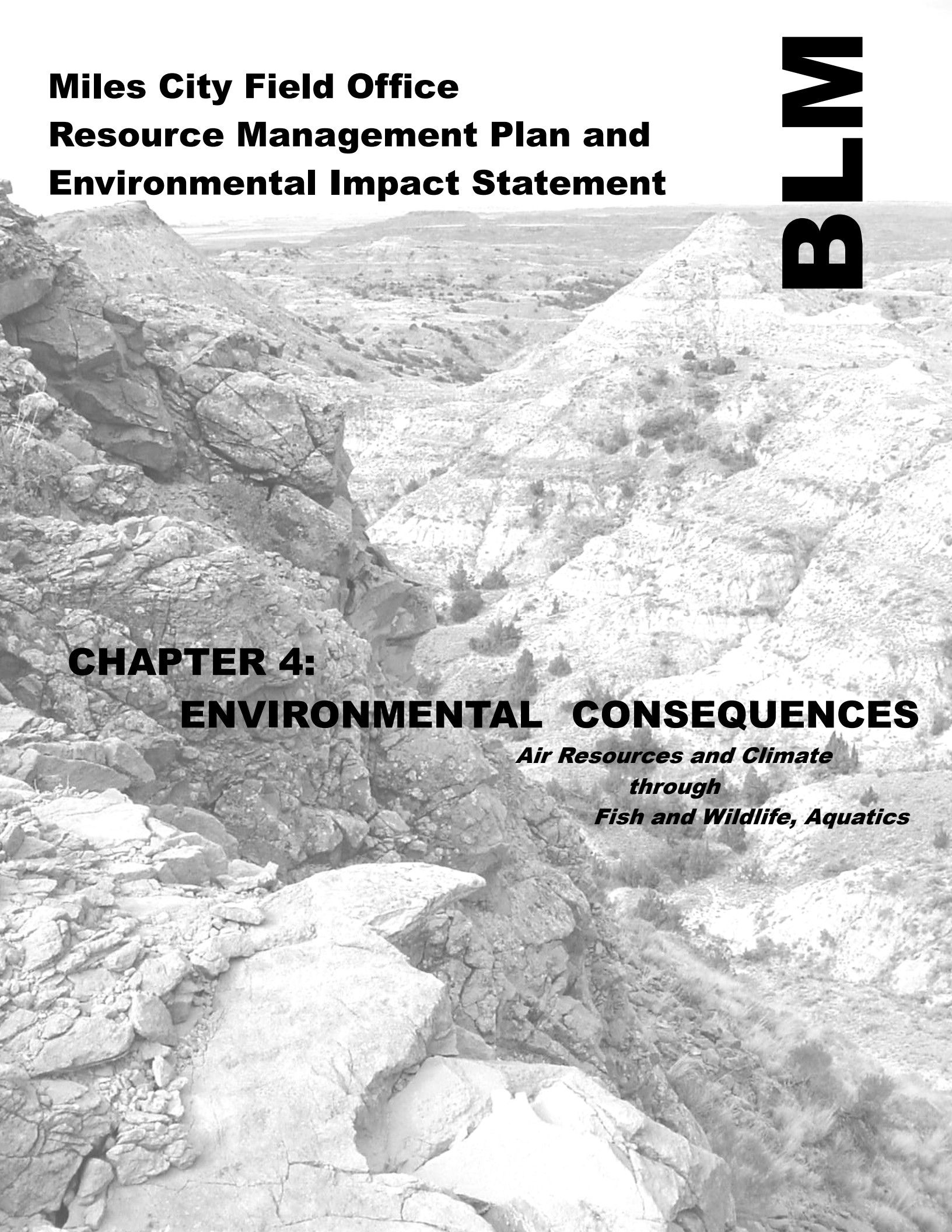
Miles City Field Office Resource Management Plan and Environmental Impact Statement

BLM



CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

Air Resources and Climate
through
Fish and Wildlife, Aquatics

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES, SECTION 1

INTRODUCTION

Chapter 4 presents the likely direct, indirect, and cumulative impacts on the human and natural environments in terms of environmental, social, and economic consequences projected to occur when the alternatives presented in Chapter 2 are implemented. Because the alternatives generally describe overall management emphasis, the environmental consequences are most often expressed in comparative general terms.

Impact analyses and conclusions are based on the interdisciplinary team's knowledge of the resources and planning area, information provided by Bureau of Land Management (BLM) experts or those from other agencies, and information contained in pertinent existing literature. The current condition or situation as described in Chapter 3, *Affected Environment* was the baseline used for the impact analysis. Analysis assumptions have also been developed to help guide the determination of impacts (see *Analytical Assumptions*). Because this resource management plan (RMP) provides a broad management framework and because exact locations of development or management are often unknown, the analysis in this chapter represents best estimates of impacts. Impacts are quantified to the greatest extent practical with available data. In the absence of quantitative data, best professional judgment provides the basis for the impact analysis.

AVAILABILITY OF DATA AND INCOMPLETE INFORMATION

Although programmatic planning efforts typically utilize site-specific data to the extent possible, site-specific data is not always available. Some information was unavailable for use in developing the RMP, primarily because resource-specific inventories have not been conducted or completed. Data unavailable for development of this RMP included:

- regional oil and gas emission inventories appropriate for photochemical grid modeling,
- certain cultural surveys,
- planning-area-wide vegetation by species,
- detailed soil surveys for lands,
- certain wildlife inventory data (e.g., peregrine falcon nest sites or other sites),
- wildlife monitoring data,
- 100-year floodplain mapping,
- certain American Indian traditional use areas,
- detailed climate change impact data at the local level, and
- visitor use trend data for recreational areas.

As a result, some impacts could not be quantified in relationship to the proposed management actions. Where data is insufficient to quantify the potential impacts, the impacts are projected in qualitative terms or, in some cases, described as unknown. Subsequent project-level analysis of impacts would provide the opportunity to collect and examine site-specific inventory data necessary to determine appropriate application of the RMP programmatic level guidance. Ongoing inventory efforts by the BLM and other agencies within the planning area would be used to continually update and refine the information used to implement this plan.

ANALYTICAL ASSUMPTIONS

To estimate the impacts of the alternatives, several assumptions are made (Table 4-1). These are made only for the purpose of analysis and do not represent potential RMP decisions; however, the assumptions do provide reasonably foreseeable, projected levels of development that could occur within the planning area. These assumptions should not be interpreted to be constraining or redefining Chapter 2 management

objectives and actions proposed for each alternative. The following are the general assumptions applicable to all resource categories. Specific resource assumptions are provided in the subheading for that resource.

- Decisions and implementation of actions from any of the RMP alternatives would be in compliance with all valid existing rights, federal regulations, Bureau policies, and other requirements.
- Acre figures and other numbers used in the analysis are approximate projections for comparison and analytical purposes only. Readers should not infer that they reflect exact measurements or precise calculations.

Throughout the planning area, BLM-authorized activities associated with all resource and all resource use programs would be subject to mitigation and minimization guidelines and best management practices (BMPs) (see the *Best Management Practices Appendix*) including those specific *Mitigation Measures, Conservation Actions, and Best Management Practices* for greater sage-grouse (see the *Best Management Practices Appendix*). For analysis purposes, it has been assumed that these measures and conservation actions would be implemented during site-specific project planning, where appropriate.

TABLE 4-1.
ASSUMPTIONS FOR THE ANALYSES (SHORT- AND LONG-TERM EFFECTS TO BLM-ADMINISTERED ACRES)

Resource	Acres Affected in the Short-term (5 years)	Acres Affected in the Long-term (20 years)
Vegetation	17,500 prescribed fire	70,000 prescribed fire
Vegetation Treatments	12,000 mechanical	80,000 mechanical
Recreation Facilities	N/A	50 to 500 (10 to 50 facilities)
Livestock Grazing (range improvements) Pits or Reservoirs	49.5	198
Wells	6.75	27
Pipelines	6	24
Fences	<1 (0.7)	2.8
Oil and Gas	3,524	1,352
Coal Bed Natural Gas (CBNG)	139	134
Locatable Minerals	100	100
Mineral Material	50	50
ROWs	550	2,200
Overhead Power lines	<1 (0.12)	<1 (0.12)
Major Pipelines (5)	600	1,440
Major Power line (1)	60	480
Railroad Right-of-Way (ROW)	140	N/A
Carbon Sequestration Test	6	15
2920 Permits	3	150
Wind Energy	50 to 75	350 to 525
Solar Energy	N/A	500

TYPES OF IMPACTS

DIRECT AND INDIRECT

Consistent with direction provided in 40 Code of Federal Regulations (CFR) 1502.16, direct, indirect, and cumulative impacts were considered in this impact analysis. Direct impacts are caused by implementation of an action or alternative and occur at the same time and place. Indirect impacts also result from implementation of an action or alternative but usually occur later in time or further removed in distance. Indirect impacts are reasonably certain to occur.

Impacts were quantified, where possible, primarily using geographic information systems (GIS) applications. In the absence of quantitative data, best professional judgment prevailed; subsequently, impacts are sometimes described using ranges of potential impacts or qualitative terms.

Only management programs with impacts were included in Chapter 4. The standard definitions for terms referring to impact duration used in the impact analysis are as described below, unless otherwise stated.

- Short-term impact: The impact occurs only during implementation or immediately after implementation of the alternative. For the purposes of this RMP, short-term impacts would occur during the first 5 years.
- Long-term impact: The impact could occur for an extended period after implementing the alternative. The impact could last several years or more and could be beneficial or adverse. For the purposes of this RMP, long-term impacts would occur beyond the first 5 years.

CUMULATIVE IMPACTS

Cumulative impacts are defined as the direct and indirect impacts of a proposed project alternative's incremental impacts in combination with other past, present, and reasonably foreseeable actions, regardless of who carries out the action (40 CFR Part 1508.7). Guidance for implementing the National Environmental Policy Act (NEPA) requires that federal agencies identify the timeframe and geographic boundaries within which they would evaluate potential cumulative impacts of an action and the specific past, present, and reasonably foreseeable projects that would be analyzed. Impacts of past actions and activities on resources are manifested in the current condition of the resource, which is described in Chapter 3, *Affected Environment*, for resources on BLM-administered lands.

Actions anticipated over the next 20 years on all lands in the planning area, including those with private, state (Montana Fish, Wildlife, and Parks [MFWP] and the Montana Department of Natural Resources and Conservation [MDNRC]), and federal (United States Forest Service [USFS], Bureau of Reclamation, National Park Service, and the United States Fish and Wildlife Service [USFWS]) ownership or administration, have been considered in the analysis to the extent reasonable and possible, by resource and program area. The analysis remains general because decisions about other actions in the planning area could be made by many other public and private entities, and the location, timing, and magnitude of such actions cannot be predicted. Actions outside of the BLM's jurisdiction considered in the cumulative impacts analysis include:

- those pertaining to the Tongue River Railroad Project (near Colstrip and Decker, Montana);
- an increase in the number of conservation easements within the planning area to prevent subdivisions and development;
- increased purchase or operation of private land for purposes other than commodity production (including recreational, philosophical, and quality of life values);
- continued vegetation manipulation on private lands, which might lead to a decrease in sagebrush canopy;
- continued timber harvest on MDNRC lands;
- the continuation and maintenance of commercial saw log harvest by the USFS;
- the increased use of prescribed and natural ignition fires by the USFS;
- the expectation that large-scale, stand-replacing wildfires would be expected to cross into lands under the jurisdiction of the Miles City Field Office (MCFO);
- the continuation of livestock and wildlife grazing on state lands;
- increased use of communication sites and corridors;
- continued development of unincorporated areas;
- continued county maintenance of roads under the jurisdiction of counties within the RMP area;
- those pertaining to the Nelson Creek Project (near Circle, Montana, in McCone County) 500-megawatt, lignite-burning, coal-fired power plant;
- an increased number of concentrated animal feeding operations;
- an annual average of 90 wildfires that burn an average of 34,582 total acres of federal surface (the average fire size is 400 acres in grass/shrub fuel types and 25 acres in forested fuel types) in the Eastern Montana Fire Zone (20-year average as of December 31, 2006), which includes BLM-administered, USFS, USFWS, and state lands;
- increasingly consolidated private land holdings to form larger private land ownership holdings;
- an increase in private lands leased for outfitted hunting opportunities, resulting in more pressure to BLM-administered lands;

- the continuation of increased demands for energy (oil, gas, coal, and alternative sources such as wind) on federal, state, and private mineral estate; and
- continued alteration of hydrologic function on and off public lands due to reservoir and pit construction and implementation or continuation of fish passage projects to restore historic migratory patterns on the Tongue and Yellowstone rivers and important tributary streams.

For a description of the impacts from management actions in Chapter 2, see below or, for electronic drafts, click on the following link to take you to a specific resource:

Air Resources and Climate; Fish and Wildlife (Aquatics, including Special Status Species); Soils; Vegetation – Invasive Species; Vegetation - Riparian and Wetland Areas; Vegetation (including Special Status Species – Plants); and Water Resources.

RESOURCES

This section of Chapter 4, *Environmental Consequences*, contains a description of potential impacts to existing biological and physical resources of the planning area and follows the order of topics addressed in Chapter 2 as follows:

- Air Resources and Climate,
- Soil,
- Water Resources,
- Vegetation,
    - Riparian and Wetland Areas,
    - Invasive Species, and
- Fish and Wildlife,
    - Aquatics (including Special Status Species).

See Volume II for the rest of Chapter 4, *Environmental Consequences.*

AIR RESOURCES AND CLIMATE

ASSUMPTIONS AND METHODOLOGY

The air resources impact analysis includes emission inventories for each alternative, quantitative analysis for near-field air resource impacts from oil and gas activity, and qualitative descriptions of potential far-field impacts to air pollutant concentrations and air quality related values (AQRV), including visibility and deposition.

Emission inventories include BLM sources and non-BLM sources within the planning area. Criteria pollutants include carbon monoxide (CO), nitrogen oxide (NO_x), ozone (O_3), fine particulate matter ($PM_{2.5}$), particulate matter (PM_{10}), and sulfur dioxide (SO_2), as well as volatile organic compounds (VOCs), which are ozone precursors. Hazardous air pollutants (HAPs), such as benzene and toluene, are also included in the inventories. Lead emissions were not estimated because there are few lead-emitting sources in the planning area. As described in Chapter 3, *Affected Environment*, ozone is not emitted directly into the atmosphere; instead, it is formed in atmospheric reactions involving nitrogen oxide and VOCs. Emissions of greenhouse gases (GHGs) (carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]) are described in the climate change impact analysis. An emissions inventory was completed for the planning area and is included in the *Miles City Field Office Resource Management Plan Air Resource Technical Support Document* (BLM 2013).

Proposed management activities would cause GHG emission increases from many types of sources. This section quantifies GHG emissions from each alternative and provides a qualitative discussion of potential climate impacts. As described in Chapter 3, *Affected Environment*, climate change is occurring and will continue to occur for many years because of the longevity of GHGs that are already in the atmosphere. Approximate atmospheric lifetimes for carbon dioxide, methane, and nitrous oxide are 50 to 200 years, 12

years, and 120 years, respectively (USEPA 2010i). Consequently, GHG emissions would cause long-term climate change impacts.

Ongoing scientific research has identified the potential impacts of GHG emissions on climate change. Through complex interactions at regional and global scales, atmospheric GHG concentrations cause a net warming of the atmosphere (which makes surface temperatures suitable for life on Earth), primarily by decreasing the amount of heat energy Earth radiates back into space. Although GHG concentrations in the atmosphere and climatic conditions have varied throughout Earth's history, industrialization and combustion of fossil fuels have caused global atmospheric carbon dioxide concentration to increase dramatically (NRC 2006). Global atmospheric concentrations of carbon dioxide are expected to increase from 385 parts per million (ppm) in 2008 to more than 400 ppm by 2020 and may plateau at 450 ppm if emissions are stabilized at current or reduced levels (Karl, Melillo, and Peterson 2009).

The global increase in carbon dioxide concentrations is due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are due to agricultural soil management, animal manure management, sewage treatment, and mobile and stationary combustion of fossil fuels (IPCC 2007). According to climate change researchers, the impacts of climate change are expected to vary by region, season, and time of day (NRC 2006; Karl et al. 2009). Computer model forecasts indicate that increases in temperature will not be evenly or equally distributed but are likely to be accentuated at higher latitudes.

The lack of scientific tools (models with sufficient spatial and temporal resolution) to forecast climate change at local scales limits the ability to quantify many future impacts of climate change in the planning area. The following paragraphs describe potential future impacts of climate change that can be reasonably anticipated for the region; some of these impacts are known to already be occurring. However, over the next 20 years, tools may become available that will allow for better local analysis of climate change impacts and for better capability to predict carbon storage. The United States Geological Survey (USGS), for example, is developing GIS-based tools to determine the carbon storage of specific soils. Ongoing research is analyzing the response of different vegetation types to increasing carbon dioxide, longer growing seasons, higher heat, and more unpredictable rain patterns.

The Earth's atmosphere is warming and these warming trends are expected to continue through the life of this plan. Climate changes predicted for the region include the changes described below.

- Surface temperature: average annual temperatures may increase 3 to 5 degrees (°) Fahrenheit (F) from the 1960 to 1979 baseline years by the mid-21st century (Karl et al. 2009). The largest increase in average temperature is likely to occur in the winter months. Relatively cold days in the region are becoming less frequent and relatively hot days are becoming more frequent (Karl et al. 2009).
- Precipitation: regional precipitation is expected to increase during winter and spring, decrease during summer, and remain relatively stable during fall (Karl et al. 2009).

Within North America, warming is predicted to affect many resources and human health. In western mountain areas, warming is projected to cause decreased snowpack, more winter flooding, and reduced summer river and stream flows, which would exacerbate competition for water resources and could cause declining water quality. The warming of lakes and rivers would adversely affect the thermal structure and water quality of hydrological systems, which would add additional stress to water resources in the region (IPCC 2007). The region depends on springtime snowpack to meet demand for water from municipal, industrial, agricultural, recreational uses, and BLM-authorized activities. The USGS notes that mountain ecosystems in the western United States are particularly sensitive to climate change, particularly in the higher elevations, where much of the snowpack occurs. Some of these areas have experienced three times the global average temperature increase over the past century (USGS 2010a). Higher temperatures are also causing more winter precipitation to fall as rain rather than snow, which would contribute to earlier snowmelt. Additional declines in snowmelt associated with climate change are projected, which would reduce the amount of water available during summer (Karl et al. 2009). Rapid spring snowmelt resulting from sudden and unseasonal temperature increases could also lead to greater erosive events and unstable soil conditions.

Increasing temperatures could also increase the amount of water vapor in the atmosphere, the timing and amount of precipitation, and the intensity of storm systems. Climate models predict continued increases in the heaviest rainfall events, while the lightest precipitation is predicted to decrease. Heavy downpours that are now 1-in-20-year occurrences are predicted to occur approximately every 4 to 15 years by the end of this century, depending on location, and the intensity of heavy downpours is also expected to increase.

There is evidence that recent warming is affecting aquatic biological systems (IPCC 2007). Increases in algal abundance in high-altitude lakes have been linked to warmer temperatures, while range changes and earlier fish migrations in rivers have also been observed (IPCC 2007). Increased temperatures would raise water temperatures in lakes, reservoirs, rivers, and streams. Fish populations are expected to decline due to warmer waters, which could lead to the closure of fishing waters (Saunders, Montgomery, Easley, and Spencer 2008).

Climate change is likely to combine with other human-induced stress to further increase the vulnerability of ecosystems to pests, invasive species, and loss of native species. Warming temperatures are leading to earlier timing of spring events such as leaf-unfolding, bird migration, and egg-laying (IPCC 2007). The range of many plant and animal species is shifting north and to higher elevations, as the climate of these species' traditional habitat changes (Lawler et al. 2009). Warming temperatures are also linked to longer thermal growing seasons (IPCC 2007). Climate change is likely to affect wildlife breeding patterns, water and food supply, and habitat availability to some degree. Sensitive species in the planning area, such as sage-grouse, which are already stressed by declining habitat, increased development, and other factors, could experience additional pressures as a result of climate change.

Increases in average summer temperatures and earlier spring snowmelt in the region are expected to increase the risk of wildfires by increasing summer moisture deficits (Karl et al. 2009). Studies have shown that earlier snowmelts can lead to a longer dry season, which increases the incidence of landscape-level fire (Westerling, Hidalgo, Cayan, and Swetnam 2006b). Together with historic changes in land use, climate change is anticipated to affect the variability in the occurrence of wildfire throughout the western United States. Although the impact of climatic factors varies by ecosystem type and from year to year, drought, low winter precipitation, wind conditions, and high summer temperatures are positively associated with wildfire occurrence (Ashton 2010). During the last 20 years, research has shown that these factors have led to an increase in the frequency of very large wildfires and total acres burned throughout the region (Ashton 2010).

Climate change also poses challenges for many resource uses on BLM-administered land. Increased temperatures, drought, and evaporation may reduce seasonal water supplies for livestock and could impact forage availability. However, in non-drought years, longer growing seasons resulting from thermal increases may increase forage availability throughout the year. In the next few decades, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20 percent, but with important variability among regions (NRC 2011). Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources. Shifts in wildlife habitat due to climate change may influence hunting and fishing activities, and early snowmelt may impact winter and water-based recreational activities. Drought and resulting stress on vegetation could increase the frequency and intensity of mountain bark beetle and other insect infestations.

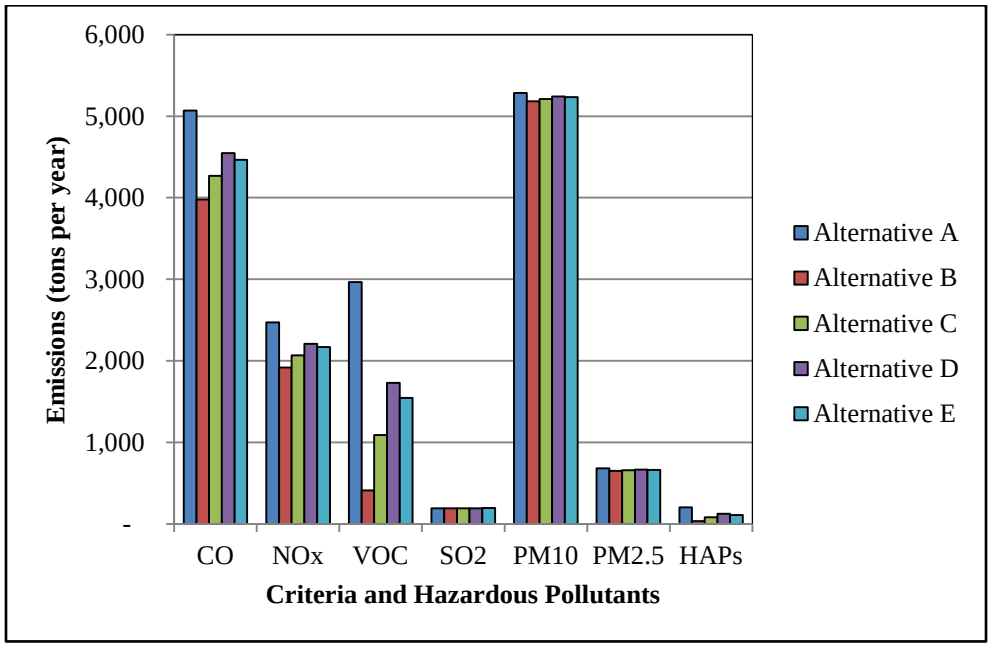
Climate change science and predictions of climate change impacts are a continually growing and emerging science. Additional and recent information on climate change and regional predictions can be found at the United States Global Change Research Program (http://www.globalchange.gov/) and the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/).

MANAGEMENT COMMON TO ALL ALTERNATIVES

BLM emission sources include fluid mineral development (conventional natural gas, CBNG, and oil), solid mineral development (primarily coal), fuels management (prescribed fire, mechanical vegetation treatment), resource road maintenance, forest and woodland treatments, livestock grazing, vegetation management, recreation, and general BLM travel. These emissions would be long-term emissions because most activities would be expected to occur over the life of the plan. However, if activities ceased, concentrations of criteria air

pollutants and HAPs would decrease through emission reductions. In this respect, air resource impacts would be short-term, reversible impacts. BLM-authorized emissions of criteria pollutants and HAPs are shown in Figure 4-1.

FIGURE 4-1.
CRITERIA AND HAZARDOUS AIR POLLUTANT EMISSIONS FROM BLM SOURCES IN THE PLANNING AREA



For each of the alternatives, the largest BLM criteria pollutant and HAP emission sources would be associated with coal mining, fluid mineral development, and fire management. Detailed emission breakdowns by resource are included for each of the alternatives. For most of these resources, emissions would be similar to emissions associated with current levels of activity. For example, forestry management and general BLM travel would not be expected to increase over current activity levels and emissions from these activities would remain relatively constant. Consequently, emissions from these ongoing resource management activities would not represent increases to regional emissions. However, oil and gas activity emissions would reflect increased activity in future years and would add to regional emissions. Oil and gas emission estimates reflect the year with the greatest total emissions from development and production activities.

Oil and gas emission inventories were generally based on emission standards required by the Montana Department of Environmental Quality (MDEQ) and United States Environmental Protection Agency (USEPA). An exception is emission estimates based on the use of Tier 4 nonroad engine standards for diesel drill rig engines, which would be required under BMPs and as an initial mitigation measure. A list of initial mitigation measures to be applied upon issuance of the ROD is included in the air resource management plan (ARMP) provided in the *Air Resources and Climate Appendix*. For drill rig and completion engines greater than 750 horsepower, generator set engines with low emission rates were assumed when developing the emission inventories. With regard to other oil and gas emission sources, emissions were estimated conservatively because they do not include more stringent emission controls mandated by the USEPA on August 16, 2012, nor do these inventories account for the use of newer, cleaner non-drill-rig engines that will replace older engines. The USEPA's August 16, 2012 *New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants* would substantially decrease emissions from many types of oil and gas equipment (USEPA 2012). For example, the final rule is expected to decrease national oil and gas VOC emissions by approximately 25 percent and substantially decrease HAP emissions. Some of these emission reduction requirements apply only to sources with emissions exceeding specified levels. For those types of sources, the oil and gas emission inventories assume no control in order to be conservative. Because some of these sources

would be subject to control, the emission inventories presented in this chapter overestimate emissions. The VOC and HAP portions of the oil and gas emission inventories will be updated in the final RMP to address these regulatory changes.

Emissions associated with each of the alternatives represent a fraction of the USEPA's National Emission Inventory emissions reported for calendar year 2008 (Table 4-2). Criteria pollutant emissions associated with management actions included in this RMP would be between 1.1 percent and 51.9 percent of total emissions in the planning area (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties). Although National Emission Inventory emissions include stationary sources, non-road sources, and vehicle sources, National Emission Inventory emissions do not necessarily include all existing oil and gas emissions since some small sources and many fugitive emissions have not been included historically. The oil and gas activity emissions represent a potential increase in county emissions because these emissions are associated with additional authorized activity. Emission increases associated with oil and gas activity vary from less than 0.01 percent to 47.1 percent of National Emission Inventory emissions.

TABLE 4-2.
ESTIMATED MAXIMUM ANNUAL CRITERIA POLLUTANT EMISSIONS AS A PERCENTAGE OF EXISTING EMISSIONS

Alternative	Percentage of Total Emissions Within Planning Area Counties (%) [1]					
	CO	NOx	VOC	SO_2	PM_{10}	$PM_{2.5}$
Alternative Emissions for Multi-Resource Activities Excluding Wildfire Smoke [2, 3]						
A	15.1	6.2	51.9	1.1	21.6	18.1
B	11.8	4.9	7.2	1.1	21.2	17.3
C	12.7	5.3	19.1	1.1	21.3	17.5
D	13.5	5.6	30.3	1.1	21.4	17.7
E	13.3	5.5	27.1	1.2	21.4	17.6
Increase Due to Oil and Gas Activity Emissions [4]						
A	3.4	1.3	47.1	0.01	0.4	0.8
B	0.2	0.1	2.4	<0.01	0.0	0.05
C	1.0	0.5	14.2	<0.01	0.1	0.3
D	1.9	0.7	25.4	<0.01	0.2	0.5
E	1.6	0.6	22.2	0.01	0.2	0.4

[1] Counties included in the National Emission Inventory comparison include Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties.
[2] Wildfire smoke is excluded since it is caused by natural events and is not included as part of the National Emission Inventory.
[3] A large share of these emissions are from activities that are already occurring; therefore, they do not necessarily represent an increase in emissions over current emission inventories.
[4] Oil and gas emissions represent an increase above National Emission Inventory emissions because they are associated with new well development and production.

Near-field Criteria Air Pollutant Concentrations from Oil and Gas Activities

Near-field dispersion modeling was performed for oil and gas development for drilling and completion of wells, in addition to well pad construction activities. The USEPA guideline model for estimating near-field impacts is the AERMOD dispersion model. AERMOD is suitable for modeling discrete sources of emissions to a distance of 50 kilometers from the source, and provides conservative estimates of potential air quality impacts from such sources. Receptors were placed in the modeling domain, which extended 3 kilometers from the center of the central well pad. Information describing AERMOD meteorology, modeling parameters, and data processing is provided in the *Near-Field Air Quality Assessment Protocol for Resource Management Plans and Environmental Impact Statements: Billings Field Office, HiLine District, Miles City Field Office, South Dakota Field Office* (BLM 2012c). Emission inventories for each alternative and detailed near-field modeling results are provided in the *Miles City Field Office Air Resource Technical Support Document* (BLM 2013) and summarized below.

Three well pad development scenarios (construction, drilling, and completion) were modeled at a central well pad. Well development activities would be temporary and occur at different times. Well pad construction would occur first over a period of up to 3 days of active site construction involving soil movement (e.g., digging and

grading). Drilling would occur next, with up to 15 days of active drilling. Then well completion would occur for up to 5 days. Once well development is complete, a long-term production phase typically begins. The construction modeling scenario has the greatest short-term (24-hour) emission rates for particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$). Temporary drilling activities account for the greatest short-term (1-hour) emission rates for all non-particulate criteria air pollutants. Completion activities have greater non-particulate emissions than the construction phase. In order to represent production activities at nearby wells, estimated oil and gas production emissions were modeled at four producing wells surrounding the central pad. Production emissions at outlying pads were modeled concurrently with each of the three well development scenarios (construction, drilling, and completion).

Modeled concentrations were compared to National Ambient Air Quality Standards (NAAQS), Montana Ambient Air Quality Standards (MAAQS), and Prevention of Significant Deterioration (PSD) increments. Comparisons to the NAAQS and MAAQS were performed by summing modeled concentrations with background concentrations (representing current air quality) and comparing the total concentrations to the standards. The results of the near-field modeling performed for Alternative A are shown in Table 4-3. Alternative A near-field modeling represents dense well pad and equipment spacing that could occur in localized areas within high potential oil and gas activity areas; because this dense spacing could also occur under Alternatives B, C, D, and E, the Alternative A modeling results conservatively predict impacts that could occur in localized areas under each of the alternatives.

Table 4-3 summarizes modeled results by showing the largest modeled and total concentrations based on the three scenarios and 5 years (2005 through 2009). Additional modeling results are included in the air resource technical support document (BLM 2013). For example, the maximum total 1-hour carbon monoxide concentration of 7,534 micrograms per cubic meter (µg/m3) was predicted during the drilling scenario using 2009 meteorology. Predicted concentrations were below the NAAQS and MAAQS, as shown by the percentages in the last column of the table. Total concentrations of 50 percent of a NAAQS or greater were predicted for the 1-hour nitrogen dioxide (NO_2), 24-hour particulate matter (PM_{10}), and 24-hour fine particulate matter ($PM_{2.5}$) standards. The maximum 1-hour nitrogen dioxide impacts were due to heavy-duty construction equipment exhaust during the brief well construction period. Maximum 24-hour particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) impacts occurred during short-term construction-related activities. Predicted ambient concentrations associated with production activities were much less than emissions associated with temporary activities.

Modeled concentrations can also be compared to PSD increments, which are designed to prevent good air quality from deteriorating to the level set by the NAAQS. In areas attaining the NAAQS, PSD increment analysis is required prior to construction of a major stationary source of air pollutants that have the potential to emit at least 100 tons per year (tpy) or 250 tpy of a criteria air pollutant. The sources included in this near-field modeling analysis do not meet the definition of a major source of criteria air pollutants and would not be required to undergo PSD analysis. The following PSD analysis is not a regulatory analysis; its purpose is to provide context for evaluating potential air quality impacts.

The USEPA established PSD increments for Class I areas (e.g., national parks and large wilderness areas) and Class II areas (all non-Class I areas). Oil and gas activities are expected to occur within Class II areas and the modeled (not total) concentration can be compared directly to the Class II increment. Temporary 24-hr particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) concentrations greater than the Class II PSD increments are predicted to occur during construction and completion activities. Temporary concentrations above the Class I increments for particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) are also possible during construction, drilling, and completion if these activities were located very close to a Class I area.

Air pollutant concentrations generally decrease as distance from the source increases. Figure 4-2 provides an illustration of 24-hr particulate matter (PM_{10}) modeled concentrations during construction activity. At the center of the figure is a well pad with short-term construction activities. The four surrounding well pads are modeled with emissions representing production activity. Red markers indicate emission sources and green markers indicate receptors (points at which concentrations are calculated). Shaded areas indicate the extent of the area for which particulate matter (PM_{10}) concentrations are predicted to be greater than the PSD Class I increment

(8 µg/m3) or Class II increment (30 µg/m3) on the day with the second-highest particulate matter (PM_{10}) modeled concentration during 2005. Wells would be located in Class II areas and concentrations above the Class II PSD increment are predicted to extend up to approximately 300 meters from the well pad boundary. In order for concentrations to exceed the Class I increment, well pad construction activity would need to be within approximately 1,500 meters of a Class I area. Concentrations of these magnitudes could occur only on days when well pad construction activity is concurrent with meteorological conditions causing high ambient particulate matter (PM_{10}) concentrations.

