Memo

SUBJECT
Blue Seam Mining Analysis

TO
Mr. Nick Mason
Environmental Coordinator
New Elk Coal Company

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OUR REF
Permit Revision 6

DEPARTMENT
Planning and Permitting

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1. Introduction

This report presents the results of hydrologic and subsidence analyses that were prepared to support underground mining in the Permit Revision area (PR-6) at the New Elk Mine in Las Animas County, Colorado. Current mining at New Elk is producing coal from the Blue Coal Seam in the Raton Formation. The PR-6 will expand the area to be mined in the Blue Seam to the east by 843 acres with 219 acres being affected, and that area is the focus of this analysis (Map 3 of the permit document).

2. Mine History and Planned Operation

Previous production from the New Elk Mine occurred from the Allen Seam between 1952 and 1988. The mining method was predominantly room and pillar. The mine was temporarily sealed in 1988 and allowed to flood.

The current operation is a typical underground mine with access to the Blue Seam through a set of inclined slopes that were driven from the surface at the East Portal. Mine ventilation is provided by two air return fans located at the East Portal. Mining in the Blue Seam will be a room and pillar operation using continuous mining methods (Map 3 of the permit document). Surface facilities include a raw coal stockpile, preparation plant, conveyor belt, clean coal stockpile, development waste disposal area (DWDA), refuse disposal area (RDA), sediment ponds, shops, warehouses, administrative buildings, and a bathhouse (Map 11 of the permit document).

Mine development will advance to the east and south. Two sets of seven to nine entry sections are planned. Both the east mains and first south panel will advance towards the permit boundary. The first south panel will have subpanels turned south with rooms turned running east or west. No secondary mining is planned throughout the project. No future mining is planned for the current permit term in the Allen or Apache Seams and revised mine plans will be submitted for approval if mining is proposed for these seams. Production panels will be developed from the mains by room and pillar mining methods. Coal refuse from the mining operation and preparation plant will be permanently placed in the RDA. The RDA is an existing facility that was permitted in 1984. Development waste from the underground mine is placed in the DWDA south of Highway 12 (Map 11 of the permit document). The material is similar to other waste rock that has been previously stockpiled on site and has low potential to form acid drainage. Appropriate controls have been implemented at the RDA and DWDA to capture runoff and comply with all conditions prescribed by the applicable permits.

3. Hydrogeologic Setting

The geologic and hydrologic setting of the mine area and PR-6 area have been described in numerous reports by the United States Geological Survey (USGS; Wood et al. 1951, 1956; Johnson 1961, 1969; Flores and Bader 1999; Watts 2006a,b) and in consultant reports that have been prepared to support permitting analyses for the New Elk and Golden Eagle mines (Waste, Water, and Land, Ltd. [WWL] 1980; Greystone 1994; Whetstone Associates 2011). Land uses and vegetation communities of the PR6 area are shown on Maps 4 and 10 of the permit document. A summary of the geology and groundwater hydrology for the site is presented in the following sections.

3.1 Geology

Coal that will be produced by the New Elk Mine in the PR-6 area is contained within the Upper Cretaceous to Tertiary Raton Formation. The Raton Formation is a heterogeneous sequence of lenticular, argillaceous sandstone, siltstone, mudstone, and coal. Lithology types are highly variable, both laterally and vertically, with correlations being best established through the occurrence of coalbeds. Surface and near–surface bedrock in the mine area is limited to the Tertiary Poison Canyon Formation and the Raton Formation. Rocks in the permit area dip gently to the east – northeast with an average inclination of 2 to 4 degrees.

