American Fisheries Society
Western Division

Comments on the Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project

Water Quality and Quantity

The sub-watersheds with the greatest number of sensitive fish species are the Upper Tongue River (7 of 10 species possible), the Upper Powder River (7 of 10 possible), and the Little Powder River (5 of 10 possible) (Table 3-54). Of existing wells, 6.8% are in the Upper Tongue sub-watershed, 23% in the Upper Powder, and 15% in the Little Powder (Table 2-2). The project will place 6.6% of new wells in the Upper Tongue, and only 5.1% in the Little Powder; however, 48% of the new wells will be located in the Upper Powder sub watershed (Table 2-1). The potential adverse effects on sensitive fish species might therefore be disproportionately high in the Upper Powder River. However, the status and potential impacts to native non-game fish and amphibian species are not generally well identified or discussed in the FEIS. This seems to be due in part to a lack of baseline information on abundance, distributions, and life histories of these species. Information regarding aquatic macroinvertebrates is even sketchier. Nonetheless, the FEIS does indicate that indirect effects on health and reproduction in most species might occur due to disposal of production water.

The project is expected to produce 1.2 million acre-feet of water in the Upper Powder River sub-watershed. The primary method of production water management will be by infiltration impoundments (60%); 30% will be given passive treatment for oxidation and precipitation of iron. Of the water sent to infiltration impoundments, 28 % is expected to evaporate, 57% to infiltrate, to groundwater, and 15% to resurface. This means that, during the life of the project, approximately 100,000 acre-feet of production water can be expected to enter surface flows after percolating through the soil. The quality of this water might be problematic. Table 4-6 indicates that a SAR of 13.4 is predicted for minimum flow conditions in the Upper Powder, exceeding proposed SAR limits of 2 (most restrictive) and 10 (least restrictive) (Table 4-2). In addition, several trace elements in CBM production water (Tables 3-2 and 3-3) exceed various toxicity-screening values recommended by Suter and Tsao (1996). These are summarized in the following table:

Element	Exceedence Values
Barium	Minimum value of 140 ug/l exceeds the secondary acute value of 110 ug/l
Boron	Maximum value of 390 ug/l exceeds the secondary acute value of 30 ug/l
Copper	Maximum value of 208 ug/l exceeds the secondary chronic value of 14 ug/l
Lithium	Maximum value of 208 ug/l exceeds the secondary chronic value of 14 ug/l
Nickel	Maximum value of 35 ug/l exceeds the chronic value for daphnids and aquatic plants of 5 ug/l
Silver	Minimum reporting level of 1 ug/l exceeds the chronic value for fish of 0.12 ug/l
Sodium	Maximum value of 1,000 mg/l exceeds the chronic value for daphnids of 680 mg/l
Strontium	Maximum value of 1,900 ug/l exceeds the secondary chronic value of 1,500 ug/l
Zinc	Maximum value of 80 ug/l exceeds the chronic value of 30 ug/l for all aquatic organisms
Zirconium	MRL of 50 ug/l exceeds the secondary chronic value of 17 ug/l

The FEIS suggests that effects of CBM production water on surface water quality, and consequently on fish, will be minimal. However, Salt Creek, which is augmented by production water from oil and gas fields, and provides the majority of flow to the Powder River in low-flow conditions, is acknowledged to cause some level of toxicity to *Cereodaphnia* spp. and fathead minnows (*Pimephales promelas)*. This begs questions about potential impacts when an additional 18,000 CBM wells are established in the Upper Powder River. The potential for evaporation to increase concentrations of trace elements in impounded water is also not well characterized, and degradation of sediment quality is not addressed at all.

Tables depicting ambient water quality data are absent, including information on metals, suspended solids and total dissolved solids (TDS). Throughout the document, conductivity is used to gage effects on aquatic organisms, rather than the more useful TDS. And, as explained below, concentrations of individual ions should be used to more accurately predict toxicity when conductivity and/or TDS indicate potential concerns.