TABLE 4-3.
NEAR-FIELD NAAQS MODELING SUMMARY FOR ALL ALTERNATIVES

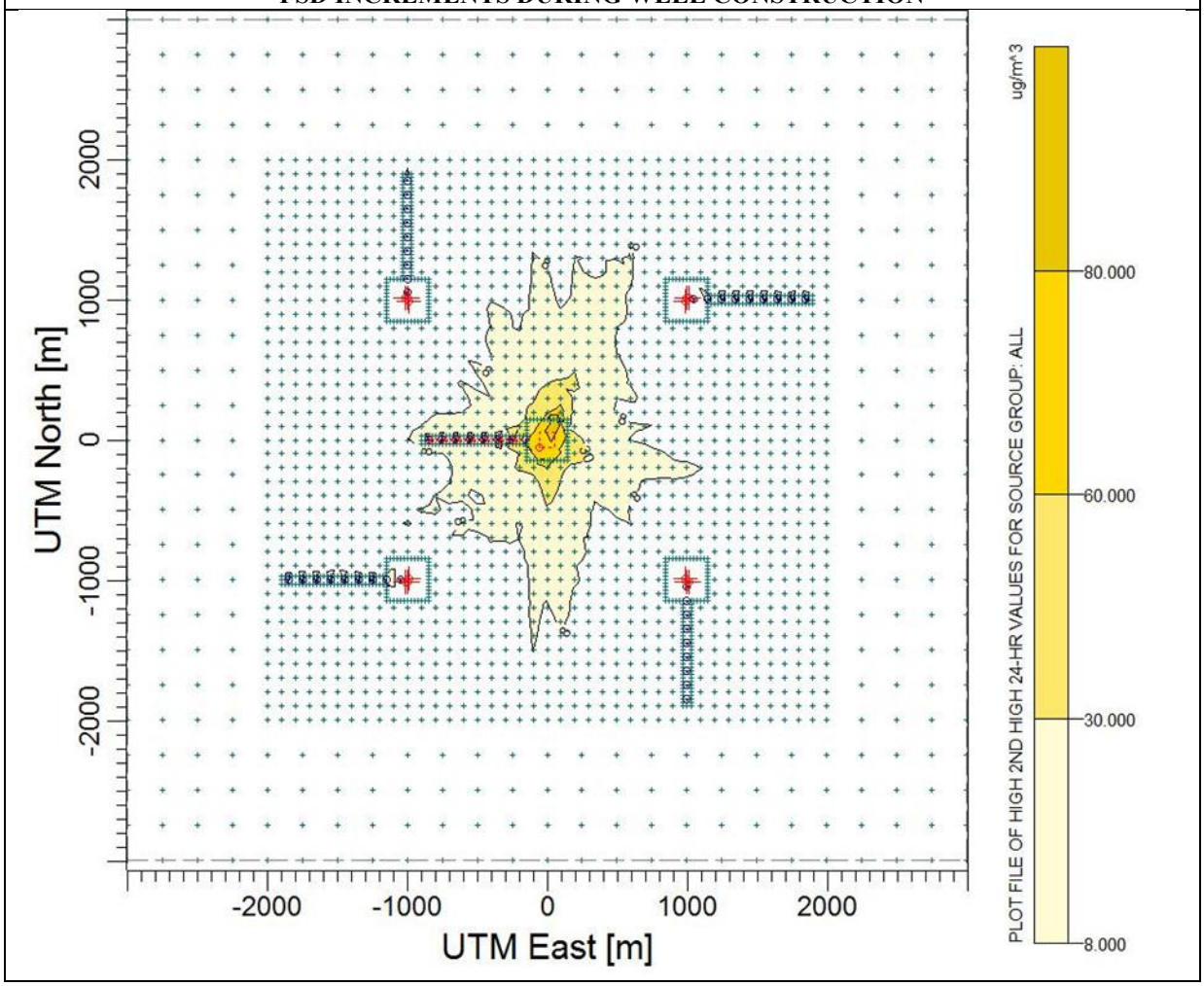
Pollut.	Avg. Period	Model Output Rank	Value (µg/m³)						Percentage of NAAQS (%)
			Modeled Conc.	PSD Increment		Bckgrnd Conc.[1]	Total Conc.	NAAQS or MAAQS	
				Class I	Class II				
CO	1-hour	H2H	321	None	None	7,213	7,534	26,450[6]	28
	8-hour	H2H	231	None	None	2,175	2,406	10,000	24
NO_2	1-hour	H8H [2]	89.7	None	None	40	129.7	188	69
	Annual	H1H [3]	2.8E-02	2.5	25	6	6.28	94[6]	7
PM_{10}	24-hour	H2H	108.0	8	30	30	138.0	150	92
	Annual	H1H	0.6	4	17	8	8.6	50[6]	17
$PM_{2.5}$	24-hour	H8H [4] (H2H)[7]	9.2	2	9	22.5	31.7	35	91
	Annual	H1H	0.86	1	4	5.5	6.36	15	42
SO_2	1-hour	H4H[5]	3.3	None	None	35	38.3	196	20
	24-hour	H2H[3]	0.58	5	91	11	11.58	365[6]	4
	Annual	H1H[2]	1.12E-03	2	20	3	3.00	80[6]	6

H1H = highest-first-high
H2H = highest-second-high
H4H = highest-fourth-high
H8H = highest-eighth-high
[1] Background concentrations were provided by the MDEQ (MDEQ 2012a; MDEQ 2012b).
[2] 5-year average of the 98th percentile (H8H) 1-hour modeled NO_2 concentrations. Post processed using the 1-hour and annual NO_2 Tier 2 method using 80 percent conversion of modeled NO_x to NO_2.
[3] Post processed using the annual NO_2 Tier 2 method using 75 percent conversion of modeled NO_x to NO_2.
[4] 5-year average of the 98th percentile (H8H) 24-hour modeled $PM_{2.5}$ concentrations.
[5] 5-year average of the 99th percentile (H4H) 1-hour modeled SO_2 concentrations.
[6] This is a Montana standard.
[7] The H2H rank provided in parentheses is used to compare to the PSD increments, while the H8H rank is compared to the NAAQS.

Near-field Hazardous Air Pollutant Concentrations from Oil and Gas Activities

Near-field modeling was also conducted to determine predicted ambient air quality impacts of HAP emissions. HAPs are defined by the USEPA as toxic air pollutants known or suspected to cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental effects. Similar to the NAAQS modeling, HAP modeling consisted of construction, drilling, and completion of wells. Modeled impacts were compared to established health-based thresholds to determine the incremental increase in risk associated with the proposed activities. Health-based thresholds are established for both short-term (acute, typically 1-hour) and long-term (chronic, 1-year) exposures. The short-term thresholds used in the analysis consisted of acute reference exposure levels and are defined as short-term concentrations at or below which no adverse health effects would be expected. The long-term non-carcinogenic thresholds used in the analysis consisted of chronic reference concentrations and are the threshold at which no long-term, non-carcinogenic adverse health effects would be expected. The long-term carcinogenic thresholds used in the analysis consisted of unit risk factors to estimate the increased risk of developing cancer associated with the ambient concentration of the HAP being analyzed. Six HAPs were modeled (benzene, ethyl benzene, formaldehyde, n-hexane, toluene, and xylene) (Table 4-4).

FIGURE 4-2.
EXTENT OF PM_{10} CONCENTRATIONS ABOVE PSD INCREMENTS DURING WELL CONSTRUCTION



To estimate the incremental increase in risk, the modeled impacts were compared directly to reference exposure levels. Table 4-5 presents the results of the acute HAP modeling. The maximum acute impacts for benzene, formaldehyde, n-hexane, toluene, and xylene were associated with drilling operations. The maximum impacts for ethyl benzene were associated with well completions. Acute HAP modeling impacts were well below the reference exposure levels. Table 4-6 presents the results of HAP modeling of potential chronic effects and compares them to reference concentrations.

Of the HAPs evaluated, only benzene, ethyl benzene, and formaldehyde are identified by the USEPA as being carcinogens. Unit risk factors for this analysis were derived based on assuming a person is exposed to the HAP for a 70-year lifetime. Cancer risk was estimated by calculating the annual model-predicted concentrations by the unit risk factor for each carcinogen. The resulting calculations were then scaled by adjustment factors to represent the most likely exposure and maximally exposed individual risks. The maximally exposed individual adjustment takes into account the lifetime of the project, which was assumed to be 50 years. The most likely exposure adjustment takes into account the average duration that a family remains at a residence as well as the time spent at home versus time spent elsewhere. Table 4-7 presents the results of the carcinogenic HAP modeling for both the most likely exposure and maximally exposed individual exposure assumptions. The

maximum cancer risks were associated with drilling operations and were well below an incremental increase in cancer risk of 1 per million.

TABLE 4-4.
HEALTH EFFECTS OF MODELED HAZARDOUS AIR POLLUTANTS

HAP	Short-term (Acute)	Long-term (Non-carcinogen)	Long-term (Carcinogen)
Benzene	X	X	X
Ethyl Benzene	X	X	X
Formaldehyde	X	X	X
N-Hexane	X	X	
Toluene	X	X	
Xylene	X	X	

Far-field Criteria Air Pollutant Concentrations

Far-field photochemical grid modeling would be performed in the future, as explained in the ARMP in the *Air Resources and Climate Appendix*. Photochemical grid modeling would assess ozone and other criteria pollutant concentrations and would be performed when adequate regional oil and gas emission inventories become available.

TABLE 4-5.
ACUTE SHORT-TERM HAZARDOUS AIR POLLUTANTS MODELING RESULTS FOR ALL ALTERNATIVES

HAP	Modeled 1-Hour Concentration ($\mu g/m^3$)	Reference Exposure Levels ($\mu g/m^3$)	Percentage of Reference Exposure Level (%)
Benzene	1.37	1,300	0.11
Ethyl Benzene	2.91	350,000	<0.1
Formaldehyde	7.49	55	14
N-Hexane	9.98	390,000	<0.1
Toluene	1.05	37,000	<0.1
Xylene	0.72	22,000	<0.1

Based on the highest-emitting alternative (Alternative A), a qualitative description of potential air quality impacts is provided below for each criteria air pollutant. Impacts to air pollutant concentrations would be direct impacts with durations similar to the duration of emission-producing activities. The impacts would be reversible because they decline or disappear when emissions cease. For each criteria air pollutant, impacts would be expected to be below the NAAQS and MAAQS based on recent monitoring in oil and gas areas. The Sidney monitor in Richland County had quality assured data for years 2009 to 2011 for most criteria air pollutants except sulfur dioxide (2011 data only). The Birney (Rosebud County) and Broadus (Powder River County) monitors had quality assured data for 2010 to 2011, with the exception of sulfur dioxide concentrations which were not monitored at these sites. Data for 2012 have not yet been quality assured by MDEQ.

TABLE 4-6.
CHRONIC NON-CARCINOGENIC HAZARDOUS AIR POLLUTANT MODELING RESULTS FOR ALL ALTERNATIVES

HAP	Modeled Annual Concentration ($\mu g/m^3$)	Reference Concentration ($\mu g/m^3$)	Percentage of Reference Concentration (%)
Benzene	0.02	3	<10.2
Ethyl Benzene	0.06	1,000	
Formaldehyde	0.02	9.80	
N-Hexane	0.36	700	
Toluene	0.03	5,000	
Xylene	0.01	100	

TABLE 4-7.
CARCINOGENIC HAZARDOUS AIR POLLUTANT MODELING RESULTS FOR ALL ALTERNATIVES

HAP	Modeled Annual Concentration ($\mu g/m^3$)	Unit Risk Factor $(\mu g/m^3)^{-1}$	Adjustment Factor	Cancer Risk (Per Million)	Risk Exceeds 1 Per Million?
Most Likely Exposure					
Benzene	0.025	7.80×10^{-6}	0.0949	0.02	No
Ethyl Benzene	0.064	2.50×10^{-6}	0.0949	0.02	No
Formaldehyde	0.018	1.30×10^{-5}	0.0949	0.02	No
Maximally Exposed Individual					
Benzene	0.025	7.80×10^{-6}	0.71	0.14	No
Ethyl Benzene	0.064	2.50×10^{-6}	0.71	0.11	No
Formaldehyde	0.018	1.30×10^{-5}	0.71	0.17	No

- Carbon monoxide: carbon monoxide concentrations are not monitored within the planning area because expected concentrations are low. A 3.4-percent emission increase (based on oil and gas activities under the highest-emitting alternative) in the planning area would cause a negligible increase in carbon monoxide concentrations.
- Nitrogen dioxide: nitrogen dioxide monitors in Birney and Broadus measured 2-year average 98th percentile 1-hour nitrogen dioxide concentration from 2010 to 2011 of 8 percent and 20 percent of the NAAQS. Based on 2009-2011 data, 1-hour nitrogen dioxide concentrations at Sidney were 9 percent of the NAAQS. An emission increase of approximately 1.3 percent in the planning area would cause a negligible increase in nitrogen dioxide concentrations in most areas. A larger increase in ambient concentrations may occur in some localized areas in which large engines operate continuously.
- Sulfur dioxide: the sulfur dioxide monitor in Sidney measured a 2011 average 99th percentile 1-hour concentration equivalent to 8 percent of the NAAQS. Because increased sulfur dioxide emissions would be less than 1 percent of planning area emissions and would be dispersed over large areas, these emissions would cause a negligible increase in sulfur dioxide concentrations.
- Particulate matter (PM_{10}): From 2010 to 2011, 24-hour second maximum particulate matter (PM_{10}) concentrations were approximately 37 percent and 66 percent of the NAAQS at the Birney and Broadus monitors, respectively. At Sidney, the 2009 to 2011 average was 64 percent of the standard. An emission increase of up to 0.4 percent would cause a negligible or minor increase in particulate matter (PM_{10}) concentrations. At locations with construction activities, vehicle traffic on unpaved

roads, or off-road travel, temporary particulate matter (PM_{10}) concentration increases may be moderate or high if adverse weather conditions occurred.

- Fine particulate matter ($PM_{2.5}$): The 2010 to 2011 average fine particulate ($PM_{2.5}$) concentrations were approximately 31 percent and 44 percent of the 24-hour NAAQS at the Birney and Broadus monitors, respectively. At Sidney, the 2009 to 2011 average was 39 percent of the NAAQS. For the fine particulate matter ($PM_{2.5}$) annual NAAQS, monitored values were 27 percent, 37, percent, and 40 percent of the NAAQS at the Birney, Broadus, and Sidney monitors, respectively. An emission increase of up to 0.8 percent in the planning area could cause a minor increase in fine particulate ($PM_{2.5}$) concentrations. At locations with construction activities, vehicle traffic on unpaved roads, or off-road travel, temporary fine particulate ($PM_{2.5}$) concentration increases may be moderate or high if adverse weather conditions occurred.
- Lead: lead emissions would be negligible.

Compared to the other pollutants described above, current ozone concentrations are closest to the NAAQS. Ozone concentrations are variable and highly dependent on weather conditions. Consequently, compliance with the ozone NAAQS is based on a 3-year average of the fourth-highest daily maximum 8-hour concentration. The Sidney monitor measured a 3-year average fourth-highest 8-hour ozone concentration of 0.056 ppm, which is equivalent to approximately 74 percent of the standard. At Birney and Broadus, the 2010 to 2011 2-year average fourth-highest daily maximum 8-hour concentrations were 74 and 73 percent of the NAAQS, respectively.

NO_x and VOC emissions contribute to ozone formation. BLM-authorized emission increases would be estimated to increase by up to 1.5 percent for nitrogen oxide and by 2.4 percent to 47.1 percent for VOCs, depending on the alternative. However, recent USEPA regulations imposing more stringent VOC emission controls will cause future VOC emission increases to be significantly less than predicted. Based on current monitoring data, cumulative emissions would be unlikely to cause or contribute to a violation of the ozone NAAQS.

Far-field AQRV Impacts

The best modeling method to determine far-field AQRV impacts for large modeling domains is photochemical grid modeling, which can model long-range regional transport of air pollutants that cause atmospheric deposition and visibility impacts. Reliable photochemical grid modeling requires comprehensive regional emission inventories and ambient monitoring data throughout the 48 contiguous United States. As described in the ARMP in the *Air Resources and Climate Appendix*, the BLM is actively acquiring data needed to perform photochemical grid modeling, which is expected to be completed after this RMP is finalized. For the Draft RMP, the following qualitative analysis is provided for atmospheric deposition and visibility. A request from the USFWS and the National Park Service (NPS) prompted a limited modeling effort using the CALPUFF model that would be performed to assess visibility impacts at the UL Bend Wilderness Class I area and the Medicine Lake Wilderness Class I area, and at nearby potential sensitive Class II areas. The CALPUFF modeling effort would include estimated emissions from BLM-authorized oil and gas activities. This modeling would be completed prior to publication of the Final Proposed RMP/EIS.

Sulfur and nitrogen deposition impacts would likely be minor at Class I and sensitive Class II areas. Increases in nitrogen oxide and sulfur dioxide emissions would be less than 10.5 percent and 0.01 percent, respectively. Potential total nitrogen and sulfur deposition would likely remain below the levels of concern (3.0 kg/ha/yr and 5.0 kg/ha/yr, respectively). Precipitation pH would be unlikely to become acidified because of predicted emission increases. The closest federally mandated Class I areas to oil and gas development areas are the Medicine Lake Wilderness in the planning area, the UL Bend Wilderness adjacent to the planning area, and Theodore Roosevelt National Park in North Dakota. Tribal Class I areas include the Northern Cheyenne and Fort Peck Indian Reservations. With regard to potential sensitive Class II areas listed in Table 3-5, some of these areas could experience small increases in deposition. As part of a future photochemical modeling effort, deposition impacts would be assessed as described in the ARMP included in the *Air Resources and Climate Appendix*.

Small increases in sulfur and nitrogen deposition would potentially cause minor potential lake acidification impacts at Class I and potential sensitive Class II areas. As part of a future photochemical modeling effort, lake acidification impacts would be assessed as described in the ARMP included in the *Air Resources and Climate Appendix*.

A qualitative analysis of visibility impacts based on the relative emission increase is provided below. Potential visibility impacts are likely to be small for the following reasons:

- increases in emissions of sulfur dioxide, nitrogen oxide, and fine particulate matter ($PM_{2.5}$) would be relatively low; and
- emission sources would be spread over a large geographic area that would likely lead to relatively low concentration increases of haze-inducing pollutants.

Under the highest-emission alternative, total emissions of nitrogen oxide and sulfur dioxide from existing and future activities would be approximately 2,668 tons per year, compared to National Emission Inventory emissions of 38,914 tons per year (Figure 4-3). This represents a regional emission increase of 7 percent; however, in localized areas with oil and gas activities, the percentage increase in emissions would be greater. As part of the future photochemical modeling effort mentioned above, visibility impacts at Class I and sensitive Class II areas would be assessed as described in the *Air Resources and Climate Appendix*.

Air Resource Management Plan and Adaptive Management Strategy for Oil and Gas Resources

The ARMP for oil and gas activities is provided in the *Air Resources and Climate Appendix*. The ARMP describes the air quality adaptive management strategy that would be used to assess future air quality and AQRVs. The goal of the strategy is to maintain the good air quality that the population in the planning area currently enjoys. By assessing monitored and modeled air resource and AQRV impacts, the BLM can identify mitigation measures to address unacceptable impacts that may be associated with future oil and gas development. As described in the ARMP, the BLM would work with the MDEQ and the AQTW to identify successful strategies to address air quality and AQRV concerns.

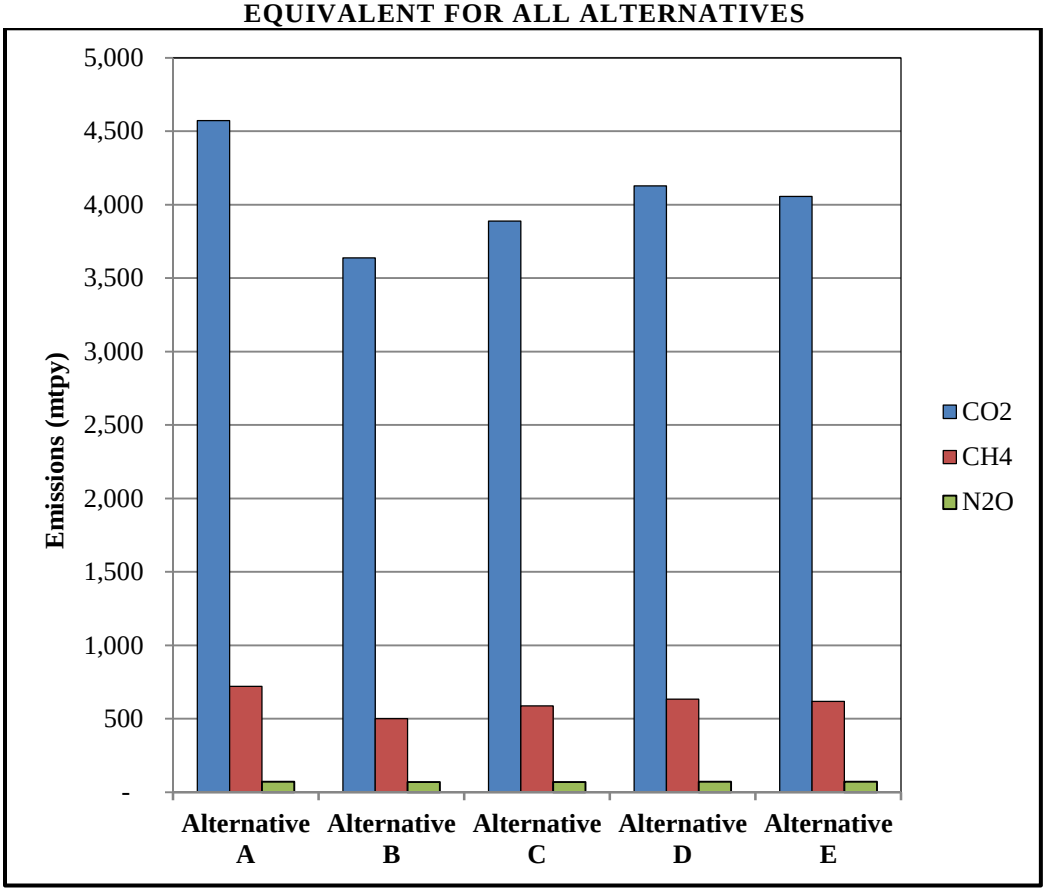
The adaptive management strategy focuses on oil and gas activity because aggregated emissions from multiple small sources at well sites can potentially cause significant air quality and AQRV impacts under certain circumstances. Many of these small oil and gas emission sources are not required to obtain air quality permits from the MDEQ, unlike large stationary sources such as coal mines that are permitted and inspected by the MDEQ. The oil and gas adaptive management strategy was prepared in collaboration with the USEPA and three federal land management agencies under the *Understanding Among the U.S. Department of Agriculture, U.S. Department of the Interior, and U.S. Environmental Protection Agency, Regarding Air Quality Analyses and Mitigation for Federal Oil and Gas Decisions Through the National Environmental Policy Act [NEPA] Process* (USDA, USDI, and USEPA 2011). This Memorandum of Understanding (MOU) is summarized in the ARMP.

The ARMP includes both near-term actions and long-term actions. In the near-term, the ARMP sets forth initial mitigation measures to maintain good air quality until regional photochemical grid modeling can be performed to further assess potential impacts to air quality (including ozone) and AQRVs. Additional monitoring data and regional emission inventory data are being acquired to support photochemical grid modeling, which is expected to be completed in 2015. In the longer term, the ARMP provides ongoing management strategies to assess and adapt to new air quality and AQRV ambient monitoring and modeling data during the life of this RMP.

The ARMP includes a multifaceted approach involving the following activities:

- oil and gas activity assessment,
- ambient air quality monitoring support,
- air quality and AQRV assessment,
- future air quality and AQRV modeling, and
- mitigation.

FIGURE 4-3.
GREENHOUSE GAS EMISSIONS IN TERMS OF CARBON DIOXIDE EQUIVALENT FOR ALL ALTERNATIVES



Pollutants addressed by the ARMP include nitrogen dioxide, O_3, particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). The ARMP also addresses modeling and mitigation for the following AQRVs:

- deposition of sulfur and nitrogen,
- lake acid neutralizing capacity, and
- visibility.

The adaptive management strategy for oil and gas resources provides the flexibility to respond to changing conditions that could not have been predicted during RMP development. The strategy also allows for the use of new technology and methods that may minimize or reduce impacts.

Air Quality Impacts from Climate Change

Air quality impacts from climate change may include increases in ambient ozone concentrations and increases or decreases in particulate matter concentrations (USEPA 2009d). Increased temperatures associated with climate change have the potential to increase ground-level ozone formation, although this effect would be more pronounced in regions with relatively high ozone concentrations rather than in regions with relatively low ozone concentrations. Climate change also has the potential to increase emissions of ozone precursors, such as increased biogenic and fugitive source VOC emissions although there is much uncertainty in this regard. The potential cumulative impact of climate change on particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) is less well understood. A range of increases and decreases in particulate matter (PM_{10}) and fine particulate matter

($PM_{2.5}$) concentrations may occur in different regions, and for different component chemical species in the same region. For example, climate changes that involve increased precipitation would decrease fugitive dust emissions while drier soils (particularly during the summer and fall) would increase fugitive dust emissions.

Because of the inability to accurately model the effects of local GHG emissions on climate change, this analysis provides a summary of GHG emissions associated with the alternatives and a comparison of these emissions to other GHG inventories. GHG emissions were estimated using methodologies similar to those used for criteria air pollutants and included GHG emission that would be directly emitted from sources related to fluid mineral development, coal mining, fuels management, resource road maintenance, BLM travel, forest and woodland treatments, vegetation treatments, and livestock grazing. The emission estimates reflect GHG emissions from BLM-authorized activities occurring within the planning area. GHG emissions from activities outside the planning area were not included because insufficient data exist to accurately quantify these emissions. For example, combustion emissions associated with oil and natural gas produced within the planning area and combusted outside the planning area were not included in the inventory. GHG emissions from wildfires were not included in the emission inventories because these emissions would be beyond the BLM's control and occur every year (although wildfire intensity and magnitude can vary greatly from year to year). GHG emissions from prescribed fire and fire prevention activities were included in the inventory since these activities result from BLM-authorized activities. GHG emission inventories are included in the *Air Resources and Climate Appendix*.

GHG emission sinks caused by sequestration and changes in land use were not estimated because insufficient data and methodologies exist for estimating carbon uptake in vegetation and soils. BLM activities that improved forest and vegetation health would tend to increase carbon dioxide uptake from the atmosphere and reduce atmospheric concentrations. Increased carbon sequestration on land administered by the BLM would offset GHG emission increases from other BLM sources.

GHG emission inventories developed as part of this analysis are expressed in short tons per year because emission factors used to calculate emissions were available in units of pounds and short tons. However, state, national, and global emission inventories are typically provided in terms of metric tons per year (mtpy). Consequently, GHG emissions provided in this section are also given in terms of mtpy in order to compare alternative emissions with other GHG inventories.

Differences in cumulative GHG emission impacts among the alternatives would be negligible when considered on state, national, or global scales. GHG emissions under the highest-emitting alternative would be a small percentage of Montana, United States, and global emissions. Based on emission inventory data included in Table 4-8, Alternative A carbon dioxide equivalent (CO_2e) emissions would be less than 1.07 percent of Montana emissions, 0.01 percent of United States emissions, and 0.002 percent of global GHG emissions.

GHG emissions from multiple activities would likely decrease in future years as a result of future federal regulation of GHGs. The USEPA's August 16, 2012 New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants rule is expected to decrease national CH_4 emissions from affected oil and gas systems by approximately 26 percent (USEPA 2012). A previous light-duty vehicle regulation imposed carbon dioxide emission standards for new vehicles. As new vehicles replace existing vehicles, carbon dioxide emissions will decline on a per-mile basis. The USEPA is collecting GHG emission data and is considering additional future regulation.

Several federal initiatives have been launched to improve the ability to understand, predict, and adapt to the challenges of climate change. The Secretary of the Interior signed Secretarial Order 3289 on February 22, 2010, establishing a Department-wide, science-based approach to increase understanding of climate change and to coordinate an effective response to impacts on managed resources. The order reiterated the importance of analyzing potential climate change impacts when undertaking long-range planning issues, and also established several initiatives including the development of eight Regional Climate Science Centers. Regional Climate Science Centers would provide scientific information and tools that land and resource managers can apply to monitor and adapt to climate changes at regional and local scales (Secretarial Order 3289, February 22, 2010). The North Central Climate Science Center, which will incorporate the planning area, was established in 2011.

TABLE 4-8.
BLM SOURCE GREENHOUSE GAS EMISSIONS UNDER ALTERNATIVE A

Resource or Resource Use	Emission (Tons per Year)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Development and Production					
Oil	69,637	414	0	78,464	71,169
Natural Gas	28,786	384	0	36,657	33,249
Coal bed Natural Gas	10,282	197	0	14,433	13,091
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	178	0	0	179	163
Livestock Grazing	1,382	2,666	0	57,377	52,043
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	285	0	0	297	269
Road Maintenance	147	0	0	147	134
BLM Emission Total	**503,884**	**3,783**	**25**	**590,981**	**536,039**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Given the broad spatial influence of climate change that requires response at the landscape-level, the USDI also established Landscape Conservation Cooperatives, which are management-science partnerships that help to inform management actions addressing climate change across landscapes. These cooperatives are formed and directed by land, water, wildlife, and cultural resource managers and interested public and private organizations, to increase the scope of climate change response beyond federal lands.

In addition to efforts being undertaken to better respond and adapt to climate change, other federal initiatives are being implemented to mitigate climate change. The Carbon Storage Project was implemented to develop carbon sequestration methodologies for geological (i.e., underground) and biological (e.g., forests and rangelands) carbon storage. The project is a collaboration of federal agency and external stakeholders to enhance carbon storage in geologic formations and in plants and soils in an environmentally responsible manner. The Carbon Footprint Project is a project to develop a unified GHG emission reduction program for the USDI, including setting a baseline and reduction goal for the Department's GHG emissions and energy use. More information about the USDI's efforts to respond to climate change is available at http://www.doi.gov/whatwedo/climate/cop15/index.cfm.

In addition to emissions of GHGs regulated by the USEPA under climate change regulations, emissions of diesel combustion particulate and other black carbon emissions from forest fires contribute to climate change by reducing the reflectivity of the earth's surface. This effect is greatest when black carbon is deposited on snow because the darker surface absorbs more sunlight, melts the snow more quickly, and heats the earth's surface. Current and future air quality regulations will reduce emissions of carbon dioxide, methane, and nitrous oxide from many types of sources including oil and gas equipment and operations, vehicles, and many types of engines.

Soil management occurs as an integral part of many activities, including oil and gas development, road maintenance, mining, fire management, forestry and woodland management, livestock grazing, and vegetation management. Consequently, emissions related to soil management are included in emission inventories for these specific types of activities.

Management of soil resources throughout the planning area would require submission of an approved reclamation plan before beginning surface-disturbing activities. These plans would reflect the complexity, environmental concerns, and reclamation potential of the site. Reclamation would reduce fugitive dust emissions by revegetating areas after project completion. Additionally, although projects to promote soil

stabilization, including emergency stabilization and rehabilitation following wildfire, would have a beneficial long-term impact to air quality by reducing susceptibility to wind erosion, they could create short-term increases in fugitive dust and exhaust emissions during and immediately following project implementation.

Soil management occurs as an integral part of many activities, including oil and gas development, road maintenance, mining, fire management, forestry and woodland products, livestock grazing, and vegetation management. GHGs, primarily carbon dioxide, are stored in soil and in plant mass (foliage and roots). Activities that disturb soil and remove vegetation can release soil carbon dioxide into the atmosphere and reduce future carbon dioxide sequestration in plant matter. However, once site reclamation occurs and new vegetation is planted, carbon dioxide uptake into plant matter increases. GHG emission inventories for surface-disturbing activities include GHG emissions released by equipment and vehicles but do not include estimates of GHG emissions from soil or plant matter. Methods for accurately estimating soil and plant matter GHG releases to the atmosphere and uptake from the atmosphere are not available.

Vegetation treatments improve overall land health using manual, mechanical, chemical, and biological treatment techniques. Emissions associated with vegetation management activities were calculated based on the amount of surface disturbance and primarily reflect fugitive dust and equipment exhaust emissions. Emissions from chemical substances (such as herbicides) were not estimated. Vegetation management projects would have a long-term beneficial air quality impact by reducing susceptibility to wind erosion. However, short-term increases in fugitive dust and equipment exhaust emissions would occur during and immediately following vegetation management activities.

Vegetation treatments improve overall land health and may increase long-term soil and vegetative uptake of carbon dioxide from the atmosphere. However, short-term increases in carbon dioxide and nitrous oxide emissions from equipment exhaust would occur during vegetation management activities. Short-term decreases in carbon dioxide uptake may also occur if vegetation is removed during treatment activities.

Management activities to protect wildlife and special status species would typically reduce air quality impacts or relocate them to other areas. Habitat protection activities that limit vehicle and human access, surface-disturbing activities, and noise would reduce engine exhaust and fugitive dust emissions in locations subject to these limitations. In some cases, emission-producing activities would be relocated to other areas and total emissions would not change. In other cases, these activities might not occur or might occur on state or private land. Emission calculations generally do not account for habitat protection management actions because insufficient data are available to determine the likelihood of emission source relocation to other areas.

Management activities to protect wildlife and special status species would typically decrease GHG emissions or relocate them to other areas. Habitat protection activities that limit surface-disturbing activities and vehicle and human access would reduce engine exhaust emissions in locations subject to these limitations. In some cases, GHG-producing activities would be relocated to other areas and total GHG emissions would not change. In other cases, these activities might not occur. GHG emission calculations generally do not account for habitat protection management actions because insufficient data are available to determine the likelihood of emission source relocation to other areas.

Fire management and ecology activities include preventive activities such as forest thinning and prescribed fires, as well as fighting wildfires. Smoke contains all criteria air pollutants (carbon monoxide, nitrogen oxide, VOC, sulfur dioxide, particulate matter [PM_{10}], and fine particulate matter [$PM_{2.5}$]), many HAPs, and large quantities of GHGs, primarily carbon dioxide. Prescribed burns are begun only when atmospheric conditions provide safe fire control conditions and when ambient concentrations of fire-related pollutants would be acceptable. The size of the prescribed fire, and the current and expected weather conditions, including the predicted wind speed and direction, would be reviewed prior to burning to assure good smoke dispersal. Prescribed burns would be completed in a manner that is consistent with procedures established by the Montana/Idaho Airshed Group under the authority of the Montana Open Burning Regulations (Administrative Rules of Montana [ARM] Title 17, Section 8, Subchapter 6). Wildfire smoke quantities and pollutant concentrations would vary with the amount and type of fuel burned and atmospheric conditions. Wildfires would cause short-term emissions from smoke and the use of heavy equipment during fire suppression

activities. Long-term wildfire impacts include increased fugitive dust emissions from lack of vegetation. In addition, intense wildfires would alter soil chemistry and reduce natural vegetative growth. Fire mitigation activities following wildfires would cause increased equipment exhaust and fugitive dust emissions.

During large wildfires, fine particulate matter ($PM_{2.5}$) could spread over many miles and affect areas outside the planning area, including Class I areas and sensitive Class II areas. In addition to increased concentrations of particulate, carbon monoxide, VOCs, and HAPs, large wildfires adversely affect visibility. Individual wildfire impacts can last from a few days to several weeks, while impacts from multiple fires within the region can occur throughout the fire season.

Fire management and ecology activities include preventive activities such as forest thinning and prescribed burning, as well as fighting wildfires. Smoke from prescribed burning and wildfires contain large quantities of carbon dioxide. In addition to emissions from smoke, vehicle and equipment exhaust emissions contribute small amounts of carbon dioxide and nitrous oxide to the atmosphere.

Short-term fugitive dust emissions would occur primarily while woodland treatments are in progress. Emissions of carbon monoxide, nitrogen oxide, particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulfur dioxide, VOCs, and HAPs would be released from vehicles and equipment used during these activities. Over the long term, revegetation and land reclamation would reduce fugitive dust.

Short-term vehicle exhaust emissions would occur while woodland treatments are in progress. Carbon dioxide emissions would increase if woodland slash was burned.

Livestock grazing has the potential to affect air quality through land disturbance from grazing animals, land disturbance for range improvements, wind erosion, and vehicle usage to access and transport livestock. Rangeland health standards would be used to determine if soil and site stability was achieved. Adjustments to the grazing authorization would be made as needed to ensure that fugitive dust emissions were not excessive.

Livestock grazing releases large quantities of methane, which is approximately 21 times more potent than carbon dioxide in terms of global warming potential (according to USEPA regulations). Methane has a short atmospheric lifetime of 12 years.

Coal mining is the largest solid mineral mining activity within the planning area and it would be expected to continue at rates similar to those experienced in the past. This activity would contribute to the generation of fugitive dust (PM_{10} and $PM_{2.5}$) at surface facilities from material handling, wind erosion from material stockpiles, and vehicle traffic. Additional pollutants would include carbon monoxide, nitrogen oxide, sulfur dioxide, VOCs, and HAPs from engine exhaust.

Coal mining is the largest solid mineral mining activity within the planning area and it is expected to continue at rates similar to those experienced in the past. This activity would contribute to the generation of GHG emissions associated with exhaust from vehicles and equipment. Fugitive coal dust also contributes to climate change if it is deposited on snow or other highly reflective surfaces.

Fluid mineral development and production activities in the planning area would increase criteria air pollutant and HAP emissions through engine exhaust, fugitive organic emissions, and fugitive dust.

Oil and gas development and production activities in the planning area would increase GHG emissions, particularly emissions of carbon dioxide and methane. GHG emissions from oil and gas activities were estimated conservatively and did not include emission reductions that may be mandated by future USEPA regulations. For example, the USEPA's proposed oil and gas sector National Emission Standards for Hazardous Air Pollutants regulation is expected to reduce methane emissions by approximately 26 percent.

Relatively few developed recreation sites are located within the planning area. Limited hunting, dispersed limited camping, hiking, and off-road travel occur within the area. Recreational uses may cause minor localized emission increases through vehicle exhaust and small areas of surface disturbance. Because of the relatively

small quantity of air pollutants associated with recreational activities, emissions from recreational activities were not included in the emission inventory.

GHG emissions from recreational activities are caused primarily by vehicle emissions of carbon dioxide and nitrous oxide.

Air quality and AQRV impacts from vehicle travel, including road maintenance and OHV use, would result from fugitive dust and exhaust emissions attributable to vehicle travel, including road maintenance and OHV use. Travel-related impacts depend on the route or trail surface material and condition, type of vehicle, size of vehicle, and vehicle speed. Although the alternatives differ in terms of the number of routes that would remain open, open with restrictions, or closed, emissions would depend largely on total vehicle miles traveled. Because the public may shift use to other roads in the same area or move to a different area, emissions may remain consistent for the planning area regardless of road closure and restrictions.

Fugitive dust from wind erosion would decrease in areas in which road closures allowed native plants to recolonize previously disturbed areas. Limiting authorized travel to administrative use would reduce traffic and emissions on these routes.

