TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
SOILS	soil erosion, uplands	area-wide where management activities are occurring or expected to occur	visual observation and surveyed erosion pins	soil loss in tons per acre	site will be visually examined quarterly. Where erosion is deemed excessive, measurements of site characteristics will be taken to determine rate of soil loss.	visual evidence of rill, gully, or sheet erosion. Loss of soil exceeding 10 tons per acre	report exceedance to BLM, MDEQ, or EPA. If caused by CBNG discharge or activities, enforcement action will be taken.
	soil erosion, streambank, and floodplain	area-wide along rivers and tributaries where management activities are occurring or expected to occur	visual observation and surveyed erosion pins	area effected in square feet or acres	site will be visually examined quarterly. Where streambank erosion is deemed excessive, measurements of site characteristics will be taken to determine soil loss.	a 10% increase in streambank loss	report exceedance to BLM, MDEQ, or EPA. If caused by CBNG discharge or activities, enforcement action will be taken.
	soil salinization	area-wide where management activities are occurring or expected to occur	visual observation, measurement of soil characteristics such as pH, EC, SAR	area effected in square feet or acres	site will be visually examined quarterly. Where salinity levels show an increase because of vegetation or soil effects, measurements of site characteristics will be taken to determine salinity levels.	a 20% increase in conductivity levels	report exceedance to BLM, MDEQ, or EPA. If caused by CBNG discharge or activities, enforcement action will be taken.
	compaction	areas affected by extraction activities	penetrometer or visual inspection	pounds per square inch	1 to 2 times yearly	10% increase in density	limit or block access to compacted sites

TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
VEGETATION							
	ecological status	areas affected by disturbance through the pre-production, production, post-production processes	ecological site method in key areas	composition, production compared to potential natural community for each site	pre-development ecological status baseline data	status is reduced by 15% or a drop in class	ecological site integrity will be altered to increase status of ecological site index by 15% or an increase in ecological class
	trend	areas affected by disturbance through the pre-production, production, post-production processes	any suitable methods as described in TR 4400-4 or the National Range Handbook	apply to the technique selected, may include number of individuals per unit area, percent cover, percent frequency, or percent species composition	every 3 to 5 years after the collection of ecological status baseline data	a change in the direction of trend away from management	measure implementation of action put forth to mitigate reduction of ecological status using techniques listed in monitoring appendix for vegetative trend
Noxious Weeds	trend	areas affected by disturbance through the pre-production, production, post-production processes	Montana Noxious Weed Standards	acres, plants per square feet, species	yearly (through post production reclamation)	10% increase beyond objectives for the area/new species occurrence or infestation	operators will be required to contain and suppress noxious weeds. Conservation measures will be required in noxious weed sites to decrease population of noxious weeds and increase population of native plant community

TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
Riparian/ Wetlands	condition, trend, age class structure, streambank alteration	any federal action (including split estate)	photo plot, estimate key areas by sight inspection, Cole Browse Method, Key Forage Method, other methods found in Technical References (TR4400-3, TR4400-4, TR4400-7, TR1737-3, TR1737-8, TR1737-9) including MRWA (Montana Riparian Wetland Association) Riparian Inventory for areas not previously inventoried MRWA PFC on inventory areas	percent species composition, percent in each age class, percent utilization, height, percent of the streambank	based on activity plan schedule- a minimum of once every 5 years	trend away from objective or when no improvement occurs, in unsatisfactory habitat condition/functioning at risk with downward trend	oil and gas operators will be required to alter activities in order to provide environmental factors for increasing functionality or habitat conditions of the streams/wetlands. Oil and gas operators may be required to develop replacement wetlands in order to compensate for overall loss of wetlands according to Section 404 of Clean Water Act.
Special Status and Threatened and Endangered (T&E) Plant Species	condition	areas affected by disturbance through the pre-production, production, post-production processes	Montana Natural Heritage Program and visual inspection	presence and condition	once during the growing season, at a minimum	downward trend in plant condition caused by oil and gas activities	oil and gas operators will be required to alter their activities in order to benefit environmental factors required by special status or T&E plant species
WILDLIFE (see also Wildlife Monitoring and Protection Plan in Appendix A)							
Aquatic Biological Diversity (flora/fauna)	population diversity	intermittent/perennial streams associated with produced water discharge	stream sampling	diversity index	every 3 years	downward trend overall stream biological diversity	reduction or elimination of untreated produced water into drainage or watershed
Big Game	seasonal habitat use	project area plus 1-mile buffer	air/ground field inspection	occupancy	annually	downward trend in habitat occupancy caused by oil and gas activity	extension of timing stipulations or COAs, off-site habitat management or enhancement

TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
Black-footed Ferret	occupancy	prairie dog towns larger than 80 acres located within 0.5 mile of proposed activity	ground inspection	occupancy	determined on a site-specific basis in coordination with FWS	habitat decline or prairie dog fatalities caused by oil and gas activities - occupancy of black-footed ferrets would be managed in a Black-Footed Ferret Management Plan	no incidental take; reinitiate consultation if new information shows black-footed ferrets may be effected
Burrowing Owl	active nest locations	specific project area plus 0.5-mile buffer (within active prairie dog town)	ground inspection	occupancy	twice yearly (June to August)	human-caused disturbance to owls related to oil and gas activities such as vandalism and harassment	extension of timing and/or increase of distance from nest; stipulations or COAs
Grey Wolf	occupancy	Billings RMP area	air/ground field surveys	number of sitings	annually until reintroduction objectives are met	1- to 3-year downward trend in production or occupancy	no incidental take; reinitiate consultation if new information shows it may be effected
Migratory Non-game Birds	occupancy	project area plus 0.25-mile buffer	ground observations	occupancy	periodically	documented fatalities caused by oil and gas activities	refinements in infrastructure planning (project plans), implementation of travel corridors, enhanced reclamation standards, and off-site habitat management or enhancement

TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
Mountain Plover	active nest locations	specific project area plus 0.5-mile buffer (within areas less than 4-inch average vegetation height and prairie dog towns)	ground inspection	occupancy	twice yearly (April 15 to June 30)	human-caused disturbance to mountain plovers related to oil and gas activities such as vandalism and harassment	BLM received an exemption from the prohibitions of Section 9 of ESA regarding take by agreeing to terms and conditions in biological opinion (BO). Incidental take of habitat and individuals allowed up to level stated in BO. Take must be monitored. Reinitiation of Section 7 will occur before allowable take is exceeded.
Prairie Dog	active prairie dog colony	specific project area plus 0.5-mile buffer	air/ground inspection	occupancy	annually	documented prairie dog fatalities caused by oil and gas activities	establishment of no surface occupancy zones and/or establishment of timing restrictions within prairie dog towns
Raptors	active nest locations (excluding burrowing owls)	project area plus 1-mile buffer	air/ground field inspection	number of nests	every 3 years	downward trend in occupancy	extension of timing and/or increase in distance from nest; stipulations or COAs
	raptor productivity (including Burrowing owl)	active nests within 1-mile of project disturbance plus 1-mile buffer	air/ground field inspection	nest success/failure species productivity	annually	downward trend in nest success, overall productivity	extension of timing and/or increase in distance from nest; stipulations or COAs
	raptor productivity-selected undeveloped comparison area	project area	air/ground field inspection	nest success/failure species productivity	every 5 years	information used as support to determine downward trend	extension of timing and/or increase in distance from nest; stipulations or COAs

TABLE MON - 1

Element	Item	Location	Technique	Unit of Measure	Frequency and Duration	Remedial Action Trigger	Management Options
WILDLIFE (continued)							
Sage Grouse	sage grouse lek location	CBNG overall project area	aerial field inspection	number, location of leks	every 5 years	downward trend in habitat occupancy	extension of timing and/or increase in distance from lek; stipulations or COAs; off-site habitat management/mitigation
	sage grouse lek attendance	specific project development areas plus 2-mile buffer	air/ground field inspection	number of males/lek	annually	downward trend in lek attendance (compared to control LEK)	extension of timing and/or increase in distance from lek; stipulations or COAs; off-site habitat management/mitigation
	sage grouse winter habitat	project area plus 2 mi. buffer	air/ground field inspection	occupancy	annually	downward trend in habitat occupancy or quality caused by oil and gas activities	extension of timing and/or increase in distance from lek; stipulations or COAs; off-site habitat management/mitigation
Special Status Species (BLM and Montana Natural Heritage Program lists)	occupancy	specific project area plus 1-mile buffer	ground field inspection	occupancy	annually at a minimum via species habitat requirements	downward trend in habitat occupancy or quality caused by oil and gas activities	establishment of timing and/or distance from breeding area through stipulations or COAs
Threatened, Endangered and Proposed Species other than previously described	occupancy, productivity	CBNG overall project area	air/ground field inspection	occupancy	determined on a site-specific basis in coordination with FWS	habitat decline or fatalities caused by oil and gas activities; occupancy of species would be managed in a site-specific Management Plan	reinitiate section and consultation with FWS

Prepared in cooperation with the Montana Department of Environmental Quality

Surface-Water Monitoring in Watersheds of the Powder River Basin, 2005

Powder River Basin Interagency Working Group

The Powder River Basin (PRB) is a geologic structural basin that contains an extensive natural gas resource associated with regional coal deposits. This coalbed natural gas (CBNG) is located beneath millions of acres of private and public land in southeastern Montana and northeastern Wyoming (fig. 1). The PRB Interagency Working Group (IWG) was established in June 2003 as a forum to identify, discuss, and find solutions to issues of common concern to government agencies involved in permitting and monitoring CBNG development. The PRB IWG is led by the Bureau of Land Management (BLM) and is composed of managers and technical staff from local, State, tribal, and federal government agencies with land management, conservation, or regulatory responsibilities in the PRB, as well as agencies like the U.S. Geological Survey (USGS) that provide technical support.

The mission of the PRB IWG is to: (1) provide for environmentally sound energy development, (2) develop coordinated and complementary best management practices, guidelines, and programs related to CBNG activities to conserve and protect resources, (3) monitor the impact of CBNG activities and assess the effectiveness of mitigating measures, (4) develop and integrate the databases and scientific studies needed for effective resource management and planning, and to make that information readily available, and (5) promote compatibility in the application of each agency's mission.

In order to more effectively address the technical issues presented by CBNG development, Task Groups that are staffed by technical specialists from the member agencies of the PRB IWG were formed to address specific resource issues. The Task Groups include Air, Aquatics, Water, and Wildlife. More information about the PRB IWG and Task Group activities is available at URL *http://www.wy.blm.gov/bfo/prbgroup/index.htm*.

Water Task Group

Substantial volumes of ground water are extracted from coalbeds in order to produce CBNG. The removal of ground water from aquifers and use or disposal of produced water on the surface have the potential to cause environmental impacts. One objective of the Water Task Group is to develop and implement monitoring plans for surface water and ground water at local and regional scales. This monitoring will help agencies make more informed decisions regarding CBNG permitting, and allow for dissemination of information to the public. This factsheet summarizes the surface-water-monitoring plan developed by the Water Task Group and describes the surface-water monitoring accomplished during 2005.

Surface-Water-Monitoring Plan

The surface-water-monitoring plan is a proposed sampling network that is generally composed of sites where PRB IWG member agencies have been conducting surface-water monitoring. Sampling sites may be located on mainstems or selected tributaries in each watershed (fig. 1, table 1). Proposed sampling frequencies vary with stream type and constituent class (table 2). The constituent classes recommended for monitoring include:

- Streamflow
- Field measurements—pH, dissolved oxygen, specific conductance, and temperature
- Major ions—dissolved calcium, magnesium, potassium, sodium, alkalinity, chloride, fluoride, sulfate, and silica; dissolved solids; and sodium-adsorption ratio
- Nutrients—total and dissolved nitrogen and phosphorus species
- Trace elements (primary)—total and dissolved aluminum, arsenic, barium, beryllium, iron, manganese, and selenium
- Trace elements (secondary)—total and dissolved cadmium, copper, chromium, lead, nickel, and zinc.
- Suspended sediment