Four coal seams are of mining interest in the permit area. In stratigraphic order from bottom to top, they include the Allen, Apache, Maxwell, and Blue Seams. Previous mining in the project area produced coal from the Allen and Maxwell Seams. The Blue Seam occurs in the northern part of the PR-6 area approximately 175 to 200 feet above the Maxwell Seam and is contained in the Upper Coal Zone of the Raton Formation. The thickness of the Blue coal varies from 1.5 to 7.4 feet as exposed in exploration boreholes. Coalbeds within the Raton Formation are targets for numerous coalbed methane (CBM) wells that are active within the permit and surrounding areas. Cross sections showing the stratigraphic relationship of coal seams within the Raton Formation are presented in Whetstone Associates (2011) Exhibit 8 of the permit document)).

3.2 Hydrogeology

Groundwater flow in the Raton Basin is largely dependent on geologic structure and topography. Regional flow is generally to the east and is deflected toward stream valleys. The water table north of the permit area slopes southeast away from the Spanish Peaks. Locally, igneous intrusions (dikes) may form barriers to groundwater flow (Geldon 1989). Flow paths within the Raton, Vermejo, and Trinidad aquifers and overlying aquifers are complex because of the effects of geology and topography.

The probable hydrologic consequences analysis for the New Elk Mine follows Watt's recommendations and defines the hydrostratigraphic units in the mine area to include the Trinidad, Vermejo, Raton, and Poison Canyon Aquifers. Alluvium along the Purgatoire River and its tributaries is also water bearing and is an important source of groundwater for domestic and agricultural supplies. The Raton Formation, Vermejo Formation and alluvium are the aquifers of principal concern for the New Elk Mine. The Trinidad Sandstone occurs several hundred feet below the mining horizon and is separated from the Raton Formation by the Vermejo Formation. The Poison Canyon Formation crops out on hilltops in the permit area.

Alluvium and unconsolidated sediments are present along the valley floor adjacent to the Purgatoire River and are an important source of domestic and agricultural water supply for area residents. The extent of unconsolidated deposits including alluvium, colluvium, and terrace gravels has also been mapped in Apache and Ciruela Canyons (Wyoming Fuel Company [WFC] 1985). The deposits are generally thin and are narrowly confined along the canyon floors. Alluvium in the upper reaches of the drainages is unsaturated or may be seasonally saturated during spring runoff. Alluvium in the lower reaches of the canyons near the Purgatoire River is saturated.

Based on completion reports from 126 CBM wells in Las Animas County, Watts (2006a) estimates that the thickness of the Raton Formation ranges from about 1,100 to 1,900 ft where it is not eroded. Net coal thickness is about 100 ft, and the Raton Formation may contain as many as 40 coal beds that are lenticular,1 to 10 ft thick, and have limited lateral continuity of about 500 to 1,000 ft (Clarke and Turner 2002). Water levels in the Raton Formation are highly variable depending on a number of factors including location, well completion depth, lithology, and pumping activities related to CBM production. Groundwater may be confined or unconfined depending on stratigraphic conditions and location. The formation is highly heterogeneous and groundwater elevations can vary significantly over short lateral and vertical distances. Well records from Colorado Department of Water Resources (CDWR) indicate that there are 62 permitted wells in the Raton Formation within a one-mile radius of the permit boundary. The wells vary in depth from 30 to 750 feet and have completion water levels ranging from 5 to 598 feet below ground surface. Well yields from the Raton Formation near the mine range from 0.5 to 112 gallons per minute (gpm), with most wells reporting yields of 5 to 15 gpm.