Construction or maintenance of higher standard unpaved routes has the potential to allow greater travel speeds and increased fugitive dust. Unimproved and unmaintained routes generally reduce speeds and fugitive dust.

Emissions from trails and travel management are largely represented in the alternative emission inventories in the following categories: BLM travel, BLM road maintenance, and resource-specific management activities, such as fire management and vegetation management.

Vehicle travel, road maintenance activities, and OHV use would cause exhaust emissions of carbon dioxide and nitrous oxide.

Air quality and AQRV impacts from land use authorizations are expected to be minor. New road rights of way (ROWs) cause short-term (construction) and long-term (use) impacts and emissions depend on the type of road surface, length and width of the road, and the number of vehicles and speed at which they travel. Utility ROWs generally have smaller long-term air quality impacts than road ROWs because vegetation is restored and only a small number of vehicles would travel through the ROW for maintenance purposes.

Emissions from ROW authorizations were not calculated because land disturbances are expected to be small. Emissions for surface-disturbing activities associated with roads for oil and gas activities are included in the oil and gas emission calculations.

New ROWs would cause short-term (construction) and long-term (vehicle use) increases in GHG emissions. GHG emissions from ROW authorizations were not calculated because land disturbances are expected to be small. However, GHG emissions for surface-disturbing activities associated with roads for oil and gas activities are included in the oil and gas emission calculations.

ALTERNATIVE A

Alternative A would allow new oil and gas development of up to 100 percent of the RFD. Impacts in specific areas of the planning area would depend on the location of fluid mineral activity.

Fluid mineral development and production activities in the planning area would increase criteria air pollutant and HAP emissions through engine exhaust, fugitive organic emissions, and fugitive dust.

Resource-specific emissions are provided in Tables 4-8 and 4-9.

Alternative A would have carbon dioxide equivalent emissions of 536,038 mtpy.

TABLE 4-9.
BLM SOURCE EMISSIONS UNDER ALTERNATIVE A

Resource or Resource Use	Emissions (Tons per Year)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Development and Production							
Oil	734.5	321.3	0.6	74.1	20.7	2,563.1	161.9
Natural Gas	288.8	119.4	0.3	18.6	6.7	82.5	8.3
Coal Bed Natural Gas	126.3	63.9	0.1	13.6	4.2	43.7	8.3
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	0.9	1.3	0.0	3.6	0.4	0.1	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.4	1.6	0.0	74.7	7.5	1.9	0.2
Road Maintenance	0.5	1.2	0.0	1.4	0.2	0.1	0.0
BLM Emission Total	**5,067.5**	**2,393.8**	**194.6**	**5,285.3**	**681.4**	**2,967.3**	**206.2**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

ALTERNATIVE B

Alternative B would allow new oil and gas development of up to 5 percent of the RFD. Impacts in specific areas of the planning area would depend on the location of fluid mineral activity.

Resource-specific emissions are provided in Tables 4-10 and 4-11.

TABLE 4-10.
BLM SOURCE EMISSIONS UNDER ALTERNATIVE B

Resource or Resource Use	Emissions (Tons per Year)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Development and Production							
Oil	39.5	16.6	0.0	4.2	1.1	129.3	8.2
Natural Gas	15.1	6.2	0.0	1.0	0.4	4.2	0.4
Coal bed Natural Gas	6.7	3.4	0.0	0.9	0.2	2.3	0.4
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	0.2	0.1	0.0	0.5	0.1	0.0	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.3	1.6	0.0	73.7	7.4	1.9	0.2
Road Maintenance	0.5	1.3	0.0	1.5	0.2	0.1	0.0
BLM Emission Total	**3,978.4**	**1,914.4**	**193.6**	**5,181.1**	**651.1**	**413.7**	**36.7**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

TABLE 4-11.
BLM SOURCE GREENHOUSE GAS EMISSIONS UNDER ALTERNATIVE B

Resource or Resource Use	Emissions (Tons per Year)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Development and Production					
Oil	4,016	21	0	4,470	4,055
Natural Gas	1,529	20	0	1,950	1,769
Coal bed Natural Gas	545	11	0	778	706
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	9	0	0	9	8
Livestock Grazing	1,382	2,458	0	53,010	48,082
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	282	0	0	293	266
Road Maintenance	154	0	0	154	140
BLM Emission Total	**401,104**	**2,632**	**25**	**464,091**	**420,948**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

ALTERNATIVE C

Alternative C would allow new oil and gas development of up to 30 percent of the RFD. Impacts in specific areas of the planning area would depend on the location of fluid mineral activity.

Alternative C would potentially result in relatively low carbon dioxide and methane emissions.

Resource-specific emissions are provided in Tables 4-12 and 4-13.

ALTERNATIVE D

Alternative D would allow new oil and gas development of up to 54 percent of the RFD. Impacts in specific areas of the planning area would depend on the location of fluid mineral activity.

Oil and gas activity would be approximately 54 percent of the RFD.

Resource-specific emissions are provided in Tables 4-14 and 4-15.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Alternative E would allow new oil and gas development of up to 47 percent of the RFD. Impacts in specific areas of the planning area would depend on the location of fluid mineral activity.

Alternative E would have mid-range emissions resulting from oil and gas activity that would be approximately 47 percent of the RFD.

Resource-specific emissions are provided in Tables 4-16 and 4-17.

TABLE 4-12.
BLM SOURCE EMISSIONS UNDER ALTERNATIVE C

Resource or Resource Use	Emissions (Tons per Year)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Development and Production							
Oil	223.1	97.2	0.2	22.7	6.3	772.9	48.8
Natural Gas	87.9	36.1	0.1	5.8	2.1	24.9	2.5
Coal bed Natural Gas	38.4	19.4	0.0	4.7	1.3	13.3	2.5
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	1.6	2.3	0.1	6.4	0.8	0.3	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	71.3	7.2	2.0	0.2
Road Maintenance	0.5	1.4	0.0	1.6	0.2	0.1	0.0
BLM Emission Total	**4,268.2**	**2,043.3**	**194.0**	**5,211.8**	**659.6**	**1,089.4**	**81.5**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

TABLE 4-13.
BLM SOURCE GREENHOUSE GAS EMISSIONS UNDER ALTERNATIVE C

Resource or Resource Use	Emissions (Tons per Year)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Development and Production					
Oil	21,343	125	0	24,012	21,779
Natural Gas	8,818	117	0	11,259	10,212
Coal bed Natural Gas	3,137	62	0	4,440	4,027
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	314	0	0	316	287
Livestock Grazing	1,382	2,659	0	57,243	51,921
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	300	0	0	312	283
Road Maintenance	161	0	0	161	146
BLM Emission Total	**428,642**	**3,085**	**25**	**501,170**	**454,576**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

TABLE 4-14.
BLM SOURCE EMISSIONS UNDER ALTERNATIVE D

Resource or Resource Use	Emissions (Tons per Year)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Development and Production							
Oil	399.0	174.0	0.3	40.5	11.2	1,384.6	87.5
Natural Gas	157.1	64.8	0.1	10.2	3.7	44.8	4.5
Coal bed Natural Gas	68.6	34.7	0.0	7.7	2.3	23.7	4.5
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	2.7	3.9	0.1	10.7	1.3	0.4	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	72.7	7.3	2.0	0.2
Road Maintenance	0.5	1.4	0.0	1.6	0.2	0.1	0.0
BLM Emission Total	**4,544.6**	**2,165.7**	**194.1**	**5,242.7**	**667.7**	**1,731.5**	**124.2**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

TABLE 4-15.
BLM SOURCE GREENHOUSE GAS EMISSIONS UNDER ALTERNATIVE D

Resource or Resource Use	Emissions (Tons per Year)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Development and Production					
Oil	38,079	224	0	42,857	38,872
Natural Gas	15,673	209	0	20,025	18,163
Coal bed Natural Gas	5,593	108	0	7,871	7,139
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	524	0	0	527	478
Livestock Grazing	1,382	2,663	0	57,320	51,991
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	304	0	0	316	287
Road Maintenance	161	0	0	161	146
BLM Emission Total	**454,903**	**3,326**	**25**	**532,504**	**482,997**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires

CUMULATIVE

Alternative A

Most criteria air pollutant and HAP emissions from BLM sources would be less than non-BLM emissions in the planning area. Increases in coal mining on federal solid mineral estate instead of nonfederal solid mineral estate would result in BLM particulate emissions that were greater than non-BLM particulate emissions. Figure 4-4 shows criteria pollutant and HAP emissions from BLM and from non-BLM sources. Cumulative impacts from BLM sources; projected future non-BLM oil, gas, and coal mining sources; and existing sources would not be expected to exceed the NAAQS or MAAQS for any pollutant. As described in the ARMP in the *Air Resources and Climate Appendix*, ambient concentrations would be monitored to assess impacts. Furthermore, pollutant concentration impacts as well as deposition and visibility impacts would be predicted using future photochemical grid modeling.

TABLE 4-16.
BLM SOURCE EMISSIONS UNDER ALTERNATIVE E

Resource or Resource Use	Emissions (Tons per Year)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Development and Production							
Oil	347.8	151.7	2.3	34.8	9.3	1,207.5	76.3
Natural Gas	136.1	56.3	0.1	8.8	3.2	38.9	3.9
Coal bed Natural Gas	59.6	30.1	0.0	6.7	2.0	20.6	3.9
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	2.7	3.9	0.1	10.7	1.3	0.4	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	72.7	7.3	2.0	0.2
Road Maintenance	0.5	1.2	0.0	1.4	0.2	0.1	0.0
BLM Emission Total	**4,463.4**	**2,130.1**	**196.1**	**5,234.4**	**665.0**	**1,545.4**	**111.8**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

TABLE 4-17.
BLM SOURCE GREENHOUSE GAS EMISSIONS UNDER ALTERNATIVE E

Resource or Resource Use	Emissions (Tons per Year)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Development and Production					
Oil	33,176	195	0	37,342	33,871
Natural Gas	13,516	181	0	17,278	15,672
Coal bed Natural Gas	4,862	94	0	6,843	6,207
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	524	0	0	527	478
Livestock Grazing	1,382	2,656	0	57,173	51,857
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	304	0	0	316	287
Road Maintenance	147	0	0	147	134
BLM Emission Total	**447,098**	**3,248**	**25**	**523,053**	**474,427**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Alternative B

Figure 4-5 shows criteria pollutant and HAP emissions from BLM and from non-BLM sources. Cumulative impacts from projected future BLM and non-BLM sources would not be expected to exceed the NAAQS or MAAQS. As described in the ARMP in the *Air Resources and Climate Appendix*, pollutant concentrations would be monitored to assess impacts. Furthermore, pollutant concentration impacts as well as deposition and visibility impacts would be predicted using future photochemical grid modeling.

Alternative C

Figure 4-6 shows criteria pollutant and HAP emissions from BLM and non-BLM sources. Alternative C cumulative pollutant concentrations are expected to be less than the NAAQS and MAAQS. As described in the

ARMP in the *Air Resources and Climate Appendix*, pollutant concentrations would be monitored to assess impacts. Furthermore, pollutant concentration impacts as well as deposition and visibility impacts would be predicted using future photochemical grid modeling.

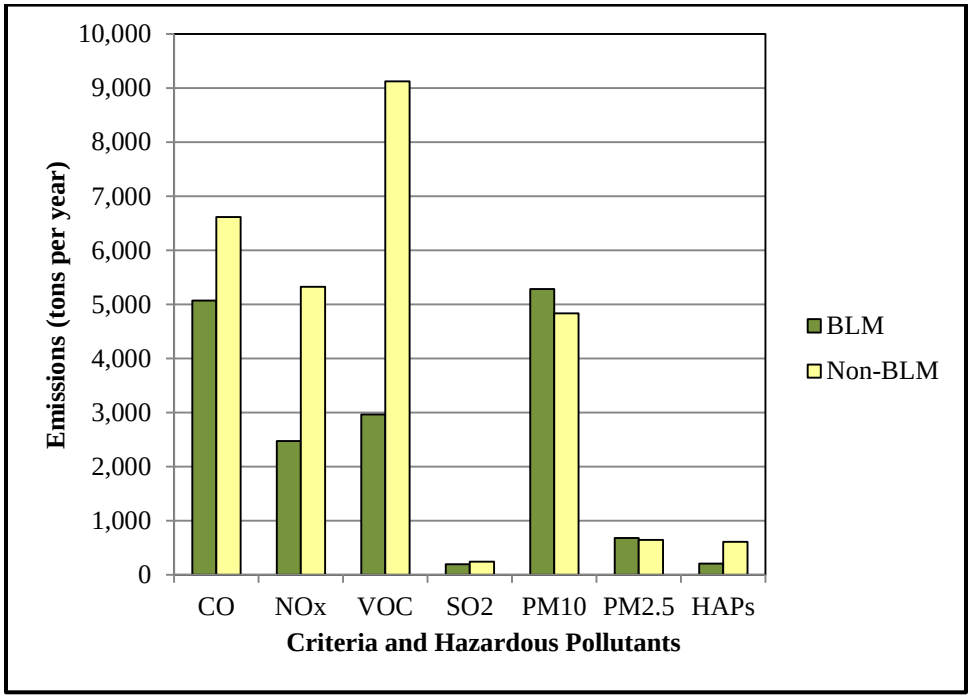
Alternative D

Figure 4-7 shows criteria pollutant and HAP emissions from BLM and from non-BLM sources. Cumulative pollutant concentrations would be expected to be less than the NAAQS and MAAQS. As described in the ARMP in the *Air Resources and Climate Appendix*, pollutant concentrations would be monitored to assess impacts. Furthermore, pollutant concentration impacts as well as deposition and visibility impacts would be predicted using future photochemical grid modeling.

Alternative E (Preferred Alternative)

Figure 4-8 shows criteria pollutant and HAP emissions from BLM and from non-BLM sources. Cumulative pollutant concentrations are expected to be less than the NAAQS and MAAQS. As described in the ARMP in the *Air Resources and Climate Appendix*, pollutant concentrations would be monitored to assess impacts. Furthermore, pollutant concentration impacts as well as deposition and visibility impacts would be predicted using future photochemical grid modeling.

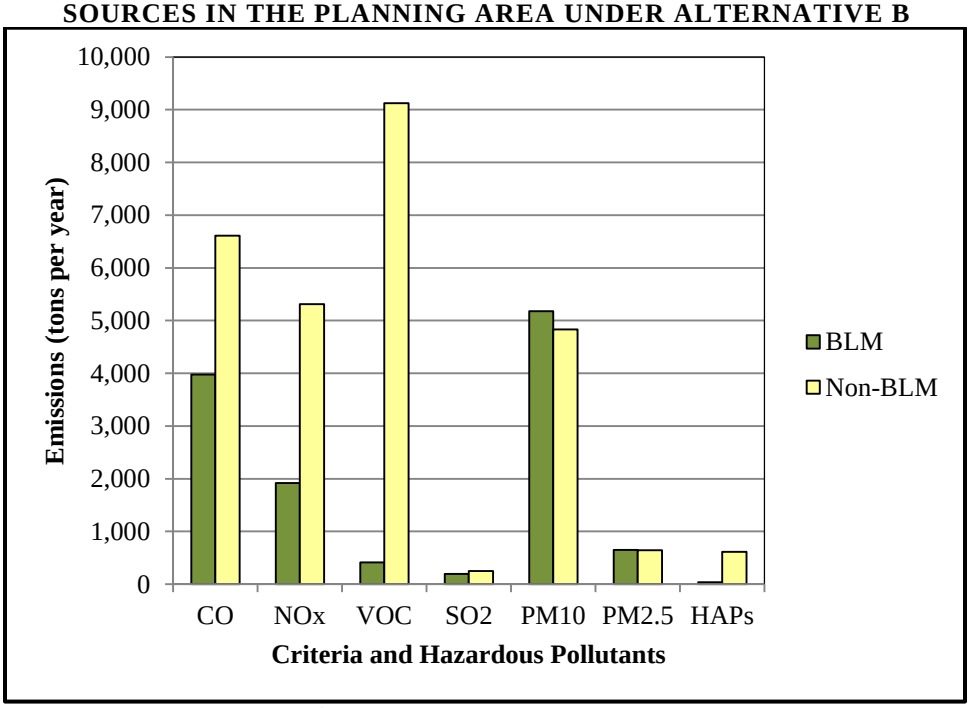
FIGURE 4-4.
LONG-TERM EMISSIONS FROM BLM AND NON-BLM SOURCES IN THE PLANNING AREA UNDER ALTERNATIVE A



BLM emissions include emissions from multiple resources, including BLM-authorized oil and gas emissions.

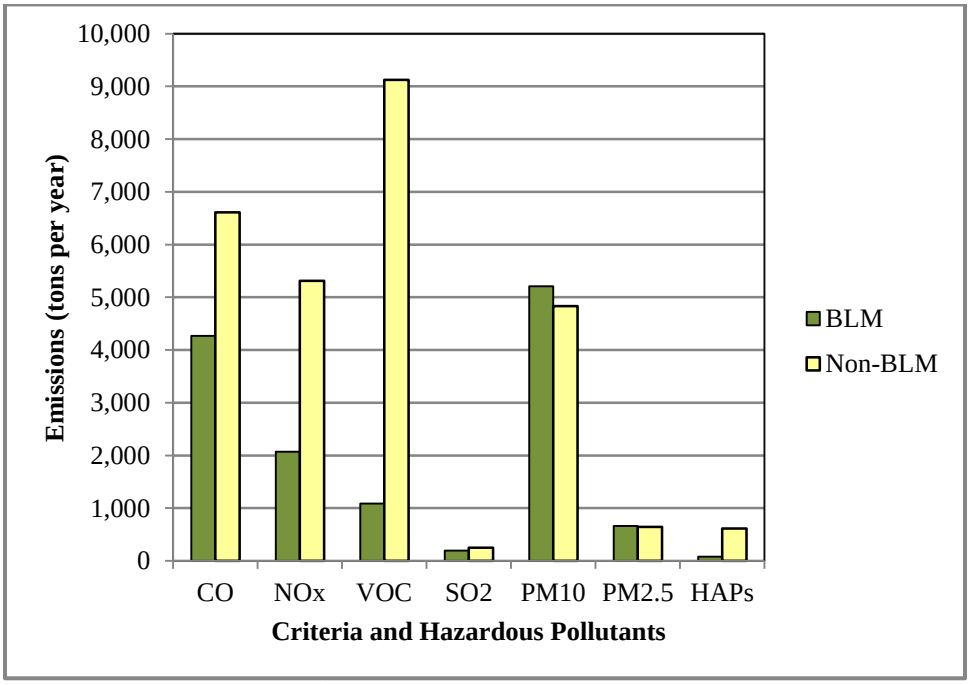
Non-BLM emissions include emissions from oil and gas activities on state and private mineral estate.

FIGURE 4-5.
LONG-TERM EMISSIONS FROM BLM AND NON-BLM SOURCES IN THE PLANNING AREA UNDER ALTERNATIVE B



BLM emissions include emissions from multiple resources, including BLM-authorized oil and gas emissions.
Non-BLM emissions include emissions from oil and gas activities on state and private mineral estate.

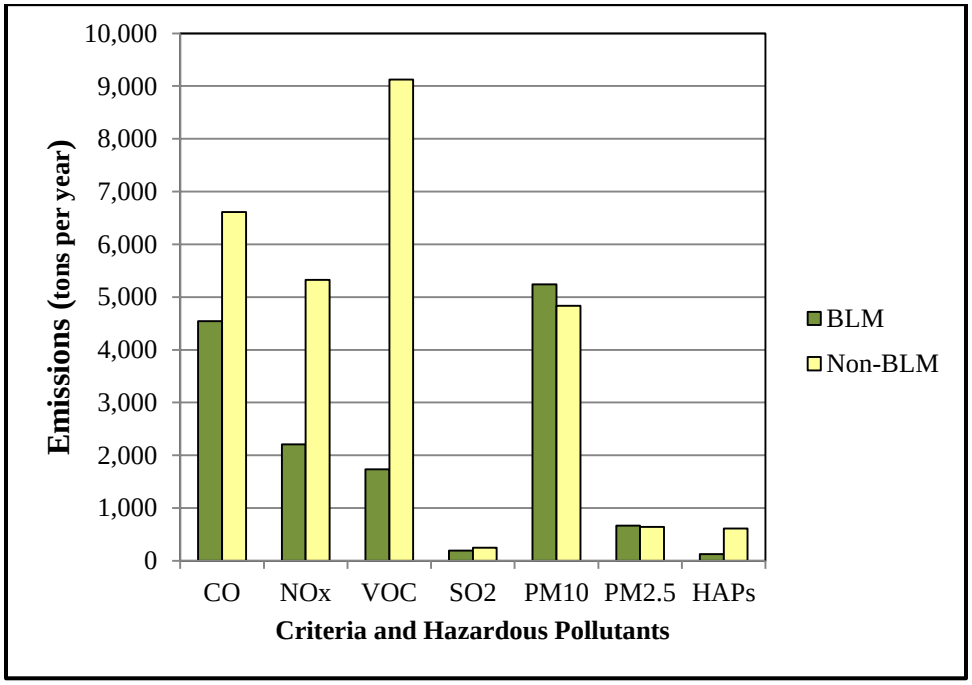
FIGURE 4-6.
LONG-TERM EMISSIONS FROM BLM AND NON-BLM SOURCES IN THE PLANNING AREA UNDER ALTERNATIVE C



BLM emissions include emissions from multiple resources, including BLM-authorized oil and gas emissions.

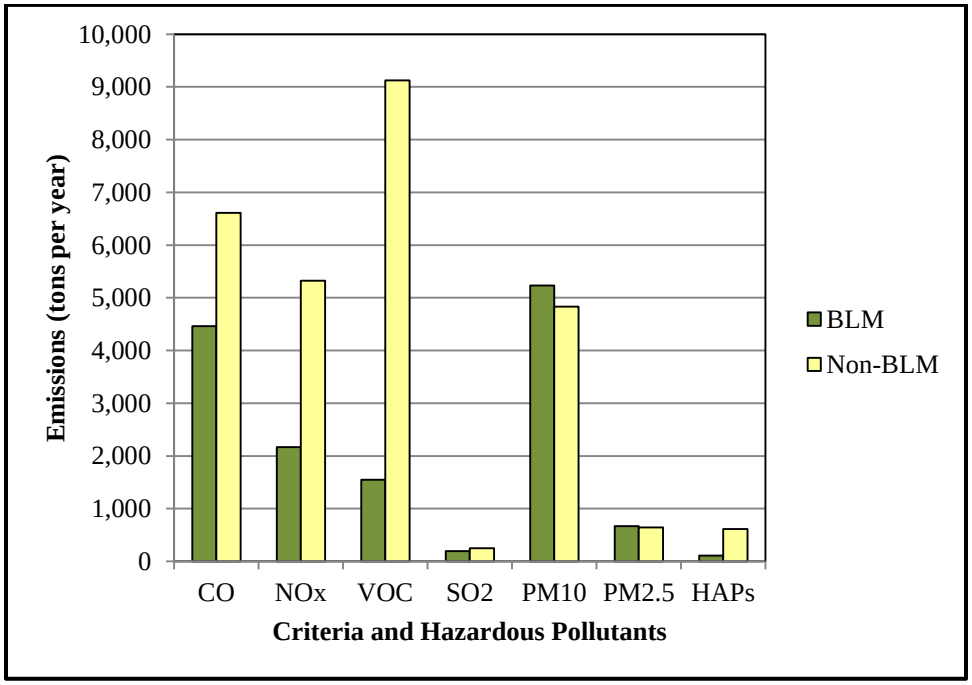
Non-BLM emissions include emissions from oil and gas activities on state and private mineral estate

FIGURE 4-7.
LONG-TERM EMISSIONS FROM BLM AND NON-BLM SOURCES IN THE PLANNING AREA UNDER ALTERNATIVE D



BLM emissions include emissions from multiple resources, including BLM-authorized oil and gas emissions.
Non-BLM emissions include emissions from oil and gas activities on state and private mineral estate.

FIGURE 4-8.
LONG-TERM EMISSIONS FROM BLM AND NON-BLM SOURCES IN THE PLANNING AREA UNDER ALTERNATIVE E



BLM emissions include emissions from multiple resources, including BLM-authorized oil and gas emissions.
Non-BLM emissions include emissions from oil and gas activities on state and private mineral estate.

SOILS

ASSUMPTIONS

Acre figures and other numbers used in this analysis are approximate projections for comparison and analytical purposes only. Readers should not infer that they reflect exact measurements or precise calculations. GIS analysis is based on a 1:24,000-scale 2009 Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (also known as SSURGO) for each county in the planning area. Acre figures in all tables, except where noted, may overlap, and adding these figures will not result in accurate total acreage values.

Naturally functioning soils sustain biotic productivity and maintain water and air quality. Important components of the soil system include physical properties (e.g., bulk density, texture, structure, parent material, and porosity), chemical properties (e.g., pH, salts, calcium carbonate, clay, and humus), and biotic properties (e.g., microorganisms, macroorganisms, and organic matter). Soils within the planning area are rejuvenated by natural disturbances such as fire and grazing. See Chapter 3, *Soils* for further discussion on natural soil structure and function.

Controlled uses of resources (controlled surface disturbance and controlled surface use) would provide for the conservation of soil resources by reducing impacts to soils. Prohibiting surface-disturbing activities and surface use would provide for the maintenance of soil resources and allow soils to recover from past disturbances (natural or anthropogenic).

MANAGEMENT COMMON TO ALL ALTERNATIVES

Management actions that promoted organic soil carbon storage would inherently improve soil quality by increasing vegetative ground cover, soil development, soil organic matter, fertility, water-holding capacity, and by reducing soil loss from wind and water erosion. Various ecosystem processes are influenced by the carbon cycle; therefore, management of soil carbon would affect other ecosystem processes, such as nutrient and water cycles. Management actions that maintained or improved habitat would promote organic soil carbon storage. For example, applying a rest-rotation regime in order to enhance vegetative carbon stocks would also increase soil carbon stocks. Reclaiming or improving existing degraded areas would also improve organic carbon stocks in soils.

Surface-disturbing actions, such as vegetation or fuels treatments (up to approximately 18,000 acres in the short term and 70,000 acres in the long term), range or habitat improvements (up to approximately 420 acres annually), mechanical invasive species (vegetation) control (up to approximately 12,000 acres in the short term and 80,000 acres in the long term), fire suppression activities (up to approximately 15 acres in the short term and 60 acres in the long term), excavation of cultural and paleontological sites (up to approximately 45 acres in the short term and 150 acres in the long term), minerals exploration and extraction (up to approximately 8,900 acres in the short term and 51,000 acres in the long term), vehicle use, infrastructure, and lands and realty or renewable energy projects (up to approximately 1,600 acres in the short term and 5,700 acres in the long term) would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance;

including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Management actions that prohibited surface-disturbing activities would maintain soil resources (Table 4-18). Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures, relocation, or denial to maintain the soil system. Although surface-disturbing actions on BLM-administered lands on up to approximately 50,000 acres in the short term and up to 330,000 acres in the long term would potentially occur, all land uses under all alternatives would meet the Standards for Rangeland Health.

The application of BMPs (see the *Best Management Practices Appendix*) would provide for sustainable land use methods or relocation of the surface-disturbing activity to a more suitable soil type. Mitigation would potentially include limiting the total area of disturbance, rapid reclamation (see the *Reclamation Appendix*), erosion or sediment control, soil salvage, decompaction, revegetation, weed control, slope stabilization, surface roughening, and fencing.

**TABLE 4-18.
BLM-ADMINISTERED SOIL RESOURCES MAINTAINED UNDER MANAGEMENT COMMON TO ALL ALTERNATIVES**

Area or Resource	Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Oil and gas closures (discretionary and those under Management Common to all Alternatives)	56,000	24,000
Oil and gas, no surface occupancy (NSO)	29,000	3,800
WSAs	76,000	24,000

Monitoring soil systems (see the *Monitoring Appendix*) would promote sustainable use of the soil resource. Meeting Rangeland Health Standards would maintain soil health, and Standards 1 and 2, which promote soil biota, stability, nutrient cycling, and water storage, would be particularly important. Maintaining proper functioning condition (PFC) for riparian and wetland areas would sustain soil stability and hydric function on approximately 110,000 acres of hydric soils, which is 4 percent of the planning area. Activities that met water quality standards would reduce accelerated streambank erosion and sedimentation.

Management actions that maintained, conserved, or improved vegetation conditions, including managing for PFC, riparian buffers, forest resilience, special status species plants, and range improvements, or wildlife habitat would promote natural soil structure and function (up to approximately 420 acres annually). Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

Using an integrated approach for controlling invasive vegetation species (e.g., weed-free forage; vehicle washing; and mechanical, biological, and chemical control) would promote a natural soil system. Although soil disruption from treatments would cause short-term, localized impacts the treatment would promote long-term soil health (up to approximately 5,000 acres disturbed in the short term and 50,000 acres in the long term). Herbicides with residual soil activity would inhibit soil biodiversity and biotic activity (BLM 2007d). Biological control using sheep and goats would cause compaction through trampling and trailing. Following standard operating practices designed to reduce impacts to soils from weed management actions would promote sustainable use of the soil resource (BLM 2007d). Use of vehicle wash stations would minimize the transport and establishment of invasive weeds.

The use of wildland fire chemicals (foam and retardant) would cause short-term, localized imbalances in soil nutrient levels because such chemicals would potentially contain nitrogen, phosphorous, and boron (USFS 2012; Finger 1997).

Using fertilizer to accomplish vegetation community restoration would alter nutrient cycling in the short term and promote natural soil system conditions in the long term. The addition of nitrogen fertilizer would potentially favor annual bromes (Wight 1976), which would lead to alteration of the soil environment (Radosevich, Holt, and Ghersa 2007). Nitrogen fertilization would increase soil organic matter (and soil carbon stocks) from enhanced vegetative growth. Improper application of ammonium-based fertilizer would cause soil acidification (Brady and Weil 2004).

Developing minerals in conjunction with other resource uses would co-locate surface disturbances, which would promote sustainable use of the soil resource and reduce soil system fragmentation. However, the combined effects to the soil resource would amplify impacts to the soil system within those areas.

Coal extraction and the associated removal and replacement of overburden would cause surface disturbance and depress surface elevation, which would alter soil-water relationships (up to approximately 1,600 acres annually). Land application of water with high salt content, which is typical of coal seams, would reduce infiltration and productivity, increase overland flow, accelerate erosion, or cause toxic impacts to biota (see the *Soils Appendix* for further discussion on salt-affected soils) (Table 4-19). Coal development would be mitigated by a screening process that included sensitive soils in the unsuitability criteria (see the *Minerals Appendix* for further discussion of the screening process).

Geothermal extraction would include the risk of soil contamination from spills, leaks with concentrated metals, and low or high pH values. However, no federal geothermal leasing would likely occur in the short or long term.

There would be approximately 3,700 acres of oil and gas developed in the long-term. Applying the following BMPs would maintain soil resilience; and reduce soil system fragmentation, wind and water erosion, and the total area of surface disturbance:

- utilizing plans of development (a priority in the Carter MLP area),
- removing vegetation in the smallest area possible,
- co-locating infrastructure,
- using a single trench for utilities and piping,
- employing multiple completions per well bore and directional drilling,
- ensuring reclamation of all new roads at the end of the life of the well,
- preventing degradation of the watershed from produced water,
- designing impoundments or water disposal methods to minimize impacts to soil, and
- initiating interim reclamation within 25 days of drilling the well.

**TABLE 4-19.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION
UNDER MANAGEMENT COMMON TO ALL ALTERNATIVES**

Area or Resource	Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Coal, high and moderate development areas	140,000	11,000
Coal, further study areas, pending further study	11,000	2,100
Coal, further study areas	74,000	11,000
Current oil and gas leases	350,000	39,000
High reasonably foreseeable development (RFD), oil and gas development	220,000	27,000
Moderate RFD, oil and gas development	380,000	39,000
Low RFD, oil and gas development	1,200,000	39,000
Carter MLP Area	96,000	850

The risk of accelerated erosion following bentonite extraction would be compounded by the site's poor reclamation suitability, which is typically high in clay and salt content (up to approximately 40 acres annually). Segregating suitable topsoil material and the addition of soil amendments would improve

vegetation recovery (see the *Soils Appendix* for a discussion of suitable topsoil characteristics and suggested soil amendments).

Uranium extraction would include the risk of soil contamination from spills, leaks, or land application of treated wastewater, which would result in accumulated radionuclides, selenium, salt content, and other metals and potentially cause the soil to become toxic to biota (USNRC and WDEQ 2009). Although impacts would potentially be severe in the short-term, the required rapid response (including remediation) and routine monitoring would cause minimal long-term impacts (USNRC and WDEQ 2009).

Although infrastructure construction and use would cause accelerated erosion, increased overland flow, and sedimentation (up to approximately 1,000 acres in the long term for recreational purposes); road and infrastructure maintenance would reduce such impacts. Considering constraints of the soil resource and co-locating ROWs when constructing infrastructure would encourage sustainable use of the soil resource, which would include avoiding sensitive soils. Designing infrastructure on stabile, high-bearing-strength locations with proper drainage would avoid destabilizing erosive soils. Developing roads with gentle grades and along contours would reduce accelerated erosion from overland flow. Closing and restoring unauthorized user-created roads or trails and closing dispersed camping within 300 feet of roads or trails in degraded, ecologically sensitive areas would promote natural soil structure and function.

Vehicles would act as vectors for weeds and cause ground cover loss, compaction, and rutting, which would result in increased overland flow, accelerated erosion, and sedimentation, particularly in areas of rough or erosive terrain. Wet soils would be especially susceptible to rutting, which would lead to braiding of roads and trails, channeling, and accelerated water erosion. Avoiding vehicle use during conditions causing ruts greater than 4 inches deep would reduce such impacts. Although disturbing areas prone to producing dust would result in the loss of topsoil and nutrients and inhibit biotic production, dust would potentially be controlled by biodegradable dust suppressants or water with low salt content.

Areas of concentrated Open off-highway vehicle (OHV) use would result in compaction, accelerated erosion, and reduced ground cover, infiltration, nutrient cycling, and organic matter (BLM 2003m; Bainbridge 2007), particularly in areas of highly erodible soils. OHV use on slopes greater than 25 percent would have a severe risk of accelerated water erosion (NRCS 1998). Soils with biotic, physical, or chemical crusts in areas with low vegetative cover would be particularly susceptible to destabilization from cross-country travel, which would result in accelerated erosion. Disturbance of areas dependent on biotic crusts for nutrient cycling would result in reduced fertility (Evans and Ehleringer 1993).

Acquired lands that improved habitat connectivity would promote the soil system's resilience to climate change and future disturbances (e.g., wildfire, and drought) (Perrow and Davy 2003).

ALTERNATIVE A

Land uses proposed under Alternative A, such as vegetation or fuels treatments, range or habitat improvements, mechanical invasive species (vegetation) control, oil and gas exploration and extraction, geophysical exploration, vehicle use, infrastructure development, and ROW activities, would cause surface disturbance. Surface disturbances would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen

content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance; including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Reserve, brine, and water disposal pits would contain material (e.g., drilling fluids, mud, cuttings, and salts) that altered soil chemistry and created soil toxic to biota if the material leaked out of the pit. Implementing closed-loop drilling or other pitless methods would avoid such impacts and reduce the total area of disturbance. Disposal of water with high salt content using land application or seepage ponds would result in reduced infiltration and productivity, increased overland flow, accelerated erosion, or cause impacts toxic to biota. Discharge of produced water would result in gullying, headcutting, and sedimentation (ALL 2001a; BLM 2008g). Spills or leaks of produced hydrocarbons, fuels, or produced water high in salt content would create soil toxic to biota (BLM 2008g). Early detection, containment, and cleanup would keep such impacts localized.

As slopes approached 30 percent, the risk of soil instability following disturbance would increase, particularly if cover, structure, permeability, or bulk density had been altered (Monsen, Stevens, and Shaw 2004). Reclamation suitability would be low for slopes greater than 20 percent (Monsen et al. 2004). Activities on slopes greater than 30 percent within the Big Dry RMP area (48,000 acres, 2 percent of the planning area) would require mitigation to ensure sustainable use of the soil resource (Table 4-20).

Mechanical treatment of vegetation on slopes greater than 15 percent (280,000 acres, 10 percent of the planning area) and highly erodible soils (160,000 acres, 6 percent of the planning area) within the Big Dry RMP area would require mitigation to ensure sustainable use of the soil resource.

