after mining and subsidence was complete. The landslides located north and south of Minnesota Reservoir are similar to those on Jumbo Mountain. Both occur in surficial material (rocks, gravel, sand, silt, clay, and soil) and local outcrops of bedrock that have slumped and flowed downhill during periods of increased saturation. Cracks, bulges, and depressions or troughs, and springs were locally observed in both landslide areas.

It is important to note that no earth tremors (seismic activity) were felt by Mr. Dunrud in all the annual traverses and observations made above the longwall mining areas in the Jumbo Mountain, Apache Rocks, and Box Canyon mining areas during the last 9 years (1996 through 2004). For example, no tremors were felt during the annual traverse above longwall panel 13 in 1999, when the mining face was located directly beneath one of the subsidence observation points. This point was located approximately 1,200 feet vertically above the active mining face, and 2,800 feet north of Minnesota Reservoir.

In contrast to room-and-pillar mining, longwall mining is a uniform extraction procedure that basically involves 1) the uniform cutting of a coal face, 2) the caving of the roof behind the moving coal face, and 3) the recompression of the caved material behind the support system. This system therefore causes only a minimum amount of very low magnitude seismic activity (below the threshold of feeling at the ground surface), particularly where the overburden depth to the coal being mined is less than about 1,500 feet.

Based on field observations during the past nine years (1996 through 2004), the major finding is that landslide movement occurs in response to moisture and ground saturation, and is not noticeably affected by subsidence or any mine-related seismic activity caused by longwall mining beneath or near the landslides.

Records of seismic events in the immediate area of the West Elk Mine provided by the NEIC indicate that since 1983, the largest event registered 3.60 on the Richter scale and occurred on June 20, 2002. No evidence was observed that this event resulted in new or renewed movement of landslides in the mine area or damage to Monument Dam or Minnesota Reservoir. A coal bounce measuring 3.3 on the Richter scale occurred in the mine area on October 10, 2004 and no impacts to surface features or structures was noted. Historically, coal bounces in the area have been recorded in the range of <2.0 to 3.3. None of these events appear to have impacted the area landslides, and in particular, Monument Dam or Minnesota Reservoir.

Based on the above-mentioned historical evidence from the annual observations, the landslide areas located north and south of Minnesota Reservoir are not expected to be impacted by mine-induced subsidence and seismic activity when longwall panel E9 is mined. However, in order to verify predictions, based on the historical evidence, monitoring is detailed in the section "Effects Of Subsidence And Mine-Induced Seismic Activity On Man-Made Structures And Renewable Resources".

Rockfalls

Rockfalls are the free falling movement of rocks, which have become detached from cliffs or other steep slopes, and move under the influence of gravity and the underlying ground surface. The detached rocks roll and/or bounce downhill, depending on the slope (configuration of the ground surface). Their movement continues until they are stopped by an obstruction or lose potential energy and stop naturally.

A low to medium potential exists for rockfalls in the South of Divide mining area. Analysis of the terrain in the South of Divide mining area reveals slopes that range from 30 to 80 percent along Minnesota Creek, the Dry Fork and its tributaries, and in local areas along the main fork of Lick Creek. Vertical displacement, tilt, and strain produced by mining may locally trigger already unstable rocks to fall during, or shortly after mining.

The areas with steep slopes in the South of Divide mining area, which have the greater potential for rockfalls, are located either in areas with local access roads, which have only limited travel, or are in areas remote from any access roads or other man-made features. Based on a review of aerial photographs and analysis of the USGS 7.5 minute quadrangles, there are seven areas with slopes ranging from 30 to 80 percent that contain local cliffs and ledges (small cliffs 5 to 10 feet high). The areas listed below (listed in an east-to-west, north-to-south direction) have a low to medium rockfall potential (see Map 1 of Exhibit 60):

1. Steep slopes (with an estimated rockfall potential ranging from moderate to high) located north of Dry Fork and west of Minnesota Reservoir. However, no mining is planned in this area, so this rockfall area will not be affected.

2. Two steep ridges with cliffs and ledges, located above the northern part of longwall panel E9 east of the landslide area (mostly in the SE¼, Sec 32, T 13 S, R 90 W). There are no roads or man-made structures in the area.

3. The south end of a steep ridge containing cliffs and ledges located north of the confluence of Deer Creek and Dry Fork above the western edge (within the area of mining influence) of un-mined longwall panels E1 and E2 S ½, Sec 29 and NW¼, Sec 33, T 13 S, R 90 W). The Dry Fork road is located 400 to 500 feet south of nearest area boundary.

4. A steep to moderately steep slope containing eight separate rockfall areas, located north and south of Dry Fork and its tributaries. The estimated rockfall potential is low to moderate. The rockfall areas are located above longwall panels E1 through E4 (Sec 33, Sec 34, and NE ½ Sec 35, T 13 S, R 90 W).

5. The area is located in the southwestern part of the South of Divide mining area east of the main fork of Minnesota Creek. The northeastern part of this area, which has an estimated

moderate to high rockfall potential, is within the area of mining influence of the un-mined longwall panels E8 and E9 (W½ and S½, Sec 5, T 14 S, R 90 W).

6. This area contains six rockfall areas that have locally steep ridges. The area is located near the headwaters of Deer Creek, Poison Creek, Lick Creek, and a tributary of Dry Fork. The areas, which have an estimated low to moderate rockfall potential, are located above, or partly within, the area of mining influence of un-mined longwall panels E5 through E8 (located in parts of Sections 3, 4, 9, and 10, Township 14 South, Range 90 West).

7. This area contains 3 rockfall areas that have an estimated low to high rockfall potential. It is located in the Lick Creek area south of any currently planned mining (located in parts of Sections 8, 9, and 16, Township 14 South, Range 90 West).

Of the seven areas listed above, six occur near local drill roads or agricultural access roads, which have only local, limited traffic. Any rocks that may fall in these areas could be readily removed before local traffic is impacted, should rockfalls occur on these remote roads. Evidence of naturally occurring rockfalls, such as remnant boulders located at the base of steep slopes, or in the run-out zones of these areas, will be documented prior to mining.

Based on annual observations in the Apache Rocks and Box Canyon mining areas during the last six years (1999-2004 inclusive), subsidence and any seismic activity caused by longwall mining is not expected to significantly affect rockfall areas with an estimated high to low rockfall potential. Only rockfall areas with an estimated very high rockfall potential were noticeably affected. However, because there are no rockfall areas in the South of Divide mining area with an estimated <u>very high</u> rockfall potential, longwall mining in this area will not affect the rock fall potential.

Signs stating “Watch for Falling Rock” will be posted in strategic places along more well-traveled roads, such as the roads along Minnesota Creek, Dry Fork and Lick Creek at least one month prior to longwall mining and remain in place until approximately 18 months after mining and initial subsidence is complete in the area. This procedure would be similar to signs posted along such major interstate highways as I-70 in the Glenwood Canyon area, where the rockfall potential and risk to travelers is high to very high compared to very low to risk to travelers in the South of Divide and Dry Fork Lease mining areas).

<u>Importance of Baseline Landslide and Rockfall Data</u>

The most significant landslide in the South of Divide mining area, in terms of proximity to man-made structures, is located above the northern part of longwall panel E9 (Exhibit 60B, Map 1). Although there is a large landslide within the area of mining influence of the southeast corner of longwall panel E8 (mostly in the NE¼ of Section 8), the landslides located north and south of Minnesota Reservoir are the most important in the mining area. It is important to monitor the existing, natural (baseline) conditions before mining begins in order to document their natural state. The cracks, bulges, and depressions observed in the landslide areas north and south of Minnesota Reservoir are much more extensive and dramatic than those caused by subsidence. The July 2004 aerial photographs obtained by MCC provides good baseline images of the natural, pre-mining features in the South of Divide mining area.

Observations made by Mr. Dunrud in the West Elk mining area indicate that mining may accelerate the natural landslide process, where there are landslides that have already become unstable. However, annual observations of the surface cracks and depressions in the landslide area on Jumbo Mountain above mined longwall panels 8 and 9 determined that landslides are very likely only related to natural mass-gravity movements and not related to mining.

Baseline information has been gathered in the eight areas with low to moderate rockfall potential that are listed above prior to any mining activities. Evidence of naturally-occurring rockfalls—such as remnant boulders at the base of steep slopes, or in the run-out zones of these areas with a rockfall potential will be documented prior to mining.