U.S. Department of the Interior
U.S. Geological Survey

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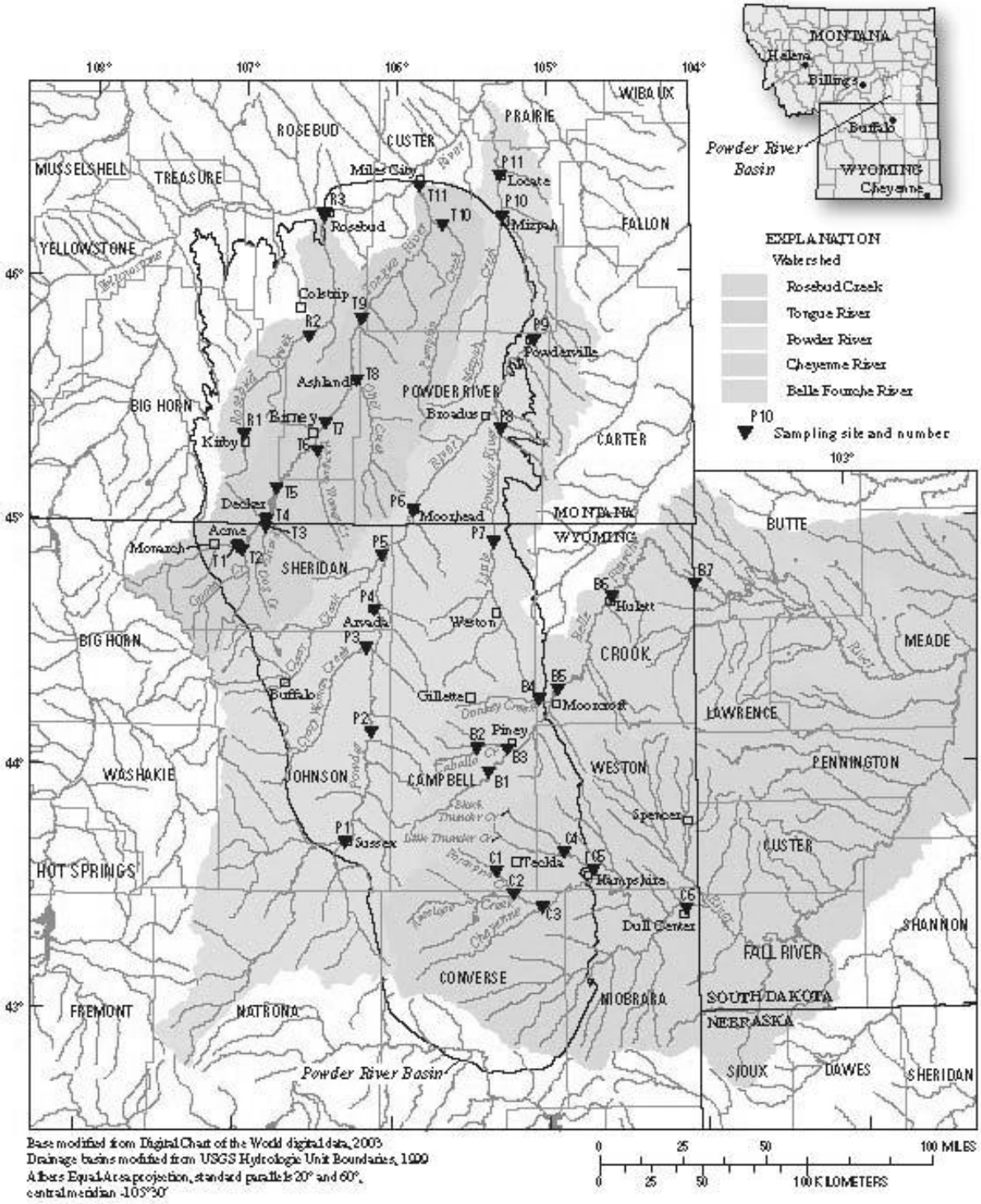

Figure 1. Location of sampling sites proposed in the Water Task Group's surface-water-monitoring plan for the Powder River Basin.

Table 1. Sampling sites proposed in the Water Task Group's surface-water-monitoring plan for the Powder River Basin.

Map number	U.S. Geological Survey site number	Site name	Stream type
R1	06295113	Rosebud Creek at reservation boundary near Kirby, Mont.	Mainstem
R2	06295250	Rosebud Creek near Colstrip, Mont.	Mainstem
R3	06296003	Rosebud Creek at mouth, near Rosebud, Mont.	Mainstem
T1	06299980	Tongue River at Monarch, Wyo.	Mainstem
T2	06305700	Goose Creek near Acme, Wyo.	Tributary
T3	06306250	Prairie Dog Creek near Acme, Wyo.	Tributary
T4	06306300	Tongue River at State line near Decker, Mont.	Mainstem
T5	06307500	Tongue River at Tongue River Dam, near Decker, Mont.	Mainstem
T6	06307600	Hanging Woman Creek near Birney, Mont.	Tributary
T7	06307616	Tongue River at Birney Day School Bridge, near Birney, Mont.	Mainstem
T8	06307740	Otter Creek at Ashland, Mont.	Tributary
T9	06307830	Tongue River below Brandenberg Bridge, near Ashland, Mont.	Mainstem
T10	06308400	Pumpkin Creek near Miles City, Mont.	Tributary
T11	06308500	Tongue River at Miles City, Mont.	Mainstem
P1	06313500	Powder River at Sussex, Wyo.	Mainstem
P2	06313605	Powder River below Burger Draw, near Buffalo, Wyo.	Mainstem
P3	06316400	Crazy Woman at Upper Station, near Arvada, Wyo.	Tributary
P4	06317000	Powder River at Arvada, Wyo.	Mainstem
P5	06324000	Clear Creek near Arvada, Wyo.	Tributary
P6	06324500	Powder River at Moorhead, Mont.	Mainstem
P7	06324970	Little Powder River above Dry Creek, near Weston, Wyo.	Tributary
P8	06325500	Little Powder River near Broadus, Mont.	Tributary
P9	06325650	Powder River near Powderville, Mont.	Mainstem
P10	06326300	Mizpah Creek near Mizpah, Mont.	Tributary
P11	06326500	Powder River near Locate, Mont.	Mainstem
C1	06364300	Porcupine Creek near Teckla, Wyo.	Tributary
C2	06364700	Antelope Creek near Teckla, Wyo.	Tributary
C3	06365900	Cheyenne River near Dull Center, Wyo.	Mainstem
C4	06375600	Little Thunder Creek near Hampshire, Wyo.	Tributary
C5	06376300	Black Thunder Creek near Hampshire, Wyo.	Tributary
C6	06386500	Cheyenne River near Spencer, Wyo.	Mainstem
B1	06425720	Belle Fourche River below Rattlesnake Creek near Piney, Wyo.	Mainstem
B2	06425800	Caballo Creek near Gillette, Wyo.	Tributary
B3	06425900	Caballo Creek at mouth, near Piney, Wyo.	Tributary
B4	06426400	Donkey Creek near Moorcroft, Wyo.	Tributary
B5	06426500	Belle Fourche River below Moorcroft, Wyo.	Mainstem
B6	06428050	Belle Fourche River below Hulett, Wyo.	Mainstem
B7	06428500	Belle Fourche River at Wyoming-South Dakota State line	Mainstem

Table 2. General sampling strategy proposed in the Water Task Group's surface-water-monitoring plan for the Powder River Basin.