4. Surface Water Hydrology

The New Elk Mine is located on the Middle Fork of the Purgatoire River, about 1.5 miles upstream of the confluence of the North Fork. Most surface facilities of the mine are adjacent to the Purgatoire River (Map 11 of the permit document); underground mining in the PR-6 area will be to the south of the Purgatoire River. The Purgatoire River is the primary stream drainage in the area of the mine. The headwaters of the Purgatoire are located on the eastern slope of the Sangre de Cristo Mountain Range west of the mine area. The general direction of stream flow is easterly to the confluence with the Arkansas River. Apache Canyon and Ciruela Canyon are the principal tributaries of the Purgatoire River that are within the mine and PR6 area. Apache Canyon drains a watershed of approximately 7,264 acres. Ciruela Canyon drains a watershed of approximately 1,966 acres within the permit boundary. Surface water monitoring programs have been conducted since February 1984 to assess the effects of past, present, and future mining operations on surface water quality and quantity. These programs provide information to the operators of the facilities as well as to regulatory agencies. The results of the surface water monitoring are contained in Annual Hydrologic Reports (New Elk Coal Company [NECC] 2021 and previous Annual Hydrology Reports). Surface water data for the New Elk Mine are available from two stations on the Purgatoire River (PRS-1 and PRS-4), three springs in Apache and Ciruela canyons, and nine ponds in the drainage bottoms. Streamflow data for the Purgatoire River are also available from USGS gauging stations at Stonewall and Madrid. Two surface water monitoring stations (PRS-1 and PRS-4) are located on the Purgatoire River near the mine. The sites have been monitored annually since 1984. PRS-1 is located on the Middle Fork of the Purgatoire River above surface facilities for the New Elk Mine. PRS-1 monitors water quality and flow above significant mining activities. PRS-4 is located downstream of the East Portal and monitors potential effects of mining on stream flow and water quality. Data for PRS-1 and PRS-4 for 2021 monitoring are summarized in the Annual Hydrology Report (NECC 2021).

The PR-6 area includes portions of the Apache and Ciruela canyon drainages. Apache Canyon is an ephemeral drainage that traverses the permit area in a northeasterly direction and is tributary to the Purgatory River. The canyon drains an area of approximately 7,264 acres and is divided into Right and Left Forks that join near the eastern edge of the permit area. The canyon is narrowly incised and contains a thin veneer of alluvium and colluvium along the valley floor. The unconsolidated deposits have limited lateral extent and are unsaturated for most of the year. Surface flows in Apache Canyon occur only in response to snow melt and precipitation in the surrounding drainage. Stream flows occurred in response to localized heavy thunderstorms and snowmelt. Three bedrock springs occur in the Apache Canyon and are shown as springs 12, 13, and 14 (Map 8 of the permit document). Springs 12 and 13 originate at contacts between shale and sandstone. Spring 14 originates from the contact between a coalbed and a shale or sandstone layer. Spring 14 is a developed pond for livestock use. Historic monitoring of the Apache Canyon alluvium was conducted at well ACAW-1 located in the lower portion of the Canyon (Map 8 of the permit document).

The upper reach of Ciruela Canyon is an ephemeral drainage in the southeast portion of the permit area. The drainage flows northeast to its confluence with the Purgatory River approximately two miles east of the permit area. The canyon drains an area of approximately 1,966 acres inside the permit boundary. The drainage within a one-mile radius of the permit area is dry for most of the year and flows only in response to localized heavy thunderstorms and snowmelt. The lower reaches of the canyon receive discharge from CBM wells. One bedrock spring in Ciruela Canyon (Spring 15) is located within the one-mile radius of the permit boundary. The spring is a minor area of seepage that occurs at the contact of a sandstone and shale bed below a thin coal seam outcrop. Spring water is reported to have a pH of 6.7 and specific conductance of 1,054 µS/cm. The spring was damp for several months a year. Historic monitoring of the Ciruela Canyon alluvium was conducted at well CCAW-1 located in the lower portion of the Canyon (Map 8 of the permit document).

A total of eight springs are documented within a one-mile radius of the PR-6 area. Spring locations are shown on Map 8 of the permit document. These springs were identified in the original survey conducted in 1984 and flow and water quality measurements are also from that survey.

5. Hydrologic Studies at the New Elk Mine

Hydrogeologic studies at the New Elk Mine during 2010 included installation of three bedrock monitoring wells and packer permeability testing in exploration boreholes. Monitoring wells NE-1-10, NE-6-10a, and NE-6-10b were installed in the Allen, Apache, and Blue Seams, respectively. Packer permeability tests focused on evaluating the hydraulic conductivity of the Raton Formation between the Allen and Green Seams.