Effects Of Subsidence And Mine-Induced Seismic Activity On Man-Made Structures And Renewable Resources

Man-made structures and renewable resources in the South of Divide mining area basically consist of 1) A dam and reservoir (Monument Dam - Minnesota Reservoir), 2) stock watering ponds, 3) streams (primarily Dry Fork and the upper part of Lick Creek), 4) roads, and 5) local cabins. Minnesota Reservoir, the ponds, and the Deep Creek Ditch diversion to Dry Fork serve the dual purpose of being both man-made structures and containment structures for the valuable water resources in the area. Based on annual subsidence observations in the Jumbo Mountain, Apache Rocks, and Box Canyon mining areas during the last nine years, the following information is considered appropriate for the South of Divide mining area.

Monument Dam - Minnesota Reservoir

Monument Dam - Minnesota Reservoir, which provides storage water primarily for irrigation, is located between two landslides—one beginning at the north shore and the other beginning at the south shore. As explained above, landslide movement on Jumbo Mountain occurred during unusually wet periods before mining began, during mining, and after mining and subsidence was complete. The conclusions were that landslide movement occurs in response to ground saturation and is not noticeably affected by subsidence and seismic activity produced by longwall mining beneath, or near, landslide areas.

Both the landslides on Jumbo Mountain and those north and south of Minnesota Reservoir occur in surficial material (loose rock, gravel, sand, silt, clay, and soil) and local bedrock outcrops. The author therefore expects that the mining of longwall panel E9 will not noticeably affect the large landslide south of Minnesota Reservoir.

Mining of the nine longwall mining panels in the South of Divide mining area, as currently planned, will not affect Minnesota Reservoir. The reservoir is located outside the area of mining influence, using the most conservative angle of draw. Measured ground subsidence will not affect Monument Dam and Minnesota Reservoir, however, seismicity caused by longwall mining is possible and could affect the dam, reservoir and the landslide abutting the dam.

Water Resources

Stock Watering Ponds and U.S. Forest Service

The stock watering ponds in the South of Divide mining area are located in debris flows or colluvium derived from the debris flows (Dunrud 1989). Several stock watering ponds were mapped in the Southern Panels mining area (for more information see Section 2.2 of Exhibit 71). Some of these ponds were also classified as U.S. Forest Service water resources. The ponds in the permit area have been photographed on the ground on an annual basis beginning in 2005. The debris flows consist of a heterogeneous mixture of clay derived from the Wasatch Formation and boulders and gravels derived primarily from the Mount Gunnison intrusive (granodiorites and quartz monzanites). Based on observations made during geologic mapping in the area, these debris flows are even less likely to be affected by longwall mining than the alluvium The debris flows have a very low permeability and, because the clay matrix is armored by the interstitial gravel and boulders, are resistant to erosion (the Deep Creek Ditch locally flows in this material at steep gradients). Based on the above-mentioned observations, no effects are expected when ponds in the South of Divide mining area are undermined. The clay-rich material that lines these ponds is expected to provide a seal against any subsidence effects. Stock watering ponds conditions will be surveyed, when accessible, before they are within twice the angle of draw. A second survey will be conducted within three months after they are no longer in the angle of draw. Stock ponds will be surveyed assuming climatic and ground conditions allow reasonable and safe access for this and other monitoring.

No impacts to stock watering ponds in the Apache Rocks,Box Canyon West Flatiron, Sylvester Gulch, SOD and Southern Panels mining areas have been noticeably affected to date when longwall mining occurred beneath them.

<u>Streams and Ditches</u>

The primary streams in the Southern Panels mining area are Dry Fork of Minnesota Creek, Deer Creek, Poison Creek, Lion Gulch and Lick Creek. South Prong Creek is in the Sunset Trail mining area. The primary source of water to Minnesota Reservoir comes from the Deep Creek Ditch, wherein a trans-basin diversion of water from the upper drainage of Deep Creek is transmitted to Dry Fork. The Deep Creek ditch was constructed in debris flows or colluvium and alluvium derived from the debris flow, as described above, this debris flow material is not expected to be impacted by longwall mining.

As is also discussed in the most current version of Exhibit 60E, the end of Deep Creek Ditch, where it transitions into Dry Fork, lies above an area that was undermined by panel E5 gate entries and will also be undermined in the B seam. Maximum horizontal strain over panel E5 in this area was predicted to be 1.0 percent (Em of 0.010) as shown in Table 3 of Exhibit 60E. Figure 2 of Exhibit 60E shows the conceptual model for surface cracking that applies to panel E5. The predicted maximum depth of surface cracks over panel E5 is 5 to 10 feet, as shown in Table 3 for slopes less than or equal to 30 percent. Surface cracks may develop within the transition area of Deep Creek Ditch into Dry Fork wherever bedrock is exposed. This may occur since the transition area is located above gate pillars, where tension cracks can develop. If cracks would develop that run across the ditch and cause water loss the cracks would be sealed by MCC to mitigate this problem.

Accelerated erosion may occur where subsidence results in a steepening of the gradient of the ditch. This is most likely to occur in the transition area where approximately 250 feet of ditch could have a steeper gradient due to subsidence. The existing pre-mining gradient in this area is approximately 1.6 percent and could steepen to a maximum post-mining gradient of 2.6 to 3.5 percent. The area of the Deep Creek Ditch that is affected primarily lies on bedrock and thus accelerated erosion should not be a major issue.

A small amount of heaving may occur in areas of exposed bedrock that lie in front of the subsidence trough but since the ditch is located above gate pillars heaving probably would not occur. Since the gradient of the ditch is expected to increase and not decrease at any location above panel E5 there should not be any ponding within the ditch from subsidence.

Mine subsidence may cause minor vibration at ground surface. The intensity of the vibration can not be estimated based on the current state of practice. According to NIOSH a mining induced seismic event occurred in Utah had a magnitude 4.2. Tetra Tech understands that this occurrence caused some rocks to become dislodged and tumble downhill. These occurrences are infrequent and are theorized to happen in areas of deep cover that has a very hard rock, such as sandstone, in the upper portion of the overburden. If the hard rock does not immediately fail (resulting in breakage to land surface) but remains in place until a large area of hard rock fails at once, the resulting event could be considered seismic in magnitude. These events have not been noted above the West Elk Mine and are considered not likely to occur. Based on this information mining induced seismicity triggering landslides in the area above the Deep Creek Ditch is considered to be a low probability. There are, however, pre-mining landslides in the area being mined. The change in the gradient in this area from the mining could increase the potential for additional landslides. Damming of the ditch by landslides could result in ponding within the ditch and channel avulsions. Avulsions could also occur if the ditch develops subsidence cracks that run across the ditch.

The potential for flow capture or accelerated erosion causing a significant disruption of flow in the Deep Creek Ditch is considered to be low. The potential for bedrock heaving, ponding or channel avulsion to cause a significant disruption of flow in the Deep Creek Ditch is also considered to be low. If flow disruption occurred for an extended period of time it could significantly reduce supplies of water available to irrigators, resulting in a reduction of crop/hay production and consequent economic damages.

As discussed in Section 5.3.2 of Exhibit 60B, no cracks were observed in the alluvium and colluvium of Sylvester Gulch and Deep Creek during periodic field observations in the Apache Rocks and Box Canyon mining areas. The near-surface alluvial material consists of primarily sand, silt, clay, and soil that range in estimated thickness of approximately 25 to 150 feet. In the two areas mentioned the drainages were located above rigid pillars and panel boundaries where the overburden depth ranges from 800 to 1,050 feet. The alluvium and colluvium in Dry Fork and Lick Creek, which has an estimated thickness range of approximately 25 to 75 feet, contains more clay than does the Deep Creek alluvium. Therefore, it is even less likely that cracks will occur in colluvium and alluvium in the stream valleys of the South of Divide mining area despite the shallow overburden.

As is also discussed in the most current version of Exhibit 60E, the Southern Panelsmining area the overburden depths utilized in the computer model to evealuate potential subsidence impacts from longwall mining in the E Seam ranges from approximately 300 feet to about 1,300 feet above the eastern limit of longwall panels E6 and E7, but impacts vary depending on the actual longwall mining heights and overburden depths. However, based on observations made by Mr. Dunrud above the Somerset Mine in the Bear Creek area, subsidence cracks are not expected to occur in the Dry Fork alluvium, as no cracks, and no change in stream flow, were observed in the Bear Creek alluvium (estimated to be 10 to 15 feet thick) when coal was extracted by room-and-pillar methods at depths ranging from 220 to 300 feet beneath Bear Creek (Bureau of Land Management, et al., 2002).