Some statements appear incorrect, which raises concerns that other incorrect conclusions or statements may be embedded in the document. Because data needed to evaluate the statements are not presented, it is difficult to resolve this issue. For example, the FEIS states:

> *The saline quality of the produced water would likely precipitate dissolved metals in the water column, such that sediments beneath CBM produced water containment reservoirs would potentially receive increasing concentrations of organic and inorganic forms of dissolved metals over time.* (p. 4-227)

The foregoing sentences are incorrect in three respects. First, metals like copper and cadmium are more toxic in saltwater than in freshwater because the increased ionic strength (concentration) of salt waters saturates binding sites, which in turn increases the bioavailability of the metal ions. Secondly, precipitated metals reaching the sediments are not dissolved, but particulate. And thirdly, metals like selenium do not behave similarly to metals like barium, copper, and cadmium, and do not precipitate readily with any substances.

Regarding turbidity it is noted that:

> *Receiving waters in streams and rivers may become less turbid because produced water is relatively low in sediments. This decrease could be detrimental to fish that depend on turbid waters and may allow for more aggressive invasion of exotic species* (p. 4-239).

The FEIS stated that increased road building will likely export more sediment to streams during rainfall events, and that the increased flow likely will increase sedimentation due to scour. There is a large body of scientific literature pertaining to the effects of sediment on aquatic organisms, but the FEIS includes little discussion of the potential effects of increased sediment. Effects will vary between watersheds and species, with some species benefiting from increased turbidity, while others will be negatively affected. This section ends by mentioning that TMDLs could be applied if sedimentation becomes a problem, while noting that none have yet been developed. Because numeric water quality standards generally do not exist for siltation or increases in the percentage of fine particulates in the gravel, it will be difficult to apply TMDLs until these standards are developed. .

The FEIS states:

> *Concentrations of TDS in CBM discharge range between 270 and 2,720 mg/L (Table 3–2). Discharges higher than 2,000 mg/L may cause adverse effects on invertebrates, as described by Chapman et al. (2000).* (p. 4-240)

Although references were cited, there was no explicit mention of effects threshold for fish, and it is unclear why the lowest LOEC for TDS for fish and invertebrates was undefined in the FEIS. More importantly, TDS is only a crude index for predicting toxicity, because the toxicity of individual ions differs considerably (Mount et al. 1997).

The FEIS is written in a manner that prevents reviewers from independently evaluating the data. The omission of explicit reference to estimated surface water concentrations and comparison to effects thresholds is an example that prevents peer review of the FEIS. For example:

> *When mixing with discharges of CBM produced water, is modeled, salinity, as measured by EC, in receiving waters is predicted to increase in the Upper Tongue River, Crazy Woman Creek, Clear Creek, and Middle Powder River sub-watersheds during low flow. Salinity is expected to decrease in the Upper Powder River, Little Powder River, Salt Creek, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River sub-watersheds during low flow.*

Also, there is no basis for the following inference and the reader cannot determine whether this statement is opinion or based on data:

> *Fish present in Salt Creek, such as the fathead minnow, flathead chub, longnose dace, plains minnow, sand shiner and white sucker, are all likely tolerant of high salinities and would be more tolerant of increases in salinity in other sub-watersheds. Other species found within the sub-watersheds with lower salinities may be less tolerant of increases in salinity.* (p. 4-240 to 4-241)

The FEIS clearly suggests concern about the risks posed by bicarbonate to aquatic life:

> *A recent study by the Montana Department of Fish, Wildlife, and Parks (Skaar 2001) described concerns relating to sodium bicarbonate toxicity to aquatic life in the Powder and Tongue Rivers. Fish and macroinvertebrates could be negatively affected by elevated levels of bicarbonate in the receiving sub-watersheds. Concentrations of bicarbonate are generally higher during low flow, and lower during high flow, resulting in greater accumulations and enhanced effects on aquatic life during low flow periods. The study suggests that bicarbonate levels should be monitored for their potential effects on aquatic life, especially fish.* (p. 4-241)

A thorough review of the existing literature may disclose that there are sufficient data to address risks rather than simply monitor concentrations. Monitoring only documents concentrations and not impacts. It is not difficult to model bicarbonate concentrations and to compare these to the literature on effects. Based on the following statements it appears the BLM may have produced these data, but if so, it is unclear why they were not presented.