Stream type	Sampling frequency	Constituent class
Mainstem	Continuous	Streamflow
	12 times per year	Field measurements
	12 times per year	Major ions
	2 times per year	Nutrients
	12 times per year	Trace elements, primary
	2 times per year	Trace elements, secondary
	12 times per year	Suspended sediment
Tributary	Continuous	Streamflow
	6 times per year	Field measurements
	6 times per year	Major ions
	2 times per year	Nutrients
	6 times per year	Trace elements, primary
	2 times per year	Trace elements, secondary
	6 times per year	Suspended sediment

Monitoring Summary, 2005

Because of funding shortfalls for surface-water monitoring, only part of the proposed sampling in the surface-water-monitoring plan was accomplished during 2005 (table 3). For the sites where the sampling was partially completed, either the sampling frequency was less than the proposed sampling frequency or not all of the constituent classes were analyzed. The Tongue River watershed was the only watershed where the sampling proposed in the surface-water-monitoring plan was fully completed.

Several of the agencies that participate on the PRB IWG contributed funding for monitoring and reporting, including:

- BLM,
- Montana Department of Environmental Quality,
- Montana Department of Natural Resources and Conservation,
- Northern Cheyenne Tribe,
- U.S. Environmental Protection Agency,
- USGS,
- Wyoming Department of Environmental Quality, and the
- Wyoming State Engineer's Office.

Streamflow data and water-quality samples were collected by USGS personnel using standard USGS field methods (*http://water.usgs.gov/owq/FieldManual/*). Samples were analyzed at the USGS National Water Quality Laboratory in Lakewood, Colorado.

Table 3. Monitoring accomplished for surface-water-monitoring plan during 2005.

[●, completed; ◌, partially completed; and ○, not completed.]

Map number	Stream-flow	Field measure-ments	Major ions	Nutrients	Trace elements, primary	Trace elements, second-ary	Sus-pended sediment
R1	●	●	●	●	●	○	●
R2	●	○	○	○	○	○	○
R3	●	○	○	○	○	○	○
T1	●	●	●	●	●	●	●
T2	●	●	●	●	●	●	●
T3	●	●	●	●	●	●	●
T4	●	●	●	●	●	●	●
T5	●	●	●	●	●	●	●
T6	●	●	●	●	●	●	●
T7	●	●	●	●	●	●	●
T8	●	●	●	●	●	●	●
T9	●	●	●	●	●	●	●
T10	●	●	●	●	●	●	●
T11	●	●	●	●	●	●	●
P1	●	●	●	○	◌	○	○
P2	○	●	●	○	◌	○	○
P3	●	●	●	●	◌	○	●
P4	●	●	●	○	◌	○	○
P5	●	●	●	○	◌	○	○
P6	●	●	●	●	●	●	●
P7	●	●	●	●	◌	◌	●
P8	○	●	●	●	●	●	●
P9	○	○	○	○	○	○	○
P10	○	○	○	○	○	○	○
P11	●	●	●	●	●	●	●
C1	●	●	●	○	◌	○	○
C2	○	●	●	○	◌	○	○
C3	●	●	●	○	◌	○	○
C4	○	●	●	○	◌	○	○
C5	○	●	●	○	◌	○	○
C6	●	●	●	○	◌	○	○
B1	○	●	●	○	◌	○	○
B2	○	●	○	○	◌	○	○
B3	○	●	●	○	◌	○	○
B4	○	●	●	○	◌	○	○
B5	●	●	●	●	◌	○	○
B6	○	●	●	●	◌	○	○
B7	●	○	○	○	○	○	○

Data Availability

Data collected as part of Water Task Group surface-water-monitoring plan are stored electronically in the USGS National Water Information System. Continuous streamflow and water-quality data are available to the public at URL: *http://waterdata.usgs.gov/nwis/*. Other USGS data for Montana and Wyoming can be accessed at *http://mt.water.usgs.gov/*, *http://tonguerivermonitoring.cr.usgs.gov/*, and *http://wy.water.usgs.gov/*.

Future Work

Another objective of the Water Task Group is to interpret the surface-water-monitoring data that are collected. Until more data are collected, much of the initial interpretive analysis may focus on sites with historical data that were collected for previous monitoring programs. For example, the Powder River at Arvada, Wyoming has been sampled for many years, and relations between constituents, such as specific conductance and the sodium-adsorption ratio, have been established (fig. 2). If the monitoring data indicate that water quality is changing, managers can use adaptive management and appropriate mitigation measures to address environmental concerns.

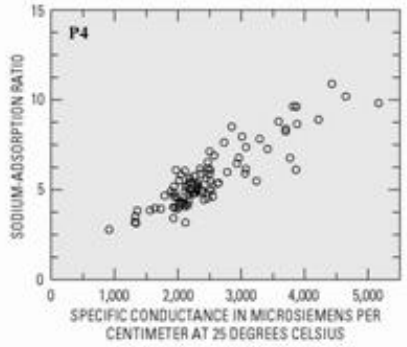

Figure 2. Specific conductance and sodium-adsorption ratio relation for the Powder River at Arvada, Wyo.