The probable reason for the lack of cracking in alluvium is that the fine sand- to clay-sized material and overlying soil yields without cracking or bulging as it deforms as a discrete unit, or as discrete units, in the subsidence process. This same reasoning also applies to the colluvium in the area. Although subsidence cracks were locally observed in colluvium less than one foot to a few feet thick, no cracks were observed in colluvium more than about ten feet thick. No cracks were observed in alluvium above mined longwall panels in the Apache Rocks and Box Canyon mining areas.

Surface-water monitoring in the Dry Fork and Lick Creek drainages will continue in order to compare the historic information derived from annual subsidence observations in the West Elk Mine area with field observations in selected areas of the Southern Panels mining area. Subsidence features that occurred when longwall panels E1 through E8 in Dry Fork and its tributaries and in Lick Creek were mined are documented in the quarterly subsidence monitoring reports.

The maximum subsidence amount, slope change (tilt), and strain are projected to occur above solid coal barriers and mined longwall panel boundaries, such as above the west ends of longwall panels E2 and E3 where the shallowest overburden occurs. Depressions, ranging in depth from 8.4 to 11.2 feet, are projected in this area. Maximum changes in slope (tilt), ranging from 1.3 to 6.4 percent, are also projected for this area. The maximum horizontal tensile and compressive strain is projected to range from 0.7 to 4.2 percent. Subsidence depressions and slope changes will be less above the gate road pillars than above solid coal barriers, because they are projected to yield during mining by as much as 4 feet (Table 2 of Exhibit 60B and 60E).

No subsidence depressions or changes in stream gradient were observed in Deep Creek, located about 1,050 feet above mined longwall panel 17 during the annual traverse in July 2004. There was no observable change in stream gradient or in stream flow. The depression and change in gradient were apparently sufficiently gradual, so as to not be perceived by the author during the traverse along the trail by the stream.

The stream area near the confluence of Dry Fork and Deer Creek, within the area of influence of the west edge of longwall panels E2 and E3, was monitored prior to, during, and after mining. This is the area where the overburden thickness was projected at a minimum for the South of Divide mining area and subsidence effects (subsidence, tilt, and strain) were expected to be at a maximum.

CDRMS***Potential for Hydraulic Connection Between Mine Workings and Surface***

As is also discussed in the most current version of Exhibit 60E, as well as Section 5.2, the effective height of fracturing in the South of Divide mining area is estimated to range from 9t to 18t, or a maximum fracture height of 252 feet for a mining height of 14 feet. However, Peng (1992) states that the upper one-third of the fractured zone has only minor fractures with little potential for water conductivity. Therefore, the height of the fractured zone capable of transmitting water would be two-thirds of the 18t, or 168 feet.

The maximum height of the caved zone is projected to be 5t, or 70 feet, for the Southern Panels mining area. When added to the effective fracture zone height of 168 feet, the combined heights of the caved and fracture zones capable of transmitting water is projected to be a maximum of 238 feet.

Springs, Aquifers, and Ground Water Wells

Map 37 shows one decreed spring (Spring 21), three springs found flowing at every site visit (in 1975, 1977, 1979, and 1980), thirty-three intermittent springs, and two groundwater wells that are currently monitored. For more information, please see Section 3 (Groundwater Hydrology) in Exhibit 71. Only a few springs in the West Elk Mine area indicate a source from a local bedrock aquifer. Most springs likely have sources from local aquifers in surficial material (debris flows, colluvium, and possibly alluvium). Three new springs are monitored in the Dry Fork Lease area.

In contrast to surface water containment structures, such as reservoirs, ponds, streams and ditches, springs and aquifers may have water sources that are either in bedrock beneath the blanket of clay-rich surficial material (debris flows, alluvium, and colluvium), or have a source from within the surficial material. Subsidence may affect a spring or aquifer source located in bedrock, whereas effects may or may not be expected where the spring source is within the surficial material. Tension cracks produced in sandstone bedrock during the subsidence process, for example, may divert water to a lower rock layer and therefore change the flow location. However, local aquifers in permeable zones, which are interlayered with clay-rich zones (Wasatch clays) in the surficial deposit, may yield to tensile stresses without cracking. There is no field documentation known to Mr. Dunrud to either support or refute this statement. Therefore, it is important to monitor all known spring flows for a few years (to account for seasonal variations) prior to any mining in the area.

Springs

Decreed Spring 21 is located within the areas of mining influence of un-mined longwall panels E5, E6, and E9 in the NE¼ of Section 5, (Township 14 South, Range 90 West). Maximum tilt and strain is expected to occur in this area, because it is located above the projected haulageway and barrier pillar to the haulageway. The overburden depth at this spring site to the E seam is about 650 feet.

Springs mapped in the South of Divide mining area, which have been found flowing at every site visit, include: 1) a spring located 800 feet west, southwest of the Minnesota Reservoir dam—outside the area of any planned mining influence; 2) a spring located along Dry Fork 700 feet west of the confluence of Poison Creek and Dry Fork, above projected longwall panel E2 in about 650 feet of overburden to the E seam; 3) Deep Creek Spring over Panel E 3; 4) the 96-2-2 Spring over Panel E 4; and 5) a spring located south, and outside of the area of influence of longwall panel E8.

Of the springs mapped, Deep Creek Spring over Panel E 3, the 96-2-2 Spring over Panel E 4, the decreed Spring 21, and the spring located along Dry Fork and above longwall panel E2 (J-7), may be impacted by longwall mining. The source of decreed Spring 21 may be a local aquifer in bedrock of the Mesaverde Formation, whereas, the source of the spring along Dry Fork (above longwall panel E2) is likely to be a local aquifer in colluvium or alluvium derived from debris flows. The Deep Creek Spring and the 96-2-2 springs are in colluvium in Deep Creek.

Aquifers

Horizontal strain produced during subsidence could impact local water-bearing bedrock beneath the blanket of clay-rich surficial material. It also may impact local aquifers in surficial material, where permeable and saturated zones are stratigraphically positioned in zones of tensile strain. Impacts may occur for long periods of time, where the aquifer is located above mine boundaries and barrier pillars, areas where permanent strain occurs. On the other hand, dynamic strains and related cracks produced by subsidence above moving longwall faces in a given area are nil and close when the longwall faces move out of the area of influence of this area. Based on this evaluation, any mining effects on local aquifers can best be identified by monitoring any changes in flow and water levels in springs and ground water.

Ground Water Wells

Ground water monitoring wells will continue to be monitored in the Southern Panels mining area. They are located above, or within the areas of mining influence of of existing and projected longwall panels. These monitoring wells will continue to be monitored for as many years prior to mining as possible, in order to determine baseline information that would yield seasonal variations. These water data are compiled and reported annually in MCC's Annual Hydrology Reports.

Roads

With the exception of the presence of minor subsidence cracks on an access road to Jumbo Mountain, no subsidence features (cracks or bulges) were observed during the annual subsidence observations. Large, extensive cracks were observed on Jumbo Mountain in landslide areas; however, they were considered to be indistinguishable from mining the B Seam.

Based on past observations in the Apache Rocks and Box Canyon mining areas, no significant effects from mine subsidence are expected on most of the access roads and drill road in the South of Divide area. Also, no effects from landslide movements or rockfalls are expected, because the highest rockfall potential is mapped in the high category. Rockfalls were observed to occur only in the very high rockfall category areas in the Box Canyon mining area.

Although no cracks are expected in the soft, pliable alluvium, some cracks are expected to occur on the harder and more highly compacted Dry Fork access road, particularly in the area near the confluence of Deer Creek and Dry Fork. As discussed previously, the range of maximum vertical displacement, tilt, and horizontal strain is projected to be 8.4 to 11.2 feet, 1.3 to 6.4 percent, and 0.7 to 4.2 percent (respectively) in the North Fork stream valley and road above the solid coal boundaries at western limits of longwall panels E2 and E3.