> *Low, moderate, and high probability thresholds were modeled for each river to establish lethal limits to the fathead minnow; these limits can then be generally applied to many species of fish. These thresholds could be used to initiate a monitoring program for bicarbonate in the sub-watersheds of the Project Area that would receive CBM produced water (p. 4-241).*

Selenium also appears to pose potentially significant risk potential to aquatic life:

> *Selenium could reach harmful levels for fish over the life of the project. It is anticipated that concentrations of selenium in containment impoundments would be higher than in the stream and river systems within the 10 sub-watersheds in the Project Area because of evaporative concentration over time.(p. 4-242). Containment impoundments receiving discharges of CBM produced water would have NPDES monitoring requirements for selenium because of its bioaccumulative nature* (p. 4-242).

The FEIS recommends monitoring while acknowledging concentrations could be hazardous. Although monitoring is important, it should not be the "action" arising from a determination of potentially significant impact. There is a substantial body of literature concerning the aquatic toxicity of selenium and the BLM could facilitate an understanding of this issue by modeling selenium concentrations in the affected environment.

The FEIS makes numerous references to metals, but it is unclear whether reference is specific to selenium and barium or to other metals (e.g., copper, zinc, cadmium, lead). In addition, the FEIS makes an incorrect comparison when inferring risks to aquatic life by referencing water quality standards for human health. EPA has water quality criteria for all environmentally important metals and these should be used instead (see http://www.epa.gov/waterscience/pc/ambient2.html)

> *All concentrations of trace elements were uniformly low and were below the primary and secondary maximum contaminant levels for drinking water established by EPA (p. 4-241).*

The FEIS does not provide enough information to deduce risks to aquatic life from water temperature. The range of produced water temperatures is not important; rather, of greater concern are the temperatures predicted to occur at different times of the year in the receiving streams as a result of the produced waters, in comparison to the temperature requirements of the resident species. Special attention should be given to critical functions such as spawning and egg incubation because these are especially temperature-dependent.

> *The temperature of CBM discharge water varies throughout the Project Area and ranges between 12 and 29°C with a median of 19°C. The temperature of streams within the Project Area can range from 0°C during winter to 25°C or more during summer; therefore, changes in temperature are not expected to be dramatic but would vary depending on the location of CBM discharge (p. 4-242).*

Cumulative Effects are addressed on pages 4-64 through 4-69 and focus mainly on the alternatives and especially on groundwater impacts. The surface water analysis is very qualitative, and the lack of specific data precludes determining whether cumulative impacts will cause adverse impacts. The FEIS' analysis concerning cumulative impacts of produced waters to surface waters is set forth as follows:

> *Both mining and development of CBM result in the collection and discharge of water to surface drainages. Mine inflow water is first stored in sediment ponds to reduce sediment picked up in the pit. Much of this water is used for dust suppression and is not discharged to surface drainages, except during certain storm events. The discharge water from sediment ponds potentially would have higher TDS values and be of lower quality as a result of sediment mixing and concentration by evaporation. CBM discharges are essentially sediment-free (as produced from CBM wells), although discharge to surface drainages can increase sediment loading caused by increased stream erosion* (p. 4-67).

A more useful quantitative analysis would estimate pollutant loadings, singly and then collectively for the cumulative analysis by watershed. Existing monitoring data would be used to estimate loadings from existing sites, and then the cumulative loadings by watershed would have been based upon the assumption that new loadings would be similar to existing loadings. Because the FEIS did not highlight any additional mitigation on produced water loadings to surface waters, it must be assumed that future loadings are predictable from extant loadings. Future loadings should be predicted.

Appendix I contains the Water Management Plan. Detection limits for chemical analyses are specified on page I-7. The recommended detection limit for total petroleum hydrocarbons (TPH) of 1 mg/l is too high to be useful for monitoring purposes. Woodward et al. (1983) showed adverse effects to juvenile cutthroat trout growth and survival with chronic exposure to concentrations as low as 39 ug/l and considered 24 ug/l a safe concentration. A detection limit less than 30 ug/l would be desirable. Likewise, the detection limit for selenium, currently set at 5 ug/l, should be less than 2 ug/l.