5.1 Monitoring Well Installation

During the fall of 2010, NECC installed monitoring wells NE-1-10, NE-6-10a and NE-6-10b in the Raton Formation near the New Elk Mine area. The wells are completed in the Allen, Apache, and Blue Seams and are designed to monitor water level and water quality. Construction oversight and design was provided by Whetstone Associates. Well locations are shown on Map 8 of the permit document. Construction and development details for the wells are summarized in Whetstone Associates (2011; Exhibit 8 of the permit document).

5.2 Packer Permeability Testing

Packer permeability tests were performed in nine exploration bore holes at the New Elk Mine to evaluate the hydraulic conductivity of coal bed sand other strata in the Raton Formation. The tests were performed using a straddle packer assembly on a rigid column and an up-stage testing method. A total of 55 tests were successfully completed for the 2010 hydrologic investigation. Locations of the tested bore holes are shown on Map 8 of the permit document.

Results from the packer tests are summarized by lithology and by bore hole. Testing data and plots of the pressure response for the tests are presented in Appendix B of the analysis presented be Whetstone Associates (2011). Packer permeability tests indicate that the average hydraulic conductivities of the Allen, Apache, Red, Upper

Bingham Canyon, Blue, Green, and Yellow Seams are similar and range from 0.43 to 0.51 ft/day. The permeability of the Maxwell Seam is lower with an average value of 0.013 ft/day. Clastic rocks including sandstone, siltstone, mudstone, and shale usually have lower permeability than the associated coals. Exceptions to this generalization include the interval between the Allen and Apache beds, which has an average hydraulic conductivity of 1.28 ft/day, and the roof of the Blue Seam, which has an average hydraulic conductivity of 0.54 ft/day.

Water level measurements during packer testing indicate that heads in the coal seams are generally lower than in the surrounding rocks (Table 14 presented by Whetstone Associates, 2011). In many cases, the observed vertical gradients are exceptionally high and exceed unity. The high vertical gradients are most likely related to groundwater pumping from CBM production wells or dewatering activities for the existing New Elk underground workings. The presence of high vertical gradients indicates that permeability is low perpendicular to bedding and limits the flow of groundwater from the surrounding clastic rocks to the coalbeds.

6. Subsidence Predictions for Mining of the Blue Coal Seam

A subsidence analysis for retreat room and pillar mining at the New Elk Mine was prepared by Agapito Associates to support the evaluation of surface and hydrologic impacts from the mining operation (Agapito 2011, Exhibit 24 of the permit document). Under that analysis, coal would be produced from the Blue and Apache Seams in different areas of the mine. Nine entry production panels would be used to access the coal. Each entry would have a width of 20 feet. The pillar and panel dimensions would vary according to cover depth. The panel lengths would be variable, with inter-panel barrier widths equal to widths of panel pillars.

The first model for the Blue Seam used an overburden depth of 200 feet above the coal seam. Projected depths to the top of the Blue Seam were obtained from bore holes in the PR-6 area including LA-200 (350 ft), LA-198 (130 ft), LA-202 (460 ft), and NE-02-10 (195 ft). The evaluations assumed sequential extraction of adjacent panels with the maximum planned mining height of 5 feet. Subsidence over the mined panels would be manifested at the surface as gentle, almost imperceptible troughs with shallow tension cracks at the edges and in other areas of local extension. The maximum potential subsidence associated with mining panels in the Blue Seam would be 1.6 feet. Subsidence would be most likely to occur in areas with thin overburden.

The mining method and extraction of coal in the PR-6 area will use room and pillar mining. No secondary or retreat mining is planned. This area was previously included in the Golden Eagle permit area where mining occurred only in the Maxwell Seam and mining in this seam did not occur in the PR-6 area. As a result, there are no seams above or below the Blue Seam that may contribute to potential subsidence. No subsidence is currently planned in the PR-6 area, however, subsidence monitoring will be conducted as mining occurs and any mitigation of effects will be conducted as described in the Subsidence Control Plan of Exhibit 24 of the permit document.