Roads will be monitored six months before they are within the angle of draw and on a weekly basis while they are within the angle of draw. After the roads are outside the angle of draw, monitoring will continue on a monthly basis for six months. All road monitoring is dependant upon accessibility. Results of the monitoring will be submitted with the semi-annual subsidence report. The report will include a description of observations, date of observations, and needed repairs, if any.

Buildings

Subsidence effects on buildings were not been observed in the Apache Rocks and Box Canyon mining areas. Baseline information on buildings, such as foundations, walls, chimneys, and roofs, has already been obtained prior to any mining on the Dry Fork Cow Camp in July 2004. A pre-mining survey of the Cow Camp structures was performed Wright Water Engineers and was reported in Exhibit 60D, and another survey was conducted by West Elk Land Surveying in February 2006 and is included in Exhibit 73. No buildings will be impacted in the Dry Fork Lease area (Ditch Rider's Cabin).

<u>Lower Dry Fork Cow Camp</u>

The cabin exterior is approximately 13 feet wide, 20 feet long, and 8.5 feet high (the wall height). A lean-to 7 feet long and a porch 5.5 feet wide are located on the north and south ends of the cabin (see Figures 7 and 8, of Exhibit 60D for details). The outside walls are of a wood, board-and-bat construction.

The foundation, which is of rock and mortar construction (and an estimated 1½ feet thick), ranges from about 1 foot high in the back to 20 inches high in the front. The roof is covered with tin. The side windows, which measure 2 by 3 feet in outside dimension, are located in the approximate center of either wall.

Estimated maximum ranges of vertical displacement (S_m), tilt (M_m), and horizontal tensile and compressive strain (E_m and $–E_m$) in the cow camp cabin area are as follows, assuming 14 ft of coal is extracted (see Table 2, Exhibit 60B):

$$S_m = 9 \text{ -}10 \text{ ft}; \quad M_m = 2 – 5\%; \quad E_m, -E_m = 0.8 – 3\%.$$

As the longwall mining face moves westward within the area of mining influence of the cabin, a subsidence wave—moving at about the same rate as the mining face— will pass beneath the cabin, subjecting it to (1) tilt and strain, (2) then maximum vertical displacement, (3) then relaxation of these effects, as the longwall mining face moves out of the area of mining influence.

The cabin, though temporarily tilted until the longwall face moves out of the area of influence of the cabin, is expected to remain intact during the subsidence episode, because it is small and light, and of wood construction. However, cracks are expected to occur in the foundation, in response to the tilt and strain caused by the subsidence wave produced by the moving longwall mining face below.

The cracks, which may reach a maximum temporary width of a fraction of an inch to perhaps 1 to perhaps 1¼ inches, will likely close again when the longwall mining face moves out of the area of mining influence of the cabin. Any cracks that develop in the foundation, however, may continue to be visible for the life of the foundation.

Cracks, of as much as 1 to perhaps 1¼ inches wide, are also expected to locally occur in the Dry Fork road near the Cow Camp and elsewhere during mining. The cracks will likely close again once the longwall mining face moves out of the area of influence of the road area.

<u>Impacts Beneath the Mined Coal Seam</u>

Based on mapping and observations by Mr. Dunrud in the B Seam of the Somerset Mine, impacts to the coal and rocks below the mined coal bed are expected to be limited to about one mining thickness. There is no expected mining impact to the underlying D Seam coal because its top commonly occurs at least a mining thickness below the base of the E Seam. Furthermore, impacts to the floors of the mine workings are expected to be limited to the chain pillars, because the floors of the longwall panels are loaded with caved roof rocks and overlying strata before deformation in the floor can occur.

Floor heaving, pillar punching (the pillar punches into the floor and roof rocks), and squeezing (plastic flowage, see Dunrud 1976 for more details) are the only expected deformation in the immediate mine floor, which consists of impure coal, shale, sandstone and claystone. Deformation in the floors of the chain pillars is expected to occur after the longwall panel is mined and the pillars begin to yield.

<u>Possible Subsidence Consequences</u>

Southern Panels Mining Area (South of Divide and Dry Fork Mining Areas) -Predicted subsidence impacts for the South of Divide mining area has been described above and in the most current version of Exhibit 60E. Subsidence features observed to date have been reported in MCC's subsidence monitoing reports that have been submitted quarterly to the CDRMS as required.

<u>Potential Impacts from Local Seismic Activity</u>

Earth tremors have been recorded or felt by local residents in the Somerset area since the early 1960s. The tremors commonly are the result of coal mine bumps and rock bursts, which are spontaneous releases of strain energy in highly stressed coal and rock. In the Somerset Mine area before closure, the bumps and rock bursts were common in room-and-pillar mining areas where stresses concentrated within isolated pillars and blocks of coal (called bump blocks). Earth tremors have continued sporadically in the Somerset Mine area since the mine was closed.

Tremors generated by bumps and rock bursts in the Somerset Mine area attain magnitudes that have shaken structures in the West Elk Mine area and have been felt sometimes by West Elk Mine personnel. These local tremors may affect underground workings, landslide or potential rockfall areas, particularly during prolonged periods of increased precipitation. It is noteworthy, however, that the Rulison nuclear shot in 1969, which produced a tremor with a Richter magnitude of 5.2, was many times greater than the magnitudes of any recorded coal bump. To Mr. Dunrud's knowledge, the Rulison nuclear shot did not trigger any known landslides, rockfalls, did not affect the Somerset Mine, neither did it impact reservoirs, ponds, nor streams in the Southern Panels mining area.

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Tremors generated by bumps and rock bursts in the Somerset Mine area attain magnitudes that have shaken structures in the West Elk Mine area and have been felt sometimes by West Elk Mine personnel. These local tremors may affect underground workings, landslide or potential rock fall areas, particularly during prolonged periods of increased precipitation. It is noteworthy, however, that the Rulison nuclear shot in 1969, which produced a tremor with a Richter magnitude of 5.2 (many times greater than the magnitudes of any recorded bump or rock burst), did not affect the Somerset Mine, and did not trigger any known landslides or rockfalls.

In contrast to microcseismic effects generated by bumps and rock bursts that are sometimes felt at the surface a mile or more from room-and-pillar mining operations, the initial cave in a longwall panel may well generate the largest seismic event. In some longwall mines which have thick and strong roof rocks, the initial cave may not occur for several hundred feet, and thus, can generate a shock wave through the mine and overburden that can be felt at the surface for considerable distances from the mine. However, the initial observed cave in the West Elk Mine occurs in 0 to 45 feet from the start of the panel. MCC has experienced no measurable microseismic events at the surface due to initial longwall caving and bumps originating from the mine. Because roof conditions are similar in the Apache Rocks and Box Canyon mining areas, MCC does not anticipate any different microseismic effects in these areas than has been experienced in the current mining area.

It is important to note that mining plans for the SOD area do not include undermining the reservoir or the escarpments adjacent to the reservoir. In fact, Minnesota Reservoir is located outside of the angle of mining influence of the nine projected panels (panels E1 through E9) for the South of Divide mining area. The northwest corner of panel E9, which is nearest to the reservoir, is located 800 feet away. The angle of draw to this nearest area of mining is 69º. The angle is much greater than the maximum of 19º projected for the SOD mining area. This means neither Minnesota Reservoir or Monument Dam will not be subsided or be within the angle of draw of longwall mining in projected panel E9.

The potential for landslides, rockfalls, and other seismic impacts to Minnesota Reservoir are discussed in detail in the preceding sections titled “Potential Impacts of Subsidence and Mine-Induced Seismic Activity on Landslides and Rockfalls” and “Effects Of Subsidence And Mine-Induced Seismic Activity On Man-Made Structures And Renewable Resources – Minnesota Reservoir”. As stated in these previous sections, field observations during the past nine years (1996 through 2004) indicate landslide movement occurs in response to moisture and ground saturation, and is not noticeably affected by subsidence or any mine-related seismic activity caused by longwall mining beneath or near the landslides. Additionally, records of seismic events in the immediate area of the West Elk Mine provided by the NEIC indicate that since 1983, the largest event registered 3.60 on the Richter scale and occurred on June 20, 2002. No evidence was observed that this event resulted in new or renewed movement of landslides in the mine area or damage to Monument Dam or Minnesota Reservoir. A coal bounce measuring 3.3 on the Richter scale occurred in the mine area on October 10, 2004 and no impacts to surface features or structures was noted. Historically, coal bounces in the area have been recorded in the range of <2.0 to 3.3. None of these events appear to have impacted the area landslides, and in particular, Monument Dam or Minnesota Reservoir. As indicated in the GEI report contained in Exhibit 72, it is unlikely that mining in the SOD will result in seismic events greater than 2.3.