The proposed mixing model for surface water and CBM produced water described in the EIS and in greater detail in the Surface Water Technical Document appears to be a good first cut for screening purposes. If appropriate conservative criteria are applied, results of the mixing model will allow potential "hot spots" to be identified for additional, more intensive and sophisticated hydrologic and toxicological investigation while simultaneously identifying regions of less concern. If subsequent monitoring indicates adverse impacts to the aquatic communities in situations in which a "hot spot" was not identified, more intensive and sophisticated hydrologic modeling would be appropriate.

Although the authors acknowledged that the concentration of TDS and conductivity are not the best predictors of toxicity (p. 4-240), they did not discuss individual ions that allow more reliable predictions of toxicity. We encourage applying the mixing model to individual major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}), in addition to the electrical conductivity modeled thus far. Because the toxicity of major ions to aquatic biota varies considerably, conductivity is a not a reliable predictor of toxicity. The Mount et al. (1997) model is discussed (p. 4-240) but is not used to predict potential toxicity to aquatic organisms in receiving waters. We recommend analysis of individual ions in the mixing model, and then applying the Mount et al. (1997) model to those results to predict potential toxicity.

Toxicity of elevated concentrations of TDS, chlorides, sulfates and sodium to *Ceriodaphnia* spp. and fathead minnows in Salt Creek is briefly mentioned (pp. 3-165,166). However, toxicity of CBM produced water does not appear to be discussed anywhere else. Forbes et al. (2001, 2002) demonstrated acute and chronic toxicity of some CBM production waters and receiving waters in the Powder River Basin (PRB) to *Ceriodaphnia dubia*, *Daphnia magna* and/or fathead minnows. Those reports are publicly available but not mentioned in the analysis of potential effects to aquatic species and they could be used to screen for "hot spots" in conjunction with the BLM's current mixing model.

In several places in the report, increases in stream flows due to CBM production water discharge are discussed as causing potential effects to aquatic species (e.g., Table S-2, p. xxxix). However, the potential effects of dampening of daily and annual cycles in stream flow and associated water quality characteristics (e.g., temperature, turbidity, concentrations and ratios of major ions) are not directly discussed. This dampening of flows and physical-chemical composition might directly affect resident biota and/or alter community composition.

The authors directly addressed some of the concerns about the potential impacts of increased salinity on aquatic communities. However, they never directly addressed the potential impacts of decreased salinity due to the influx of lower-salinity CBM production waters into receiving waters. This situation is most likely to occur in the eastern portion of the PRB (e.g., Belle Fourche River drainage), as predicted by the BLM's mixing model. Clearwater et al. (2002) recommended that this tendency to "dilute" those surface waters be considered just as important as the tendency for CBM production waters in the western portion of the PRB to "salinate" surface waters, because of the potential impacts of "dilute" water to resident biota that are adapted to more saline water.

National Pollutant Discharge Elimination System (NPDES) Regulation
The preferred alternative is a combination of Alternative 2A and Alternative 1. Alternative 1 emphasizes untreated surface discharge of produced water, while Alternative 2A emphasizes infiltration. The Preferred Alternative encourages treatment of produced water, where feasible and practicable. An estimated 9 to 52% of CBM produced water would “contribute” [directly] to surface water. The FEIS states that water quality changes downstream of produced water discharges would be “notably changed” and notes that NPDES permits would be relied upon to maintain compliance. This defers the degree of protection to the NPDES process and raises the issue of whether numeric water quality criteria, narrative water quality criteria, or biocriteria are available and enforceable for the stressors identified as significant in the FEIS. Perhaps more importantly, it implicitly assumes that the state will regulate downstream water quality, either in addition to or in lieu of, the current regulations on production water quality at the well head.