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[1]U.S. Geological Survey
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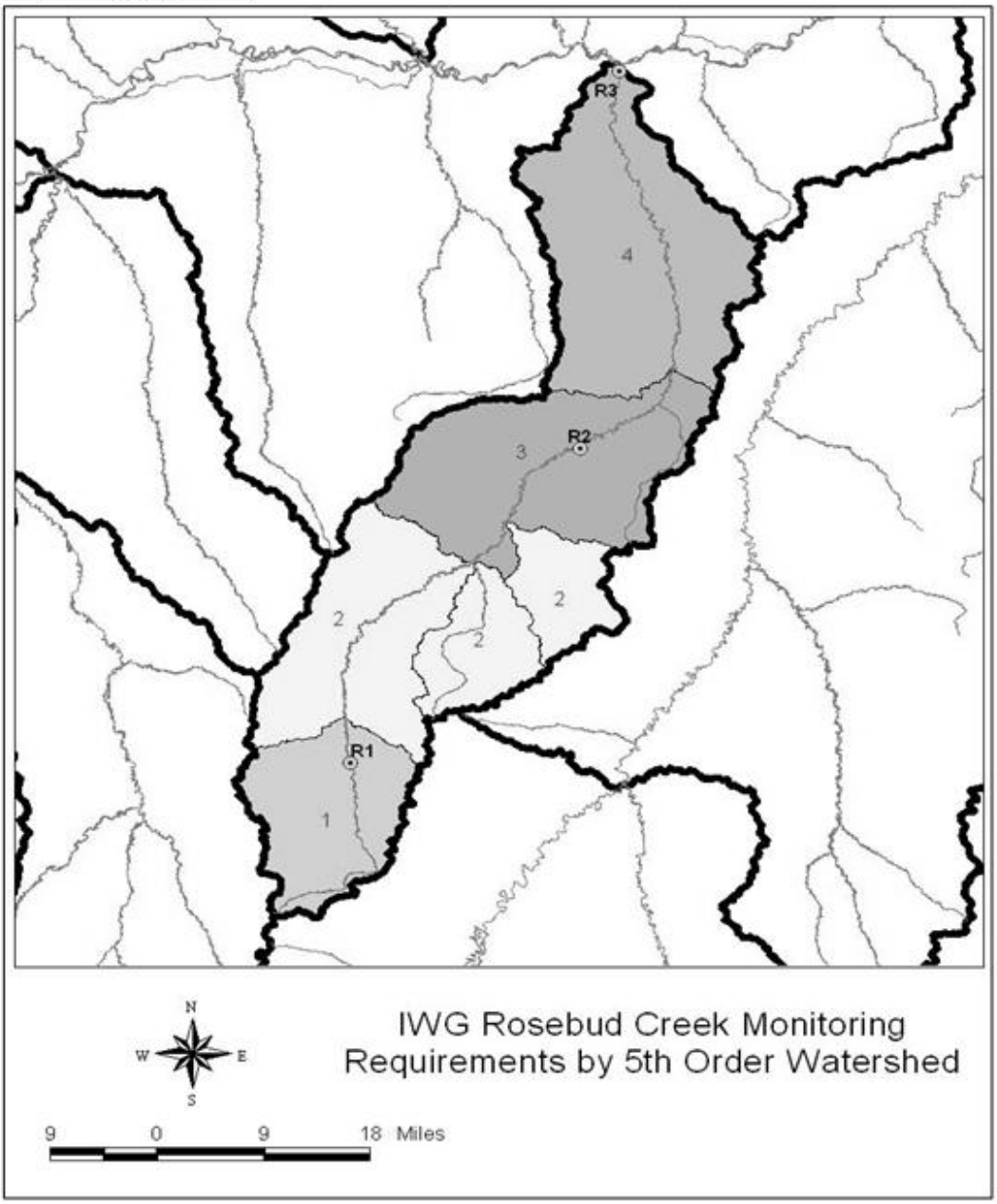
Layout by Suzanne C. Roberts