MCC recognizes the natural potential for rockfalls in the reservoir area does exist. However, as discussed previously, based on annual observations in the Apache Rocks and Box Canyon mining areas during the last six years (1999-2004 inclusive), subsidence and any seismic activity caused by longwall mining is not expected to significantly affect rockfall areas with an estimated high to low rockfall potential. Only rockfall areas with an estimated very high rockfall potential were noticeably affected. However, because there are no rockfall areas in the South of Divide mining area with an estimated very high rockfall potential, longwall mining in this area will not affect the rock fall potential. In other words, mining activity should not increase the risk of rockfalls in the Minnesota Reservoir pool area.

Landslides and rockfalls have occurred in reservoir areas in various locations throughout the world. Most have not had catastrophic results. If a rockfall were to occur where large boulders entered the reservoir, at a minimum displacement of water equal to the volume of the rocks would occur. If the rocks had a large mass, they entered the reservoir at relatively high velocities, and the boulders hit the water with the largest surface area facet entering the water first, a wave could be generated that would run up the face of the dam. If the wave over topped the dam, erosion of the downstream dam face could occur. Historically, however, the rockfalls that have occurred in the reservoir area do not appear to include large masses of rocks and do not appear to achieve significant velocities as they travel downslope, (generally large boulders in the Dry Fork area do not appear to have significant runout lengths). Therefore, the anticipated worst-case rockfall event would not create a significant overtopping event in the Minnesota Reservoir or displace volume of water significant enough to result in the erosion of the dam to the point of failure.

Landslides are present in the reservoir area, in fact are part of both dam abutments and form portions of the shoreline. The landslides in the area tend to move in response to soil saturation conditions and do not appear to move at high velocity rates. If a landslide did move into the reservoir basin, the subsequent displacement of water would occur gradually and should be sufficiently handled by the designed overflow structure, assuming the slide occurred when the reservoir was at full capacity.

Movement of the landslides on either abutment could result in a failure of the dam. Once again, the movement would be gradual. The first signs of failure would likely be discharges of sediment-laden waters on the downstream dam face. The flows would gradually increase as erosion of the internal dam structure occurred. If complete catastrophic dam failure occurred as a result of the movement of the abutment landslide and internal erosion and the reservoir was at full capacity, 467 acre-feet of water would be released into the canyon below the dam. The stream channel between the dam structure and the opening of the canyon would be significantly modified, vegetation would be removed, and the Dry Canyon access road could be compromised in a few locations. Once the waters left the confines of the Dry Fork Canyon, the velocity and depth of the released water would decrease significantly but the width of the flood would increase. Road crossings and low-lying agricultural lands could be inundated. Irrigation diversions and related structures could be damaged or destroyed. Homes built within the flood plain may be damaged as well. Livestock and wildlife should be able to move to higher ground. Residents of the farms within the lowest portions of floodplain would most likely observe the steady rise in stream flow and escape to higher ground. Those displaced by the floodwaters would likely contact local emergency services that would in turn begin the appropriate evacuation of residents living downstream along Minnesota Creek. Once the floodwaters reached the North Fork of the Gunnison, the larger channel would convey the Minnesota Reservoir water with minimal affects to man-made structures and the natural channel walls.

Detailed Description of Damage or Diminution of Reasonable Use Which Could Result from Subsidence Related Phenomena 2.05.6(6)(e)(ii)(A-C)

Based upon the anticipated subsidence phenomena previously described in this section, and the general scarcity of structures and renewable resource lands, MCC and WWE conclude that there will be little, if any, damage or destruction of reasonable use within the MCC permit area.

One structure that exists in the Dry Fork Basin and is known as Lower Cow Camp. This structure is used by the cattle pool as seasonal living quarters for the range cowboy. The cabin is owned by the USFS and leased to the Dry Fork Cattle Pool. This cabin and related corrals were inventoried and are included in Exhibits 60D and 73.

Mining in the B Seam occurred in the vicinity of the building in late 1994. Regular monitoring was conducted and no damage found. As MCC will compensate for, repair or replace this building or any other structure or resource in compliance with CMLRB Rule 4.20.3(2), no material subsidence damage will result, as defined by CMLRB Rule 2.05.6(6)(e)(ii)(A).

The "worst possible consequences" from mining to hydrologic resources, hydrology monitoring stations, and the many trails and unimproved U.S. Forest Service roads could be complete loss of surface water resources to the mine workings, total destruction of the stations and total destruction or blockage of the trails on roads. MCC will repair or replace these items as discussed later in this section.

Subsidence Monitoring Plan - 2.05.6 (6)(b)(ii), (6)(c)(i) and (6)(e)(iii)

A) Subsidence Monitoring

Until 1999, subsidence monitoring at West Elk Mine was accomplished using conventional survey methods of a monument grid. The grid was laid out over the first three B seam longwall panels mined (panels 1-3NW), and successfully verified MCC's prediction about the amount of subsidence. The grid is shown on Map 29. As subsidence of the three longwall panels was completed and the surveys no longer showed movement, monitoring of the grid was discontinued in 1999. In the Jumbo Mountain permit revision application (PR05), MCC proposed measuring subsidence using aerial photogrammetric methods. MCC collected data from aerial flights since 1995. Areas were flown prior to, during, and following mining. MCC has evaluated this data and determined that measuring subsidence using aerial methods is not feasible for a number of reasons. The first is the rugged topography of the areas that are undermined makes it difficult to place survey panels and interpret the data. In addition, placing an adequate number of survey panels has also been difficult due to limited access and thick vegetation. Another difficulty, particularly on Jumbo Mountain, is that it is difficult to distinguish between actual subsidence and ground movement due to landsliding.

The monitoring of MCC's subsidence grid established the amount of subsidence that occurs over a longwall panel, when it occurs, where it occurs, and when it is complete; therefore, there is no longer a need for additional grids. Instead, MCC will visually inspect the ground over the areas that have been undermined to document any disturbance that may have occurred. MCC will also visit new mine areas prior to any subsidence occurrence to document pre-existing conditions, and will also visit locations where cracks have previously been documented to verify that the cracks are healing. MCC will utilize traditional survey methods, as necessary, to evaluate structures of concern, for example, Dry Fork. Also, MCC will conduct subsidence monitoring of the following: Dry Fork thalwegs, roads, well casings, inverts of culverts, flumes, monuments at stock ponds, and buildings, Monument Dam, and Minnesota Reservoir.

Specific subsidence monitoring measures and plans included the verification of the subsidence angle-of-draw in the SOD and Dry Fork Lease area. The monuments established as part of the baseline survey were resurveyed at least three after the longwall face had moved past the end of the longitudinal survey line to determine the amount of subsidence that has occurred and the angle of draw of subsidence. A report detailing the angle of draw observed during the aforementioned survey was submitted to the Division with the semi-annual subsidence report. To verify the subsidence angle-of-draw in the SOD area, MCC completed a baseline survey of the first E-seam panel, prior to the start of longwall mining, with survey-grade GPS equipment. Based on that survey the actual E-seam angle-of-draw has been conservatively estimated at 16.3 degrees (see appendix B of the Spring 2010 Subsidence Report.) The angle of draw is measured using the greatest verticle distance between the top of the E-seam at the nearest edge of each longwall panel and the ground surface elevation equal to the point of no discernable subsidence. As such, the conservative approximate limit of the maximum predicted E-seam angle-of-draw is 19 degrees

To document subsidence features, MCC will conduct visual surveys, and any necessary traditional surveys, semiannually each year and provide the information in a written report by the end of September and April each year. A summary of the visual observations and monitoring will be provided in a quarterly letter report to CDRMS and to the USFS. If any mechanical response is detected during these visual inspections that is not consistent with what has been previously observed, MCC will notify CDRMS within ten working days of our observations.

The reports of the visual surveys will include photographs to document any subsidence features, including cracks, rockfalls, landslides, revegetation, and other relevant features. A map will also be included that identifies the location of the photographer and the aspect of the image for each photograph. An additional map will be prepared that identifies the location and extent of the observed features. MCC will attempt to revisit previously identified subsidence features to note any changes that have occurred since the previous visit. MCC will also attempt to replicate the aspect of the photographs taken previously to document the progression of subsidence and subsequent healing. The discussion of the field observations will in particular address the development and healing of the subsidence features, utilizing the photographic documentation. In addition, MCC will discuss baseline conditions observed in areas prior to undermining. The report will document how the inspection was conducted, and include such observations as weather and ground conditions.