The FEIS explicitly states that it is depending on NPDES permits and Total Maximum Daily Loads issued by the Wyoming Department of Environmental Quality (WDEQ) to determine compliance and remediation for water quality risks. For example:

> *Concentrations of salts and metals, particularly barium and selenium, may increase in the containment reservoirs receiving CBM produced water discharges, as water evaporates over time. Direct effects (toxicity) to waterfowl could occur, depending on the quality of the produced water. CBM produced waters discharged to off-channel containment impoundments would require an NPDES permit issued by WDEQ, which would establish effluent limitations that would be protective of use by wildlife and livestock. Concentrations of selenium within the impoundments would be monitored as a requirement of the NPDES permit, primarily because of the large volume of water that could be potentially discharged, and the bioaccumulative nature of selenium. Typically, the concentration of selenium in the produced water is fairly low and is normally less than Wyoming water quality standards. However, water quality could reach levels of concern for selenium and other constituents when inflow to the impoundments ceases, and NPDES permit monitoring requirements no longer apply (p. 4-226).*

Apparently the BLM monitoring and compliance process relies on WDEQ to monitor compliance and to enforce compliance with water quality regulations. Because the WDEQ does not necessarily have water quality standards for all of the stressors identified as posing potentially significant impacts, the “safety net” is incomplete. This process appears inadequate for accurately quantifying those risks that are significant and those that are not. For example, States usually have numeric criteria for turbidity and narrative criteria for suspended solids, but most have not adopted biocriteria as water quality standards, so they cannot be used to monitor cumulative impacts or the singular impacts of such factors as flow. For changes in substrate particle size, there usually are no standards. Also, the states can only use TMDLs to control cumulative effects.

In Table S-2 (Summary of Effects by Alternative, under Surface Water, Alternative 1, p. xxxiii), the authors imply that, because NPDES discharge permit limitations are intended to protect aquatic life in receiving waters, water quality standards and designated uses would not be degraded if an NPDES permit has been granted for CBM water discharge. This idea is also mentioned on p. 4-235. However, the WDEQ NPDES permits for CBM production water discharges do not require biological testing that integrates known and unknown components in the water. Therefore, a permitted discharge might still adversely impact biota in the receiving water. Moreover, surrogate data can be used to obtain an NPDES permit for CBM water discharge from WDEQ. Unfortunately, WDEQ's current criteria for selecting those surrogate water quality data appear to be spurious (Clearwater et al. 2002). Wyoming and Montana will impose anti-degradation requirements; yet the FEIS predicts increases in TDS, sediment and metals. While it may simply be a matter of defining degradation, the contradictory concepts regarding anti-degradation and predicted increases in some water quality parameters should be reconciled.

A policy judgment to focus on irrigation uses of surface waters is stated on page 4-69 that is easily interpreted as a conscious decision to avoid or minimize analyzing effects on aquatic biota and habitats. If this is the case, the WDAFS considers this a major omission from the FEIS protection of aquatic biota is also a beneficial use recognized and regulated by WDEQ:

> *A major beneficial use of surface water in the Project Area is the production of irrigated crops. Therefore, the surface water impact analysis focuses on the potential effects to the suitability for Irrigation of surface waters in the Project Area from proposed discharges of CBM produced water.*

The analysis of the potential effects of TDS (based on conductivity) was comprehensively modeled. Elevated TDS would be mitigated, where required via NPDES permits, using the following: *Use of active treatment, such as reverse osmosis, or ion exchange systems, to amend the produced water to meet water quality standards prior to discharge would be emphasized. Some level of active treatment would be implemented in all sub-watersheds except for the Upper Belle Fourche River sub-watershed.* (p. 4-77).

The FEIS states the following concerning impacts to water quality and quantity: These effects include: (1) changes in timing and quantity of stream flows; (2) changes in sedimentation; (3) changes in concentrations of salts in streams; (4) changes in concentrations of metals (such as barium, selenium); (5) changes in temperatures; (6) accidental spills of fuels or drilling fluids; (7) changes in species diversity; and (8) transboundary effects on water quality.

In summary, a fundamental premise of the FEIS is that discharges will meet requirements of NPDES permits issued by WDEQ. This is perhaps the documents main weakness with respect to impacts on surface water quality and aquatic life. The only means of assessing whether receiving waters are fully protected from significant water quality degradation is to implement a monitoring program. This is especially critical when streams receive CBM water from multiple sources, whereby the cumulative effects may be significant, yet individual discharge points may be in compliance with NPDES permit requirements.