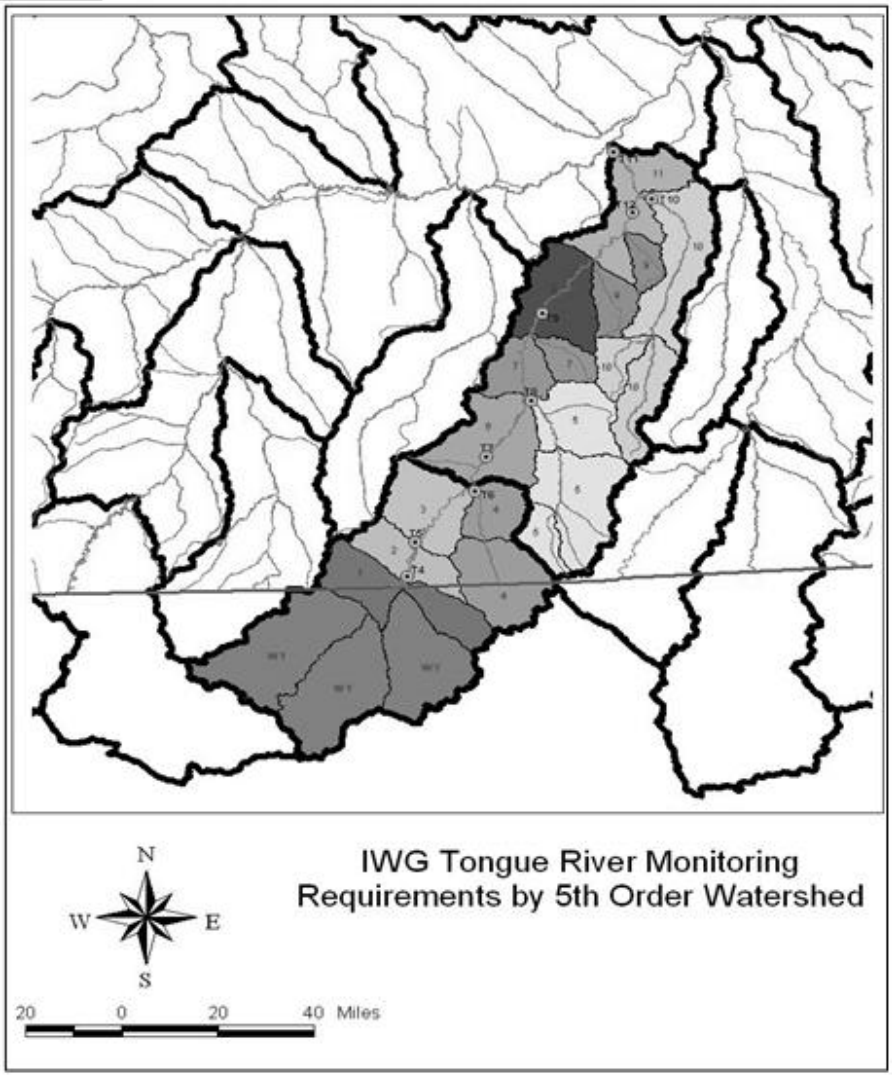
Rosebud

Group	Monitoring Required
1	R1 or R1&R2
2	R1&R2
3	R1&R2 or R2&R3
4	R2&R3



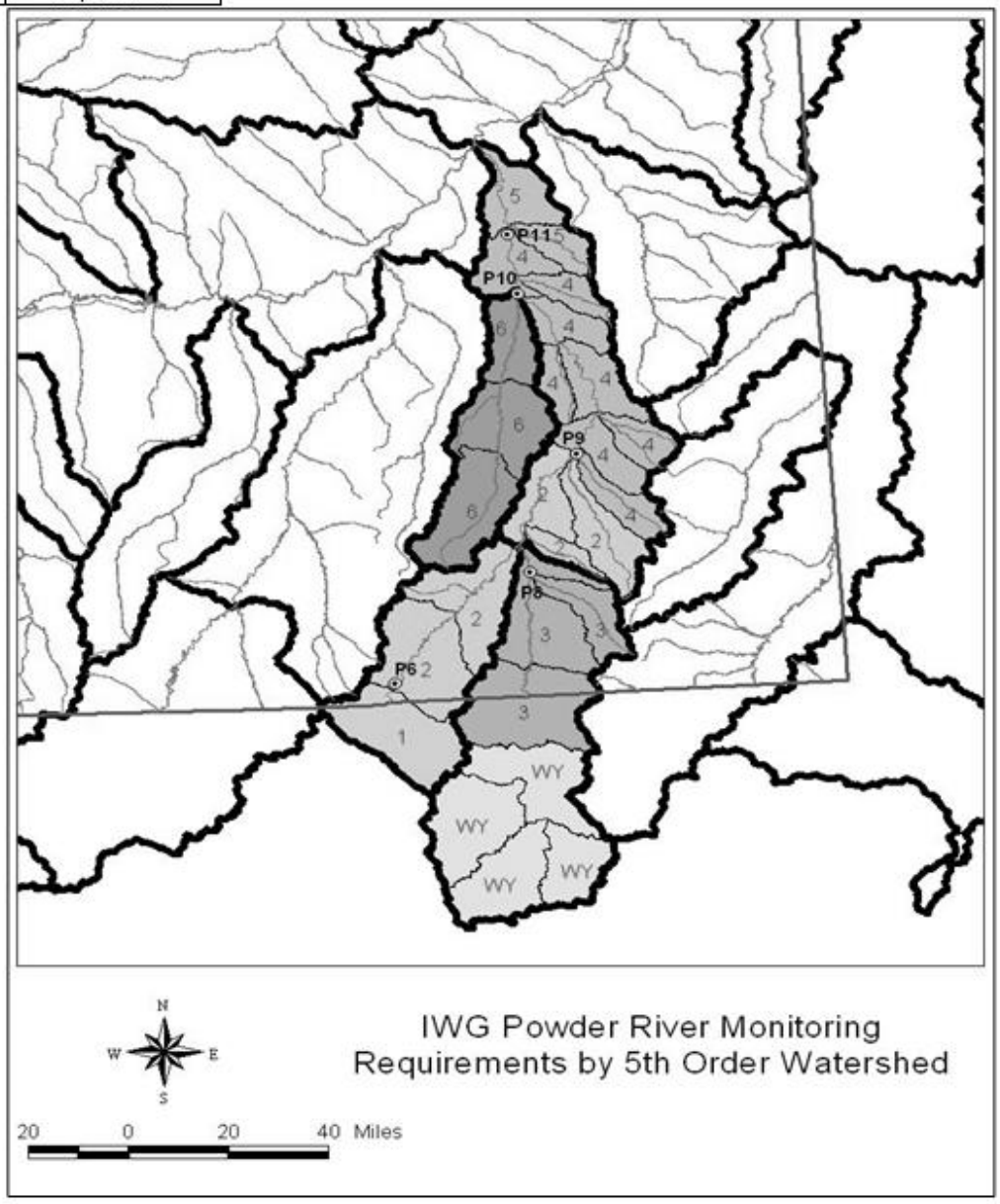
Tongue

Group	Monitoring Required
1	T4
2	T4&T5
3	T5&T7
4	T5,T6&T7
5	T7,T8,&T9
6	T5&T7 or T7&T9
7	T7&T8
8	T7&T9 or T9&T12
9	T9&T12
10	T10,T11&T12
11	T9&T12 or T12&T11



Powder

Group	Monitoring Required
1	P6
2	P6&P9
3	P6,P8&P9
4	P9&P11
5	None
6	P9,P10&P11



REGIONAL-SCALE MONITORING OF POTENTIAL EFFECTS OF COAL BED METHANE DEVELOPMENT ON WATER RESOURCES

Prepared by the Technical Advisory Committee for the Powder River Basin Controlled Groundwater Area

INTRODUCTION

Coal bed natural gas (CBNG) is released from coal seams by pumping groundwater from coal seams to lower ground water pressures. The coal seams targeted for CBNG development in the Powder River Basin constitute important regional aquifers that provide water for domestic, livestock, agricultural, and industrial uses. Consequently, CBNG production will probably affect existing water uses in the Powder River Basin, although the extent and magnitude of effects are difficult to predict.

The Montana Board of Oil and Gas Conservation (MBOGC) requires, through its Order No. 99-99, that CBNG producers submit field development plans that include groundwater characterization and monitoring. In addition to complying with existing MBOGC rules for wildcat gas wells, CBNG producers are required to describe baseline hydrologic conditions, to inventory existing wells and springs, to offer water mitigation agreements to existing water users, and to monitor water production and shut-in water pressures within coal bed methane fields. Water mitigation agreements must be offered for a minimum of one-half mile (expanded to one mile in Mont. Code Ann. 85-2-521) from CBNG fields or greater distances if effects extend father. The U.S. Environmental Protection Agency (EPA) requires monitoring under permits for Class V injection wells used to re-inject water produced during CBNG production. Specific requirements of Class V injection permits may include monitoring of injection pressure, injection rate and total volume at injection wells, and ground water elevations in monitoring wells.

There are no clear regulatory requirements for monitoring effects to ground water levels or spring flows outside the one-mile minimum specified by MBOGC or the area affected by Class V injection wells. Groundwater monitoring conducted by CBNG producers within and near CBNG fields, as required by MBOGC or the U.S. EPA, will not reveal broad regional effects. Therefore, regional-scale monitoring needs to be conducted outside areas of potential CBNG development to allow potential effects to be evaluated before, during, and after the period of CBNG production. In addition, the spacing of monitoring sites and the frequency of monitoring needs to be sufficient to distinguish potential effects attributed to CBNG development from potential effects attributed to other water users, and from ambient/seasonal variations in ground water levels and spring flows.