In addition to performing the visual surveys, aerial or other type photos will be taken prior to beginning mining in an area, periodically during mining, and after mining when subsidence is complete to document landslides, rockfalls, vegetation, etc. over the areas being mined. This documentation will provide a broader, more extensive view from which to associate or assess landslide and other surface activity due to mining.

Figure 21A

1)Verification and Accuracy of Predictions

In order to verify and demonstrate the accuracy of subsidence predictions, based on the results of past subsidence observations in past mining areas, MCC will implement the following procedures to monitor Monument Dam prior to mining. The following procedures will be implemented as soon as permitting allows, in order to account for seasonal precipitation changes.

1. Conduct annual aerial photo surveys of the landslides located north and south of the reservoir, using the July 2004 photos as a baseline reference. Surveys will continue while mining is occurring within *Panels E1 through E9*

2. Install, and measure, survey monuments strategically located on the dam and on the north, south, and east edges of the reservoir to monitor any movement prior to, during, and after mining in the area. During the monument surveys, conduct visual inspections along the monument transects for surface cracks. Monitoring (surveying and inspections) of stations in the Minnesota Reservoir area and across the crest of the Monument Dam will be initiated at least one month prior to mining of Panel E12 or E-1 and continue for two to three months after mining is complete in the panel. MCC will initially survey the monuments on the dam axis quarterly and then monthly when E-seam longwall mining is occurring within one mile of the dam. The results of the surveys will be submitted in the semi-annual subsidence reports. While mining is occurring within the one mile radius, weekly inspections will be made of the dam for cracks or other potentially damaging features and the inspection reports will be included with the semi-annual subsidence reports. The monuments along the dam and reservoir basin will be resurveyed as soon as possible if a seismic event occurs that exceeds the "threshold event" as described below. If, during the inspections, cracks or other potentially damaging features are noted to be occurring in the reservoir basin or dam structure, CDRMS, the Minnesota Reservoir Company, SEO, USFS and other appropriate agencies will be notified by MCC immediately and, depending on the severity of the damage, mining may cease until a new mine plan can be approved and mitigation performed.

3. Mining of Panel E9 will be from the south to the north. Monitoring (surveying) of stations to the south of the Minnesota Reservoir and across the crest of the Monument Dam will be re-initiated at least one month prior to mining of Panel E9 and continue for two to three months after mining is complete in the panel. MCC will initially survey the monuments on the dam axis quarterly and then monthly when E-seam longwall mining is occurring within one mile of the dam. The results of the surveys will be submitted in the semi-annual subsidence reports. While mining is occurring within the one mile radius, weekly inspections will be made of the dam for cracks or

other potentially damaging features and the inspection reports will be included with the semi-annual subsidence

reports. The monuments along the dam and reservoir basin will be resurveyed as soon as possible if a seismic event occurs that exceeds the "threshold event" as described below. If, during the inspections, cracks or other potentially damaging features are noted to be occurring in the reservoir basin or dam structure, CDRMS, the Minnesota Reservoir Company, SEO, USFS and other appropriate agencies will be notified by MCC immediately and, depending on the severity of the damage, mining may cease until a new mine plan can be approved and mitigation performed.

4. The landslide feature that is located on and is part of the left (south) abutment will be monitored for movement. MCC will install survey monuments within the landslide on the hill to the south of the dam and within the toe of the landslide. These monuments will be surveyed monthly, when accessible, during the months of February through July when movement due to high soil moisture content would be expected. The monuments will be surveyed once every three months in the period of August to January when soil moisture content is expected to be lower. If a seismic event equal to or greater than the threshold event for the Monument Dam as described below occurs, the monuments will be inspected for movement. The results of the survey will be submitted to CDRMS in the semi-annual subsidence report. If movement along the landslide appears to potentially damage the dam itself, CDRMS, the Minnesota Reservoir Company, SEO, USFS and other appropriate agencies will be notified by MCC***immediately***.

2)Frequency and Reporting

Monument Dam will be surveyed and the monuments on the dam axis monthly when E-Seam longwall mining is occurring within one mile of the dam and the information will be reported semi-annually. If mining is occurring outside the one-mile radius of the dam, the dam monuments will be surveyed on an annual basis.

B) Seismic Monitoring

In June of 2005, the mine installed one seismic monitoring station in the axis of the Monument Dam, another in Sylvester Gulch, and two more above panel 24. The purpose of installing these stations was to observe the seismic events actually related to mining longwall panels at the West Elk Mine. Monitoring of the four seismographs commenced in June of 2005, and information developed to characterize seismic response from mining activity in the vicinity of the Monument Dam and Minnesota Reservoir.

Prior to the commencement of subsidence mining in either the E-seam E-10, E-11, and E12 panels or E-1 and E-2 panels, an array of seismic stations to monitor microseismicity generated by subsidence will be created. This array will consist of at least 4 to 5 strategically placed accelerometers and seismometers that will collect seismic data. The accelerometer/seismometer already in place in the area of the Monument Dam will be used as part of this new array. The array will consist of equipment similar to other arrays established in the past by NIOSH in the North Fork Valley to monitor mining induced microseismicity, including those previously established in Sylvester Gulch and over panel 24. This data will be transmitted to data storage devices and to a central location where the data can be monitored on a real-time basis. The final number, locations and installation of the seismometers and data storage devices will be determined by an expert in the field of collecting and interpreting mining induced seismicity. As-built drawings of the location and installation of the devices will be submitted to the Division once they are in place.

Monitoring information from the MCC seismic stations and NIOSH and USGS- generated data collected from 1977 through 2005 was used to develop a stability analysis of the Monument Dam by GEI Consultants, Inc of Englewood, Co (Exhibit 72, Material Damage Prevention Measures). This stability analyses indicates the stability safety factor of the Monument Dam in its current state is less than 1.0. As indicated in the GEI report, the dam was constructed on top of and against a landslide on the dam's left abutment. According to the report, the landslide has shown active movement since at least 1985 which has resulted in negative impacts to the integrity of the dam structure. MCC recognizes that Monument Dam currently exists in a state of failure since it currently has a static safety factor of less than 1.0. MCC proposes to increase the static safety factor of the dam to 1.5 through the implementation of the measures discussed in a subsequent Section 2.05.6(6)(f)(iv)(A-D), Detailed Description of Mitigating Measures. These measures will include, among other activities, the construction of a stability berm and buttress to reduce the risk of movement of the dam itself and damage due to movement of the landslide located on the left abutment of the dam. The construction and implementation of these structures and activities will allow the dam to withstand a seismic event of at least magnitude 2.3 (Richter scale) generating a peak ground acceleration (pga) of 0.16 g. As stated in the GEI report, a maximum seismic event and pga anticipated to be generated by mining in the SOD will be M_L 2.3 and 0.06 g, respectively.

The data collected will be used to determine the future need and best locations for seismic monitoring stations in the SOD area.

1)Seismic Notification and Results of Monitoring

In the event that seismic monitoring indicates the seismic parameter (0.16 g) of the stability analysis for the Monument Dam has been exceeded by mining events, MCC will, within two days, measure the survey monuments (provided weather conditions allow finding and measuring the monuments), evaluate the condition of the dam, and provide an electronic or verbal report to the CDRMS of the survey. If the changes appear to compromise the integrity of the dam or reservoir, the Division, the Minnesota Reservoir Company, SEO, USFS, and other appropriate agencies will be notified by MCC ******immediately****.** Arrangements will be made with the Division, the irrigation company, and the SEO to inspect the dam and reservoir as soon as possible if damages due to mining activities are found. Mitigation will be implemented to repair damages to the dam or reservoir basin. A report of the event, inspection, and any mitigation requirements will be submitted to the Division within 3 months of the event.

2)Frequency of Seismic Monitoring

Quarterly reports will be generated from the above monitoring and a copy delivered to the CDRMS and USFS within a month following the end of the quarter. This monitoring will continue until mining is completed in longwall panels E-1, E-2, and E-3 and E-9 through E-12 or as long is as necessary to determine the impacts, if any, of microseismicity generated by MCC subsidence mining of the SOD on Monument Dam.