7. Probable Hydrologic Impacts of Mining in the Blue Coal Seam

Probable hydrologic consequences of mining are attributable to drawdown of the water table due to mine dewatering, subsidence of strata overlying mined areas, surface disturbances, operation of the RDA, and consumption of water to run the preparation plant and control dust during mining. The focus of this analysis is on the consequences of mining in the PR-6 area including hydrology and potential subsidence. No new surface facilities or surface disturbance are proposed for the PR-6 area and all surface operations to process and transport the coal will continue as currently being conducted for coal from the Blue Seam.

Two bedrock wells are located near the planned mining area in the Allen Seam. The wells are in the northeast half of Section 24, T33E, R68W. Well number 284213 is a monitoring well owned by NECC and is completed in the Allen Seam. The well is 442 feet deep and is designated as NE-1-10 for the monitoring program. The other bedrock well (permit number 264440) is 200 feet deep and is completed in an unidentified coalbed. The owner of record for the well is Helen Armstrong. Four shallow alluvial wells 12, 13, 14, and PAW-9 (Map 8; of the permit document) are also located in northeast half of Section 24, T33E, R68W. Wells 12, 13, and 14 are on land owned by J.I. Vialpando. Well PAW-9 is a monitoring well owned by NECC. Mining of the Allen Seam may have the potential to reduce water levels and impact water quality in the Armstrong well. In the event that water in the well is impacted by mining, the water supply will be replaced with water from the City of Trinidad (city water). Well NE-1-10 is designed to monitor potential impacts to groundwater in the mining horizon and impacts to water levels or water quality in the well are not an issue with respect to water supply. Wells 12, 13, 14, and PAW-9 are situated more than 400 feet above the planned mining horizon and impacts to water quality and availability are not anticipated to these wells. In the event that unanticipated impacts occur to the water supply, it will be replaced with city water.

Current inflow into the Blue Seam mine is intermittent, approximately 0 to 5 gpm. Dewatering discharge from the mine will be used in the mine or treated before being released to the Purgatoire River and impacts to water quality in the river from discharged water are expected to be similar to those currently observed (i.e., an average increase of about 40mg/1 total dissolved solids [TDS] downstream from the mine). Water quality in the mined coal seam in the permit area is expected to be impacted by the mining operation. Impacts to water quality will include an increase in TDS, mainly in the form of sodium and bicarbonate. Background TDS concentrations in the Blue Seam is estimated to be about 435 mg/L and 1,105 mg/L respectively based on the electrical conductivity (EC) of groundwater from monitoring wells NE-1-10 (623 µS/cm – Allen) and NE-6-10 (1,106 µS/cm – Apache) and the assumption that TDS is equal to about 70 percent of EC. Observed TDS in the sealed portion of the New Elk Mine has averaged1,628 mg/L. After mining, the TDS concentration of groundwater in the Apache and Allen Seams near the underground workings is expected to be like water in the sealed mine.

Monitoring of impacts during mining and previous studies of probable hydrologic consequences (WWL1980; Greystone 1994; Whetstone 2011) indicate that underground inflows and mine dewatering have little to no communication with surface water. This conclusion is consistent with the subsidence analysis and conceptual models for the New Elk Mine. No hydrologic impacts or only temporary minor changes in water level are expected to occur in the continuous zone. No flow or water quality impacts are expected to occur to surface water including springs and seeps from mining in the Blue Seam.

8. Points of Compliance

For mining the Blue Seam in the PR-6 area, points of compliance will be monitored for potential effects to the hydrologic balance. These points include well NE-06-10b completed in the Blue Seam, alluvial wells ACAW-1 and CCAW-1 completed in the alluvium of Apache and Ciruela canyons, and surface water station PRS-4 located on the Purgatoire River. All of these stations are located down dip and downstream of the mining operations.

9. References

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