The purpose of this document is to establish design criteria for a regional-scale monitoring program intended to detect potential effects of CBNG development on existing water uses. The objectives of the regional scale monitoring program are to characterize baseline hydrologic conditions, detect changes in ground water levels and flows from springs attributable to CBNG development, and verify recovery of ground water levels after CBNG development ends. Regional-scale monitoring of wells and springs is intended to augment and compliment field-scale monitoring established under MBOGC Order No. 99-99 or EPA UIC Class V injection well permits.

Criteria for selecting locations and spacing for monitoring sites, consisting of wells and springs, and monitoring practices are proposed here to ensure that long-term monitoring is sufficiently comprehensive to detect effects that CBNG development might have on ground-water systems. Priorities are proposed to coordinate monitoring with the pace of development and the need to evaluate potential effects, and recommendations are presented for implementing monitoring and managing monitoring data. The criteria and monitoring recommendations described below are not meant as rigid rules, but rather are intended to guide qualified personnel in selecting monitoring locations and implementing monitoring that meet the objectives stated above.

The BLM, at its discretion, will administer the regional-scale monitoring program, while operators will be responsible for all in-field monitoring. The BLM has a commitment to maintaining the water monitoring of the PRB region, similar to their continued (25+ years) funding of the MBMG for coal mine water monitoring. The BLM will also partner with operators for in-field monitoring when federal gas is produced.

CRITERIA AND MONITORING PRACTICES

The portion of the Powder River Basin underlain by coals of the Tongue River Member of the Fort Union Formation is generally considered to have potential for CBNG development. Within this area, however, CBNG is less likely to be developed from coal seams with limited thickness and ambient ground water pressures; conditions that indicate limited potential for gas production. These areas, located primarily within 2 to 5 miles of coal outcrops, should be targeted for monitoring wells.

The Anderson-Dietz, Canyon, Wall, and Knobloch are the four primary coal seams within the Tongue River Member (Map 1). Separate monitoring sites located within 5 miles of the outcrops of each of these coal zones are proposed. Clusters of wells will be completed in different coal zones where outcrop areas overlap and, where present, springs will be monitored near each monitoring site. Monitoring wells will need to be completed in alluvial aquifers, in areas where water from CBNG production is discharged to surface impoundments, or in selected sandstone aquifers within coal outcrop areas or CBNG fields (when not required by MBOGC or the U.S. EPA). Springs that are current, historical, or potential sources of water but located away from established monitoring sites may also be monitored.

The focus of overall monitoring of the potential effects of CBNG development will change as CBNG fields mature, and gas production declines and eventually ends. Monitoring performed by CBNG operators that is required by MBOGC or the U.S. EPA, will gradually be discontinued as portions and eventually all of fields are played out. Abandoned producing wells or monitoring wells within CBNG fields should be incorporated into the regional monitoring program as field mature, in order to effectively monitor post-production groundwater recovery in affected areas.

The need for detailed information, and the cost of installing monitoring wells and monitoring ground water-levels and spring flows, will need to be balanced to determine the ultimate spacing between monitoring sites. At a minimum, one monitoring site will be located in every township that lies within 5 miles of the outcrop of a targeted coal. The ultimate spacing of monitoring sites might be greater, depending on site-specific conditions such as thickness of coal zone and importance of coal or sandstone aquifers, and priorities for monitoring outlined below.

Monitoring wells may be newly constructed wells, existing monitoring or water supply wells, or abandoned or transferred CBNG production wells. Ground-water levels in monitoring wells and flows of springs will need to be measured monthly to obtain a sufficient data record to characterize patterns of seasonal changes in ground-water level or spring flows, before the wells or springs can be effected by CBNG development. Typically two to three years of monitoring record is desirable. Monitoring frequency should be reduced once a sufficient record of baseline conditions is established.

PRIORITIES

The following priorities are proposed for initiating monitoring and selecting monitoring well density and frequency, to ensure that a regional ground water monitoring program is established in advance of anticipated CBNG development and before potential effects of CBNG development can occur.

- *Sequence of CBNG development*—Areas most likely to be affected by CBNG development first are the highest priority for initiating monitoring. CBNG development is expected to focus initially on the Anderson-Dietz coal zone and, therefore, monitoring near its outcrop should begin first. Records of exploration wells, pipeline plans, and identification of prospective coal zones can provide more specific information regarding the sequence of CBNG development.

- *Extent of water use*—Areas where water from coal-beds is heavily used are high priorities for monitoring. Within the general area of the Anderson-Dietz outcrop, areas of concentrated water use, such as the headwaters of Otter Creek, will need immediate and more intensive monitoring.

- *Proximity to political boundaries*—Monitoring should be established along political boundaries, specifically the Montana-Wyoming border and reservation boundaries, in order to detect potential effects from areas outside the regional monitoring network.

- *Sensitivity or hydrogeologic setting*—More intensive monitoring will be necessary where faulting or complex stratigraphy result in complex hydrogeologic settings.

- *Existing monitoring networks*—Monitoring should be re-established at monitoring wells near operating coal mines and coal mining prospects studied in the past. New monitoring well construction should focus on areas where wells are not available.

- *Land or mineral ownership*—Monitoring should be conducted at sites with stable land and/or mineral ownership. For example, federally owned land, or other land with long-term access easements provide more reliable long-term access for monitoring.

IMPLEMENTATION AND DATA MANAGEMENT

An important goal of the proposed regional monitoring program is to ensure that all monitoring data collected are made readily accessible to the public. The regional monitoring program can, and probably will, be conducted by more than one agency, with funding from various sources. However, one agency or interagency will need to coordinate or review all regional monitoring activities in order to assure that monitoring occurs where needed and to prevent duplication. Data from field-scale monitoring pursuant to MBOGC Order 99-99 and EPA UIC Class V injection well permits will need to be managed similarly. A further responsibility of the lead agency or group should be to ensure that regional- and field-scale monitoring data are compiled and made available to the public in the Ground-Water Information Center (GWIC) and the National Resource Information Systems (NRIS).