Monitoring Frequency – 2.05.6 (6)(b)(I)(D,E & F)

Unless as otherwise noted above, the subsidence and seismic monitoring will be performed semi-annually and reported to the CDRMS semi-annually, as well. A summary of the visual observations and monitoring of subsidence will be provided in a quarterly letter report to CDRMS and to the USFS.

Subsidence Control Plan - 2.05.6 (6)(b)(iii)(B), (6)(d)(i&ii), (6)(e)(iv) & (6)(f)(i-vii)

Description of Mining Methods – 2.05.6 (6)(f)(iv)(A& B)

As discussed in Section 2.05.6(6)(e)(i)(A), *Brief Description of Mining Method*, the longwall mining method is planned for the SOD, Apache Rocks West, Southern Panels and Sunset Trail mining areas. A general east-west panel layout, is planned except for the E-seam longwall panel E9 that will be in a north-south orientation. Although longwall mining may initially induce more caving and fracturing of the roof rocks, it offers the advantages of maximizing resource recovery. The longwall method also causes more uniform subsidence (full extraction of panel) and causes equilibrium conditions to be reached in a shorter period of time (i.e., there is no additional, lingering pillar crushing in panels). See further discussions in the current version of Exhibit 60E.

*Although subsidence is primarily a result of the secondary recovery of coal from a longwall coal panel, subsidence type features may occur when developing main entries/roadways under shallow, unconsolidated and saturated cover. Such was the case in October 2020 when developing main entries under South Prong Creek. To avoid similar issues in the future, MCC has performed an analysis of the minimum depth of cover required for development mining in the West Elk Mine to avoid the potential for this type of surface subsidence impacts. WWE has included this Technical Memo as Appendix A to this exhibit.**Preventive Measures – 2.05.6(6)(f)(iii)***

State-of-the-art longwall mining technology will continue to be utilized for extraction of the B Seam and for the extraction of the E Seam in the permit area. Although longwall mining may initially induce more caving and fracturing of the roof rocks, as compared to the room-and-pillar method, it offers the advantages of maximizing resource recovery; more complete subsidence; equilibrium conditions occurring in a shorter period of time; more uniform and predictable parameters necessary for the evaluation of probable hydrologic consequences; and in general, fewer and less significant adverse hydrologic impacts than room-and-pillar mining.

A small portion of Deep Creek Ditch (about 250 feet)lies over the southern gate pillars near the end of the panel (see Sketch A). The base of the ditch at this location is primarily shale. With the ditch being located over the longwall gateroad pillars, impacts from subsidence will be reduced. As mining approaches the ditch, the pre-mining condition of the ditch will be documented in a pre-subsidence survey. This survey will be added to the permit application in the semi-annual subsidence reports. Before, during and after mining, the amount of the ditch that is subsided will be determined by surveying reflector stations in the ditch, as set forth in Section 2.05.6(6) (c). In addition to the surveying, changes in the ditch caused by subsidence will be detected by visually inspecting the ditch on a weekly basis while active longwall mining is within 1000 feet of the ditch. MCC will repair any mining-caused damage found during the monitoring or during visual inspections, in accordance with the agreement between MCC and the Minnesota Canal and Reservoir Company. If mining activity disrupts flow in the ditch, MCC will apply methods set out in the subsidence mitigation plan or injured parties will be compensated with water resources that are owned by MCC. These are identified in Exhibit 52.

Anticipated Effects – 2.05.6 (6)(f)(iii)(A)

Long-term impacts on the surface are predicted to be minimal above the mined longwall panels. The few surface cracks over the mining panels that may occur are expected to close once the longwall face moves past the surface area of influence. Surface cracks present above the chain or barrier pillars or mine boundaries may remain open where permanent tensile strains remain after mining is completed. However, at least several hundred feet of unfractured rock will typically exist between any mine-induced surface fractures and the upper part of any mine-induced fractures above the caved zone in the mining panels. Therefore, from a practical standpoint, no interconnection between the surface fractures and the mine workings is anticipated. Again, under a worst case scenario, if a surface fracture were to occur concurrently within an area controlled by faults or bedrock lineaments, there could be interconnection between adjacent sandstones. However, even under these conditions, the fractures would most likely not extend through the claystones and shales present in the overburden.

Monument Dam and Minnesota Reservoir are located outside of the angle of mining influence of the nine projected panels (panels E1 through E9) for the South of Divide mining area (see Map 51). The northwest corner of panel E9, which is nearest to the reservoir, is located 800 feet away. The angle of draw to this nearest area of mining is 69º. The angle is much greater than the maximum of 19º projected for the SOD mining area. This means that Minnesota Reservoir will not be affected by longwall mining in projected panel E9.

Reduction Measures (Underground) - 2.05.6 (6)(f)(iii)(B)(I-III)

Underground measures that may be taken to reduce surface strains above the chain pillars could include, but are not limited to; (1) Designing the pillars to yield and crush after mining (thus minimizing humps in the subsidence profile), and/or (2) Planning a rapid and uniform mining rate. Any plans in order to reduce chain pillar dimensions to reduce subsidence impacts must, of course, be balanced with health and safety conditions in the mine. Plans for a rapid and uniform mining rate are affected by market demands (or lack there of) for constant, high volumes of coal. MCC will notify CDRMS if plans that may affect the subsidence profile are implemented.

Preventive Measures (Surface) - 2.05.6 (6)(f)(iii)(C)(I-V)

Surface measures that may be taken to reduce or prevent damage to applicable structures or water resources could include, but are not limited to; (1) Engineering, design, and construction of structures to withstand varying ground stresses, (2) Re-locating structures or ponds to mid-panel or outside the angle of mining influence, and/or (3) Enhancing or reinforcing water resource production or delivery systems (e.g., pipeline), respectively.

A total of five reflector stations will be placed in the ditch at the transition of Deep Creek Ditch to the Dry Fork Basin. They will be surveyed on the following schedule.

1) Pre-mining – At least one baseline survey will be conducted within the 30-day period before the longwall starts in Panel E5. If the ditch will be undermined during winter conditions this survey may be done at the end of the period of seasonal access prior to the expected start of mining in panel E5.
2) During Mining – Monthly surveying will be conducted while the longwall face is within 1000 feet of being underneath the ditch (if seasonal access permits). This will include mining under Panel E6.
3) Post-mining – Monthly surveys will be completed for the first two months after each longwall face has proceeded to more than 1000 feet from being underneath the ditch (or only one final survey will be done if seasonal access is unavailable during the 30-day period immediately following undermining of the ditch). Data from the surveys will be reported in the semi-annual subsidence report.

Detailed Description of Mitigating Measures – 2.05.6(6)(f)(iv)(A-D)

Impacts to structures (buildings) and ground and surface water resources will be monitored and mitigated, if necessary, as presented later in this section, in Sections 2.04.7(3) and 2.05.6(6)(e)(ii)(A-C), in Exhibit 19C, and in Exhibit 52. Monitoring personnel (e.g. hydrology, subsidence survey) are regularly in the field throughout the permit area and note observations of cracking, landslides, rockfalls, or other natural and/or subsidence hazards or impacts. Roads will be repaired through regrading or filling if adversely affected by subsidence. Should cracking or blockage of a trail or an unimproved road that is open for use (i.e. is not blocked, reclaimed, or otherwise "closed" from use) occur from subsidence, the damage would be repaired (i.e. fill crack, buttress, install drains, or remove blockage etc.) or the area barricaded or blocked to prevent access. MCC will also place an informational sign along the primary public access to the USFS lands for mining and/or natural hazards awareness.

MCC recognizes that proposed mitigation to surface waters, roads, vegetation, wetlands, etc. on Forest lands in the SOD will be accomplished in accordance with the USFS stipulations specified in MCC's coal leases. This document contains the stipulations agreed to by MCC with the Forest regarding, in part, the mitigation requirements for mining related impacts within the Forests Lands in the SOD area.

MCC will repair impacts of subsidence on surface drainages on USFS lands (or other private lands), including revegetation as necessary to control erosion. For any impacts occurring on USFS lands, MCC will consult the USFS immediately to determine a) The level of mitigation needed, and b) The feasibility of employing the proposed mitigations. Should these impacts occur on USFS lands, MCC, in conjunction with the USFS, will evaluate the impacts on a case by case basis to assess the most appropriate mitigation. MCC will seek Forest Service approval for any mitigation(s) on USFS lands.