Under this alternative, oil and gas extraction would require mitigation on slopes 30 percent or greater (90,000 acres, 3 percent of the planning area) to ensure sustainable use of the soil resource.

Management actions that prohibited surface-disturbing activities would maintain soil resources, particularly hydric function in floodplains, waterbodies, riparian, wetland, and aquatic wildlife habitat (Table 4-21). Prohibiting such activities within designated wildlife habitat and paleontological areas would inhibit treatment strategies that would improve soil resources.

Management actions designed to maintain, conserve, or improve vegetation conditions (including managing for PFC, fencing new spring developments, using timber harvest or salvage for habitat improvement, haying, fuels management, approximating natural disturbance regimes, and supporting forest resilience) would promote natural soil structure and function. Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

Impoundments would accumulate sediment flows that would have been deposited naturally downstream in other areas, which would alter natural erosion and deposition rates at the impoundment and downstream (Zelt, Boughton, Miller, Mason, and Gianakos 1999). Impoundments would also reduce riparian vegetative cover along the channel, which would result in accelerated erosion and sedimentation (Poff et al. 1997). Dam failure would result in accelerated water erosion and sedimentation. Unlined water impoundments would change subsurface water flow regimes, which would alter natural soil formation processes, including nutrient cycling, mobilization (e.g., sulfate, selenium, arsenic, manganese, barium, chloride, and nitrate), and salt distribution (NAS 2010). Salts from the impoundment concentrated in soils would reduce infiltration and productivity, increase overland flow, accelerate erosion, or cause impacts toxic to biota (see the *Soils Appendix* for further discussion on salt-affected soils). Wet soils surrounding the impoundment would be susceptible to compaction from concentrated use.

Trough and tank development in riparian and wetland areas would result in compaction from concentrated livestock use. Compacted soils would be at risk of increased surface salt accumulation, which would further reduce infiltration and productivity, increase overland flow, accelerate erosion, or cause impacts toxic to biota.

Although allowing surface-disturbing activities in areas of invasive vegetation species infestations would degrade soil resources already affected by the infestation, it would permit treatment strategies that maintained or enhanced soil resources. Treating invasive vegetation species on a case-by-case basis would promote natural soil systems in localized areas. However, basing priority treatment areas on sites either particularly susceptible to, or particularly affected by, weed invasions, would more effectively maintain or enhance the soil resource.

Wildlife requirements would potentially inhibit treatment strategies that improved soil resources. For example, revegetation would potentially be prohibited in the spring, which would result in accelerated erosion due to lack of vegetative cover.

TABLE 4-20.
BLM-ADMINISTERED SOIL RESOURCES CONSERVED UNDER ALTERNATIVE A

Area or Resource		Acres of Sensitive Soils	Acres of Slopes Greater than 15%	Acres of Slopes 25% or Greater	Acres of Slopes 30% or Greater
Soils	Mechanical treatment on steep slopes avoided (Big Dry only)	230,000	300,000	84,000	NA
Soils	Surface disturbance avoided (Big Dry) or oil and gas controlled surface use (CSU) stipulation (Powder River) on steep slopes	79,000	NA	NA	90,000
Soils	Mechanical treatments avoided on highly erodible soils (Big Dry only)	160,000	NA	4,800	NA
Fish and Wildlife	Wildlife, CSD[1]	150	NA	20	NA
Travel Mgmt and OHV	Limited OHV Use	1,600,000	NA	150,000	NA

[1]CSD=Controlled Surface Disturbance

The absence of sage-grouse habitat compensation requirements under this alternative would cause soil system fragmentation, which would alter soil structure and function. Soil system fragmentation would result in altered soil heterogeneity, microclimate, hydrology, nutrient cycling, biotic richness, and diversity (Perrow and Davy 2003). Localized impacts would include microclimatic changes tens of meters into the patch (from the edge) but altered biota and nutrient cycling would extend even further (Perrow and Davy 2003). Pre-existing disturbance regimes (e.g., fire) would be altered on a landscape scale, which would change natural rates of soil formation (Perrow and Davy 2003).

Although fuels reduction treatments would cause a surface disturbance in the short term, they would reduce the intensity and severity of wild and prescribed fire (Arno and Allison-Bunnell 2002; Perrow and Davy 2003). However, requiring pre-commercial or commercial fuels removal prior to prescribed fire actions would cause unnecessary degradation of the soil resource if other mitigation alternatives existed (Table 4-22). Allowing prescribed fire (up to approximately 7,500 acres annually) in B and C fire management sites and management of wildland fire to meet multiple objectives only within Fire Management Categories C and D sites would promote

**TABLE 4-21.
BLM-ADMINISTERED SOIL RESOURCES MAINTAINED UNDER ALTERNATIVE A**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater	Acres of Slopes 40% or Greater
Soils	Ground-based harvest and slash-treating equipment prohibited on steep slopes (Big Dry only)	12,000	NA	15,000
Water	Floodplain, NSO	30,000	220	NA
	Waterbody, NSO	8,700	160	NA
Veg.	Riparian and wetland, oil and gas NSO	39,000	1,400	NA
Fish and Wildlife	Wildlife, oil and gas NSO	84,000	14,000	NA
	Sage-grouse, oil and gas NSO/NSD[1]	560,000	22,000	NA
Travel Mgmt and OHV	Closed OHV	0	7	NA

[1]**NSD=No Surface Disturbance**

natural soil development within those areas and inhibit this development in areas in which prescribed fire or management of wildland fire to meet multiple objectives was prohibited.

Although implementing terms and conditions in allotments that failed to meet Rangeland Health Standards would encourage recovery of the soil system as the allotments progressed toward improvement, the compaction and accelerated erosion associated with further grazing would slow the recovery of the compromised soil system. Allotments that failed to meet Rangeland Health Standards because of livestock grazing would contain soil in poor health, which would potentially include characteristics such as reduced ground cover, compaction, accelerated erosion, sedimentation, and decreased productivity, fertility, moisture, and organic matter (Evans and Ehleringer 1993; Bainbridge 2007). Potential terms and conditions that supported soil system recovery would include exclosures around sensitive areas, optimization of herd distribution, reductions in animal unit months (AUMs), and alteration of grazing regimes.

Deferring grazing for at least 1 growing season following fire within the Big Dry RMP area or temporarily closing grazing in the Powder River RMP area would encourage soil recovery from fire. However, reestablishing grazing before ground cover was reestablished would expose the soil resource to compaction and accelerated erosion by livestock. Reestablishment of vegetative cover following fire would typically occur over a minimum of 2 growing seasons (BLM 2007d). Prohibiting grazing until vegetation objectives were met would allow for climatic events (e.g., drought) that slowed the recovery of the system.

Basing carrying capacity on livestock species and age class would reduce the productivity of the soil resource because carrying capacity assessments would not include soil resource conditions, such as potential soil productivity.

Areas of concentrated open OHV use would result in accelerated erosion and reduced ground cover, infiltration, nutrient cycling, and organic matter (BLM 2003m; Bainbridge 2007), particularly in areas of highly erodible soils. OHV use on slopes greater than 25 percent would have a severe risk of accelerated water erosion (NRCS 1998). Soils with biotic, physical, or chemical crusts in areas with low vegetative cover would be particularly susceptible to

**TABLE 4-22.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION UNDER ALTERNATIVE A**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fire	Fuels in Condition Class 3	21,000	4,000
Travel Mgmt and OHV	Open OHV Areas	2,000	69

destabilization from cross-country travel, which would result in accelerated erosion. Disturbance of areas dependent on biotic crusts for nutrient cycling would result in reduced fertility (Evans and Ehleringer 1993).

ALTERNATIVE B

Land uses proposed under Alternative B, such as vegetation or fuels treatments, range or habitat improvements, mechanical invasive species (vegetation) control, oil and gas exploration and extraction, geophysical exploration, vehicle use, infrastructure, and ROW activities, would cause surface disturbance. Surface disturbances would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance; including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Reserve, brine, and water disposal pits would contain material (e.g., drilling fluids, mud, cuttings, and salts) that altered soil chemistry and created soil toxic to biota if the material leaked out of the pit. Implementing closed-loop drilling or other pitless methods would avoid such impacts and reduce the total area of disturbance. Disposal of water with high salt content using land application or seepage ponds would result in reduced infiltration and productivity, increased overland flow, accelerated erosion, or cause impacts toxic to biota. Discharge of produced water would result in gullying, headcutting, and sedimentation (ALL 2001a; BLM 2008g). Spills or leaks of produced hydrocarbons, fuels, or produced water high in salt content would create soil toxic to biota (BLM 2008g). Early detection, containment, and cleanup would keep such impacts localized.

As slopes approach 30 percent, the risk of soil instability following disturbance increases, particularly if cover, structure, permeability, or bulk density has been altered (Monsen et al. 2004). Reclamation suitability is low for slopes greater than 20 percent (Monsen et al. 2004). However, surface disturbances would only impact soils on slopes less than 25 percent and soils well suited to reclamation. Allowing only management actions that benefited the functionality of soil resources would maintain or improve soil resources, including sensitive soils (1.6 million acres, 57 percent of the planning area) and soils on slopes greater than 25 percent (150,000 acres, 5 percent of the planning area) (Table 4-23).

Management actions that prohibited surface-disturbing activities would maintain soil resources. Allowing only surface-disturbing activities that benefited the functionality of floodplains, waterbodies, and aquatic wildlife habitat would enhance natural soil structure and function, particularly hydric soils. However, prohibiting such activities within designated riparian, wildlife habitat, cultural, and paleontological areas would inhibit treatment strategies that would improve soil resources.

Management actions designed to maintain, conserve, or improve vegetation conditions (including timber harvest or salvage for habitat improvement, haying, riparian and wetland areas, fuels management, approximating natural disturbance regimes, and supporting forest resilience) would promote natural soil

structure and function. Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

TABLE 4-23.
BLM-ADMINISTERED SOIL RESOURCES MAINTAINED UNDER ALTERNATIVE B

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Soils	Sensitive soil, NSD[1]	1,600,000	140,000
	Steep slope, NSD	140,000	150,000
Water	Floodplain, NSD	29,000	250
	Waterbody, NSD	8,700	160
Veg.	Riparian and wetland, NSD	39,000	1,400
	Riparian and wetland, livestock water developments prohibited	53,000	1,700
Fish and Wildlife	Wildlife, NSD	880,000	95,000
Travel Mgmt and OHV	Closed OHV Areas	18,000	2,900

[1]**NSD=No Surface Disturbance**

Impoundments would accumulate sediment flows that would have been deposited naturally downstream in other areas, which would alter natural erosion and deposition rates at the impoundment and downstream (Zelt et al. 1999). Impoundments would also reduce riparian vegetative cover along the channel, which would result in accelerated erosion and sedimentation (Poff et al. 1997). Dam failure would result in accelerated water erosion and sedimentation. Unlined water impoundments would change subsurface water flow regimes, which would alter natural soil formation processes, including nutrient cycling, mobilization (e.g., sulfate, selenium, arsenic, manganese, barium, chloride, and nitrate), and salt distribution (NAS 2010). Salts from the impoundment concentrated in soils would reduce infiltration and productivity, increase overland flow, accelerate erosion, or cause impacts toxic to biota (see the *Soils Appendix* for further discussion on salt-affected soils). Wet soils surrounding the impoundment would be susceptible to compaction from concentrated use. Requiring mitigation for such actions would encourage sustainable use of the soil resource.

Although prohibiting surface-disturbing activities in areas of invasive vegetation species infestations would maintain soils degraded by such infestations, it would inhibit treatment strategies that maintained or enhanced the soil resource. Basing priority treatment areas on Montana-designated invasive vegetation species would promote natural soil systems within areas particularly affected by such species. However, basing priority treatment areas on sites either particularly susceptible to, or particularly affected by, weed invasions, would more effectively maintain or enhance the soil resource.

Wildlife requirements would potentially inhibit treatment strategies that improved soil resources. For example, revegetation would potentially be prohibited in the spring, which would result in accelerated erosion due to lack of vegetative cover.

Mitigating surface-disturbing activities to maintain habitat functionality within 2 miles of sharp-tailed grouse nesting habitat and leks would encourage sustainable use of the soil resource within these areas (Table 4-24).

Requiring sage-grouse habitat compensation would encourage habitat connectivity, which would promote the soil system's ability to adapt to climate change and resilience to future disturbances (Perrow and Davy 2003).

**TABLE 4-24.
BLM-ADMINISTERED SOIL RESOURCES CONSERVED UNDER ALTERNATIVE B**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fish and Wildlife	Wildlife, CSD[1]	760,000	86,000
Travel Mgmt and OHV	Limited OHV Use	1,600,000	150,000

[1]CSD=Controlled Surface Disturbance

Although fuels reduction treatments would cause surface disturbance in the short term, they would reduce the intensity and severity of wild and prescribed fire (Arno and Allison-Bunnell 2002; Perrow and Davy 2003). However, requiring pre-commercial or commercial fuels removal prior to prescribed fire actions would cause unnecessary degradation of the soil resource if other mitigation alternatives existed (Table 4-25). Prohibiting prescribed fire and management of wildland fire to meet multiple objectives would inhibit natural soil development.

Allotments that failed to meet Rangeland Health Standards as a result of livestock grazing would contain soil in poor health, which would potentially include characteristics such as reduced ground cover, compaction, accelerated erosion, sedimentation, and decreased productivity, fertility, moisture, and organic matter (Evans and Ehleringer 1993; Bainbridge 2007). Prohibiting grazing in allotments that failed to meet Rangeland Health Standards would promote full recovery of the soil system.

Requiring grazing restrictions for 2 growing seasons following fire would promote soil recovery. However, prohibiting grazing until vegetation objectives were met would allow for climatic events (e.g., drought) that slowed the recovery of the system. Reestablishment of vegetative cover following fire would typically occur over a minimum of 2 growing seasons (BLM 2007d).

Basing carrying capacity on soil resource conditions, such as potential soil productivity, would promote sustainable use of the soil resource.

ALTERNATIVE C

Land uses proposed under Alternative C, such as vegetation or fuels treatments, range or habitat improvements, mechanical invasive species (vegetation) control, oil and gas exploration and extraction, geophysical exploration, vehicle use, infrastructure development, and ROW activities, would cause surface disturbance. Surface disturbances would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

**TABLE 4-25.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION UNDER ALTERNATIVE B**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fish and Wildlife	Sage-grouse Habitat – General Habitat Areas, aboveground power line restriction	1,400,000	93,000
Fire	Fuels in Condition Class 3	21,000	4,000

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance; including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Reserve, brine, and water disposal pits would contain material (e.g., drilling fluids, mud, cuttings, and salts) that altered soil chemistry and created soil toxic to biota if the material leaked out of the pit. Implementing closed-loop drilling or other pitless methods would avoid such impacts and reduce the total area of disturbance. Disposal of water with high salt content using land application or seepage ponds would result in reduced infiltration and productivity, increased overland flow, accelerated erosion, or cause impacts toxic to biota. Discharge of produced water would result in gullying, headcutting, and sedimentation (ALL 2001a; BLM 2008g). Spills or leaks of produced hydrocarbons, fuels, or produced water high in salt content would create soil toxic to biota (BLM 2008g). Early detection, containment, and cleanup would keep such impacts localized.

TABLE 4-26.
BLM-ADMINISTERED SOIL RESOURCES CONSERVED UNDER ALTERNATIVE C

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Soils	Sensitive soil, CSD[1]	1,600,000	140,000
	Steep slope, CSD	140,000	150,000
Water	Floodplain, CSD	29,000	250
	Waterbody, CSD	8,700	160
Veg.	Riparian and wetland, CSD	39,000	1,400
Fish and Wildlife	Wildlife, CSD	880,000	95,000
Travel Mgmt and OHV	Limited OHV Use	1,600,000	150,000

[1]CSD=Controlled Surface Disturbance

As slopes approached 30 percent, the risk of soil instability following disturbance would increase, particularly if cover, structure, permeability, or bulk density had been altered (Monsen et al. 2004). Reclamation suitability would be low for slopes greater than 20 percent (Monsen et al. 2004). Surface disturbance would impact soils on slopes less than 25 percent and soils well suited to reclamation; actions on slopes greater than 25 percent (150,000 acres, 5 percent of the planning area) and areas of sensitive soils (1.6 million acres, 57 percent of the planning area) would require mitigation to ensure sustainable use of the soil resource (Table 4-26).

Management actions that prohibited surface-disturbing activities would maintain soil resources (Table 4-27). However, prohibiting such activities within designated wildlife habitat, cultural, and paleontological areas would inhibit treatment strategies that improved soil resources. Allowing surface disturbances within floodplains, waterbodies, riparian areas, and along sport-fish reservoirs would impact natural soil structure and function, including hydric soils, which would result in compaction and accelerated water erosion and reduced productivity, infiltration, and water storage. Requiring mitigation for such actions would encourage sustainable use of the soil resource.

Management actions designed to maintain, conserve, or improve vegetation conditions (including timber harvest or salvage for habitat improvement, managing for PFC, haying, fuels management, approximating natural disturbance regimes, and supporting forest resilience) would promote natural soil structure and function. Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

Impoundments would accumulate sediment flows that would have been deposited naturally downstream in other areas, which would alter natural erosion and deposition rates at the impoundment and downstream (Zelt et al. 1999). Impoundments would also reduce riparian vegetative cover along the channel, which would result in accelerated erosion and sedimentation (Poff et al. 1997). Dam failure would result in accelerated water erosion and sedimentation. Unlined water impoundments would change subsurface water flow regimes, which would alter natural soil formation processes, including nutrient cycling, mobilization (e.g., sulfate, selenium, arsenic, manganese, barium, chloride, and nitrate), and salt distribution (NAS 2010).

Although allowing surface-disturbing activities in areas of invasive vegetation species infestations would degrade soil resources already affected by the infestation, it would permit treatment strategies that maintained or enhanced the soil resource. Basing priority treatment areas on sites either particularly susceptible to, or particularly affected by, weed invasions, would more effectively maintain or enhance the soil resource.

Wildlife requirements under this alternative would potentially inhibit treatment strategies that improved soil resources. For example, revegetation would potentially be prohibited in the spring, which would result in accelerated erosion due to lack of vegetative cover.

Mitigating surface-disturbing activities to maintain habitat functionality within 2 miles of sharp-tailed grouse nesting habitat and leks would encourage sustainable use of the soil resource within these areas.

Requiring sage-grouse habitat compensation would encourage habitat connectivity, which would promote the soil system's ability to adapt to climate change and resilience to future disturbances (Perrow and Davy 2003).

Although fuels reduction treatments would cause surface disturbance in the short-term, they would reduce the intensity and severity of wild and prescribed fire (Arno and Allison-Bunnell 2002; Perrow and Davy 2003). Allowing prescribed fire (up to approximately 7,500 acres annually) and management of wildland fire to meet multiple objectives would promote natural soil development.

Allotments that failed to meet Rangeland Health Standards as a result of livestock grazing would contain soil in poor health, which would potentially include characteristics such as reduced ground cover, compaction, accelerated erosion, sedimentation, and decreased productivity, fertility, moisture, and organic matter (Evans and Ehleringer 1993; Bainbridge 2007). Prohibiting grazing in allotments that failed to meet Rangeland Health Standards for 5 years would promote recovery of the soil system. However, the compaction and accelerated erosion associated with grazing over the course of the 5-year evaluation would slow the recovery of the compromised soil system.

Requiring temporary grazing restrictions until the allotment reached vegetation objectives following fire would encourage soil recovery and allow for climatic events (e.g., drought) that slowed the recovery of the system. Reestablishment of vegetative cover following fire would typically occur over a minimum of 2 growing seasons (BLM 2007d).

Basing carrying capacity on soil resource conditions, such as potential soil productivity, would promote sustainable use of the soil resource.

**TABLE 4-27.
BLM-ADMINISTERED SOIL RESOURCES MAINTAINED UNDER ALTERNATIVE C**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Veg.	Riparian and wetland, livestock water developments prohibited	53,000	1,700
Fish and Wildlife	Wildlife, oil and gas NSO	950	12
	Wildlife, NSD[1]	21,000	770
Travel Mgmt and OHV	Closed OHV Areas	49	0

[1]NSD=No Surface Disturbance

Areas of concentrated open OHV use would result in compaction, accelerated erosion, and reduced ground cover, infiltration, nutrient cycling, and organic matter (BLM 2003m; Bainbridge 2007), particularly in areas of highly erodible soils (Table 4-28). OHV use on slopes greater than 25 percent would have a severe risk of accelerated water erosion (NRCS 1998). Soils with biotic, physical, or chemical crusts in areas with low vegetative cover would be particularly susceptible to destabilization from cross-country travel, which would result in accelerated erosion. Disturbance of areas dependent on biotic crusts for nutrient cycling would result in reduced fertility (Evans and Ehleringer 1993).

TABLE 4-28.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION UNDER ALTERNATIVE C

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fish and Wildlife	Sage-grouse Habitat – General Sage-grouse Areas, aboveground power line restriction	930,000	43,000
Travel Mgmt and OHV	Open OHV Areas	480	2

Although soil compaction would occur in areas of concentrated use for big game retrieval, these impacts would be alleviated by annual freeze and thaw action, root penetration, or the shrink-swell action of clays.

ALTERNATIVE D

Land uses proposed under Alternative D, such as vegetation or fuels treatments, range or habitat improvements, mechanical invasive species (vegetation) control, oil and gas exploration and extraction, geophysical exploration, vehicle use, infrastructure development, and ROW activities, would cause surface disturbances. Surface disturbances would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance; including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Reserve, brine, and water disposal pits would contain material (e.g., drilling fluids, mud, cuttings, and salts) that altered soil chemistry and created soil toxic to biota if the material leaked out of the pit. Implementing closed-loop drilling or other pitless methods would avoid such impacts and reduce the total area of disturbance. Disposal of water with high salt content using land application or seepage ponds would result in reduced infiltration and productivity, increased overland flow, accelerated erosion, or cause impacts toxic to biota. Discharge of produced water would result in gullying, headcutting, and sedimentation (ALL 2001a; BLM 2008g). Spills or leaks of produced hydrocarbons, fuels, or produced water high in salt content would

create soil toxic to biota (BLM 2008g). Early detection, containment, and cleanup would keep such impacts localized.

As slopes approached 30 percent, the risk of soil instability following disturbance would increase, particularly if cover, structure, permeability, or bulk density had been altered (Monsen et al. 2004). Reclamation suitability would be low for slopes greater than 20 percent (Monsen et al. 2004). Surface disturbance would impact soils on slopes less than 25 percent, soils well suited to reclamation, and slopes greater than 25 percent (150,000 acres, 5 percent of the planning area). Areas of sensitive soils (1.6 million acres, 57 percent of the planning area) would require mitigation to ensure sustainable use of the soil resource (Table 4-29).

**TABLE 4-29.
BLM-ADMINISTERED SOIL RESOURCES CONSERVED
UNDER ALTERNATIVE D**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Soils	Sensitive soil, CSD[1]	1,600,000	140,000
	Steep slope, CSD	140,000	150,000
Water	Floodplain, CSD	29,000	250
	Waterbody, CSD	8,700	160
Veg.	Riparian and wetland, CSD	39,000	1,400
Fish and Wildlife	Wildlife, CSD	880,000	95,000
Travel Mgmt and OHV	Limited OHV Use	1,600,000	150,000

[1]CSD=Controlled Surface Disturbance

Management actions that prohibited surface-disturbing activities would maintain soil resources. However, prohibiting such activities within designated cultural areas would inhibit treatment strategies that improved soil resources. Allowing surface disturbances within floodplains, waterbodies, riparian areas, and along sport-fish reservoirs would impact natural soil structure and function, including hydric soils, and result in compaction, accelerated water erosion, and reduced productivity, infiltration, and water storage. Requiring mitigation for such actions would encourage sustainable use of the soil resource. Prohibiting livestock water developments in riparian and wetland areas would maintain 53,000 BLM-administered acres of sensitive soils and 1,700 BLM-administered acres of slopes 25 percent or greater.

Management actions designed to maintain, conserve, or improve vegetation conditions (including timber harvest or salvage for habitat improvement, managing for PFC, fuels management, approximating natural disturbance regimes, and supporting forest resilience) would promote natural soil structure and function. Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

Impoundments would accumulate sediment flows that would have been deposited naturally downstream in other areas, which would alter natural erosion and deposition rates at the impoundment and downstream (Zelt et al. 1999). Impoundments would also reduce riparian vegetative cover along the channel, which would result in accelerated erosion and sedimentation (Poff et al. 1997). Dam failure would result in accelerated water erosion and sedimentation. Unlined water impoundments would change subsurface water flow regimes, which would

alter natural soil formation processes, including nutrient cycling, mobilization (e.g., sulfate, selenium, arsenic, manganese, barium, chloride, and nitrate), and salt distribution (NAS 2010). Requiring mitigation for such actions would encourage sustainable use of the soil resource.

Although allowing surface-disturbing activities in areas of invasive vegetation species infestations would degrade soil resources already affected by the infestation, it would permit treatment strategies that maintained or enhanced the soil resource. Basing priority treatment areas on the area's proximity to private lands with active weed management would conserve the soil resource in areas with particularly manageable weed infestations. However, basing priority treatment areas on sites either particularly susceptible to, or particularly affected by, weed invasions, would more effectively maintain or enhance the soil resource.

Mitigating surface-disturbing activities to maintain habitat functionality within 2 miles of sharp-tailed grouse nesting habitat and leks would encourage sustainable use of the soil resource in these areas.

Requiring sage-grouse habitat compensation would encourage habitat connectivity, which would promote the soil system's ability to adapt to climate change and resilience to future disturbances.

Although fuels reduction treatments would cause surface disturbance in the short-term, they would reduce the intensity and severity of wild and prescribed fire (Arno and Allison-Bunnell 2002; Perrow and Davy 2003). Allowing prescribed fire (up to approximately 7,500 acres annually) and management of wildland fire to meet multiple objectives would promote natural soil development.

Allotments that failed to meet Rangeland Health Standards as a result of livestock grazing would contain soil in poor health, which would potentially include characteristics such as reduced ground cover; compaction; accelerated erosion; sedimentation; and decreased productivity, fertility, moisture, and organic matter. Although prohibiting grazing in allotments that failed to meet Rangeland Health Standards for 5 years would promote recovery of the soil system, the compaction and accelerated erosion associated with grazing over the course of the 5-year evaluation would slow the recovery of the compromised soil system.

Requiring grazing restrictions for 2 growing seasons following fire would promote soil recovery. However, prohibiting grazing until vegetation objectives were met would allow for climatic events (e.g., drought) that slowed the recovery of the system. Reestablishment of vegetative cover following fire would typically occur over a minimum of 2 growing seasons (BLM 2007d).

Areas of concentrated open OHV use would result in compaction, accelerated erosion, and reduced ground cover, infiltration, nutrient cycling, and organic matter (BLM 2003m; Bainbridge 2007), particularly in areas of highly erodible soils (Table 4-30). Although soil compaction would occur in areas of concentrated use for big game retrieval, these impacts would be alleviated by annual freeze and thaw.

**TABLE 4-30.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION
UNDER ALTERNATIVE D**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fish and Wildlife	Sage-grouse Habitat – General Sage-grouse Areas, aboveground power line restriction	560,000	22,000
Travel Mgmt and OHV	Open OHV Areas	1,700	56

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Land uses proposed under Alternative E, such as vegetation or fuels treatments, range or habitat improvements, mechanical invasive species (vegetation) control, oil and gas exploration and extraction, geophysical exploration, vehicle use, infrastructure development, and ROW activities, would cause surface disturbance. Surface disturbances would result in reduced ground cover or soil mixing, compaction, or removal; exposure of the soil resource to accelerated wind and water erosion; and the irretrievable loss of topsoil and nutrients. Surface disturbances would potentially result in mass movement or sedimentation. Surface disturbances would also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Mixed soils would have decreased bulk density and altered porosity, infiltration, air-

water relationships, salt content, and pH (Perrow and Davy 2003; Bainbridge 2007). Soil compaction would result in increased bulk density and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; Perrow and Davy 2003; Bainbridge 2007). Altering such characteristics would reduce the soil system's ability to adapt to climate change and withstand future disturbances.

Soils would take decades to hundreds of years to recover from the impacts of altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Mixed or removed soil horizons are perpetually altered by the disturbance; including texture class, rock fragment content, structure, and depth to bedrock. Soil recovery following disturbance would be accelerated by mitigation and reclamation to reduce natural recovery rates, typically hundreds of years, to within several decades (Perrow and Davy 2003). Within 2 to 5 years of reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (BLM 2008g). Exceptions to this timeline would include sites poorly suited to reclamation (1.6 million acres, 57 percent of the planning area), which would require unconventional or site-specific reclamation measures.

Reserve, brine, and water disposal pits would contain material (e.g., drilling fluids, mud, cuttings, and salts) that altered soil chemistry and created soil toxic to biota if the material leaked out of the pit. Implementing closed-loop drilling or other pitless methods would avoid such impacts and reduce the total area of disturbance. Disposal of water with high salt content using land application or seepage ponds would result in reduced infiltration and productivity, increased overland flow, accelerated erosion, or cause impacts toxic to biota. Discharge of produced water would result in gullying, headcutting, and sedimentation (ALL 2001a; BLM 2008g). Spills or leaks of produced hydrocarbons, fuels, or produced water high in salt content would create soil toxic to biota (BLM 2008g). Early detection, containment, and cleanup would keep such impacts localized.

**TABLE 4-31.
BLM-ADMINISTERED SOIL RESOURCES CONSERVED
UNDER ALTERNATIVE E**

	Area or Resource	Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Soils	Sensitive soil, CSD[1]	1,600,000	140,000
	Steep slope, CSD	140,000	150,000
Water	Floodplain, CSD	29,000	250
	Waterbody (including 300-foot buffer), CSD	8,700	160
Veg.	Riparian and wetland, CSD	46,000	1,400
Fish and Wildlife	Wildlife, CSD	880,000	95,000
Travel Mgmt and OHV	Limited OHV Use	1,600,000	150,000

[1]CSD=Controlled Surface Disturbance

As slopes approached 30 percent, the risk of soil instability following disturbance would increase, particularly if cover, structure, permeability, or bulk density had been altered (Monsen et al. 2004). Reclamation suitability would be low for slopes greater than 20 percent (Monsen et al. 2004). Surface disturbance would impact soils on slopes less than 25 percent and soils well suited to reclamation. Actions on slopes greater than 25 percent (150,000 acres, 5 percent of the planning area) and areas of sensitive soils (1.6 million acres, 57 percent of the planning area) would require mitigation to ensure sustainable use of the soil resource (Table 4-31).

Allowing surface disturbance within floodplains, waterbodies, within 300 feet of waterbodies and streams, and along sport-fish reservoirs would impact natural soil structure and function, including hydric soils, which would result in compaction and accelerated water erosion and reduced productivity, infiltration, and water storage. Requiring mitigation for such actions would encourage sustainable use of the soil resource.

Management actions that were designed to maintain, conserve, or improve vegetation conditions (including timber harvest or salvage for habitat improvement, managing for PFC, haying, fuels management, approximating natural disturbance regimes, and supporting forest resilience) would promote natural

soil structure and function. Although some treatments would cause surface disturbance in the short term, such treatments would promote nutrient cycling, soil development, soil biodiversity, and site stability in the long term.

Impoundments would accumulate sediment flows that would have been deposited naturally downstream in other areas, which would alter natural erosion and deposition rates at the impoundment and downstream (Zelt et al. 1999). Impoundments would also reduce riparian vegetative cover along the channel, which would result in accelerated erosion and sedimentation (Poff et al. 1997). Dam failure would result in accelerated water erosion and sedimentation. Unlined water impoundments would change subsurface water flow regimes, which would alter natural soil formation processes, including nutrient cycling, mobilization (e.g., sulfate, selenium, arsenic, manganese, barium, chloride, and nitrate), and salt distribution (NAS 2010). Wet soils surrounding the impoundment would be susceptible to compaction from concentrated use. Requiring mitigation for such actions would encourage sustainable use of the soil resource.

Trough and tank development in riparian and wetland areas would result in compaction from concentrated livestock use. Compacted soils would be at risk of increased surface salt accumulation, which would further reduce infiltration and productivity, increase overland flow, accelerate erosion, or cause impacts toxic to biota. Requiring mitigation to maintain the integrity and functionality of the system would encourage sustainable use of the soil resource

TABLE 4-32.
BLM-ADMINISTERED SOIL RESOURCES MAINTAINED UNDER ALTERNATIVE E

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Water	Floodplain, oil and gas NSO	29,000	250
	Waterbody, oil and gas NSO	39,000	1,400
Veg.	Riparian and wetland, oil and gas NSO	39,000	1,400
Fish and Wildlife	Aquatics, sport-fish reservoirs, oil and gas NSO	770	12
Travel Mgmt and OHV	Closed OHV Areas	1,100	96

Although allowing surface-disturbing activities in areas of invasive vegetation species infestations would degrade soil resources already affected by the infestation, it would permit treatment strategies that maintained or enhanced the soil resource (Table 4-32). Delineating priority treatment areas would enhance the soil resource in sites either particularly susceptible to, or particularly affected by, weed invasions.

Mitigating surface-disturbing activities to maintain habitat within 2 miles of sharp-tailed grouse nesting habitat and leks would encourage sustainable use of the soil resource in these areas.

The absence of sage-grouse habitat compensation requirements under this alternative would cause soil system fragmentation, which would alter soil structure and function. Soil system fragmentation would result in altered soil heterogeneity, microclimate, hydrology, nutrient cycling, biotic richness, and diversity (Perrow and Davy 2003). Localized impacts would include microclimatic changes tens of meters into the patch (from the edge) but altered biota and nutrient cycling would extend even further (Perrow and Davy 2003). Pre-existing disturbance regimes (e.g., fire) would be altered on a landscape scale, which would change natural rates of soil formation (Perrow and Davy 2003).

Although fuels reduction treatments would cause surface disturbance in the short-term, they would reduce the intensity and severity of wild and prescribed fire (Arno and Allison-Bunnell 2002; Perrow and Davy 2003). Allowing prescribed fire (up to approximately 7,500 acres annually) and management of wildland fire to meet multiple objectives would promote natural soil development.

Allotments that failed to meet Rangeland Health Standards as a result of livestock grazing would contain soil in poor health, which would potentially include characteristics such as reduced ground cover, compaction,

accelerated erosion, sedimentation, and decreased productivity, fertility, moisture, and organic matter (Evans and Ehleringer 1993; Bainbridge 2007). Prohibiting grazing in allotments that failed to meet Rangeland Health Standards for 5 years would promote recovery of the soil system. However, the compaction and accelerated erosion associated with grazing over the course of the 5-year evaluation would slow the recovery of the compromised soil system.

Requiring temporary grazing restrictions until the allotment reached resource objectives following fire would allow for climatic events (e.g., drought) that slowed the recovery of the soil system. Reestablishment of vegetative cover following fire would typically occur over a minimum of 2 growing seasons (BLM 2007d).

Basing carrying capacity on livestock species and age class would reduce the productivity of the soil resource, because carrying capacity assessments would not include soil resource conditions, such as potential soil productivity.

Areas of concentrated open OHV use would result in compaction, accelerated erosion, and reduced ground cover, infiltration, nutrient cycling, and organic matter (BLM 2003m; Bainbridge 2007), particularly in areas of highly erodible soils (Table 4-33). OHV use on slopes greater than 25 percent would carry a severe risk of accelerated water erosion (NRCS 1998). Soils with biotic, physical, or chemical crusts in areas with low vegetative cover would be particularly susceptible to destabilization from cross-country travel, which would result in accelerated erosion. Disturbance of areas dependent on biotic crusts for nutrient cycling would result in reduced fertility (Evans and Ehleringer 1993).

**TABLE 4-33.
BLM-ADMINISTERED SOIL RESOURCES AT RISK OF DEGRADATION UNDER ALTERNATIVE E**

Area or Resource		Acres of Sensitive Soils	Acres of Slopes 25% or Greater
Fish and Wildlife	Sage-grouse Habitat – General Sage-grouse Areas, aboveground power line restriction	560,000	22,000
Travel Mgmt and OHV	Open OHV Areas	1,700	56

CUMULATIVE IMPACTS

Historical and ongoing activities adjacent to or within the planning area include mineral exploration and development, livestock grazing, on- and off-road vehicle use, recreation, infrastructure development, fire suppression, altered fire regimes, forestry, urbanization, invasive vegetation species infestations, pollution, and agriculture. The cumulative effects of such activities have contributed to compaction, increased overland flow, mass movement, and accelerated erosion by wind and water and resulted in sedimentation and the irretrievable loss of topsoil and nutrients. Long-term impacts have included altered pH and reduced soil stability, organic matter content, microbial mass, biotic richness and diversity, and phosphorus and nitrogen content (Perrow and Davy 2003). Permanent impacts have included altered texture class, rock fragment content, structure, and depth to bedrock. Such activities have also caused habitat fragmentation, which has resulted in altered soil heterogeneity, microclimate, hydrology, nutrient cycling, biotic richness, and diversity (Perrow and Davy 2003). Pre-existing disturbance regimes (e.g., fire) have been altered, which also altered natural rates of soil formation (Perrow and Davy 2003).