SUMMARY OF RECOMMENDATIONS

A regional-scale monitoring program is necessary to characterize baseline hydrologic conditions, to detect potential effects resulting from CBNG development, and to verify recovery of ground water levels after the period of CBNG development. The following constitutes the main elements of a regional-scale monitoring program that should accomplish these objectives:

- Monitoring is needed to augment and compliment field-scale monitoring established under MBOGC Order No. 99-99 and EPA UIC Class V injection permits.

- Groundwater levels need to be measured in wells in coals and overlying or underlying sandstone aquifers at locations near coal outcrops outside of areas of prospective CBNG development.

- Groundwater levels need to be measured in wells in alluvial aquifers in areas where water CBNG production is discharged to surface impoundments, or selected sandstone aquifers within CBNG fields.

- Flows from springs need to be monitored when they are near well monitoring sites or if they are important water sources.

- Groundwater levels need to be measured in abandoned or transferred CBNG wells as CBNG fields mature.

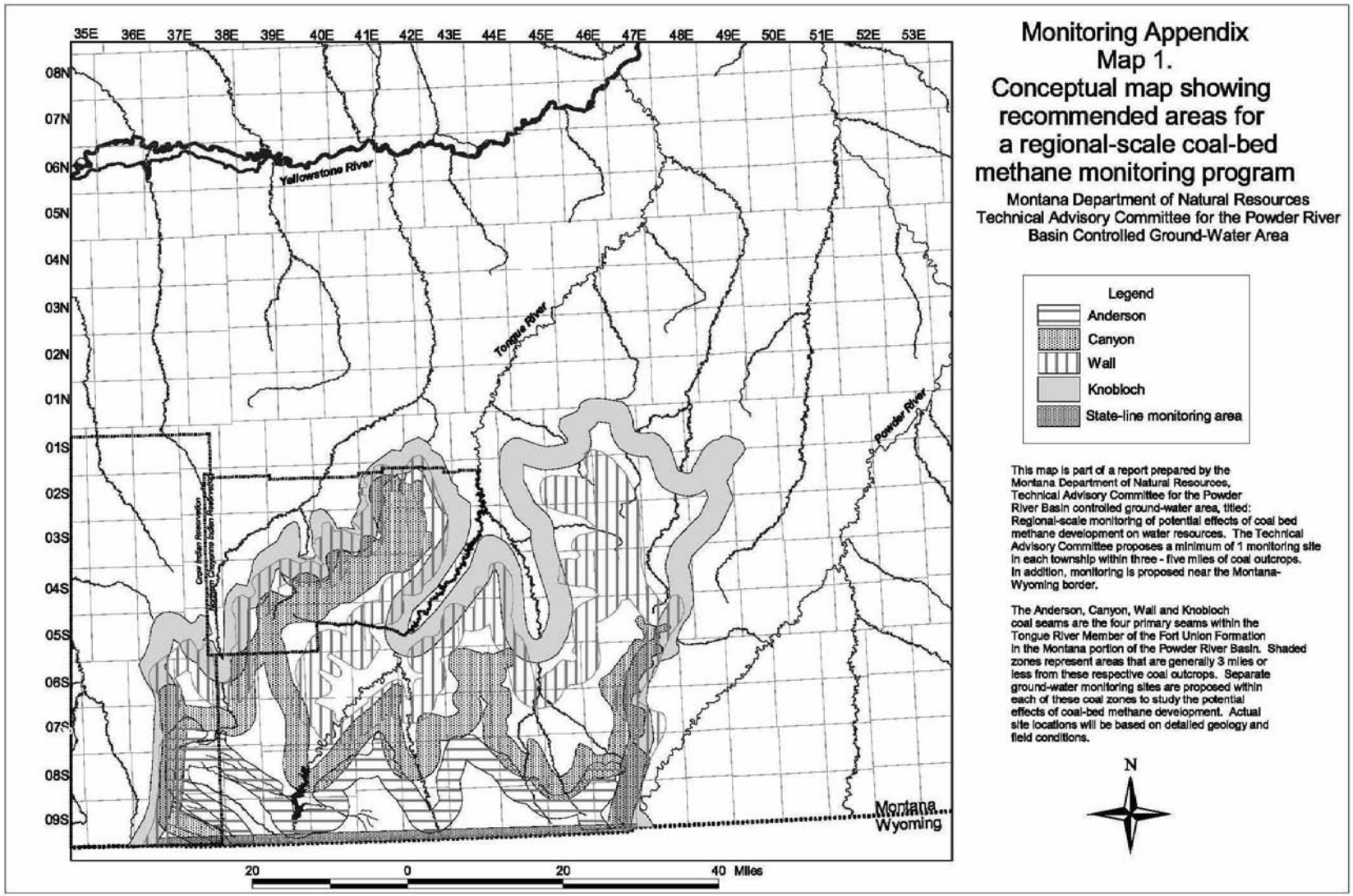
- Monitoring sites need to be located in every township near coal outcrops at a minimum.

- Groundwater levels in wells and flows from springs need to be measured monthly to characterize ambient seasonal patterns.

- Monitoring sites need to be established to ensure that the regional monitoring program is implemented in advance of localized CBNG development and, consequently, that potential effects can be detected.

- One oversight agency or interagency group responsible for collecting and compiling comprehensive and consistent data should implement the proposed regional monitoring program.

- Monitoring data need to be compiled and made available to the public through GWIC and NRIS.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Powder River
Crow Indian Reservation
Northern Cheyenne Indian Reservation
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Monitoring Appendix
Map 1.
Conceptual map showing recommended areas for a regional-scale coal-bed methane monitoring program
Montana Department of Natural Resources
Technical Advisory Committee for the Powder River Basin Controlled Ground-Water Area
Legend
Anderson
Canyon
Wall
Knobloch
State-line monitoring area
This map is part of a report prepared by the Montana Department of Natural Resources, Technical Advisory Committee for the Powder River Basin controlled ground-water area, titled: Regional-scale monitoring of potential effects of coal bed methane development on water resources. The Technical Advisory Committee proposes a minimum of 1 monitoring site in each township within three - five miles of coal outcrops. In addition, monitoring is proposed near the Montana-Wyoming border.
The Anderson, Canyon, Wall and Knobloch coal seams are the four primary seams within the Tongue River Member of the Fort Union Formation in the Montana portion of the Powder River Basin. Shaded zones represent areas that are generally 3 miles or less from these respective coal outcrops. Separate ground-water monitoring sites are proposed within each of these coal zones to study the potential effects of coal-bed methane development. Actual site locations will be based on detailed geology and field conditions.
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