If stream channels are impacted by subsidence, efforts will be made to repair the channel to ensure that flow continues in the channel. If cracking, headcutting or significant channel incising occurs, MCC will evaluate the channel morphology and prepare a mitigation plan. Mitigation may require the sealing of fractures, if they occur in the stream channel, with bentonite/soil mixes to stop water loss, excavating ridges or high areas created by subsidence within the stream channel that impede flow, and redirecting flow, if necessary, back into the original channel if diverted due to subsidence. Temporary culverts in ditches and streams may also be used to bridge surface cracks while the best method to seal the fractures is determined. A 0.6 acre area of subsidence on South Prong Creek at the confluence with the North Fork of South Prong Creek (see Map 34) on MCC property was repaired by backfilling with nearby native soils, injecting the backfill with cementitious grout and sealing the area with a bentonite cap.

If stream courses are blocked by mining induced slide movement, MCC will use hand tools or appropriate heavy equipment to reopen affected channels. The necessary permits to perform such work will be obtained prior to performing mitigation. Other mitigation may include the placement of straw bale dikes or silt fences below slide areas to reduce sediment loading. If ponding occurs due to rockfalls or slides within the stream channels and is not determined to create a hazard to the public, no additional mitigation is proposed. However, if the ponding creates hazardous conditions, the structure creating the ponding may be breached or bypass channel built. The mitigation work will only be accomplished after the appropriate permits are obtained.

If ponding occurs within the stream channels due to differential subsidence and is not determined to create a hazard to the public, no additional mitigation is proposed. However, if the ponding creates hazardous conditions, the structure creating the ponding may be breached or bypass channel built. The mitigation work will only be accomplished after the appropriate permits are obtained.

If subsidence of existing SOD wetlands raises the water table to a point where the wetlands are in danger of destruction, the CDRMS and Forest will be notified and appropriate actions be taken. These actions may include excavating the portion of the channel that has created the damming effect on the wetlands. No action may be appropriate where the ponding would result in an overall increase in wetlands and creation of habitat that would benefit waterfowl and other wildlife.

If subsidence in the area of SOD wetlands creates a change in the gradient that would result in a lowering of wetland water table, modifications to the stream channel to stabilize the water table may be necessary. The mitigation efforts may include the construction of rock dams or weirs that would act as impediments to stream flow and result in the re-establishment of the wetland water table levels. The Best Currently Available Technology will be used to restore the water levels of the wetlands if necessary and only implemented after obtaining approval.

Additional mitigation of mining impacts may be necessary if loss or diversion of flow or a significant change in the stream profile will significantly impact vegetation. Efforts will be made to re-establish riparian vegetation in areas negatively impacted by changes in flow locations. These re-establishment efforts may include, but not be limited to, planting of new seedlings or reseeding with appropriate species. The appropriate permits and approvals of plant or seed mixes will be obtained prior to performing mitigation activities.

It is anticipated that little or no impacts to wildlife and domestic livestock uses, and their respective habitat will occur as a consequence of mining-induced subsidence on the permit area. In the unlikely event that subsidence effects adversely impact wildlife or domestic livestock uses associated mitigation measures will focus on returned disturbed areas to a capability and land use(s) which existed prior to mining. These mitigation measures may include, but not be limited to, repairs of surface cracks that are deemed dangerous to human, wildlife, or livestock. The repairs of the cracks may include backfilling with available native soils, gravels, concrete block, etc. Livestock fences damaged by mining related activities will be repaired as soon as possible.

MCC will work with the Minnesota Ditch and Reservoir Company to obtain the appropriate approvals, permits, and implement a preventative measures construction project to modify and improve the Monument Dam. MCC recognizes that any dam modifications proposed to and carried out by the Minnesota Reservoir and Ditch Company will require the activities be consistent with the reservoir company's existing Forest-issued Special-Use Permit or will require a modification to the permit. Implementation of this project will prevent damage to the dam/reservoir from the potential of mining-induced microseismicity, strengthen the dam against damage due to naturally occurring seismicity, and control damage due to past and future periodic movement of the landslide located on the left (south) abutment of the dam. Exhibit 72, Prevention Measures, contains the general design of the measures to be implemented that will allow the dam to reach a static safety factor of 1.5 and will safely withstand any mine-induced microseismic event. The plans include the construction on the downstream face of the dam of a sand chimney drain covered by stability berm. Additionally, a buttress constructed of erosion resistant fill will be placed at the toe of the dam. The purpose of the berm and buttress is to increase the stability of the dam fill itself and to impede further movement of the landslide located in the left abutment. Other preventative measures to increase dam and landslide stability may include the slip-lining of the existing outlet conduit with HDPE pipe to eliminate the possibility of further damage to the existing cast iron pipe, replacement of the inlet structure to outlet conduit to eliminate leakage around the existing structure, and construction of dewatering trench to further stabilize a portion of the landslide.

MCC in addressing 2.05.6(6)(f)(iv)(A-D), will complete preventative measures on Monument Dam (Exhibit 76) and may do one or more of the following: replace, repair, and otherwise restore structures downstream or will purchase insurance policies addressing downstream damage and will be in effect at the time of longwall mining, should catastrophic failure of the dam occur as a result of mine-induced impacts. The dam and dam failure hazards are addressed in Exhibit 74, and are briefly mentioned here from the Keith Bakeman, Dam Breach Analysis of 2/8/84, contained in Jim Norfleet's letter to Grant Farnsworth, dated May 21, 1990:

"The clear weather breach of Minnesota Dam (sic) produced a calculated peak flow at the dam of 10,280 cfs. The peak flow was reduced to 8,230 cfs by the time it reached the mouth of Minnesota Creek at the North Fork of the Gunnison River in Paonia, 9.8 miles downstream. The computed overbank flooding depths vary from 0.3 feet to 3.5 feet in the lower 6 miles of Minnesota Creek, that contain road crossings and buildings. Five gravel road crossings will sustain damage, up to complete failure. Perhaps four houses will sustain shallow flooding but loss of life is not expected. These houses will experience water damage up to structural collapse, depending on the distance from the stream and stream movement due to erosion. Computed flood velocities within the stream channel ranged from 42 feet per second down to 13 feet per second. The quantity and velocity of flood waters are expected to cause extensive erosion and resource damage along Minnesota Creek and probably deposit a sediment bar in the Gunnison River (sic).

This evaluation of the clear weather breach indicates that the failure of Minnesota Reservoir would probably not cause loss of life or excessive private or public property damage. If a field check of the flood plain supports the findings of this report, the hazard classification of Minnesota Reservoir will be reduced to moderate.

The clear weather breach of Minnesota Reservoir will:

1. Cause resource damage along 9.8 miles of Minnesota Creek.
2. Damage five gravel road crossings, probably completely breaching the roads.
3. Probably cut road access to 20 homes.
4. Damage 0-4 (sic) houses; some may eventually collapse from erosion of their foundations."

MCC will perform a survey of the structures downstream of the Monument Dam that could be impacted by dam failure six months prior to longwall mining in the SOD. The survey results will be incorporated into the permit as a revision.

Detailed Description of Measures to Determine Degree of Damage – 2.05.6 (6)(f)(v)(A & B)

As discussed previously, all structures and renewable resources in the permit area have been located, inventoried and/or mapped (see Maps 34, 37, 67, 68, and Exhibits 10, 10A, 10B, 10C, 10D, 10E, 60B, 60E, 72, 73, and 74, as part of the baseline analysis. The location of current and planned mine workings is shown on Maps 50, 51, and 52. The subsidence monitoring program is discussed in Section 2.05.6(6)(c)(i)(A-C), and monitoring of the only building undermined is discussed in Section 2.05.6(6)(e)(ii)(A-C). This baseline analysis establishes the status of these features prior to mining. Departures from this baseline resulting from mining impacts will be evaluated and mitigated in accordance with the regulations.

Schedule of Submittal of Detailed Plan of Underground Working – 2.05.6(6)(f)(v)(A&B)

The F Seam workings in West Elk Mine are depicted on Map 50. MCC's B Seam workings and mine plans are shown on Map 52. Mine plans for the E Seam are shown on Map 51. Longwall panels will continue to be developed and recovered as described earlier in this section.