From the 1860s through the 1890s, the United States military brought great numbers of livestock (horses, mules, sheep, and cattle) to eastern Montana, replacing bison as the dominant large ungulate. Although the planning area evolved with large ungulate herbivory, uncontrolled grazing (first by the military and then by ranchers beginning in the late 19th century) has caused reduced ground cover, compaction, accelerated erosion, sedimentation, decreased productivity, fertility, moisture, and organic matter (Evans and Ehleringer 1993; Bainbridge 2007). Beginning in 1934, the Taylor Grazing Act and subsequent grazing management (e.g., proper stocking rates and season of use) improved range condition and soil conservation.

Beginning in the late 1800s, commercial production of coal caused soil mixing, removal, compaction, accelerated erosion, and sedimentation. Starting in 1977, coal development became subject to the Surface

Mining Control and Reclamation Act (also known as SMCRA) (30 U.S.C. 1201 et seq.), which provided protection for soil resources. Such surface disturbances continue to this day, including oil and gas extraction (beginning in the 1950s), along with several other forms of minerals extraction such as bentonite, gravel, and scoria.

Homesteaders arriving in the early 20th century developed croplands, subjecting soils to surface-disturbing actions and irrigation, which resulted in accelerated erosion, nutrient depletion, soil salinity, and sodicity. Land application of water has resulted in saline seeps. Drought, in combination with cropland development in 1919 and again in the 1930s, resulted in accelerated wind erosion of agricultural lands. The Soil Conservation and Domestic Allotment Act of 1935 (P.L. 74-46) encouraged farmers in eastern Montana to conserve the soil resource on croplands, which led to a decline in accelerated wind erosion. In 1985, the Conservation Reserve Program began promoting conservation of erodible soils by supporting cover crops, reduced surface-disturbing actions, and the conversion of marginal croplands to grassland.

Beginning early in the 20th century, fire suppression (in conjunction with grazing, development, and nonnative vegetation) has altered natural fire regimes in eastern Montana (USFS and USDI 2007), resulting in altered soil development, nutrient cycling, and soil biodiversity. Recently, fuels treatments on lands adjacent to the planning area have reduced the intensity and severity of wild fire and resulted in the landscape trending toward a natural fire regime.

Although land management within watersheds contiguous to the planning area contributes to increased overland flow onto BLM-administered lands (leading to accelerated water erosion and sedimentation), soil conservation and improvement is a fundamental component of most management on lands adjacent to the planning area. Accelerated erosion from roads has been reduced with improved road construction and maintenance methods. Federal and state requirements for water quality have contributed to reductions in accelerated erosion and sedimentation. Federal and state air quality standards have contributed to fugitive dust control and reductions in atmospheric deposition of pollutants. Management for wildlife under the Endangered Species Act (ESA) and state sensitive species guidelines and regulations has contributed to soil conservation and restoration. Invasive weed control on adjacent lands continues to protect soils from many nonnative species. The *Custer National Forest Plan* provides for soil resource conservation (USFS 1986). Management actions that promoted organic soil carbon storage on adjacent lands would inherently reduce overland flow onto BLM-administered lands and would potentially alter water cycles and other ecosystem processes. Management of soil resources on lands adjacent to the planning area is expected to continue on the path of conservation and improvement, which would result in increased soil health and reduced accelerated erosion and sedimentation. Although surface-disturbing actions on BLM-administered lands on up to approximately 50,000 acres in the short term and up to 330,000 acres in the long term would potentially occur, all land uses under all alternatives would meet the Standards for Rangeland Health. Alternatives vary in the amount of localized site-level impacts.

Alternative A

The assessed resources, ecosystems, and human communities of concern are approaching conditions in which additional stresses associated with the proposed action and past, present, and future foreseeable actions would have cumulative effects. Alternative A would contribute to a decline in soil resource health and conservation. This alternative would maintain 17,000 acres of sensitive soils and 470 acres of slopes 25 percent or greater under surface-disturbing actions and require mitigation on 6,800 acres of sensitive soils and 590 acres of slopes greater than 25 percent. Historically, management actions proposed under Alternative A have led to allotments that failed to meet Rangeland Health Standards or that contained downward trend riparian or wetland areas, ecosystems with moderate to high departures from natural fire regimes, and disturbed lands with insufficient reclamation.

Alternative B

The assessed resources, ecosystems, and human communities of concern are approaching conditions in which additional stresses associated with the proposed action and past, present, and future foreseeable actions would have cumulative effects. Alternative B would contribute to the continuing increase in soil resource health and

conservation because many actions under Alternative B would not allow surface uses and ground-disturbing actions. This alternative would maintain 1.6 million acres of sensitive soils and 150,000 acres of slopes 25 percent or greater under surface-disturbing actions and require mitigation on 6,400 acres of sensitive soils and 470 acres of slopes greater than 25 percent.

Alternative C

The assessed resources, ecosystems, and human communities of concern are approaching conditions in which additional stresses associated with the proposed action and past, present, and future foreseeable actions would have cumulative effects. Alternative C would contribute to the continuing increase in soil resource health and conservation because many actions within Alternative C would require controlled management of surface uses and ground-disturbing actions, including those aimed toward ecological improvement. Consequently, Alternative C would provide for conservation of the soil resources. This alternative would maintain 520,000 acres of sensitive soils and 34,000 acres of slopes 25 percent or greater under surface-disturbing actions and require mitigation on 1.1 million acres of sensitive soils and 20,000 acres of slopes greater than 25 percent.

Alternative D

The assessed resources, ecosystems, and human communities of concern are approaching conditions in which additional stresses associated with the proposed action and past, present, and future foreseeable actions would have cumulative effects. Alternative D would contribute to the continuing increase in soil resource health and conservation because many actions under Alternative D would require controlled management of surface uses and ground-disturbing actions, including those aimed toward ecological improvement. Consequently, Alternative D would provide for conservation of the soil resources. This alternative would maintain approximately 320,000 acres of sensitive soils and 17,000 acres of slopes 25 percent or greater under surface-disturbing actions and require mitigation on 1.3 million acres of sensitive soils and 130,000 acres of slopes greater than 25 percent.

Alternative E (Preferred Alternative)

The assessed resources, ecosystems, and human communities of concern are approaching conditions in which additional stresses associated with the proposed action and past, present, and future foreseeable actions would have cumulative effects. Alternative E would contribute to the continuing increase in soil resource health and conservation because many actions under Alternative E would require controlled management of surface uses and ground-disturbing actions, including those aimed toward ecological improvement. Consequently, Alternative E would provide for conservation of soil resources. This alternative would also provide for required mitigation in areas that buffered waterbodies and riparian areas. This alternative would maintain 480 acres of sensitive soils and 170 acres of slopes 25 percent or greater under surface-disturbing actions and require mitigation on 1.6 million acres of sensitive soils and 150,000 acres of slopes greater than 25 percent.

WATER RESOURCES

ASSUMPTIONS AND METHODOLOGY

There would be 1 to 10 watershed enhancement projects (with an emphasis on MDEQ water quality impaired or threatened streams) constructed each year, disturbing a total of 1 to 100 acres per year.

Surface water impoundments are human-constructed impoundments (e.g., pits, reservoirs, stock ponds) of surface water (e.g. overland flow, streamflow, springs) confined by a dam, dike, or other constructed barrier. This does not include impoundments of groundwater (unless the water were naturally discharged to the surface, as in a spring), water from wells, or produced water sources (e.g., water disposal pit).

Waterbodies include all surface water (e.g., rivers, streams, creeks, coulees, springs, reservoirs, lakes, ponds, wetlands, and canals).

Acre figures and other numbers used in the analysis are approximate projections for comparison and analytical purposes only. The planning area is estimated to contain approximately:

- 300,000 acres of waterbodies, of which 12,000 are BLM-administered surface acres and 41,000 are BLM-administered mineral estate acres;
- 1.0 million acres of floodplains of major rivers, of which 35,000 acres are BLM-administered surface and 260,000 acres are BLM-administered mineral estate under Alternative A; and
- 1.4 million acres of floodplains, of which 42,000 are BLM-administered surface acres and 330,000 are BLM-administered mineral estate acres under Alternatives B, C, and D.

The GIS estimation of waterbody acres is based on the 1:24,000-scale 2009 USGS National Hydrography Dataset flowlines (with an approximation of 12-foot wide perennial streams and 4-foot wide intermittent and ephemeral streams) in combination with waterbody and major stream polygons.

The GIS estimation of floodplain acres are based on NRCS soil interpretation of a flood frequency classification of a rare to very frequent flooding class (a 1 percent or greater chance of flooding in any given year) in combination with the waterbodies and major stream polygons from the 1:24,000-scale 2009 USGS National Hydrography Dataset. The NRCS data are based on soil properties, evidence collected during soil survey fieldwork, and flood analyses, where available. Federal Emergency Management Agency data (of very limited extent in the planning area) were incorporated for classification of floodplains with very frequent flooding. Because it is based on known acres, the estimate is low. Data would be incorporated as they were collected.

Under Alternative A, floodplains of major streams were delineated based on floodplains within 250 feet of named streams.

Impacts analysis and conclusions are based on interdisciplinary team knowledge of resources, reviews of existing literature, and information provided by other agencies and institutions.

Mitigation, specialized design features, and CSU stipulations for oil and gas leasing and development would not correlate directly to the reduction of BLM-administered oil and gas wells or acres of surface disturbance.

Acre figures in all tables, except where noted, may overlap, and adding these figures will not result in accurate total acreage values.

BLM-authorized activities would comply with state and federal regulations, Rangeland Health Standards, and BMPs to protect the chemical, physical, and biological integrity of the water and riparian habitat.
Improving the condition of degraded uplands, riparian areas, and wetlands is a reasonable land, soil, and water conservation practice that reduces nonpoint source pollution from these source areas. Actions that increased the resiliency of ecosystems would reduce the vulnerability of the water resources to climate change impacts. A resilient ecosystem would be able to function properly during slow and moderate climate changes (CEICC 2008).

MANAGEMENT COMMON TO ALL ALTERNATIVES

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use Table [4-34]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction, and soil disturbance (Table 4-35). Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further

through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would typically be localized and short term, lasting until vegetation was reestablished, there would be the potential for severe and long-term effects to water quality and overall stream function (however the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed. Acquired lands that improved the continuity of BLM-administered lands within a particular watershed or increased BLM-administered land along streams would enable greater efficacy in altering water management and potentially prevent impacts of surface disturbance in these areas.

TABLE 4-34.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALL ALTERNATIVES

	Area or Resource	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Recreation	Powder River Depot Special Recreation Management Area (SRMA)	3	0	7	4
	Calypso SRMA	<1	0	50	0
Special Desig. Areas	Ash Creek Divide, Hell Creek, Sand Arroyo, and Bug Creek ACECs[1]	130	170	34	490
	Hoe	2	2	0	0
	Jordan Bison Kill	1	1	0	0
	Finger Buttes	4	4	0	0
	Piping Plover	0	0	3	0
	Smoky Butte	<1	<1	0	0

[1]areas of critical environmental concern

Management actions that limited emissions and enhanced or maintained air quality would benefit water resources by limiting reductions in water quality through atmospheric deposition and limiting wind erosion. Management actions that reduced contributions to climate change and accommodated or mitigated long-term changes in seasonal weather patterns would reduce impacts on water resources.

Management actions that limited soil erosion or compaction, such as requiring reclamation or limiting soil disturbances, would benefit water resources. Soil erodibility would increase with increasing slope; subsequently, the magnitude of water quality degradation would increase with surface disturbance on steeper slopes. Eroded soil would introduce sediment, nutrients, metals, and chemicals to water. Because approximately 60 percent of water-eroded soil enters streams (Pimentel and Kounang 1998), reducing soil erosion would reduce impacts to water quality. Soil compaction would change watershed hydrology by reducing infiltration and increasing overland flow, which would subsequently accelerate erosion. Impacts to water quality would be reduced by the application of appropriate mitigation, relocation or denial of the activity, consideration of reclamation suitability, and use of reclamation plans (see the *Reclamation Appendix*).

Consulting with other agencies would facilitate water management on a watershed level across multiple agency boundaries. Meeting water quality standards and minimizing or controlling contributions of nonpoint source pollution would protect or improve water quality. However, water quality would vary considerably while meeting water quality standards. Filing for water rights would help to ensure that over-appropriation of water resources would not occur. Although leaks or spills from equipment would contaminate water, the potential for

this occurrence would be reduced by requiring that vehicle and equipment servicing and refueling activities take place away from wet areas and drainages. Appropriate well completion would reduce the potential for contamination from salts, drilling fluids, fluids and gases from other formations, detergents, solvents, hydrocarbons, metals, and nutrients.

Actions that maintained or improved vegetation conditions would generally maintain erosion rates and hydrologic cycles, which would maintain or enhance water resources in the long term. Actions that increased the resiliency of ecosystems would reduce the vulnerability of the water resources to climate change impacts (CEICC 2008).

Vegetation manipulation treatments, forest health, or vegetation projects would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance described above. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity). In the long term, treatments would promote watershed function and improve water quality.

TABLE 4-35.
WATER RESOURCES AT RISK OF DEGRADATION UNDER MANAGEMENT COMMON TO ALL ALTERNATIVES

Area or Resource	Waterbodies (miles)	Floodplains (acres)
Coal, high and moderate development areas	8,300	42,000
Coal, further study areas	6,100	35,000
Current oil and gas leases	5,700	20,000
High RFD, oil and gas development	45,000	23,000
Moderate RFD, oil and gas development	1,300	8,400
Low RFD, oil and gas development	8,700	240,000

Herbicide treatments would have the potential to impact surface or groundwater quality (or both). The use of paint-on chemicals would reduce the potential for surface water contamination in comparison to spraying. Generally, shallow groundwater aquifers would be at greater risk for contamination. Dicamba and diquat are known groundwater contaminants. Although diflufenzopyr is not known to contaminate groundwater, it would have a high potential to leach to groundwater. Except for fluridone, which has a high potential for surface water runoff, there is low potential for herbicide treatments to reach aquatic bodies in overland flow. These risks would be reduced by chemical choice and standard operating procedures designed to reduce potential, unintended impacts to water (BLM 2007d). In the long term, treatments would promote natural nutrient cycling patterns, erosion rates, stream morphology, evapotranspiration, infiltration (Hansen, Pfister, Boggs, Cook, Joy, and Hinckley 1995), and flow regimes associated with native vegetation.

Actions that preserved or established vegetated riparian buffer zones, wetland function, PFC, and riparian enclosures would maintain or enhance water resources. Managing prairie streams for PFC would enhance riparian vegetation, water quality, and water quantity. Riparian and wetland areas would function as a buffer for waterbodies by reducing or eliminating nonpoint source pollution from upland areas (MDEQ 2007) and improve water quality, allow groundwater recharge, filter sediment, retain floodwater, and remove pollutants (Prichard et al. 1999). Maintaining PFC in riparian and wetland areas would preserve watershed resilience and facilitate rapid reclamation, which would reduce the impact of surface-disturbing activities on water resources. Erosion, turbidity, and sedimentation would be reduced and channel morphology and water quality maintained because healthy riparian vegetation would dissipate the energy of high water flows, filter sediment, stabilize streambanks, and allow for floodplain functionality. Actions that increased the resiliency of ecosystems would reduce the vulnerability of the water resources to climate change impacts (CEICC 2008).

Habitat restoration projects would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity). Actions that conserved habitats would generally maintain erosion rates and hydrologic cycles, which would maintain or enhance water resources in the long term.

Although 300-foot buffers would be applied under Wildland Fire Management actions in compliance with the *Guidelines for Aerial Delivery of Retardant or Foam near Waterways* (USFS, BLM, NPS, and USFWS 2000) and the *Policy for Delivery of Wildland Fire Chemicals (Retardant and Foam) Near Waterway*s (USFS, BLM, NPS, and USFWS 2009), fire retardant would have the potential to enter waterbodies through wind or overland flow, which would impair water quality (e.g., through the introduction of nitrogen, phosphorus, and boron) (Little and Calfee 2004) (see impacts from surface disturbance above).

Impacts to the watershed from fire would depend on fire size and severity, soils, watershed slope, vegetation, regrowth, precipitation, location in the watershed, and extent of watershed burned. Severe or highly intense fire would reduce watershed function and water quality by reducing infiltration, reducing vegetation cover, increasing erosion, and increasing overland flow. Soil erosion (0.42 tons per acre) for a single precipitation event in a wildfire burned watershed could be up to 90 percent of the estimated annual erosion (Elliot, Miller, and Audin 2010). Management of wildland fire to meet multiple objectives in riparian areas would cause erosion and sedimentation before revegetation occurred. Mechanical treatments would provide coarse woody debris that stabilized streambanks and dissipated energy. If applied in locations in which overland flow or soil erosion introduced fertilizer to water, fertilizer use would lead to short-term increases in nutrients and metals in surface water, which would subsequently lead to eutrophication and lower dissolved oxygen content. Short-term impacts of surface disturbance would occur during vegetation treatment and establishment. In the short to long term, watershed health and water quality would increase.

Reduction of hazardous fuel loads would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity). Reducing hazardous fuel loads would reduce the vulnerability of the water resources to climate change impacts (CEICC 2008).

Cultural Resources management actions that required an NSO stipulation for oil and gas leasing, closed areas to leasing, and prohibited surface disturbance would maintain water quality. Allowing surface disturbances would decrease water quality in these areas (see impacts from surface disturbance above).

Forest management activities and harvest of dead or dying timber would have the potential to increase overland flow, erosion, and sedimentation, which would alter flow regimes and decrease water quality. Post-fire salvage logging would delay or prevent natural watershed recovery, particularly in areas of high-severity fires, riparian areas, steep slopes, and erosion-prone soils (Karr et al. 2004). Salvage harvest of sawtimber would remove vegetation in a watershed with an already reduced canopy cover, which would further accelerate erosion and add to the impacts caused by harvesting.

Cottonwood (*Populus sp.*) harvest would occur in riparian areas, wetlands, floodplains, and near stream channels, which would cause short-term erosion, increased overland flow, decreased infiltration, and degradation of water quality associated with increasing sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants (MDEQ 2007). Riparian vegetation and large woody debris removal would reduce the system's capacity to dissipate flood energy. Harvest of cottonwood species would have the

potential to change a riparian forest-type community to a shrub- or graminoid-dominated community (Hansen, Thompson, Massey, and Thompson 2008).

Meeting Rangeland Health Standards would help to maintain water quality. Standard 1 requires stable soils, adequate ground cover, minimal accelerated erosion, and hydrologic function (the capacity of the site to capture, store, and release water). Standard 2 requires that riparian areas attain PFC. Standard 3 requires that the beneficial uses as defined by Montana Water Quality Standards are fully supported, which would reduce impacts to water quality (MDEQ 2007). Beneficial uses would not be supported when sources such as sediment, pollutants, stream modifications, riparian habitat degradation, and excessive water withdrawal caused impairment. Standard 4 requires compliance with air quality standards and limited emissions from nonpoint sources, which reduces the atmospheric deposition of pollutants such as nitrogen, phosphorus, mercury, and chemicals (MDEQ 2007). Standard 5 requires maintenance of upland watershed health through the improvement or maintenance of healthy, native plant populations. Standards 1 through 5 would maintain watershed functionality.

The magnitude of impacts from livestock grazing would vary based on utilization, location in the watershed, duration, and season of use. Livestock grazing would potentially alter the watershed hydrology by lowering the water table; compacting soils; decreasing low flows and infiltration rates; and increasing overland flow, volume of peak flows, and floodwater velocity (Belsky, Matzke, and Uselman 1999). Livestock grazing would accelerate soil erosion, reduce riparian vegetation, increase water temperature, decrease dissolved oxygen, degrade the stream channel, and introduce pollutants such as sediment, salinity, bacteria, and nutrients to water (MDEQ 2007). Wide and shallow channels, high sediment yield, and high turbidity (Magilligan and McDowell 1997) would characterize grazing-disturbed streams. However, proper management (Mosley, Cook, Griffis, and O'Laughlin 1999; Saunders and Fausch 2007) and compliance with Rangeland Health Standards and Guidelines would minimize these impacts.

Improved livestock management would reduce or reverse the impacts of livestock grazing, which would result in declines in erosion within 5 to 14 years and increased vegetation cover, riparian and wetland functionality, and recruitment of desired riparian woody species; however, some channel and bank morphological properties would take longer (14 or more years) (Magilligan and McDowell 1997). Exclosures would allow stream systems the total rest from grazing required for full recovery of structure and function (Belsky et al. 1999) in the long term. Exclosures would allow for stream channel recovery (lower width-to-depth ratio and increased pool area) in the long term and riparian vegetation recovery (increased percent cover, increased bank stability, reduced water temperature, and restored natural nutrient cycling) in the short to long term (Magilligan and McDowell 1997). AUM decreases, grazing plans and systems, and range improvements that reduced utilization in waterbodies and riparian areas would reduce impacts of grazing. Livestock grazing use adjustments (decreased use) due to drought, fire, flood, and insect infestations would decrease the compounded impacts of livestock grazing during watershed disturbance.

Coal Unsuitability Criterion 16 designates 100-year floodplains as unsuitable for coal leasing according to risks of substantial threat of loss of life or property, not resource values. As applied in the Powder River RMP, water resources on 3,215 acres along the Tongue River and 2,966 acres along the Powder River would be maintained. Floodplains of "lesser streams" would be affected by mining. Potential alluvial valley floors along 856 stream miles would be listed as unsuitable at the planning stage, which would maintain water resources (BLM 1985c). Monitoring by lessees in accordance with federal and state requirements would assure compliance and protect the quality and quantity of surface water and groundwater. Reclamation would reconstruct drainage with the approximate original contour and lower surface elevation, which would cause permanent changes in stream channels (BLM 1984).

Coal mining activities (e.g., surface disturbance, road construction, overburden removal, rerouting of stream systems, and the presence of sediment ponds) would disrupt surface water, reduce streamflow downstream, and reduce peak flows. During mining, sedimentation would be reduced by sedimentation ponds. Spoils would experience decreased infiltration following reclamation (for 10 to 15 years) and, as a result, overland flow and peak flows would increase by approximately 5 percent (BLM 1984). Discharge of produced water during

operations and discharge of groundwater with leached salts following operations would impact surface water quality and quantity.

Coal seams typically serve as groundwater aquifers. Drawdown from mining operations would be up to 75 feet and extend up to 5 miles from the site (BLM 2008g), which would take years to recover. Impounding or discharging produced water would increase evaporative losses of groundwater. Seepage from holding ponds would impact groundwater. As coal and overburden was removed, local groundwater quality and quantity would be affected permanently by replacement with a spoil aquifer (BLM 1984). After mining, for hundreds to thousands of years, groundwater discharged from the site would contain increased leached salts (increases of 500 to 2,000 milligrams per liter total dissolved solids [TDS]). The degree of this increase would depend on the geology and the extent would be several miles downgradient (BLM 1984). Agricultural beneficial uses would not be supported in isolated areas in which groundwater was a major contributor to surface water (BLM 1984). Water quality and discharge impacts would be mitigated by compliance with state regulations.

Produced water from conventional oil and gas, uranium recovery, and CBNG development would impact the quality of surface water and groundwater through impoundments, injection, and discharge. Permits from the BLM, Montana Board of Oil and Gas Conservation (MBOGC), and MDEQ would mitigate these actions. Impounding or discharging produced water would increase evaporative losses of groundwater. Left untreated, produced water discharge and infiltration or leaking produced water disposal pits would be likely to reach stream channels via subsurface flow, which would decrease water quality. If aquifers were hydraulically connected to nearby streams and springs, the drawdown of groundwater would result in flow depletion. Typically, produced water from conventional oil and gas wells would originate from a depth below useable aquifers or coal seams. Underground injection control regulations would isolate injection zones from useable or potentially useable aquifers, which would limit the impacts.

Bore crossing or horizontal directional drilling (HDD) would avoid contact with waterbodies. If staging areas were located in uplands with a sufficient vegetative buffer, there would be no direct impacts other than the possibility of an unexpected release of drilling fluids (commodity referred to as a “frac-out”).

Hydraulic fracturing would have the potential to reduce water quality through the introduction of fluids containing biocides, acids, diesel fuel, solvents, and alcohols (USEPA 2004). In the Powder River basin (PRB) for CBNG, fracturing is used very infrequently because the coal seams are naturally highly permeable (NAS 2010). Hydraulic fracturing would cause changes in vertical and horizontal aquifer permeability and potentially increase hydrologic communication with adjacent aquifers (USEPA 2004).

The contents of reserve pits would depend on the type of drilling system, formation, and chemicals added to the mud circulation system. Reserve pits would possibly contain drill cuttings, water, diesel oil, mineral oil, synthetic compounds (e.g., internal olefins, esters, linear alpha-olefins, poly alpha-olefins, or linear paraffins), weighting agents (e.g., barium sulfate or barite), oil-based muds (including polynuclear aromatic hydrocarbons), polymers (partially hydrolyzed polyacrylamide, and polyanionic cellulose), glycols, chromium, zinc, polypropylene glycol, acrylamide copolymers, drilling detergents, bentonite, surfactants, hydrochloric acid, sodium carbonate (soda ash), lignosulfonates, and lignites (Ramirez 2009). Typically, water-based muds would have the lowest potential for impacts to water resources, followed by synthetic-based muds then oil-based muds. Reclamation of reserve pits would typically consist of fluid removal, followed by evaporation or solidification, then encapsulation and on-site burial. Other disposal methods would include off-site disposal, downhole injection, or treatment and reuse (Ramirez, Jr. 2009).

The use of reserve pits and burial of reserve pits onsite would have the potential to contaminate groundwater and surface water with metals and hydrocarbons if improperly managed or closed. Evaporation would concentrate water-soluble metals, salts, and other chemicals. Precipitation, fluctuation of shallow groundwater, and flooding would potentially mobilize these contaminants into groundwater. Liners “most often do not adequately seal the drilling wastes, especially if they are torn” (Ramirez, Jr. 2009, p. 8). Solidification would prevent mobilization of potential contaminants. Removal and off-site disposal of liquids would remove most of the water-soluble metals, salts, and chemicals from the drilling waste material. The use of pitless or closed-loop technology would potentially conserve water, recycle drilling fluids, reduce surface disturbance, and eliminate

the use of pits. If pits were not lined or buried onsite, drill cuttings would potentially leach metals and hydrocarbons to groundwater (Ramirez, Jr. 2009). Off-site disposal or treatment and reuse would reduce impacts to water.

Drawdown in coal seams after 20 years of CBNG development is expected to be 20 feet within 5 miles of development, which would impact groundwater wells completed in developed coal seams in these areas. These wells would have reduced yields but would not be expected to become dry because the aquifer would remain saturated. Within 3 to 4 years of the end of development, recovery would be expected be to within 20 to 30 feet, with complete recovery within hundreds of years (BLM 2008g). "Little evidence exists to substantiate that surface water has been depleted by pumping water during CBM [CBNG] production at the large watershed scale" in the PRB (NAS 2010, p. 185).

Treated and untreated discharged produced water would have the potential to degrade water quality. The water produced by CBNG wells would be typically saline (electrical conductivity) and sodic (sodium adsorption ratio). Although surface water quality in some watersheds would be altered in combination with new and existing permits, beneficial uses would not be diminished. Surface water flow would moderately increase through the discharge of produced water, which would alter the natural hydrologic regimes (such as changes in the magnitude and timing of low and peak flows) and cause erosion, headcutting, and increased sedimentation (BLM 2008g). Produced water spilled or treated in infiltration, unlined, or leaking evaporation impoundments (water disposal pits) would impact shallow groundwater aquifers and contain the potential to reach and contaminate surface water through groundwater interface. The infiltration of produced water would potentially dissolve and mobilize sulfate, selenium, arsenic, manganese, barium, chloride, nitrate, and TDS from soils to water (NAS 2010). For a detailed analysis of CBNG impacts, refer to the BLM's 2008 *Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment to the Powder River and Billings Resource Management Plans* (FSEIS).

Geothermal leasing has the potential to impact water quality and temperature through the discharge of hot water with concentrated metals and low or high pH values and the subsequent contamination of surface or groundwater. NSO stipulations for oil and gas leasing and development for waterbodies, riparian areas, wetlands, playas, 100-year floodplains, and slopes in excess of 40 percent or soils with high erosion potential and CSU stipulations within 500 feet of riparian or wetland vegetation and erosive soils and soils on slopes greater than 30 percent would mitigate these effects (BLM 2008h). However, no federal geothermal leasing would likely occur in either the short or long term. For a detailed analysis of impacts, refer to BLM and USFS 2008 *Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States*.

Pit mining of locatable minerals and mineral materials would impact water resources through surface disturbance and removal and replacement of overburden. Drainage patterns would be affected during mining and, depending on the local geology salts, leach from spoils to surface water and groundwater.

Surface disturbance associated with locatable mineral activities on waterbodies and streams (300,000 acres) and on floodplains (320,000 acres) would cause destabilization of banks; sedimentation; altered channel morphology; decreased water quality; and increased erosion, turbidity, and water temperature (MDEQ 2007). Surface disturbance would reduce the capacity of these areas to dissipate the energy of high water events and cause changes in infiltration rates, water storage, and aquifer recharge. Any construction activity in flowing waterbodies would be likely to exceed Montana's water quality criteria for turbidity and require a variance. The lack of vegetative buffers on waterbodies would further increase sedimentation and reduce water quality. The capability of floodplains to dissipate energy associated with high water events would be reduced and infiltration rates, water storage, and aquifer recharge would be altered. These impacts would be mitigated on a site-specific basis (see the *Best Management Practices Appendix*).

Bentonite mining would increase TDS and turbidity of surface water. Impacts to surface water and groundwater from in situ leach uranium recovery would be small to moderate (USNRC and WDEQ 2009). The process of in situ uranium mining would inject a solution that dissolved uranium minerals into groundwater, which would potentially migrate beyond the project area through equipment failures, aquifer

heterogeneity, fractures, or improper well completions. In addition to impacts from surface-disturbing activities, impacts would include the potential for contamination of aquifers at varying depths (including domestic water supplies and adjacent aquifers) by radionuclides or other constituents (e.g., selenium, metals, salinity, high or low pH) (Meredith 2010).

Transportation infrastructure is ranked second by the USEPA as a potential source of groundwater contaminants to Montana's public water supply (MDEQ 2007). The transportation system would cause erosion, nutrient loading, channel instability, changes in stream morphology, increased water temperature, and sedimentation. These impacts would be long term and accelerated by road construction or maintenance, stream channelization, vehicle fords, improper design and location, and inadequate maintenance. Vehicle use would introduce pollutants such as oil, grease, dust, and metals to water systems (MDEQ 2007). In addition to short-term impacts from construction, permanent impacts to streamflow and bank stability would include impacts from culverts and bridge column fill within waterbodies. Compaction of soil and impermeable road surfacing would reduce infiltration and increase overland flow, which would increase erosion and sedimentation; however, appropriate road surfacing would decrease wind and water erosion of the road surface. Impacts would be minimized by reducing the number and extent of road systems, avoiding riparian areas and stream crossings, installing erosion control features, placing and designing culverts properly, designing roads properly, reclaiming closed roads, and complying with BMPs. Redesign, rerouting, closure, or decommissioning of existing roads, primitive roads, or trails would improve water quality and stream health. Watersheds with low to moderate numbers of stream crossings and properly located, designed, and maintained roads would have near background levels of sediment production (MDEQ 2007).

Because OHV use is not evenly distributed across BLM-administered lands, impacts are localized in intensively used areas. OHV use is a source of nonpoint source pollution and associated vegetation loss would cause accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Weed invasion would lead to accelerated erosion and changes in watershed hydrology. Sheet or rill erosion would be the most common on poorly designed or maintained (or both) roads and trails during periods of high moisture; these impacts would increase with increasing OHV use. Impacts would be reduced and localized in areas in which vehicles were limited to existing roads (e.g., Limited OHV areas). In general, these impacts are estimated to occur in less than 1 percent of a watershed (BLM and USFS 2001). Although the BLM's 2003 *Record of Decision, Off-Highway Vehicle Environmental Impact Statement and Proposed Plan Amendment for Montana, North Dakota, and South Dakota* would not restrict use in areas in which user-created roads and trails were established in riparian areas or areas of high soil erodibility (BLM 2003m), areas in which considerable impacts were occurring would be closed, in accordance with 36 CFR 295.5 and 43 CFR 8341.2 and 8364.1.

Maintaining wilderness values of WSAs would maintain water quality and quantity in these watersheds, on 490 miles of waterbodies on BLM-administered acres, and on 880 acres of floodplains on BLM-administered lands.

ALTERNATIVE A

Management actions that limited surface disturbance on approximately 1.0 million acres of mineral estate and 960,000 acres of BLM-administered surface in the planning area would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer to reduce impacts from upland areas (Table 4-36).

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use [Table 4-37]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction,

and soil disturbance. Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would typically be localized and short term, lasting until vegetation was reestablished, there would be the potential for severe and long-term effects to water quality and overall stream function (however, the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed.

TABLE 4-36.
WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE A

Area or Resource		Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Water	Floodplain, waterbody, and riparian, oil and gas NSO	640	580	35,000	92,000
	Waterbodies and streams, oil and gas NSO	13,000	26,000	1,700	3,100
Veg.	Riparian and wetland, oil and gas NSO	1,700	4,000	10,000	30,000
Fish and Wildlife	Aquatics, reservoirs with fisheries, 0.25-mile oil and gas NSO	27	26	60	187
	Sharp-tailed Grouse, 0.25-mile oil and gas buffer	87	160	300	440
	Colonial Waterbirds, NSD[1]	1	2	84	110
	Bighorn Sheep Range, oil and gas NSO	330	490	770	1,500
	Piping Plover and Interior Least Tern, oil and gas NSO	18	150	830	3,900
	Prairie Falcon, oil and gas NSO	41	73	290	280
	Special Status Species Raptors, oil and gas NSO	240	360	800	1,700
	Sage-grouse, 0.25-mile oil and gas buffer	110	190	370	750
Travel Mgmt and OHV	Limited OHV	13,000	NA	34,000	NA
	Closed OHV	0	NA	0	NA

[1]NSD=No Surface Disturbance

Surface-disturbing activities that occurred on various slopes, sensitive soils, soils with poor reclamation potential, and highly erodible soils (particularly on 130,000 acres within 300 feet of waterbodies) under this alternative would cause soil erosion and sedimentation. Disturbance on soils with poor reclamation potential would cause permanent increases in erosion and sedimentation.

Offering oil and gas leasing with an NSO stipulation on waterbodies and streams would prohibit surface disturbance associated with oil and gas activities on 41,000 acres of waterbodies on BLM-administered

mineral estate, which would maintain water quality. Other surface disturbance on 300,000 acres of waterbodies and streams would cause destabilization of banks; sedimentation; altered channel morphology; decreased water quality; and increased erosion, turbidity, and water temperature (MDEQ 2007). Surface disturbance would reduce the capacity of these areas to dissipate the energy of high water events and cause changes in infiltration rates, water storage, and aquifer recharge. The presence of aboveground facilities would create flood hazards. Any construction activity in flowing waterbodies would be likely to exceed Montana's water quality criteria for turbidity and require a variance. The lack of vegetative buffers on waterbodies under this alternative would further increase sedimentation and reduce water quality.

TABLE 4-37.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE A

Area	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Glendive OHV	4	12	200	200
Lewis and Clark Trail SRMA	78	110	3,700	7,700
Terry OHV SRMA	1	1	0	0
Battle Butte	1	1	0	0
Powder River Depot ACEC	7	6	13	21
Reynolds Battlefield	1	1	4	126

Prohibiting permanent facilities and requiring an NSO stipulation for oil and gas leasing and development on 100-year floodplains of major rivers would prohibit oil- and gas-associated surface disturbance of floodplains on 260,000 acres (of 26,000 river miles) of BLM-administered mineral estate, which would maintain water quality. Allowing oil- and gas-associated surface disturbance on 65,000 acres of floodplains of non-major waterbodies (95,000 river miles) and all other surface disturbances on all floodplains (320,000 acres) would increase erosion, overland flow, sedimentation, and turbidity and degrade channel morphology and water quality. The capability of floodplains to dissipate energy associated with high water events would be reduced and infiltration rates, water storage, and aquifer recharge would be altered.