Risk Assessment

Although potential impacts to aquatic biota were mentioned in various places throughout the FEIS, they do not appear to have been factored into the decision to proceed with CBM development. A transparent decision tree did not appear to be implemented when BLM chose to proceed with CBM development. Also, the lack of a decision tree outlining post-CBM development evaluation and monitoring results creates an impression of inevitability regarding continued CBM extraction and additional development.

The FEIS does not provide the data needed to determine if conclusions concerning risk magnitude are valid. Data upon which the risk assessments are based need to be presented for review. While the document makes it apparent that stream flow, TDS, suspended and settleable sediment, turbidity, and selenium, pose potentially significant risks to aquatic life (i.e., fish, invertebrates, algae), the information needed to quantify risks to these biologic elements is generally lacking. Because the risks are not quantified, it is impossible to decide whether the risks are so substantial that produced waters need further treatment. Additionally, neither remediation nor monitoring is recommended to address those potential impacts.

Assessing a project of this magnitude with potential ecosystem-level effects would best be approached with a quantitative cumulative impact analysis, and the lack of such analysis is a major weakness of this document. While this would require a substantial modeling effort to predict concentrations of many substances in individual streams, it was apparently not considered for those elements the FEIS indicated posed risks (i.e., flow-induced changes in aquatic habitat, TDS, sedimentation, and selenium). The WDAFS strongly recommends that a cumulative impacts assessment be conducted.

Monitoring, Mitigation and Adaptive Management

There are no provisions for conducting acute and chronic toxicity testing upstream and downstream from CBM product water discharges during and after CBM development. Although tissue residues in fish will be monitored (p. 4-398), those analyses will not provide reliable predictions of adverse effects due to increased or decreased concentrations of major ions in the receiving waters.

Given the juxtaposition of more intense well development in a potentially vulnerable sub-watershed (the Upper Powder River), a monitoring program that allows adaptive management of production water treatment methodologies and evaluates project effects on biota seems prudent. Appendix D describes the monitoring effort that is anticipated for the project area. In addition to identifying a process to secure adequate funding for implementation, we suggest the following elements be given serious consideration to ensure the effectiveness of this critical development component.

- Baseline (i.e., pre-project) fish and invertebrate IBIs, and water and sediment chemical analysis at designated sites. Existing monitoring stations can be used to the extent possible, but new stations will probably need to be identified to provide meaningful coverage. Toxicity testing with CBM production water, using fathead minnows and *Cereodaphnia* spp., with emphasis on early life stage survival, growth, and development; bioaccumulation and reproduction in adults; and effects of contaminants in conjunction with an appropriate range of water temperatures.

- Periodic monitoring after wells are installed at the same locations at which baseline data were collected to evaluate long-term trends in aquatic populations and communities.

- Water quality should be monitored annually in all ponds, reservoirs, and containment reservoirs. A protocol should be developed to determine for each discharge if CBM produced water should be discharged into closed containment reservoirs, based on salt and metal concentrations and the potential for these contaminants to reach unacceptable levels through evaporative concentration during life of the impoundment. Because selenium toxicity usually is predominately caused by ingestion of contaminated food rather than by exposure to aqueous selenium, concentrations of selenium should be monitored in all trophic levels in the retention ponds and compared to threshold dietary toxicity levels; in addition to monitoring aqueous selenium concentrations.

- For purposes of adaptive management, the FEIS should answer the following questions: Will the discharge of CBM produced water be discontinued if salt and/or metal concentrations pose a threat to aquatic species and migratory birds? If so, what concentrations will trigger cessation of the CBM discharges? If discharge is ceased, what measures will be taken to remediate contaminated exposed sediments when the impoundments dry up?

- The monitoring plan should specify responsibility for water quality sampling and stream channel monitoring. Additionally, the monitoring plan should (1) state what actions will be taken if this monitoring shows adverse effects to riparian habitat and/or fish and wildlife, and (2) specify what resources, in terms of staff and funding, would be required to ensure compliance with mitigation measures as well as compliance with the Clean Water Act and if such resources would be available to ensure compliance to avoid, reduce, or minimize adverse effects to fish and wildlife resources.

References

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