Surface water impoundments would reduce streamflow, dissolved oxygen, and floodplain size and extent downstream (Vörösmarty and Sahagian 2000); increase infiltration to groundwater, scour of the downstream streambed, and water temperature (Dodds, Gido, Whiles, Fritz, and Matthews 2004); substantially increase evaporative losses; degrade water quality; and change nutrient cycling, timing and magnitude of peak and low flows, sediment load, and riparian vegetation recruitment and succession. Under this action, there would also be the potential for permanent impacts including channel scour, erosion, and sedimentation downstream (if a dam broke). Water impoundments and developments in and near waterbodies, riparian areas, and wetlands would increase use in these areas, which would change morphology, increase water temperature, alter ecosystem processes, and decrease water quality by introducing sediment, salinity, bacteria, and nutrients. Expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources (IPCC 2007).

Use of groundwater for livestock water developments would drawdown groundwater and increase evaporative losses. New spring developments would reduce water flow locally and downstream, lower the local water table, and increase water temperatures, which would reduce riparian vegetation, change channel morphology, and increase sedimentation (Sada et al. 2001). Spring developments would not maintain the riparian community. Where used, flow-control devices would reduce water loss, soil erosion, riparian community losses, evaporative losses, and vulnerability of water resources to climate change. Impacts would not be minimized in areas in which flow-control devices were not installed on a case-by-case basis.

Depending on the fuel type, haying within 200 feet of waterbodies would increase sedimentation, cause soil compaction, reduce litter and vegetation cover, decrease infiltration, and increase erosion (Ellis 2008) but reduce the risk of high-intensity or severity fire in the long term, which would improve watershed functionality.

Management actions that required NSO stipulations for oil and gas leasing and development in riparian areas would prohibit oil and gas surface disturbance on 41,000 acres of waterbodies, which would maintain water quality. Other surface disturbance in riparian areas would cause soil compaction, vegetation removal, and soil disturbance, which would increase overland flow, sedimentation, and turbidity. In these localized areas, riparian areas would be incapable of dissipating flood energy or buffering waterbodies from upland nonpoint source pollution although the reach would remain in PFC.

Allowing surface disturbance (including oil and gas disturbance) in wetlands would reduce the capacity of wetlands to improve water quality, allow groundwater recharge and discharge, filter sediment, retain floodwater, and remove pollutants from water (Prichard et al. 1999). Surface disturbance would increase soil compaction, overland flow, sedimentation, instability of stream channel and streambanks, and turbidity. Draining of wetlands would potentially increase the magnitude of large flooding events (Poff et al. 1997). Although many of these impacts would be short term with successful reclamation, success of reclamation activities would probably be low and impacts would be likely to persist. Following pipeline construction, the wetland restoration success rate (defined as at least 80 percent vegetative cover by native species and a plant diversity of the restored wetland that attains 50 percent of the pre-construction condition) was found to be 32 percent in the arid western ecoregions (FERC 2004). There is the potential for changes to surface and subsurface drainage, which would result in permanent changes in wetland integrity and function if water retention were reduced or eliminated through the disturbance of impermeable layers.

Although all methods would cause surface disturbance, the magnitude and duration of the impacts of surface-disturbing activities such as linear underground facilities (including buried power lines) crossing perennial streams, intermittent streams, wetlands, and riparian areas would vary and depend on the method used to cross the waterbody. Because open-cut wet crossings (trenching) of flowing water would result in direct contact with water during all stages of construction and potential in-stream storage of spoil, these actions would increase sedimentation; destabilize streambanks; decrease streambed porosity; alter channel morphology; and cause short-term increases in total suspended solids (TSS), TDS, nutrients, metals, and total organic carbon (Lévesque and Dubé 2007). Additionally, riparian vegetation would be removed: "Excavation of streambeds composed primarily of clay or silt sized particles can generate persistent plumes of high suspended sediment concentration or turbidity" and "small particle diameters (e.g., clays) can, however, limit the ability of sediment control structures to reduce downstream sediment concentrations" (Reid, Ade, and Metikosh 2004, p. 6). Generally, if bank stabilization occurred, sediment entrainment would occur during construction (typically within 24 to 48 hours but potentially up to a few weeks) and the impacts would not be evident within 4 years (Reid et al. 2004).

Isolated crossing methods (e.g., dam-and-pump and flume methods) would have, on average, peak TSS (i.e., turbidity) 3 to 20 times lower than open-cut wet methods (Reid et al. 2004) and more effectively mitigate sediment loading (Lévesque and Dubé 2007). Isolated methods would cause impacts with reduced severity and duration because the increases in turbidity and sedimentation would be limited to installation and removal of dam or flume structures (up to 10 hours) (Lévesque and Dubé 2007).

Unless the surface-disturbing activity established native vegetation, management actions that allowed surface-disturbing activities in areas of invasive vegetation species infestations would increase damage to watersheds and reduce water quality and quantity (BLM 2007d).

Management actions that required an NSO stipulation for oil and gas leasing and development within 0.25 miles of designated reservoirs with fisheries would prohibit oil- and gas-associated surface disturbance on 300,000 acres, which would maintain water quality on these acres. Other surface-disturbing activities and permanent facilities within 0.25 miles of designated reservoirs would reduce water quality. Because there would be no vegetative buffers, impacts (reducing sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent to water, riparian areas, and wetlands on 300,000 acres would not be

reduced or eliminated. Impacts would include sedimentation, erosion, soil compaction, decreased biodiversity, altered stream channel morphology, increased water temperature, reduced bank stability, reduced aquifer recharge, increased floodwater velocities and energy, altered nutrient input to aquatic habitats, and a lowered water table (which would decrease forage) (MDEQ 2007).

In the long term, management actions that required fish passage on a case-by-case basis would reduce sedimentation, streambed erosion, and streambank erosion. Existing and new culverts that impeded fish passage would result in sedimentation, streambed erosion, and streambank erosion.

Management actions that required an NSO stipulation for oil and gas leasing and development within 0.25 miles of piping plover and interior least tern habitat would prohibit surface disturbance associated with oil and gas activities on 1,800 miles of streams, which would maintain water quality. Other surface disturbances would decrease water quality in these areas.

Management actions that required the burial of oil and gas low-voltage power lines would increase surface disturbance and decrease water quality.

The absence of limits for cumulative, direct, and indirect disturbance within the sagebrush habitat in sage-grouse areas would result in an "extreme impact (which is defined in the Wyoming Department of Fish and Game's (WDFG) March 2010 *Recommendations for Development of Oil and Gas Resources Within Important Wildlife Habitats* as more than 80 acres of disturbance per square mile)" from development on habitat function of aquatic and water resources (WDFG 2010a, p. 45).

Removal or treatment of pre-commercial or commercial material on 53,000 acres of Condition Class 3 sites would decrease water quality but reduce the intensity and severity of prescribed fire. High-intensity fire and fire suppression that resulted in fuel buildup would lead to increased erosion and sedimentation, which would impact water quality in both the short and long term. The impacts would be the same for low-intensity fire (including prescribed fire) except that the magnitude of impacts would be reduced and erosion rates would be similar to natural levels. Although typical timber harvest activities have been estimated to increase erosion rates to 0.05 to 0.25 tons per acre per year, intensive methods would potentially increase rates to 5 tons per acre per year (Elliot et al. 2010). Depending on the severity, fire in riparian areas would reduce water quality by reducing vegetation and riparian function. In the long term, although water quality would benefit from healthy uplands, road construction and use of heavy equipment would lead to increased soil compaction, erosion, and sedimentation, which would reduce water quality.

Paleontological Resources management actions that required an NSO stipulation for oil and gas leasing and prohibited surface disturbance would maintain water quality.

Managing forestlands for resources would enhance water quality. Wood product sales would cause nonpoint source pollution, the magnitude of which would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would increase erosion, sedimentation, and overland flow. Streamside vegetation removal would increase water temperatures and reduce the ability of vegetative buffers to reduce nonpoint source pollution. However, forest management activities would use BMPs (e.g., *Water Quality BMPs for Montana Forests* [Logan 2001], see the *Forestry and Woodland Products Appendix*) and comply with the Streamside Management Zone Law, which would reduce these impacts.

Because cottonwood harvest would occur near water, there would not be a sufficient vegetative buffer to reduce impacts of these activities.

Management actions that allowed livestock grazing on 2.7 million acres would reduce water quality and the ability of vegetative buffers to filter sediments and contaminants from upland areas. Excluding 200 acres from grazing would maintain water quality.

Allotments in which livestock grazing has contributed to declines in riparian areas and water quality management would be managed to meet riparian and water quality standards.

Allowing livestock grazing during or immediately after mining or development would accelerate impacts from multiple land use activities (e.g., mineral extraction and livestock grazing). Multiple land uses would compound land uses and cause impacts greater than impacts caused by livestock grazing, mining, or development alone. This action would increase erosion, sedimentation, and streambank instability and decrease water quality and riparian functionality.

Deferring livestock grazing for 1 growing season following fire activities would help minimize impacts to waterbodies from erosion during the first year. However, studies suggest that timing, use, and duration of grazing of burned rangelands are more important than a specific period of rest after fire (Bates, Rhodes, Davies, and Sharp 2009); therefore, during subsequent seasons (until vegetation recovered), livestock grazing would inhibit restoration of watershed function (Beschta et al. 2004), and the impacts of grazing and fire would be compounded. For areas with moderate to high fire intensity or severity (or both), severe erosion and sedimentation would occur.

Management actions that ensured that Standards for Rangeland Health were met and maintained would maintain water resource conditions. Calculation of livestock carrying capacities exclusive of watershed and riparian objectives would not protect these areas from increased grazing.

Prohibiting coal exploration on 200,000 acres would maintain water quality and quantity.

CSU stipulations for oil and gas leasing and development would reduce impacts to water resources on 16,000 miles of streams and 16,000 acres of floodplains. Management actions that allowed oil and gas leasing and surface disturbance with lease terms on 2.7 million acres would decrease water quality.

Mineral sales and permitting on 2.5 million acres would decrease water quality.

Although closing 80 acres to OHV use would improve water quality and quantity, allowing Open OHV use on 2,400 acres and Limited OHV use on 2.8 million acres would decrease water quality.

Streams and floodplains would be affected in Recreation and Special Designation Areas under Alternative A.

ALTERNATIVE B

Actions that limited surface-disturbing activities on approximately 5.5 million acres of mineral estate and 2.5 million acres of BLM-administered surface would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer that reduced impacts from upland areas (Table 4-38).

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use [Table 4-39]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction, and soil disturbance. Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would

typically be localized and short term, lasting until vegetation was reestablished, there would be the potential for severe and long-term effects to water quality and overall stream function (however the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed.

TABLE 4-38.
ESTIMATED WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE B

Area or Resource		Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Soils	Steep, NSD[1]	8,900	8,500	35,000	89,000
	Sensitive, NSD	270	700	250	640
Water	Floodplain, NSD	770	1,900	42,000	110,000
	Waterbody, NSD	13,000	26,000	1,700	3,100
Veg.	Riparian and wetland, NSD	1,700	4,200	13,000	33,000
Fish and Wildlife	Aquatics, sport-fish reservoirs, 0.5-mile buffer	57	64	230	510
	Big Game Crucial Winter Range, NSO	7,500	15,000	29,000	75,000
	Colonial Waterbirds	1	2	160	140
	Bighorn Sheep Range, oil and gas NSO	330	490	780	1,500
	Prairie Falcon, NSO	41	73	320	400
	Special Status Species Raptors	240	360	900	0
	Piping Plover and Interior Least Tern, 0.25-mile NSO buffer	18	150	1,300	5,800
	Black-tailed prairie dog, NSD	650	1,300	3,000	6,400
	Pallid Sturgeon, 0.5-mile, NSD	75	94	3,200	6,800
	Sage-grouse Habitat – Protection Priority ACEC, oil and gas NSO	4,900	9,600	12,000	36,000
Travel Mgmt and OHV	Limited OHV	13,000	12,000	41,000	NA
	Closed OHV	150	NA	570	NA

[1]NSD=No Surface Disturbance

Limiting surface-disturbing activities to slopes of 25 percent or less would decrease the magnitude of accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality. Slopes 25 percent or greater within 300 feet of waterbodies (44,000 acres) would potentially act as vegetated buffers for nearby waterbodies.

Sensitive soils (1.8 million acres) would contain greater potential for reduced vegetation cover, accelerated wind and water erosion, and occurrence near waterbodies (such as hydric soils, which occur on 110,000 acres in the planning area). Prohibiting surface disturbance and offering oil and gas leasing with an NSO stipulation in these areas would maintain water quality. Under this alternative, 630,000 acres of sensitive soils within 300 feet of waterbodies would potentially act as a vegetated buffer for nearby waterbodies.

Under this alternative, all waterbodies (300,000 acres or 120,000 river miles) and floodplains (330,000 acres) would be protected from surface-disturbing activities, which would maintain water quality. Offering oil and gas leasing with an NSO stipulation on waterbodies and streams would prohibit surface disturbance

associated with oil and gas activities on 41,000 acres of waterbodies on BLM-administered mineral estate, which would maintain water quality.

The impacts of constructing surface water impoundments (37 locations per year) would be reduced with mitigation or eliminated where new impoundments were prohibited. Surface water impoundments would reduce streamflow, dissolved oxygen, and floodplain size and extent downstream (Vörösmarty and Sahagian 2000); increase infiltration to groundwater, scour of the downstream streambed, and water temperature (Dodds et al. 2004); substantially increase evaporative losses; degrade water quality; and change nutrient cycling, timing and magnitude of peak and low flows, sediment load, and riparian vegetation recruitment and succession. Under this action, there would also be the potential for permanent impacts, including channel scour, erosion, and sedimentation downstream (if a dam broke). Although impacts from existing impoundments would continue to occur, riparian vegetation, watershed functionality, and natural flow regimes would be maintained under this alternative (see the *Reclamation Appendix*). Expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources (IPCC 2007).

TABLE 4-39.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE B

Area	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Lewis and Clark Trail SRMA	72	100	3,500	8,800
Howrey Island	4	0	590	0
Matthews Recreation Area	0.5	0	11	0
Dean S. Reservoir	1	1	0	0
Pumpkin Creek Ranch and Recreation Area	100	40	630	9
Glendive OHV SRMA	2	11	200	200
Terry OHV SRMA	1	1	0	0
Strawberry Hill Recreation Area	21	13	24	22
Moorhead	<1	0	11	0
Powder River Depot ACEC	7	6	13	21
Battle Butte	1	1	0	0
Reynolds Battlefield ACEC	2	2	8	170
Walstein Area	11	11	5	33

Installing flow-control devices on all water wells would reduce the impacts of all existing and new (10 wells per year) developments. Evaporative losses would be reduced, riparian vegetation would be maintained, and the vulnerability of water resources to climate change would be reduced.

Depending on the fuel type, haying within 200 feet of waterbodies would increase sedimentation, cause soil compaction, reduce litter and vegetation cover, decrease infiltration, and increase erosion (Ellis 2008) but reduce the risk of high-intensity or severity fire in the long term, which would improve watershed functionality.

Prohibiting surface-disturbing activities and oil and gas leasing within riparian and wetland areas would maintain water quality under this alternative. Wetlands would improve water quality, allow groundwater recharge, filter sediment, retain floodwater, and remove pollutants from water (Prichard et al. 1999). Approximately 1.1 million acres of riparian and wetland areas would function as a buffer for streams by reducing or eliminating nonpoint source pollution from upland areas (MDEQ 2007).

Locating new livestock water developments at least 0.25 miles from riparian and wetland areas and waterbodies would reduce impacts caused by grazing.

Prohibiting surface-disturbing activities in areas of invasive vegetation species infestations would reduce impacts to water resources by preventing activities that contributed to the spread of invasive species.

Prohibiting surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development within 0.5 miles of designated sport-fish reservoirs and pallid sturgeon habitat would maintain water quality and preserve a vegetative buffer that reduced or eliminated impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent to 160 miles of streams. Buffers would reduce sedimentation, floodwater velocities and energy, erosion, and soil compaction; increase biodiversity; maintain stream channel shape, a higher water table (which would increase forage), late summer stream flows, and water temperature; stabilize streambanks; recharge aquifers; and facilitate nutrient input to aquatic habitats (MDEQ 2007). Because there would be no vegetative buffers, impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent to 26,000 miles of streams, waterbodies, riparian areas, and wetlands would not be reduced or eliminated.

Requirements for stream-crossing structures under this alternative would cause short-term surface disturbance and impacts (such as erosion and increased sediment load) but reduce the risk of erosion and damming in the long term.

Prohibiting surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development within 0.25 miles of piping plover and interior least tern habitat would protect 1,300 miles of streams from surface disturbance, which would maintain water quality. This action would preserve a 24,000-acre vegetative buffer for wetlands and streams to reduce impacts from upland areas.

Management actions that required the burial of power lines would increase surface disturbance and decrease water quality. Management actions that required the burial of low-voltage power lines would increase surface disturbance and decrease water quality.

Limiting the cumulative, direct, and indirect disturbance to no more than 5 percent of the sagebrush habitat per section in Sage-grouse Habitat – General Habitat Areas, the Protection Priority ACEC, and Restoration Areas would limit impacts to aquatic and water resources (WDFG 2010a). An NSO stipulation for oil and gas leasing and development within the sagebrush habitat in the Sage-grouse Habitat – Protection Priority ACEC would decrease impacts from surface disturbances. The resiliency of these ecosystems would increase, which would reduce the vulnerability of the water resources to climate change impacts (CEICC 2008).

Prohibiting prescribed fire on 2.5 million acres under this alternative would result in intense, stand-replacing wildfires, which would increase erosion and sedimentation and decrease water quality. Soil erosion (0.42 tons per acre) for a single precipitation event in a wildfire burned watershed would potentially be up to 90 percent of the estimated annual erosion (Elliot et al. 2010). Although requiring the removal or treatment of pre-commercial or commercial material on 53,000 acres of Condition Class 3 sites would decrease water quality in the short term, it would reduce the intensity and severity of fires, which would reduce erosion rates. Although typical timber harvest activities have been estimated to increase erosion rates to 0.05 to 0.25 tons per acre per year, intensive methods would potentially increase rates to 5 tons per acre per year (Elliot et al. 2010).

Paleontological Resources management actions that required an NSO stipulation for oil and gas leasing and prohibited surface disturbance would maintain water quality.

Not managing forestlands for forest products or sawtimber would enhance water quality.

Because cottonwood harvest would occur near water, there would not be a sufficient vegetative buffer to reduce impacts of these activities.

Allowing cattle grazing on 2.4 million acres and sheep and goat grazing on 2.0 million acres would reduce water quality and the ability of vegetative buffers to filter sediments and contaminants from upland areas. Excluding 320,000 acres from grazing and closing 190,000 acres of allotments that fail to meet Rangeland Health Standards would substantially improve water quality and quantity. Closing allotments would decrease erosion, improve watershed function, and allow the total rest from grazing required for full recovery of

structure and function of waterbodies (Belsky et al. 1999). In some areas, streams would have been degraded permanently, beyond recovery to a natural state, and adjust within the new potential.

Calculation of livestock carrying capacity based on watershed and riparian objectives would reduce the site-specific impacts of grazing. Prioritizing allotments for monitoring and land health evaluations based on functionality of riparian areas would expedite the improvement of riparian health. Improved riparian health would decrease erosion; improve waterbody functionality, and increase water quality, infiltration, streambank stability, and the buffering capacity of riparian vegetation. Erosion and sedimentation from upland areas would be reduced.

Excluding livestock within locatable mining areas, suspending AUMs based on acres of oil- and gas-associated surface disturbance, and suspending grazing during coal development would facilitate reclamation and reduce impacts to water resources. Multiple land uses would compound land uses and cause impacts greater than impacts caused by the individual land uses alone.

Prohibiting coal exploration on 8.5 million acres would maintain water quality and quantity.

CSU stipulations for oil and gas leasing and development would reduce impacts to water resources on 16,000 miles of streams and 16,000 acres of floodplains. Surface disturbance associated with offering oil and gas with lease terms on 328,000 acres would decrease water quality.

Mineral sales and permitting on 300,000 acres would decrease water quality.

Closing 35,000 acres to OHV use under this alternative would maintain water quality and quantity. Open OHV use on 2,900 acres would impact 200 acres of floodplains and Limited OHV use on 2.8 million acres would decrease water quality.

Streams and floodplains would be affected in Recreation and Special Designation Areas under Alternative B.

ALTERNATIVE C

Management actions that prohibited surface-disturbing activities; required NSO stipulations for oil and gas leasing and development; and removed BLM-administered mineral acreage from oil and gas leasing in uplands on approximately 2.1 million acres of mineral estate and 1.6 million acres of BLM-administered surface would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer that reduced impacts from upland areas (Table 4-40).

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use [Table 4-41]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction, and soil disturbance. Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would typically be localized and short term, lasting until vegetation was reestablished, there would be the potential

for severe and long-term effects to water quality and overall stream function (however the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed.

TABLE 4-40.
ESTIMATED WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE C

Area or Resource		Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Fish and Wildlife	Aquatics, sport-fish reservoir, 0.25-mile NSO buffer	27	26	170	240
	Black-tailed Prairie Dog, NSD[1]	270	490	1,500	2,900
	Pallid Sturgeon, 0.5-mile NSD	75	94	3,300	6,800
Travel Mgmt and OHV	Limited OHV	13,000	NA	41,000	NA
	Closed OHV	1	NA	0	NA

[1]**NSD=No Surface Disturbance**

Avoiding or mitigating activities on slopes of 25 percent or greater (150,000 acres in the planning area) and sensitive soils would reduce impacts to water resources. Activities in these areas would cause accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality. Sensitive soils (1.8 million acres) would contain greater potential for reduced vegetation cover, accelerated wind and water erosion, and occurrence near waterbodies (such as hydric soils, which occur on 110,000 acres in the planning area). Surface disturbances on slopes of 25 percent or greater or sensitive soils within 300 feet of waterbodies (44,000 acres and 630,000 acres) would inhibit the ability of vegetative buffers to reduce impacts from upland areas.

Surface-disturbing activities in floodplains, streams, and waterbodies (when they could not be avoided) would reduce streambank stability; increase sedimentation, erosion, and turbidity; decrease water quality; remove riparian vegetation; increase flood severity; and alter channel morphology (MDEQ 2007) if they could not be avoided. Surface disturbance would reduce the capacity of these areas to dissipate the energy of high water events and cause changes in infiltration rates, water storage, and aquifer recharge. The presence of aboveground facilities would create flood hazards. Spills would potentially contaminate surface water and shallow groundwater. Construction activity in flowing waterbodies would be likely to exceed Montana water quality standards for turbidity and a variance would be required. The efficacy of mitigation measures would determine the severity of short- and long-term impacts caused by these management actions.

**TABLE 4-41.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE C**

Area	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Lewis and Clark Trail SRMA	72	100	3,500	8,800
Howrey Island	4	0	590	0
Matthews Recreation Area	<1	0	11	0
Dean S. Reservoir	1	1	0	0
Pumpkin Creek Ranch and Recreation Area	100	40	630	9
Glendive OHV SRMA	2	11	200	200
Terry OHV SRMA	1	1	0	0
Strawberry Hill Recreation Area	21	13	24	22
Moorhead	<1	0	11	0
Powder River Depot ACEC	7	6	13	21
Powderville Paleontological Area	110	120	18	660
Battle Butte	1	1	0	0
Reynolds Battlefield ACEC	2	2	8	170
Walstein Area	11	11	5	33

Management actions that allowed surface water impoundments (37 locations per year) would reduce streamflow, dissolved oxygen, and floodplain size and extent downstream (Vörösmarty and Sahagian 2000); increase infiltration to groundwater, scour of the downstream streambed, and water temperature (Dodds et al. 2004); substantially increase evaporative losses; degrade water quality; and change nutrient cycling, timing and magnitude of peak and low flows, sediment load, and riparian vegetation recruitment and succession. Under this action, there would also be the potential for permanent impacts including channel scour, erosion, and sedimentation downstream (if a dam broke). Water impoundments and developments in and near waterbodies, riparian areas, and wetlands would increase use in these areas, which would change morphology, increase water temperature, alter ecosystem processes, and decrease water quality by introducing sediment, salinity, bacteria, and nutrients. Expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources; however, maintaining natural flow regime and watershed functionality would reduce these impacts (IPCC 2007). The efficacy of approved specialized design features in maintaining the natural flow regime and watershed functionality would determine the severity of long-term impacts caused by these management actions. Installing flow-control devices on new all water wells and spring developments would reduce the impacts of all new (10 wells and 2 springs per year) developments including water loss, soil erosion, riparian community losses, evaporation, and the vulnerability of water resources to climate change would be reduced. Riparian vegetation would be maintained at new sites. Current impacts (changes to the water table, soil erosion, loss of riparian communities, and evaporation) would continue.

Depending on the fuel type, haying within 200 feet of waterbodies would increase sedimentation, cause soil compaction, reduce litter and vegetation cover, decrease infiltration, and increase erosion (Ellis 2008) but reduce the risk of high-intensity or severity fire in the long term, which would improve watershed functionality.

Riparian and hydrologic function would be affected if surface-disturbing activities in riparian and wetlands areas were not avoided. Although PFC would be maintained in the long term, surface disturbance in these areas would cause erosion, turbidity, and sedimentation in the short term. The functionality of riparian vegetation (such as the dissipation of the energy of high water flows, filtration of sediment, stabilization of streambanks, and enhancement of floodplain functionality) and wetlands (such as the improvement of water quality, facilitation of groundwater recharge, filtration of sediment, maintenance of floodwater, and removal of pollutants) would be reduced. Spills would potentially contaminate shallow groundwater and surface water. The severity of short-term and, potentially, long-term impacts would depend on the efficacy of the mitigation measures.

Boring of streams, wetlands, or riparian areas would reduce surface disturbance and maintain water quality in these areas. Implementing linear underground facilities (including buried power lines) using open-cut wet or isolated crossing methods would reduce water quality.

Although all methods would cause surface disturbance, the magnitude and duration of the impacts of surface-disturbing activities such as linear underground facilities (including buried power lines) crossing perennial streams, intermittent streams, wetlands, and riparian areas would vary and depend on the method used to cross the waterbody. Because open-cut wet crossings (trenching) of flowing water would result in direct contact with water during all stages of construction and potential in-stream storage of spoil, these actions would increase sedimentation; destabilize streambanks; decrease streambed porosity; alter channel morphology; and cause short-term increases in total suspended solids (TSS), TDS, nutrients, metals, and total organic carbon (Lévesque and Dubé 2007). Additionally, riparian vegetation would be removed: "Excavation of streambeds composed primarily of clay or silt sized particles can generate persistent plumes of high suspended sediment concentration or turbidity" and "small particle diameters (e.g., clays) can, however, limit the ability of sediment control structures to reduce downstream sediment concentrations" (Reid, Ade, and Metikosh 2004, p. 6). Generally, if bank stabilization occurred, sediment entrainment would occur during construction (typically within 24 to 48 hours but potentially up to a few weeks) and the impacts would not be evident within 4 years (Reid et al. 2004).

Isolated crossing methods (e.g., dam-and-pump and flume methods) would have, on average, peak TSS (i.e., turbidity) 3 to 20 times lower than open-cut wet methods (Reid et al. 2004) and more effectively mitigate sediment loading (Lévesque and Dubé 2007). Isolated methods would cause impacts with reduced severity and duration because the increases in turbidity and sedimentation would be limited to installation and removal of dam or flume structures (up to 10 hours) (Lévesque and Dubé 2007).

Not allowing new spring developments would maintain water flow locally and downstream, the local water table, water temperatures, riparian vegetation, and channel morphology (Sada et al. 2001). Locating water developments 0.25 miles from perennial and intermittent streams would reduce grazing impacts in these areas. Allowing new livestock water developments in and near ephemeral streams, springs, and riparian areas would lead to increased use in these areas, which would cause changes in morphology, increase water temperature, alter ecosystem processes, and decrease water quality by increasing sediment, salinity, bacteria, and nutrients.

Unless the surface-disturbing activity established native vegetation, management actions that allowed surface-disturbing activities in areas of invasive species infestations would increase damage to watersheds and reduce water quality and quantity (BLM 2007d). The magnitude of damage to surrounding watersheds would depend on the efficacy of mitigation.

Prohibiting surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development within 0.5 miles of pallid sturgeon habitat and avoiding surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development within 0.25 miles of designated sport-fish reservoirs would maintain water quality and preserve a vegetative buffer that reduced or eliminated impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent to 64 miles of streams. Buffers would reduce sedimentation, floodwater velocities and energy, erosion, and soil compaction; increase biodiversity; maintain stream channel shape, a higher water table (which would increase forage), late summer stream flows, and water temperature; stabilize streambanks; recharge aquifers; and facilitate nutrient input to aquatic habitats (MDEQ 2007). Because there would be no vegetative buffers, impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent 26,000 miles of streams, waterbodies, riparian areas, and wetlands would not be reduced or eliminated.

Requirements for stream-crossing structures under this alternative would cause short-term surface disturbance and impacts (such as erosion and increased sediment load) but reduce the risk of erosion and damming in the long term.

Allowing surface-disturbing activities within 0.25 miles of piping plover and interior least tern habitat would reduce water quality.

Management actions that required the burial of low-voltage power lines would increase surface disturbance and decrease water quality.

Limiting the cumulative, direct, and indirect disturbance to no more than 10 percent of the sagebrush habitat per 640 acres in Sage-grouse Habitat – Protection Priority Areas would limit impacts to aquatic and water resources (WDFG 2010a).

High-intensity fire and fire suppression that resulted in fuel buildup would lead to increased erosion and sedimentation, which would impact water quality in both the short and long term. The impacts would be the same for low-intensity fire (including prescribed fire) except that the magnitude of impacts would be reduced and erosion rates would be similar to natural levels. Depending on the severity, fire in riparian areas would reduce water quality by reducing vegetation and riparian function. In the long term, although water quality would benefit from healthy uplands, road construction and use of heavy equipment would lead to increased soil compaction, erosion, and sedimentation, which would reduce water quality.

Although requiring the removal or treatment of pre-commercial or commercial material on 53,000 acres of Condition Class 3 sites would decrease water quality in the short term, it would reduce the intensity and severity of fires, which would reduce erosion rates. Although typical timber harvest activities have been estimated to increase erosion rates to 0.05 to 0.25 tons per acre per year, intensive methods would potentially increase rates to 5 tons per acre per year (Elliot et al. 2010). Forest product production and sawtimber harvest are a source of nonpoint source pollution, and the magnitude of impacts from these activities would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would result in an increase in erosion, sedimentation, and overland flow. The removal of streamside vegetation would change water temperature and reduce the ability of vegetative buffers to reduce nonpoint source pollution. Forest management activities that complied with the Streamside Management Zone Law, the *Water Quality BMPs for Montana Forests* (Logan 2001) *(*see the *Forestry and Woodland Products Appendix)*, and other BMPs would reduce these impacts. Salvage harvest of sawtimber would remove vegetation in a watershed with a reduced canopy cover, which would further accelerate erosion.

Paleontological Resources management actions that required an NSO stipulation for oil and gas leasing and prohibited surface disturbance would maintain water quality.

Managing forestlands for a diversity of forest products would reduce water quality by increasing the acres of surface disturbance. Wood product sales and sawtimber harvest would cause nonpoint source pollution, the magnitude of which would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would increase erosion, sedimentation, and overland flow. Streamside vegetation removal would increase water temperatures and reduce the ability of vegetative buffers to reduce nonpoint source pollution. However, forest management activities would use BMPs (e.g., *Water Quality BMPs for Montana Forests* [Logan 2001], see the *Forestry and Woodland Products Appendix*) and comply with the Streamside Management Zone Law, which would reduce these impacts.

Different methods of timber harvest would have various impacts (e.g., hand harvesting would cause localized disturbances but mechanized methods would disturb a greater area). Whole tree harvesting would generate skid trails, which would accelerate erosion. Leaving slash in place would reduce erosion, and BMPs and the Streamside Management Zone Law would reduce the magnitude of these impacts.

Forest health projects would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change

would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity).

Because cottonwood harvest would occur near water, there would not be a sufficient vegetative buffer to reduce the impacts of these activities; however, mitigation would reduce impacts of these activities. If this action resulted in healthier cottonwood stands, streambank stability and the system's ability to dissipate flood energy would increase.

Livestock grazing on 2.7 million acres under this alternative would reduce water quality and the ability of vegetative buffers to filter sediments and contaminants from upland areas. Excluding 8,000 acres from livestock grazing, excluding sheep and goats from 64,000 acres, and closing allotments in which the Standards for Rangeland Health were not met (190,000 acres) would improve watershed function, water quality, and quantity. However, in the 5 years before allotments that failed to meet Standards for Rangeland Health were closed, sedimentation and erosion would continue to reduce water quality. In the long term, this management action would decrease erosion and sedimentation and allow the total rest from grazing required for full recovery of structure and function of waterbodies (Belsky et al. 1999). In some areas, streams would have been degraded permanently, beyond recovery to a natural state, and adjust within the new potential.

Because grazing would slow revegetation and reclamation, allowing livestock grazing immediately after locatable mineral and coal mining and during oil and gas development would cause persistent impacts (even if the Standards for Rangeland Health were met) and accelerate impacts from multiple land use activities. In areas in which associated surface disturbance would decrease forage, maintaining AUM numbers during oil and gas development would cause impacts from grazing to increase. Multiple land uses would compound land uses and cause impacts greater than impacts caused by livestock grazing, mining, or development alone. This action would increase erosion, sedimentation, and streambank instability and decrease water quality and riparian functionality.

Management actions that deferred livestock grazing until the area attained identified vegetative objectives following a wildfire, prescribed fire, or non-fire vegetative treatment would facilitate vegetative reestablishment and improve water quality.

Water quality and riparian health monitoring would be prioritized on allotments in which grazing management contributed to the failure to meet Rangeland Health Standards. Management practices or levels of use would be adjusted to meet water quality or riparian health standards.

Prohibiting coal exploration on 200,000 acres would maintain water quality and quantity.

CSU stipulations for oil and gas leasing and development would reduce impacts to water resources on 16,000 miles of streams and 16,000 acres of floodplains. Management actions that allowed oil and gas surface disturbance with lease terms on 737,000 acres would decrease water quality. Development of BLM-administered mineral estate would be predicted to cause surface disturbance on 1,000 to 4,000 acres under this alternative.

Mineral sales and permitting on 1.1 million acres would decrease water quality.

Allowing big game retrieval would reduce water quality in areas in which vehicles crossed drainages, compacted soils, and accelerated erosion.

Closing 550 acres to OHV use under this alternative would maintain water quality and quantity. Open OHV use on 660 acres and Limited OHV use on 2.8 million acres would decrease water quality.

Streams and floodplains would be affected in Recreation and Special Designation Areas under Alternative C.

ALTERNATIVE D

Management actions that prohibited surface-disturbing activities and required NSO stipulations for oil and gas leasing and development in uplands on approximately 500,000 acres of mineral estate and 1.2 million acres of BLM-administered surface would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer that reduced impacts from upland areas (Table 4-42).

TABLE 4-42. ESTIMATED WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE D

Recreation Area	Waterbodies (acres)	Floodplains (acres)
Limited OHV	132,000	41,000
Closed OHV	0	0

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use [Table 4-43]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction, and soil disturbance. Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would typically be localized and short term, lasting until vegetation was reestablished, there would be the potential for severe and long-term effects to water quality and overall stream function (however the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed.

Prohibiting surface-disturbing activities and requiring NSO stipulations in uplands on approximately 500,000 acres of mineral estate and 1.2 million acres of BLM-administered surface would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer that reduced impacts from upland areas.

Avoiding or mitigating activities on slopes of 25 percent or greater (150,000 acres in the planning area) and sensitive soils would reduce impacts to water resources. Activities in these areas would cause accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality. Sensitive soils (1.8 million acres) would contain greater potential for reduced vegetation cover, accelerated wind and water erosion, and occurrence near waterbodies (such as hydric soils, which occur on 110,000 acres in the planning area). Surface disturbances on slopes of 25 percent or greater or sensitive soils within 300 feet of waterbodies (44,000 acres and 630,000 acres) would inhibit the ability of vegetative buffers to reduce impacts from upland areas.

Surface-disturbing activities in floodplains (330,000 acres) and waterbodies (300,000 acres) would reduce sedimentation, turbidity, and water temperature; decrease floodplain functionality, streambank stability, and water quality; cause riparian vegetation removal; and alter channel morphology in the short to long term when they could not be avoided. Because a sufficient vegetative buffer would not be preserved, nonpoint source pollution from uplands would not be reduced. Watershed resilience would be reduced, which would prolong the current and future periods until reclamation success. Construction activity in flowing waterbodies would be likely to exceed Montana water quality standards for turbidity and a variance would be required. The efficacy of mitigation measures would determine the severity of impacts caused by these management actions.

**TABLE 4-43.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE D**

Area	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Lewis and Clark Trail SRMA	72	100	3,500	8,800
Howrey Island	4	0	590	0
Matthews Recreation Area	<1	0	11	0
Dean S. Reservoir	1	1	0	0
Pumpkin Creek Ranch and Recreation Area	100	40	630	9
Glendive OHV SRMA	2	11	200	200
Terry OHV SRMA	1	1	0	0
Strawberry Hill Recreation Area	21	13	24	22
Moorhead	<1	0	11	0
Powder River Depot ACEC	7	6	13	21
Powderville Paleontological Area	110	120	18	660
Battle Butte	1	1	0	0
Reynolds Battlefield ACEC	2	2	8	170
Walstein Area	11	11	5	33

Management actions that allowed surface water impoundments (37 locations per year) would reduce streamflow, dissolved oxygen, and floodplain size and extent downstream (Vörösmarty and Sahagian 2000); increase infiltration to groundwater, scour of the downstream streambed, and water temperature (Dodds et al. 2004); substantially increase evaporative losses; degrade water quality; and change nutrient cycling, timing and magnitude of peak and low flows, sediment load, and riparian vegetation recruitment and succession. Under this action, there would also be the potential for permanent impacts including channel scour, erosion, and sedimentation downstream (if a dam broke). Water impoundments and developments in and near waterbodies, riparian areas, and wetlands would increase use in these areas, which would change morphology, increase water temperature, alter ecosystem processes, and decrease water quality by introducing sediment, salinity, bacteria, and nutrients. Expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources; however, maintaining natural flow regime and watershed functionality would reduce these impacts (IPCC 2007). The efficacy of approved specialized design features in maintaining the natural flow regime and watershed functionality would determine the severity of long-term impacts caused by these management actions.

Installing flow-control devices on all new water wells and spring developments would reduce the impacts of all new (10 wells and 2 springs per year) developments including water loss, soil erosion, riparian community losses, evaporation, and the vulnerability of water resources to climate change would be reduced. Riparian vegetation would be maintained at new sites. Current impacts (changes to the water table, soil erosion, loss of riparian communities, and evaporation) would continue.

Depending on the fuel type, haying within 200 feet of waterbodies would increase sedimentation, cause soil compaction, reduce litter and vegetation cover, decrease infiltration, and increase erosion (Ellis 2008) but reduce the risk of high-intensity or severity fire in the long term, which would improve watershed functionality.

Although PFC would be maintained, surface-disturbing activities and surface disturbance associated with oil and gas activities in riparian and wetland areas would reduce riparian and hydrologic function. In the short term, surface disturbance in riparian and wetland areas would result in erosion, turbidity, and sedimentation. The functionality of riparian vegetation (such as the dissipation of the energy of high water flows, filtration of sediment, stabilization of streambanks, and enhancement of floodplain functionality) and wetlands (such as the improvement of water quality, facilitation of groundwater recharge, filtration of sediment, maintenance of

floodwater, and removal of pollutants) would be reduced. Spills would potentially contaminate shallow groundwater and surface water. Nonpoint source pollution from uplands would not be reduced under this alternative. Watershed resilience would be reduced, which would prolong the period until reclamation success. Spills, chemicals from drilling processes, and use of infiltration ponds in riparian and wetland areas would potentially contaminate shallow groundwater and surface water. The severity of short-term and, potentially, long-term impacts would depend on the efficacy of the mitigation measures.

Boring of streams, wetlands, or riparian areas would reduce surface disturbance and maintain water quality in these areas. Implementing linear underground facilities (including buried power lines) using open-cut wet or isolated crossing methods would reduce water quality.

Unless the surface-disturbing activity established native vegetation, management actions that allowed surface-disturbing activities in areas of invasive species infestations would increase damage to watersheds and reduce water quality and quantity (BLM 2007d). The magnitude of damage to surrounding watersheds would depend on the efficacy of mitigation.

Allowing surface-disturbing activities adjacent to sport-fish reservoirs would reduce water quality, reduce infiltration rates, increase erosion, and increase overland flow. A CSU stipulation for oil and gas leasing and development within 0.5 miles of pallid sturgeon habitat and prohibiting surface disturbances within 0.5 miles of pallid sturgeon habitat would reduce impacts to water resources. The magnitude of impacts would depend on the efficacy of mitigation. The lack of prescribed buffers on waterbodies would increase sedimentation and reduce water quality, and impacts (reducing sediment, nutrients, metals, and other pollutants) from surface-disturbing activities adjacent to water, riparian areas, and wetlands would not be reduced or eliminated. Impacts would include sedimentation, erosion, soil compaction, decreased biodiversity, altered stream channel morphology, increased water temperature, reduced bank stability and aquifer recharge, increased floodwater velocities and energy, altered nutrient input to aquatic habitats, and lowered water table (which would decrease forage) (MDEQ 2007).

In the long term, management actions that required fish passage on a case-by-case basis would reduce sedimentation, streambed erosion, and streambank erosion. Existing and new culverts that impeded fish passage would result in sedimentation, streambed erosion, and streambank erosion.

Surface-disturbing activities within 0.25 miles of piping plover and interior least tern habitat would reduce water quality.

Management actions that required the burial of low-voltage power lines would increase surface disturbance and decrease water quality.

Limiting the cumulative, direct, and indirect disturbance to no more than 10 percent of the sagebrush habitat per 640 acres in Sage-grouse Habitat – Protection Priority Areas would limit impacts to aquatic and water resources (WDFG 2010a).

High-intensity fire and fire suppression that resulted in fuel buildup would lead to increased erosion and sedimentation, which would impact water quality in both the short and long term. The impacts would be the same for low-intensity fire (including prescribed fire) except that the magnitude of impacts would be reduced and erosion rates would be similar to natural levels. Depending on the severity, fire in riparian areas would reduce water quality by reducing vegetation and riparian function. In the long term, although water quality would benefit from healthy uplands, road construction and use of heavy equipment would lead to increased soil compaction, erosion, and sedimentation, which would reduce water quality.

Although requiring the removal or treatment of pre-commercial or commercial material on 53,000 acres of Condition Class 3 sites would decrease water quality in the short term, it would reduce the intensity and severity of fires, which would reduce erosion rates. Although typical timber harvest activities have been estimated to increase erosion rates to 0.05 to 0.25 tons per acre per year, intensive methods would potentially increase rates to 5 tons per acre per year (Elliot et al. 2010). Forest product production and sawtimber harvest

are a source of nonpoint source pollution, and the magnitude of impacts from these activities would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would result in an increase in erosion, sedimentation, and overland flow. The removal of streamside vegetation would change water temperature and reduce the ability of vegetative buffers to reduce nonpoint source pollution. Forest management activities that complied with the Streamside Management Zone Law, the *Water Quality BMPs for Montana Forests* (Logan 2001) *(*see the *Forestry and Woodland Products Appendix)*, and other BMPs would reduce these impacts.

Paleontological Resources management actions that required an NSO stipulation for oil and gas leasing and prohibited surface disturbance would maintain water quality.

Managing forestlands for a diversity of forest products would reduce water quality by increasing the acres of surface disturbance. Wood product sales and sawtimber harvest would cause nonpoint source pollution, the magnitude of which would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would increase erosion, sedimentation, and overland flow. Streamside vegetation removal would increase water temperatures and reduce the ability of vegetative buffers to reduce nonpoint source pollution. However, forest management activities would use BMPs (e.g., *Water Quality BMPs for Montana Forests* [Logan 2001], see the *Forestry and Woodland Products Appendix*) and comply with the Streamside Management Zone Law, which would reduce these impacts.

Different methods of timber harvest would have various impacts (e.g., hand harvesting would cause localized disturbances but mechanized methods would disturb a greater area). Whole tree harvesting would generate skid trails, which would accelerate erosion. Leaving slash in place would reduce erosion, and BMPs and the Streamside Management Zone Law would reduce the magnitude of these impacts.

Forest health projects would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity).

Because cottonwood harvest would occur near water, there would not be a sufficient vegetative buffer to reduce impacts of these activities. If this action resulted in healthier cottonwood stands, streambank stability and the system's ability to dissipate flood energy would increase.

Livestock grazing on 2.7 million acres under this alternative would reduce water quality and the ability of vegetative buffers to filter sediments and contaminants from upland areas. Excluding 8,000 acres from livestock grazing, excluding sheep and goats from 64,000 acres, and closing allotments in which the Standards for Rangeland Health were not met (190,000 acres) would improve watershed function, water quality, and quantity. However, in the 5 years before allotments that failed to meet Standards for Rangeland Health were closed, sedimentation and erosion would continue to reduce water quality. In the long term, this management action would decrease erosion and sedimentation and allow the total rest from grazing required for full recovery of structure and function of waterbodies (Belsky et al. 1999). In some areas, streams would have been degraded permanently, beyond recovery to a natural state, and adjust within the new potential.

Because grazing would slow revegetation and reclamation, allowing livestock grazing immediately after locatable mineral and coal mining and during oil and gas development would cause persistent impacts (even if the Standards for Rangeland Health were met) and accelerate impacts from multiple land use activities. In areas in which associated surface disturbance would decrease forage, maintaining AUM numbers during oil and gas development would cause impacts from grazing to increase. Multiple land uses would compound land uses and cause impacts greater than impacts caused by livestock grazing, mining, or development alone. This action would increase erosion, sedimentation, and streambank instability and decrease water quality and riparian functionality.

Management actions that allowed grazing the season following wildfire or prescribed fires would cause accelerated erosion, overland flow, and sedimentation, particularly if the wildfires were intense. Livestock grazing would inhibit restoration of aquatic ecosystem functionality (Beschta et al. 2004). Potentially (depending on site-specific fire situations, riparian areas, climatic conditions, and watershed conditions), a 1-season resting period would not enable riparian and upland vegetative reestablishment sufficient to reduce the compounded impacts of grazing and fire. Multiple land uses would compound land uses and cause impacts greater than impacts caused by the individual land uses alone. Impacts from both activities would cause erosion, sedimentation, streambank instability, decreased water quality, and reduced riparian vigor.

Water quality and riparian health monitoring would be prioritized on allotments in which grazing management contributed to the failure to meet Rangeland Health Standards. Management practices or levels of use would be adjusted to meet water quality or riparian health standards.

Prohibiting coal exploration on 1.8 million acres would maintain water quality and quantity.

Management actions that allowed surface disturbance associated with oil and gas activities under lease terms on 914,000 acres would decrease water quality on 2,000 to 6,000 acres of surface disturbance that occurred during development of BLM-administered mineral estate.

CSU stipulations for oil and gas leasing and development would reduce impacts to water resources on 16,000 miles of streams and 16,000 acres of floodplains.

Mineral sales and permitting on 1.1 million acres would decrease water quality.

Allowing big game retrieval would reduce water quality in areas in which vehicles crossed drainages, compacted soils, and accelerated erosion.

Management actions that allowed Open OHV use on 2,000 acres would impact 200 acres of floodplains, and Limited OHV use on 2.8 million acres would decrease water quality.

Streams and floodplains would be affected in Recreation and Special Designation Areas under Alternative D.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Management actions that prohibited surface-disturbing activities; required NSO stipulations for oil and gas leasing and development; and removed BLM-administered mineral acres from oil and gas leasing in uplands on approximately 1.0 million acres of mineral estate and 1.0 million acres of BLM-administered surface would maintain water quality, watershed functionality, and potentially preserve a vegetative buffer that reduced impacts from upland areas (Table 4-44).

Management actions limiting surface disturbance would benefit water resources by reducing impacts to water resources. Water resources would be affected by surface disturbance in uplands, riparian areas, wetland areas, and waterbodies within the watershed (BLM-administered land and other ownerships). Surface-disturbing activities (including ROW actions; mineral and energy exploration [including renewable energy], leasing, and development; geophysical exploration; OHV and vehicle use; special designation and recreation area designations and use [Table 4-45]; infrastructure development; vegetation and fuel treatments [including some habitat restoration projects]; cultural or paleontological excavation; establishment of wildfire fuel breaks; burial of power lines; and range improvements) would cause vegetation removal, soil compaction, and soil disturbance. Impacts would include accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. Erosion potential would be increased further through soil compaction and low-permeability surfacing (e.g., roads and well pads), which would increase the energy and amount of overland flow, which would subsequently increase sedimentation and erosion and alter flow characteristics. The magnitude of these impacts would depend on the specific activity, season, proximity

to waterbodies, location in the watershed, condition of upland and riparian vegetation, soils, watershed resilience, efficacy of mitigation (see the *Best Management Practices Appendix*), and the time elapsed until reclamation success (see the *Reclamation Appendix*). Although impacts from surface disturbance would typically be localized and short term, lasting until vegetation was reestablished, there would be the potential for severe and long-term effects to water quality and overall stream function (however the beneficial uses would be maintained). Impacts to water resources would increase as acres of surface disturbance increased within a watershed.

TABLE 4-44.
ESTIMATED WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE E

Area or Resource		Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Water	Floodplain, NSD[1]	770	1,900	42,000	110,000
	Waterbody, NSD	13,000	26,000	1,700	3,100
Veg.	Riparian and wetland, NSO	1,700	4,200	13,000	33,000
Fish and Wildlife	Aquatics, sport-fish reservoirs, 0.25-mile buffer	27	26	170	240
	Pallid Sturgeon, 0.5-mile buffer	75	94	3,300	6,800
Travel Mgmt and OHV	Limited OHV	13,000	NA	41,000	NA
	Closed OHV	12	NA	65	NA

[1]**NSD=No Surface Disturbance**

Avoiding or mitigating activities on slopes of 25 percent or greater (150,000 acres in the planning area) and sensitive soils would reduce impacts to water resources. Activities in these areas would cause accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality. Sensitive soils (1.8 million acres) would contain greater potential for reduced vegetation cover, accelerated wind and water erosion, and occurrence near waterbodies (such as hydric soils, which occur on 110,000 acres in the planning area). Surface disturbances on slopes of 25 percent or greater or sensitive soils within 300 feet of waterbodies (44,000 acres and 630,000 acres) would inhibit the ability of vegetative buffers to reduce impacts from upland areas. Although surface disturbances on slopes of 25 percent or greater or sensitive soils within 300 feet of waterbodies (44,000 acres and 630,000 acres) would inhibit the ability of vegetative buffers to reduce impacts from upland areas, specialized design features would maintain water quality and fish and wildlife habitat.

Avoiding surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development in floodplains (330,000 acres), waterbodies, and streams (300,000 acres) would maintain water quality. Surface-disturbing activities in these areas would reduce streambank stability; increase sedimentation, erosion, and turbidity; decrease water quality; remove riparian vegetation; increase flood severity; and alter channel morphology (MDEQ 2007) when they could not be avoided. Surface disturbance would reduce the capacity of these areas to dissipate the energy of high water events and cause changes in infiltration rates, water storage, and aquifer recharge. The presence of aboveground facilities would create flood hazards. Spills would potentially contaminate surface water and shallow groundwater. Construction activity in flowing waterbodies would be likely to exceed Montana water quality standards for turbidity and a variance would be required. The efficacy of approved specialized design features to maintain the functionality of the floodplain, water quality, and fish and wildlife habitat would determine the severity of short- and long-term impacts caused by these management actions.

**TABLE 4-45.
WATER RESOURCES AFFECTED IN RECREATION OR SPECIAL DESIGNATION AREAS ON BLM-ADMINISTERED ACRES UNDER ALTERNATIVE E**

Area	Miles of streams (surface acres)	Miles of streams (mineral)	Acres of floodplains (surface)	Acres of floodplains (mineral)
Lewis and Clark Trail SRMA	72	100	3,500	8,800
Howrey Island	4	0	590	0
Matthews Recreation Area	<1	0	11	0
Dean S. Reservoir	1	1	0	0
Pumpkin Creek Ranch and Recreation Area	100	31	630	9
Glendive OHV SRMA	1	8	200	200
Terry OHV SRMA	1	1	0	0
Strawberry Hill Recreation Area	21	13	24	22
Moorhead	<1	0	11	0
Powder River Depot ACEC	7	6	16	21
Powderville Paleontological Area	38	38	3	71
Battle Butte	1	5	0	27
Reynolds Battlefield ACEC	2	4	13	190
Walstein Area	11	11	5	33

Avoiding surface-disturbing activities on perennial streams, intermittent streams, lakes, ponds, or reservoirs and requiring an NSO stipulation for oil and gas leasing and development in floodplains (330,000 acres), lakes, ponds, or reservoirs, and perennial and intermittent streams (41,000 acres) would maintain water quality. Surface-disturbing activities in these areas and in ephemeral streams (259,000 acres) would reduce streambank stability; increase sedimentation, erosion, and turbidity; decrease water quality; remove riparian vegetation; increase flood severity; and alter channel morphology (MDEQ 2007) when they could not be avoided. Surface disturbance would reduce the capacity of these areas to dissipate the energy of high water events and cause changes in infiltration rates, water storage, and aquifer recharge. The presence of aboveground facilities would create flood hazards. Spills would potentially contaminate surface water and shallow groundwater. Construction activity in flowing waterbodies would be likely to exceed Montana water quality standards for turbidity and a variance would be required. Construction activity in ephemeral streams and within 300 feet of non-riparian waterbodies and streams would compromise the integrity of the vegetative buffer and inhibit the functionality of vegetative buffers and their role in reducing impacts from upland areas. The efficacy of approved specialized design features to maintain the functionality of the floodplain, water quality, and fish and wildlife habitat would determine the severity of short- and long-term impacts caused by these management actions.

Avoiding surface-disturbing activities and requiring a CSU stipulation for oil and gas leasing and development within 300 feet of riparian areas and wetlands, would potentially preserve a vegetative buffer that reduced or eliminated impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities immediately adjacent to riparian and wetlands. Buffers would reduce sedimentation, floodwater velocities and energy, erosion, and soil compaction; increase biodiversity; maintain stream channel shape, a higher water table (which would increase forage), late summer stream flows, and water temperature; stabilize streambanks; recharge aquifers; and facilitate nutrient input to aquatic habitats (MDEQ 2007). Surface-disturbing activities in these areas (when they could not be avoided) and livestock grazing would compromise the integrity of the vegetative buffer and reduce buffer efficacy. However, reduced water quality and sedimentation would occur in riparian areas and wetlands from a lack of buffers on ephemeral streams and non-riparian waterbodies upstream.

Management actions that allowed surface water impoundments (37 locations per year) would reduce streamflow, dissolved oxygen, and floodplain size and extent downstream (Vörösmarty and Sahagian 2000); increase infiltration to groundwater, scour of the downstream streambed, and water temperature (Dodds et al. 2004); substantially increase evaporative losses; degrade water quality; and change nutrient cycling, timing and magnitude of peak and low flows, sediment load, and riparian vegetation recruitment and succession.

Under this action, there would also be the potential for permanent impacts including channel scour, erosion, and sedimentation downstream (if a dam broke). Water impoundments and developments in and near waterbodies, riparian areas, and wetlands would increase use in these areas, which would change morphology, increase water temperature, alter ecosystem processes, and decrease water quality by introducing sediment, salinity, bacteria, and nutrients. Expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources however, maintaining natural flow regime and watershed functionality would reduce these impacts (IPCC 2007). The efficacy of approved specialized design features in maintaining the natural flow regime and watershed functionality would determine the severity of long-term impacts caused by these management actions.

Including design features to conserve water at the source of the water development would reduce the impacts of new (10 wells and 2 springs per year) developments and vulnerability of water resources to climate change. The integrity and functionality of the associated wetland, riparian area, stream, or creek would be maintained at new sites. Current impacts (changes to the water table, soil erosion, loss of riparian communities, and evaporation) would continue.

Depending on the fuel type, haying within 200 feet of waterbodies would increase sedimentation, cause soil compaction, reduce litter and vegetation cover, decrease infiltration, and increase erosion (Ellis 2008) but reduce the risk of high-intensity or severity fire in the long term, which would improve watershed functionality. Although this action would inhibit the ability of vegetative buffers to reduce impacts from upland areas, specialized design features would maintain water quality and fish and wildlife habitat.

An NSO stipulation for oil and gas leasing and development and avoiding surface-disturbing activities in riparian and wetland areas would maintain water quality. However, riparian and hydrologic function would be affected where surface-disturbing activities in riparian and wetlands areas could not be avoided and from upstream sources where surface disturbance would be allowed within 300 feet of non-riparian areas and within ephemeral streams. Although PFC would be maintained in the long term, surface disturbance in these areas would cause erosion, turbidity, and sedimentation in the short term. The functionality of riparian vegetation (such as the dissipation of the energy of high water flows, filtration of sediment, stabilization of streambanks, and enhancement of floodplain functionality) and wetlands (such as the improvement of water quality, facilitation of groundwater recharge, filtration of sediment, maintenance of floodwater, and removal of pollutants) would be reduced. Spills would potentially contaminate shallow groundwater and surface water. The severity of short-term and, potentially, long-term impacts would depend on the efficacy of the mitigation measures.

Avoiding surface-disturbing activities and requiring a CSU stipulation for oil and gas leasing and development within 300 feet of riparian areas and wetlands, would potentially preserve a vegetative buffer that reduced or eliminated impacts (reduced sediment, nutrients, metals, and other pollutants) from surface-disturbing activities immediately adjacent to riparian areas and wetlands. Buffers would reduce sedimentation, floodwater velocities and energy, erosion, and soil compaction; increase biodiversity; maintain stream channel shape, a higher water table (which would increase forage), late summer stream flows, and water temperature; stabilize streambanks; recharge aquifers; and facilitate nutrient input to aquatic habitats (MDEQ 2007). Surface-disturbing activities in these areas (when they could not be avoided) and livestock grazing would compromise the integrity of the vegetative buffer and reduce buffer efficacy. However, reduced water quality and sedimentation would occur in riparian areas and wetlands from a lack of buffers on ephemeral streams and non-riparian waterbodies upstream.

Boring of streams, wetlands, or riparian areas would reduce surface disturbance and maintain water quality in these areas. Implementing linear underground facilities (including buried power lines) using open-cut wet or isolated crossing methods would reduce water quality.

New spring developments would maintain water flow locally and downstream, the local water table, water temperatures, riparian vegetation, and channel morphology (Sada et al. 2001). Locating water developments 0.25 miles from perennial and intermittent streams would reduce grazing impacts in these areas. Allowing new livestock water developments in and near ephemeral streams, springs, and riparian areas would lead to increased use in these areas, which would change morphology, increase water temperature, alter ecosystem

processes, and decrease water quality by increasing sediment, salinity, bacteria, and nutrients. Locating and designing new livestock water developments (troughs or tanks) to maintain the integrity and functionality of wetlands, riparian areas, waterbodies, or creeks would reduce impacts caused by grazing.

Unless the surface-disturbing activity established native vegetation, management actions that allowed surface-disturbing activities in areas of invasive species infestations would increase damage to watersheds and reduce water quality and quantity (BLM 2007d). The magnitude of damage to surrounding watersheds would depend on the efficacy of mitigation.

Avoiding surface-disturbing activities and requiring an NSO stipulation for oil and gas leasing and development within 0.25 miles of designated sport-fish reservoirs would maintain water quality. A CSU stipulation for oil and gas leasing and development within 0.5 miles of pallid sturgeon habitat and prohibiting surface-disturbing activities within 0.5 miles of pallid sturgeon habitat would reduce impacts to water resources. Surface-disturbing activities would cause reduced infiltration rates, increased erosion, and increased overland flow in these areas. Although the magnitude of the impacts would depend on the efficacy of mitigation, these actions would still cause short-term impacts to water resources, including increased erosion, sedimentation, and reduced water quality.

Requirements for stream-crossing structures under this alternative would cause short-term surface disturbance and impacts (such as erosion and increased sediment load) but reduce the risk of erosion and damming in the long term.

Avoiding surface-disturbing activities within piping plover and interior least tern habitat would maintain water quality.

Management actions that required the burial of low-voltage power lines would increase surface disturbance and decrease water quality.

The absence of limits for cumulative, direct, and indirect disturbance in sage-grouse habitat in Sage-grouse Habitat – General Habitat and Restoration Areas would result in an "extreme impact (which is defined in the WDFG's March 2010 *Recommendations for Development of Oil and Gas Resources Within Important Wildlife Habitats* as more than 80 acres of disturbance per square mile)" from development on habitat function of aquatic and water resources (WDFG 2010a, p. 45). The resiliency of these ecosystems would be reduced, which would increase the vulnerability of the water resources to climate change impacts (CEICC 2008).

High-intensity fire and fire suppression that resulted in fuel buildup would lead to increased erosion and sedimentation, which would impact water quality in both the short and long term. The impacts would be the same for low-intensity fire (including prescribed fire) except that the magnitude of impacts would be reduced and erosion rates would be similar to natural levels. Depending on the severity, fire in riparian areas would reduce water quality by reducing vegetation and riparian function. In the long term, although water quality would benefit from healthy uplands, road construction and use of heavy equipment would lead to increased soil compaction, erosion, and sedimentation, which would reduce water quality.

Although requiring the removal or treatment of pre-commercial or commercial material on 53,000 acres of Condition Class 3 sites would decrease water quality in the short term, it would reduce the intensity and severity of fires, which would reduce erosion rates. Although typical timber harvest activities have been estimated to increase erosion rates to 0.05 to 0.25 tons per acre per year, intensive methods would potentially increase rates to 5 tons per acre per year (Elliot et al. 2010). Forest product production and sawtimber harvest are a source of nonpoint source pollution, and the magnitude of impacts from these activities would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would result in an increase in erosion, sedimentation, and overland flow. The removal of streamside vegetation would change water temperature and reduce the ability of vegetative buffers to reduce nonpoint source pollution. Forest management activities that complied with the Streamside Management Zone Law, the *Water Quality BMPs for Montana Forests* (Logan 2001) (see the *Forestry and Woodland Products Appendix)*, and

other BMPs would reduce these impacts. Salvage harvest of sawtimber would remove vegetation in a watershed with a reduced canopy cover, which would further accelerate erosion.

Managing forestlands for a diversity of forest products would reduce water quality by increasing the acres of surface disturbance. Wood product sales and sawtimber harvest would cause nonpoint source pollution, the magnitude of which would depend on the methods used. Vegetation removal, surface disturbance, road construction, and soil compaction would increase erosion, sedimentation, and overland flow. Streamside vegetation removal would increase water temperatures and reduce the ability of vegetative buffers to reduce nonpoint source pollution. However, forest management activities would use BMPs (e.g., *Water Quality BMPs for Montana Forests* [Logan 2001], see the *Forestry and Woodland Products Appendix*) and comply with the Streamside Management Zone Law, which would reduce these impacts.

Different methods of timber harvest would have various impacts (e.g., hand harvesting would cause localized disturbances but mechanized methods would disturb a greater area). Whole tree harvesting would generate skid trails, which would accelerate erosion. Leaving slash in place would reduce erosion, and BMPs and the Streamside Management Zone Law would reduce the magnitude of these impacts.

Forest health projects would have the potential to impact water resources. Most treatments would cause initial short-term impacts similar to those caused by surface disturbance. Changes in vegetation structure and composition would alter water flows, the quantity and quality of surface water and groundwater, and the rate of groundwater recharge (BLM 2007d). However, these impacts would be a natural result of healthier vegetation. Because evapotranspiration rates, rooting depth, and vegetative cover vary by species, a change would potentially impact water (e.g., changes in erosion and sedimentation rates, infiltration, amount of overland flow, evaporation, and turbidity).

The use of mitigation and a riparian buffer would reduce impacts of cottonwood harvest. If this action resulted in healthier cottonwood stands, streambank stability and the system's ability to dissipate flood energy would increase.

Livestock grazing on 16 million acres under this alternative would reduce water quality and the ability of vegetative buffers to filter sediments and contaminants from upland areas. Excluding acres from livestock grazing, excluding sheep and goats from acres, and closing allotments in which the Standards for Rangeland Health were not met (190,000 acres) would improve watershed function, water quality, and quantity. However, in the 5 years before allotments that failed to meet Standards for Rangeland Health were closed, sedimentation and erosion would continue to reduce water quality. In the long term, this management action would decrease erosion and sedimentation and allow the total rest from grazing required for full recovery of structure and function of waterbodies (Belsky et al. 1999). In some areas, streams would have been degraded permanently, beyond recovery to a natural state, and adjust within the new potential.

Because grazing would slow revegetation and reclamation, allowing livestock grazing immediately after locatable mineral and coal mining and during oil and gas development would cause persistent impacts (even if the Standards for Rangeland Health were met) and accelerate impacts from multiple land use activities. In areas in which associated surface disturbance would decrease forage, maintaining AUM numbers during oil and gas development would cause impacts from grazing to increase. Multiple land uses would compound land uses and cause impacts greater than impacts caused by livestock grazing, mining, or development alone. This action would increase erosion, sedimentation, and streambank instability and decrease water quality and riparian functionality.

Management actions that deferred livestock grazing until the area attained identified vegetative objectives following a wildfire, prescribed fire, or non-fire vegetative treatment would facilitate vegetative reestablishment and improve water quality.

Water quality and riparian health monitoring would be prioritized on allotments in which grazing management contributed to the failure to meet Rangeland Health Standards. Management practices or levels of use would be adjusted to meet water quality or riparian health standards.

CSU stipulations for oil and gas leasing and development would reduce impacts to water resources on 13, 000 miles of streams and 110,000 acres of floodplains. Management actions that allowed oil and gas surface disturbance on 910,000 acres with lease terms would decrease water quality.

Mineral sales and permitting on 2.5 million acres would decrease water quality.

Closing 2,800 acres to OHV use under this alternative would maintain water quality and quantity on 12 miles of streams and 65 acres of floodplains. Open OHV use on 2,000 acres and Limited OHV use on 2.8 million acres would decrease water quality.

Streams and floodplains would be affected in Recreation and Special Designation Areas under Alternative E.

CUMULATIVE IMPACTS

Past and present land use, dams, natural events, changes in local and global climatic patterns, and management actions impact water resources. Impacts would increase as human populations increased and expanded. Management of water resources is complicated by scattered land ownership because water is connected throughout a watershed (longitudinally from headwaters downstream; laterally through interactions with floodplains, riparian areas, and uplands; vertically through interactions with the substrate and subsurface; and temporally).These interactions compound the impacts of all land management and land use throughout an entire watershed.

Erosive soils and arid climate across the planning area form hydrologic systems prone to erosion, channel degradation, downcutting, accelerated lateral cutting, and sedimentation. These systems have high levels of natural instability and rapid degradation can occur from human disturbance (Elmore and Kauffman 1994). Within uplands, the amount of vegetation and natural erosion control is limited by the climate. Prior to European settlement, integral factors in watershed health in the form of disturbances such as fire, beaver activity, occasional or patchy large ungulate herbivory, and flooding were common across the landscape. Beaver (*Castor canadensis*) influenced nutrient cycling, water temperature, residence time of water, aquatic habitat, vegetation dispersal, and riparian community structure. The extirpation of beaver through trapping influenced the composition, structure, and function of stream systems by decreasing surface water availability, reducing channel diversity, and converting wetland communities to xeric plant communities (Elmore and Kauffman 1994). Prior to their near extinction during the mid-1800s, bison (*Bison bison*) roamed the area in large herds, consuming vegetation in the uplands and riparian and wetland areas. Although local increases in soil bulk density at bison stream crossings decreased water infiltration and accelerated fluvial erosion, disturbance of streams was spatially and temporally minimized because bison distribution patterns were unaffected by slope or proximity to water (Fritz, Dodds, and Pontius 1999; Fleischner 1994), they grazed in patches, ranged over large areas, and typically crossed creeks at specific locations (Fritz et al. 1999).

An influx of livestock to eastern Montana beginning in the 1860s has altered stream and river ecosystems. Livestock grazing has degraded about 80 percent of stream and riparian ecosystems in the arid western United States. Livestock grazing alters watershed hydrology by increasing overland flow, the volume of peak flows, and floodwater velocity; lowering the water table; and decreasing low flows and infiltration rates (Belsky et al. 1999). Livestock grazing accelerates soil erosion, reduces riparian vegetation, increases water temperature, decreases dissolved oxygen, degrades the stream channel, and introduces pollutants such as sediment, salinity, bacteria, and nutrients (MDEQ 2007). Wide and shallow channels, high sediment yield, and high turbidity characterize grazing-disturbed streams (Magilligan and McDowell 1997). Because livestock spend a disproportionate amount of time in riparian areas for forage, shade, and water (Belsky et al. 1999; Saunders and Fausch 2007), heavy use, particularly in riparian areas, leads to major changes in stream morphology, water quality, and water availability. Grazing practices, particularly year-long grazing, have resulted in increased sedimentation, declines in woody species and deep-rooted vegetation, soil compaction, increased overland flow, accelerated erosion, decreased water quality, and extreme instability of stream channels. During high flows, channel instability created over-widened or incised channels, eventually lowering the

water table. The Taylor Grazing Act of 1934 addressed overgrazing of federal lands by attempting to reduce livestock numbers (Elmore and Kauffman 1994).

Beginning in the late 19th and early 20th century, surface disturbances such as homesteading, mining, OHV use, infrastructure development, community development, agriculture, and the introduction of invasive species has affected channel morphology and resulted in soil compaction, increased overland flow and sedimentation, accelerated erosion, and decreased water quality. Soil compaction and the presence of impervious surfaces have reduced infiltration and increased overland flow, which results in increased channel degradation, sedimentation, and reduced water quality and quantity.

Farming and grazing drastically changed native vegetation. Cropland development and drought in 1919 and the 1930s resulted in accelerated wind erosion of agricultural lands. Since the 1930s, flood control, irrigation development, and wetland conversion have modified stream channels through in-stream structures, channelization, bank modification, and placement of riprap (Elmore and Kauffman 1994). OHV use, particularly during wet conditions, has caused rutting, erosion, stream channel degradation, and established roads and trails. Many of these surface disturbances continue to degrade water quality.

Since the late 19th century, federal and state regulations have improved water quality. The Rivers and Harbors Act of 1899 (33 U.S.C. 403 10) preserved water quality by requiring permits for refuse discharge and channel alteration of navigable waters and their tributaries. Water quality has been improved through the establishment of water quality standards through the Water Pollution Control Act of 1948, Federal Water Pollution Control Act in 1956, and the Water Quality Act of 1965. The Clean Air Act of 1970 and Clean Air Act Amendments of 1990 have reduced atmospheric deposition of pollutants. In 1972, the Clean Water Act created regulations for reducing point source and nonpoint source pollution. The Water Quality Act of 1987 established numeric criteria for toxic pollutants to reduce impairment of beneficial uses.

Scattered land ownership and the absence of watershed-wide management strategies have complicated efforts for ongoing conservation and restoration. Water resources are influenced by land use throughout an entire watershed. Multiple land uses would compound land uses and cause impacts greater than impacts caused by the individual land uses alone. Land use within watersheds of the planning area is approximately 65 percent rangeland, 26 percent agriculture, 7 percent forest, less than 1 percent mines or quarries, and less than 1 percent urban or developed (MNRIS 2010).

The BLM's ability to influence future conditions in watersheds is limited by scattered and minority land ownership in many watersheds. Activity that occurs adjacent to BLM-administered lands would impact water resources on BLM-administered land. Activities occurring on BLM-administered lands or adjacent to BLM-administered lands (including livestock grazing, agriculture, urbanization, fire suppression, mineral exploration and development, weed infestation, OHV use, and pollution, decrease watershed health and water quality), cause accelerated erosion, increased overland flow, decreased infiltration, channel degradation, atmospheric deposition of pollutants, and degradation of water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants in waterbodies. These activities have resulted in 14 percent of the assessed stream miles becoming listed as impaired or threatened (see the *Water Appendix*). Crop and livestock production compose the largest percentage of nonpoint source pollution in Montana (MDEQ 2007) and is the most common anthropogenic contributor to stream impairment in the planning area (MDEQ 2010b). Fire suppression has increased fire severity and intensity, leading to increased overland flow, erosion, and sedimentation.

Overgrazing in riparian areas; historical impacts to stream morphology and groundwater; and the construction of numerous impoundments, spring developments, and stream crossings contribute to disconnection within the watershed. Connectivity is essential for the cycling of water, nutrients, and sediment throughout the watershed. Continued degradation of stream channels and riparian areas would result in accelerated loss of water resources and hydrologic function. The cumulative impacts of grazing; local geology; soils; agricultural practices; and surface-disturbing activities within uplands, riparian areas, and stream channels have contributed to accelerated erosion and increased sedimentation. Sedimentation from activities in the upper watershed is compounded as these drainages combine and flow into larger streams and rivers.

Produced water from oil, gas, CBNG, and coal development in Wyoming and Montana impacts the quality and quantity of surface water and groundwater through impoundments, injection, and discharge; impacts caused by these activities would be mitigated by permits. The combination of these activities increases the potential for degradation of water quality. The total amount of water produced by CBNG wells within the PRB in Wyoming and Montana during 2007 was approximately 85,000 acre-feet from approximately 5,500 wells (Wheaton, Reddish-Kuzara, Meredith, and Donato 2008). Although surface water quality in some watersheds would be altered in combination with new and existing permits and developments in Wyoming and Montana, beneficial uses would not be diminished. Surface water flow would moderately increase alteration of the natural hydrologic regimes (such as changes in the magnitude and timing of low and peak flows) and cause erosion and increased sedimentation (BLM 2008g). Discharge of sodic and saline water from CBNG development and the use of seepage ponds to dispose of this water cause cumulative impacts to water quality.

Hydrologic resources would be vulnerable to the impacts of climate change and mitigation or a reduction of these effects would reduce the impacts on water resources (see *Chapter 3, Water* for more information). Conversely, activities that exacerbated the effects of climate change would increase the vulnerability of water resources to impacts. Water conservation measures (including limiting the number of impoundments, limiting surface and groundwater withdrawal, and increasing irrigation efficiency) would reduce the vulnerability of water resources to climate change. Conversely, expanded water use, withdrawals, and storage would exacerbate the impacts of climate change on water resources (IPCC 2007).

Alternative A

Alternative A would contribute to a decline in water quality and quantity; however, water quality standards would be met and beneficial uses maintained. Buffers would not be established to reduce nonpoint source pollution and non-oil and gas surface disturbance would be allowed in waterbodies, floodplains, wetlands, and riparian areas. Surface disturbance associated with oil and gas activities would be allowed in wetlands, floodplains of non-major rivers, and 80 percent of the federal mineral estate in the planning area without stipulations. Surface disturbance in areas of sensitive soils, soils with poor reclamation potential, and highly erodible soils would reduce water quality and result in long-term to permanent increases in sedimentation.

Surface disturbance would be allowed on 1.7 million acres under this alternative. Closures and NSO stipulations for oil and gas leasing and development would protect approximately 2,000 miles of waterbodies, 20 miles of impaired streams, and 260,000 acres of floodplains (Table 4-46). Oil, gas, and CBNG activities would cause surface disturbance on 16,000 to 46,000 acres, with 28 percent occurring through activities on BLM-administered mineral estate.

Alternative A would continue to accelerate erosion, increase sedimentation, reduce connectivity within watersheds, increase channel degradation, increase overland flow, and impair water quality. Under Alternative A, some waterbodies and their associated riparian areas would decline, some areas beyond recovery to historical potential.

TABLE 4-46. ESTIMATED WATERBODIES MAINTAINED ON BLM-ADMINISTERED ACRES BY CUMULATIVE RESTRICTIONS

NSOs	Streams (miles)	Floodplains (acres)
A	26,000	92,000
B	26,000	110,000
C	2,000	18,000
D	0	0
E	26,000	110,000

Alternative B

Under this alternative, water quality, water quantity, and watershed health would be maintained or improved through reduced livestock grazing, restricted OHV use, use of buffers to reduce nonpoint source pollution, and restricted or prohibited surface disturbance, particularly in and near waterbodies, floodplains, wetlands, and riparian areas. These actions would increase riparian vigor and decrease impacts from surface disturbance in upland areas. The physical and biological connections between the riparian areas and streams would be maintained, which would improve water quality by decreasing sedimentation and pollution.

Surface disturbance would be allowed on 180,000 acres under this alternative. Closures and NSO stipulations for oil and gas leasing and development would protect approximately 3,000 miles of waterbodies, 40 miles of impaired streams, and 330,000 acres of floodplains (Table 4-46). Oil, gas, and CBNG activities would cause surface disturbance on 12,000 to 33,000 acres, with none occurring through activities on BLM-administered mineral estate. The elimination of several future oil, gas, and CBNG field development projects (because sufficient BLM-administered mineral estate would not be available) under this alternative would maintain water quality.

Alternative C

Surface disturbance would be allowed under this alternative (if they could not be avoided) in and near waterbodies, wetlands, riparian areas, and floodplains. Alternative C would contribute to declines in water quality and quantity. Alternative C would require minimal restrictions for construction of livestock water developments in ephemeral and intermittent streams and surface water impoundments. The long-term cumulative impacts from these actions would include the loss of hydrologic connectivity within the watershed, altered channel morphology and hydrologic flow regime, increased sedimentation, and reduced water quality.

Water quality and riparian health monitoring would be prioritized on allotments in which grazing management contributed to the failure to meet Rangeland Health Standards. Management practices or levels of use would be adjusted to meet water quality or riparian health standards.

Surface disturbance would be allowed on 1.1 million acres under this alternative. Closures and NSO stipulations for oil and gas leasing and development would protect approximately 2,000 miles of waterbodies, 3 miles of impaired streams, and 18,000 acres of floodplains (Table 4-46). Oil, gas, and CBNG activities would cause surface disturbance on 13,000 to 36,000 acres, with 11 percent occurring through activities on BLM-administered mineral estate.

Alternative C would continue to accelerate erosion, increase sedimentation, reduce connectivity within watersheds, increase channel degradation, increase overland flow, and impair water quality.

Alternative D

Alternative D would cause a decline in water quality, water quantity, and overall watershed health. Buffers would not be established to reduce impacts from upland surface disturbance and surface disturbances would be allowed in waterbodies, floodplains, wetlands, and riparian areas. Livestock water developments and surface water impoundments would be built with minimal restrictions. The long-term cumulative impacts from these actions would include the loss of hydrologic connectivity within the watershed, altered channel morphology and hydrologic flow regime, increased sedimentation, and reduced water quality.

Surface disturbance would be allowed on 1.7 million acres under this alternative. Closures and NSO stipulations for oil and gas leasing and development would not protect any waterbodies, impaired streams, or floodplains under this alternative (Table 4-46). Oil, gas, and CBNG activities would cause surface disturbance on 14,000 to 40,000 acres, with 15 percent occurring through activities on BLM-administered mineral estate.

Alternative D would accelerate erosion, alter stream morphology, decrease connectivity within watersheds, decrease streambank stability, increase overland flow, decrease infiltration, and degrade water quality through increased sedimentation, turbidity, nutrients, eutrophication, metals, and other pollutants. Under Alternative D, many waterbodies and their associated riparian areas would decline, some beyond recovery to historical potential.

Alternative E (Preferred Alternative)

Alternative E would maintain water quality and quantity through restricted OHV use, use of buffers to reduce nonpoint source pollution, and restricted or prohibited surface disturbance, particularly in and near streams, waterbodies, floodplains, wetlands, and riparian areas. Alternative E would require the maintenance of watershed and riparian functionality during water developments.

Water quality and riparian health monitoring would be prioritized on allotments in which grazing management contributed to the failure to meet Rangeland Health Standards. Management practices or levels of use would be adjusted to meet water quality or riparian health standards. Allotments still contributing to the failure to meet riparian health standards within 5 years would be closed to grazing.

Closures and NSO stipulations for oil and gas leasing and development would protect approximately 120,000 miles of streams and 16,000 acres of floodplains (Table 4-46).

VEGETATION

ASSUMPTIONS AND METHODOLOGY

Approximately 17,500 acres would be burned with prescribed fire in the short term and approximately 70,000 in the long term. Treatments such as prescribed fire and mechanical treatments are used to meet resource objectives (e.g., vegetation, wildlife, or other objectives).

Approximately 220,000 acres would be treated biologically in the short term and approximately 500,000 in the long term. Biological control for vegetation management involves the use of insects or domestic livestock to manipulate vegetation. Target-specific insect pests are used to weaken invasive plant populations and reduce their ability to spread by damaging plant parts (e.g., roots, stems, or flowers).

Approximately 5,000 acres would be treated chemically in the short term and approximately 50,000 in the long term. Pesticides (primarily herbicides) would be used to manipulate vegetation to meet resource objectives (e.g., using herbicides to reduce big sagebrush density and create a mosaic of shrubs and herbaceous vegetation).

Approximately 12,000 acres would be treated mechanically in the short term and approximately 80,000 in the long term. Mechanical treatment includes commercial thinning and pre-commercial thinning for logging as well as all mastication treatments (Hydro-axe, brush hog, and chainsaw).

Approximately 1,500 acres would be seeded in the short term and approximately 50,000 in the long term. Seeded acres include those required under reclamation plans, as contract stipulations, or included for projects such as oil and gas development.

Emergency stabilization and rehabilitation vegetation treatments are addressed in *Wildland Fire Management and Ecology*.

Vegetation treatment acres proposed under an emergency stabilization and rehabilitation plan are not included under other restoration proposals. For example, a plan to restore a Wyoming big sagebrush and prairie grassland association might call for 10,000 acres of seeding desirable species. An emergency stabilization and rehabilitation plan written for a large wildfire might propose 10,000 acres of seeding native species. Acres treated for vegetation restoration and analyzed in this RMP do not include those that would be proposed under an emergency stabilization and rehabilitation plan.

Implementing NSO stipulations for oil, gas, and geothermal leasing and development and removing federal acreage from leasing would correlate directly to the reduction of federal oil and gas wells, as predicted in the RFD (see the *Minerals Appendix*) and result in fewer acres of surface disturbance in the planning area. For example, if NSO stipulations for oil, gas, and geothermal leasing and development or no-leasing decisions

affected 10 percent of the federal mineral estate under an alternative, there would be a corresponding 10-percent reduction in the number of BLM-administered oil and gas wells predicted under the RFD. Conversely, mitigation, specialized design features, and CSU stipulations for oil, gas, and geothermal leasing and development would not correlate directly to the reduction of federal oil and gas wells or acres of surface disturbance.

Special status plant species are known to or may occur in the planning area. Designation of critical habitat or special considerations for the management of these plant species (known populations or discovered) could impact plant communities. Management for plant and wildlife species designated as threatened or endangered under the ESA or designated as special status species by the BLM can affect resource uses in areas in which these special status species occurred. Specifically, restrictions on the type, location, or period in which consumptive use activities were allowed to occur could limit management options on lands containing special status species and, in turn, could affect vegetative communities; for example, surface use restrictions could affect development or placement of range improvement projects.

MANAGEMENT COMMON TO ALL ALTERNATIVES

Actions that limited surface disturbance would benefit vegetation resources. Surface-disturbing activities would cause vegetation removal, soil compaction, and soil disturbance. Surface-disturbing activities under all alternatives would include mineral and energy exploration, leasing, and development (including renewable energy and geophysical exploration); OHV and vehicle use; ROWs; land use; infrastructure development; vegetation or fuel treatment (including the sale or harvest of hay, timber, wood, or seed); establishment of wildfire fuel breaks; and implementation of range improvements. Impacts from surface disturbance would typically be localized and short term. Impacts to vegetation resources would increase as acres of surface disturbance increased within an area. These impacts (the magnitude of which would depend on the condition of upland and riparian vegetation, the efficacy of mitigation, the specific activity and season, and the length of the period preceding reclamation success) would include accelerated erosion, increased overland flow, and increased invasion of weedy or invasive species.

Vegetation treatments would cause short-term disturbance and result in long-term impacts to grassland and shrubland communities. Vegetation treatments that successfully achieved vegetative objectives would increase plant and seral stage diversity, control invasive species, improve wildlife habitat and livestock forage, and create or maintain the desired mosaic. Natural recovery of hardwood draws would be emphasized. A pre-settlement successional pathway would include a disturbance factor (typically fire, insects, or disease) that would reinitiate natural succession of these hardwood ecosystems. Vegetation succession and the health of these hardwood draw communities would be heavily influenced by large ungulates.

Treatments to approximate natural disturbance regimes would sustain complexity, diversity, resiliency, and productivity in hardwood draws.

Livestock grazing would impact the health and productivity of vegetative communities. Livestock congregation areas, which would include areas containing water, shade, or more palatable forage, would be the most likely to impact rangeland health; subsequently, management would often be geared toward improving the overall distribution of livestock within an allotment. This distribution would be accomplished through the implementation of BMPs, such as developing allotment management plans (AMPs), altering grazing systems, and implementing range improvement projects (e.g., fencing, water developments, or salt and mineral licks).

Livestock transport of invasive species seed would increase the spread of these species when moving livestock from an allotment infested with invasive species (and the seeds are attached to the hair of the animal or in contained internally in the digestive tract).

Maintaining adaptive ecosystems of the Northern Great Plains would benefit rangeland health by improving plant vigor, increasing vegetative cover, and reducing invasive species infestations. Hoof action would remove vegetation that inhibited new growth, increased cover and vigor of native vegetation, decreased soil erosion, and

broke soil crust that would restrict infiltration and inhibit seedling establishment. Healthier plant communities would resist the spread of invasive species and other undesirable plant species. Targeted grazing in areas containing invasive species at crucial points in the species' lifecycle would decrease the spread of invasive species by decreasing seed production or limiting vegetative propagation.

Wildfire and prescribed fires impact grassland and shrubland communities. In the short term, fire would potentially cause habitat loss and promote the spread of invasive species. In the long term, because of fire's historic role in these communities, fire would increase vegetative diversity across the landscape, rejuvenate decadent plants, and improve the overall health of these communities. In shrubland communities, fire impacts, which are typically more long term than in other communities, depend on the scale and severity of the disturbance. The potential for reestablishment of sagebrush shrublands would depend on the sum of the acreage burned, the distance to seed sources, and the spread of invasive species. Invasive vegetation species, such as cheatgrass, would increase fire frequency, which would prevent shrub establishment. Limiting fire in some cases would reduce direct loss of grassland and shrubland communities and reduce the potential for the spread of invasive species in the short term. In the long term, the lack of fire would decrease the overall health of these fire-adapted communities. Fire would enhance age structure, restore vigor, and restore community types through regeneration.

Although fire suppression activities would limit short- and long-term fire damage to vegetation, they would cause mechanical and chemical damage to vegetation and increase the likelihood of the introduction or spread of invasive species. Wildland fire and suppression tactics would cause short- and long-term impacts to grassland and shrubland communities. Using full suppression or limited tactics would damage vegetation and potentially spread invasive species. If invasive species were already present, the potential for spread would increase regardless of the type of suppression used. Generally, the natural role of fire (if left unchecked by human intervention) would trend toward a natural range of variability of vegetation characteristics and fuel composition. However, with human intervention (fire suppression) the majority of the planning area is currently in a condition class of 2, which is a moderate departure from the natural (historical) regime of vegetation characteristics and fuel composition. The fire regime itself is currently at a 1, typically described by the 0 to 35-year fire frequency and low to mixed fire severity. It would appear that global climate change is having an influence on the duration and severity of the average fire season within the region. If this recent trend continues over the long term, the fire regime may increase to a 2, which indicates higher severity fires, although the frequency would likely remain the same at 0 to 35 years.

ALTERNATIVE A

Allowing surface-disturbing activities would impact the relative abundance, distribution, and occurrence of seral stages. Although these actions would not result in the complete elimination of a plant species, plant community, or seral stage, they would allow an opening for invasive species infestations. This alternative would allow disturbance on 2.8 million acres of BLM-administered land in the planning area.

NSO stipulations for oil and gas leasing and development would protect vegetation and prevent soil compaction and vegetation removal.

Treating invasive species on a case-by-case basis would be an inefficient and ineffective method for weed control on a field office level. Small, isolated treatments would not produce the same results as large-scale watershed treatments.

Allowing prescribed fire in Category B and C Fire Management Categories, which make up the entire planning area, would impact vegetation through disturbance. Usually, invasive species appear in the short term following fire. Until vegetation was reestablished, road construction and heavy equipment use associated with prescribed fire would impact soil health and vegetative buffers in the short term. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth and increase the occurrence of invasive species.

Allowing harvest of cottonwood on public lands only when human safety was a factor or disease or insect infestations were threatening cottonwood stands would improve the health, resiliency, ecological function, and sustainability of cottonwood stands and provide an incidental amount of forest products (e.g., firewood).

Because livestock grazing would impact the vigor and reproduction of palatable species, livestock management actions that enhanced associated characteristics of key plant species would benefit these species.

OHV use on BLM-administered lands would result in short- and long-term impacts to vegetation in grassland and shrubland communities. Depending on soil conditions, slope, and ground cover, light OHV use would disturb the soil surface and cause physical damage to vegetation by breaking stems and branches. However, plants and disturbed areas would recover from light disturbance. With increased use, new trails would be established, which would result in soil erosion, invasive seed introduction into grassland and shrubland habitats, and long-term vegetation losses.

ALTERNATIVE B

Minimizing surface-disturbing activities would limit the impacts to the relative abundance, distribution, and occurrence of seral stages. These actions would not result in the complete elimination of a plant species, plant community, or seral stage and would decrease the opportunity for invasive species infestations. This alternative would not allow surface disturbance on 89 percent of the BLM-administered surface (2.5 million acres) in the planning area.

Management of wildland fire to meet multiple objectives would have a long-term impact on vegetation by accelerating nutrient cycling, sprouting, and forage availability.

Because livestock grazing would impact the vigor and reproduction of palatable species, livestock management actions that enhanced associated characteristics of key plant species would benefit these species.

Targeted grazing of invasive species using sheep would support desirable plant species. Restricting this activity would allow invasive species to spread and impact native plant communities.

Allowing harvest of cottonwood on public lands only when human safety was a factor or disease or insect infestations were threatening cottonwood stands would improve the health, resiliency, ecological function, and sustainability of cottonwood stands and provide an incidental amount of forest products (e.g., firewood).

Depending on soil conditions, slope, and ground cover, light OHV use would disturb the soil surface and cause physical damage to vegetation by breaking stems and branches. However, plants and disturbed areas would recover from light disturbance. With increased use, new trails would be established, which would result in soil erosion, invasive seed introduction into grassland and shrubland habitats, and long-term vegetation losses.

ALTERNATIVE C

Although avoiding or restricting surface-disturbing and disruptive activities or requiring burial of power lines would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages. Burying power lines would create desirable conditions for invasive species infestations. Surface-disturbing activities would not be allowed on 2 percent or 63,000 acres of BLM-administered lands in the planning area. All other activities would require specialized design features.

Allowing surface-disturbing activities in areas of invasive species infestations would increase the potential for weed infestations and expansion and decrease the vigor of desirable vegetative species.

Using Early Detection Rapid Response for controlling invasive species in publicly accessible areas, riparian areas, and special status species habitat areas would assist in recovering vegetation to its native state.

Prioritizing these areas of treatment would reduce the degree of spread by invasive species in these areas (and other areas) by eliminating or significantly decreasing weed infestations, which would decrease the possibility of invasive species seed dispersal on other lands.

Management of wildland fire to meet multiple objectives would have a long-term impact on vegetation by accelerating nutrient cycling, sprouting, and forage availability.

Allowing prescribed fire throughout the entire planning area would impact vegetation through disturbance. Usually, invasive species appear in the short term following prescribed fire. Until vegetation was reestablished, road construction and heavy equipment use associated with prescribed fire would impact soil health and vegetative buffers in the short term. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth and increase the occurrence of invasive species.

Allowing limited harvest of cottonwood only to restore the health and resiliency of cottonwood stands or remove hazard trees would ensure that cottonwood trees were protected from further decline.

Because livestock grazing would impact the vigor and reproduction of palatable species, livestock management actions that enhanced associated characteristics of key plant species would benefit these species.

OHV use on BLM-administered lands would result in short- and long-term impacts to vegetation in grassland and shrubland communities. Depending on soil conditions, slope, and ground cover, light OHV use would disturb the soil surface and cause physical damage to vegetation by breaking stems and branches. However, plants and disturbed areas would recover from light disturbance. With increased use, new trails would be established, which would result in soil erosion, invasive seed introduction into grassland and shrubland habitats, and long-term vegetation losses.

ALTERNATIVE D

Allowing surface-disturbing and disruptive activities or requiring burial of power lines would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages. Burying power lines would create desirable conditions for invasive species infestations. This alternative would allow surface-disturbing activities on project sites on 99 percent of all BLM-administered lands (2.7 million acres) within the planning area.

Allowing surface-disturbing activities in areas of invasive species infestations only with approved measures would increase the potential for weed infestations and expansion and decrease the vigor of desirable vegetative species.

Allowing prescribed fire throughout the entire planning area would impact vegetation through disturbance. Usually, invasive species appear in the short term following prescribed fire. Until vegetation was reestablished, road construction and heavy equipment use associated with prescribed fire would impact soil health and vegetative buffers in the short term. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth and increase the occurrence of invasive species.

Management of wildland fire to meet multiple objectives would have a long-term impact on vegetation by accelerating nutrient cycling, sprouting, and forage availability.

Allowing limited harvest of cottonwood only to restore the health and resiliency of cottonwood stands or remove hazard trees would ensure that cottonwood trees were protected from further decline.

Because livestock grazing would impact the vigor and reproduction of palatable species, livestock management actions that enhanced associated characteristics of key plant species would benefit these species.

OHV use on BLM-administered lands would result in short- and long-term impacts to vegetation in grassland and shrubland communities. Depending on soil conditions, slope, and ground cover, light OHV use would disturb the soil surface and cause physical damage to vegetation by breaking stems and branches. However, plants and disturbed areas would recover from light disturbance. With increased use, new trails would be established, which would result in soil erosion, invasive seed introduction into grassland and shrubland habitats, and long-term vegetation losses.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Allowing surface-disturbing and disruptive activities or requiring burial of power lines would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages in the specific project areas. Burying power lines would create desirable conditions for invasive species infestations. Surface-disturbing and disruptive activities would be allowed on approximately 2.8 million acres of BLM-administered lands in the planning area. Specialized design features would be used to mitigate possible negative impacts.

Allowing surface-disturbing activities in areas of invasive species infestations would increase the potential for weed infestations and expansion and decrease the vigor of desirable vegetative species.

Using Early Detection Rapid Response for controlling invasive species in publicly accessible areas, riparian areas, and special status species habitat areas would assist in recovering vegetation to its native state. Prioritizing these areas of treatment would reduce the degree of spread by invasive species in these areas (and other areas) by eliminating or significantly decreasing weed infestations, which would decrease the possibility of invasive species seed dispersal on other lands.

Allowing prescribed fire throughout the entire planning area would impact vegetation through disturbance. Usually, invasive species appear in the short term following prescribed fire. Until vegetation was reestablished, road construction and heavy equipment use associated with prescribed fire would impact soil health and vegetative buffers in the short term. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth and increase the occurrence of invasive species.

Management of wildland fire to meet multiple objectives would have a long-term impact on vegetation by accelerating nutrient cycling, sprouting, and forage availability.

Allowing limited harvest of cottonwood only to restore the health and resiliency of cottonwood stands or remove hazard trees would ensure that cottonwood trees were protected from further decline.

Because livestock grazing would impact vigor and reproduction of palatable species, livestock management actions that enhanced these characteristics of key plant species would benefit these species.

Although closing livestock grazing in allotments that failed Standards for Rangeland Health and made no progress toward meeting those goals within 5 years would improve vegetation in the short term, vegetation would be dominated by older plants, contain a high litter cover, and experience reduced recruitment over the long term.

OHV use on BLM-administered lands would result in short- and long-term impacts to vegetation in grassland and shrubland communities. Depending on soil conditions, slope, and ground cover, light OHV use would disturb the soil surface and cause physical damage to vegetation by breaking stems and branches. However, plants and disturbed areas would recover from light disturbance. With increased use, new trails would be established, which would result in soil erosion, invasive seed introduction into grassland and shrubland habitats, and long-term vegetation losses.

CUMULATIVE IMPACTS

Historical and ongoing activities within the planning area that have affected, or are currently affecting, soils include energy and mineral development, livestock grazing, on- and off-highway vehicle use, recreation, infrastructure development, fire suppression, fuels management, forestry, urbanization, invasive weed infestations, pollutants, and agriculture; these impacts are expected to continue into the future. The cumulative effects of such activities have directly or indirectly contributed to increased compaction, increased overland waterflow, mass movement, and accelerated wind and water erosion. Currently, the BLM is not aware of any other reasonably foreseeable future actions, other than those discussed above.

The BLM's current and future goals for soil management are aimed at maintaining and improving soil health and productivity, minimizing soil erosion and compaction, and maintaining soil water infiltration rates. Under all alternatives, the standards for rangeland health would be used to assess compaction and soil erosion.

Current and future activities have the potential to cumulatively impact soil resources within the planning area as demand for resources continues to grow; however, the land pattern in the planning area would prevent anything more than minor impacts from BLM-authorized activities. Vegetation treatments, roads management, and energy and mineral resource activities would have the greatest potential to contribute to cumulative impacts to soils on BLM-administered lands.

In general, Alternative B would restrict the greatest number of surface use authorizations, subsequently protecting more soil resources than all other alternatives, and Alternative C would restrict the fewest surface use authorizations and protect the fewest soil resources of all alternatives. Alternatives A and D would also restrict surface use authorizations. Typically, there would be fewer restrictions under Alternatives A and D than under Alternative B, but more than those under Alternative C. Alternative D would generally be more restrictive than Alternative A.

Implementation of project stipulations and mitigation measures by the BLM would result in minor cumulative impacts to special status plant populations. Impacts would be caused by ground disturbances created by new road and trail construction; fuels management; energy and mineral activities; forestry activities; livestock grazing; OHVs; and utility, transportation, and communications projects.

Alternative A

Management actions on grasslands and shrublands (e.g., prescribed fire, weed treatments, livestock grazing, mechanical treatments, and reseeding) throughout the planning area would impact vegetation composition and structure. Although proposed vegetation treatments in the planning area would vary, impacts at the planning area scale would be minor for Alternative A.

Alternative B

Proposed treatments would have the potential to affect plant communities by changing the relative abundance of species within plant communities, the relative distribution of plant communities, and the relative occurrence of seral stages of those communities. Cumulative impacts would include those caused by livestock grazing, habitat manipulation, and invasive species. Changing levels of livestock use on BLM-administered lands would potentially cause changes in grazing practices on private land. A reduction of the grazing periods or quantity of livestock permitted on BLM-administered lands would potentially lead to increased or longer durations of use on private lands, which would potentially cause a decline in the ecological condition of these lands and reduce the wildlife habitat quality.

Alternative C

Although avoiding or restricting surface-disturbing and disruptive activities would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages.

Alternative D

Although avoiding or restricting surface-disturbing and disruptive activities would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages.

Alternative E (Preferred Alternative)

Although avoiding or restricting surface-disturbing and disruptive activities would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would impact the relative abundance, distribution, and occurrence of seral stages.

RIPARIAN AND WETLAND AREAS

ASSUMPTIONS AND METHODOLOGY

There would be 2 to 10 riparian and wetland projects constructed for the benefit of riparian and wetland resources each year, disturbing a total of 10 to 100 acres per year. It is assumed there are between 800,000 and 1.3 million acres of riparian and wetland areas in the planning area with a 50-foot corridor. Riparian and wetland areas were calculated using the best available data from the Montana Gap Analysis Program and the 2009 National Hydrography Dataset area waterbodies data. When data are collected on all the potential riparian and wetland areas, it is assumed that 5 percent of the total streams assessed for riparian and wetland areas would be rated functional-at risk with downward trend, and 3 percent of the total streams assessed for riparian and wetland areas would be rated nonfunctional (approximately 833 miles of the potential 15,166 streams have been assessed).

In the planning area, there are approximately 1.6 million surface acres of total riparian and wetland areas, including waterbodies and streams, with a 0.5-mile corridor (using the best available data from the known riparian and wetland areas from the MCFO riparian database and the 2009 National Hydrography Dataset area waterbodies data). These acres include both ephemeral and intermittent streams. It is assumed that 35 percent of these acres would be rated non-riparian when new data are collected.

MANAGEMENT COMMON TO ALL ALTERNATIVES

Actions to limit surface disturbance would benefit riparian and wetland areas. Surface-disturbing activities would remove vegetation and compact soils. Although impacts from surface disturbance typically would be localized and short term and last until reestablishment of vegetation, impacts of surface disturbances would increase as disturbed acres increased within a watershed.

Evaluating the activity and, if necessary, relocating the activity to a more suitable soil type or denying the authorization would minimize disturbance in riparian and wetland areas. Proper reclamation of surface-disturbing activities would decrease erosion and excess sedimentation.

Management actions that preserved or enhanced water quality would also maintain or improve riparian and wetland area functionality.

Meeting Rangeland Health Standards would ensure healthy sustainable rangelands, including healthy riparian and wetland areas. Properly functioning riparian and wetland areas would contain adequate vegetation and woody debris to dissipate the stream energy associated with high flow events, which would subsequently reduce erosion and improve water quality. Meeting all five standards would ensure riparian and wetland vegetation was in balance with upland vegetation and assist in erosion control, bank stabilization, and sediment filtration. Because timing, intensity, frequency, grazing duration, livestock behavior, and foraging preferences would potentially alter impacts to the vegetative component of riparian and wetland areas, adjusting livestock grazing use would promote sufficient vegetation within riparian and wetland buffers.

Treatments of woody and non-woody vegetation through mechanical thinning, biomass removal, and chemical and biological treatments would threaten native vegetation in riparian and wetland areas in the short term, accelerate erosion of streambanks, and increase sedimentation. Reducing hazardous fuels through woody and non-woody vegetation treatments would alter the balance of water in streams and subsurface flow for native species within riparian and wetland areas, which would subsequently impact water quality, soil health, and wildlife habitat. Over time, this reduction would be managed to ensure riparian and wetland areas continued to meet the standards to maintain functionality or maintain improving trends.

Use of fertilizer to accomplish natural vegetation community restoration would improve riparian and wetland areas rated lower than PFC. Fertilizer use in riparian and wetland areas rated at PFC would maintain functioning condition. If desired riparian and wetland native vegetation was established to stabilize soil or increase plant cover in buffers, restoration of natural vegetation communities would improve water quality. If applied where overland flow or soil erosion introduced fertilizer into water, fertilizer use would increase nutrients and metals in surface water in the short term, which would lead to short-term eutrophication and lower dissolved oxygen levels.

If herbivory were temporarily excluded or livestock grazing patterns changed to allow for desired vegetation heights, emphasizing the recovery of hardwood draws would increase seedlings, saplings, and woody species. Although limiting livestock herbivory would eliminate a treatment option, it would allow for the introduction of disturbances needed to maintain hardwood draws dominated by woody species. Because established hardwood draws decrease erosion from disturbances and increase bank stabilization for riparian and wetland areas, allowing large numbers of seedlings and saplings to reach their desired heights before authorizing livestock and wildlife to graze would improve riparian and wetland areas. Allowing the establishment of multi-aged stands of hardwood draws before introducing treatments or livestock grazing would increase bank stabilization, filter sediments, and allow nutrient cycling, which would improve riparian and wetland areas. This action would increase woody species in hardwood draws and ensure that these areas would not pass the transitional threshold into grass-dominated draws. However, hardwood draws are not necessarily riparian or wetlands, so improving these areas would potentially not impact riparian conditions.

Reducing use on riparian and wetland areas rated lower than PFC would increase desired vegetation and decrease erosion and sedimentation. However, the majority of the riparian and wetland areas within the planning area are rated at PFC. Reduced upland or riparian use would ensure that sufficient vegetation was present during high flow events to protect streambanks, dissipate energy, and trap sediments.

Healthy and diverse riparian and wetland areas would be important for watershed functionality. Under all alternatives, temporary or permanent enclosures would be built around riparian and wetland areas that required increased species diversity, recruitment, and functionality. Enclosures would also be built for any riparian and wetland system needing additional management and attention to meet site-specific goals and objectives for the system.

Herbicide treatments would potentially impact drainages within a watershed by altering riparian and wetland vegetative components. In the long term, treatments would reduce impacts from nonnative species, which would include alteration of natural nutrient cycling patterns, erosion rates, stream morphology, evapotranspiration, infiltration (Hansen et al. 1995), and flow regimes.

Managing prairie streams to provide quality aquatic wildlife habitat and meet the riparian standard for rangeland health would maintain or improve riparian and wetland areas and increase the likelihood that water quality was maintained. Riparian and wetland vegetative buffers would protect associated streams from excessive erosion or sedimentation. Riparian area vegetation would also buffer waterbodies by reducing or eliminating nonpoint source pollution from upland areas (MDEQ 2007).

Although 300-foot buffers would be applied under Wildland Fire Management actions in compliance with the *Guidelines for Aerial Delivery of Retardant or Foam near Waterways* (USFS et al. 2000) and the *Policy for Delivery of Wildland Fire Chemicals (Retardant and Foam) Near Waterways*(USFS et al. 2009), it would be

possible for fire retardant to enter waterbodies and riparian and wetland areas via wind or overland flow, which would impair water quality (Little and Calfee 2004). This action would also introduce ammonium polyphosphate and sulfate ions, iron oxide, clay, or bentonite to riparian and wetland areas (USFS 2007).

Compliance with the Streamside Management Zone Law and the *Water Quality BMPs for Montana Forests* (Logan 2001) (see the *Forestry and Woodland Products Appendix*) would reduce impacts to riparian and wetland areas from forest management activities by minimizing soil erosion and sedimentation. The Streamside Management Zone Law prescribes specific buffers for forest activities near streams or waterbodies to maintain riparian and wetland area functionality and decrease pollutants. Minimizing disturbances from forest activities may be required where necessary to increase the width of the zone to ensure consistency with the riparian and wetland standard.

The magnitude of impacts from livestock grazing would vary based on utilization, location in the watershed, duration, and season of use. Excessive livestock grazing would accelerate soil erosion, reduce the riparian vegetation, increase water temperature, degrade the stream channel, and introduce pollutants such as sediment, salinity, bacteria, and nutrients to riparian and wetland areas and water (MDEQ 2007). Wide and shallow channels, high sediment yield, and high turbidity would characterize grazing-disturbed streams (Magilligan and McDowell 1997). Livestock grazing within riparian and wetland areas would allow browsing of species important for dissipating energy during high flow events. Proper management (Mosley et al. 1999; Saunders and Fausch 2007) and compliance with, or progress toward, meeting Standards for Rangeland Health would minimize these impacts.

Coal mining activities (e.g., surface disturbance, road construction, overburden removal, rerouting of stream systems, and the presence of sediment ponds) would disrupt surface water, which would impact vegetation along riparian and wetland areas. During mining, sedimentation would be reduced by sedimentation ponds. Spoils would experience decreased infiltration following reclamation (for 10 to 15 years) and, as a result, overland flow and peak flows would increase by approximately 5 percent (BLM 1984). Because adequate vegetation cover would be necessary to dissipate energies during high flow events, operations discharging groundwater with leached salts would alter the vegetative components of riparian and wetland areas.

Carrying forward coal leasing from the Big Dry and Powder River RMPs using current suitability and unsuitability criteria on 1.6 million acres within the planning area would impact and alter riparian and wetland areas. Soil-stabilizing vegetation would be reduced, which would cause severe erosion that affected the ability of riparian areas to dissipate energy during high flow events. Considering potential alluvial valley floors along 860 stream miles to be unsuitable at the planning stage would protect native vegetation within those riparian and wetland buffers (BLM 1984).

Surface-disturbing activities and oil and gas development within riparian and wetland areas would remove riparian vegetation and increase erosion and sedimentation, which would alter streambanks.

Impacts to vegetation within riparian and wetland areas would increase as mineral extraction activity and well, road, and facility density increased. Increased road construction and stream crossings would increase erosion and sedimentation, which would impact stream channel morphology and alter riparian and wetland area vegetation. Discharged product water must meet water quality standards, which would ensure that activities would not impair water quality or riparian and wetland areas.

Impacts to riparian and wetland area vegetation from in situ leach uranium recovery would be small to moderate. In addition to impacts from surface-disturbing activities, contamination of aquifers at varying depths, shallow groundwater aquifers, and adjacent aquifers with radionuclides or other constituents (e.g., selenium, metals) would potentially occur. The resulting changes to soil properties or hydrology would alter riparian and wetland species diversity and composition.

Ground disturbance associated with transportation routes would increase bank erosion, which would degrade valuable riparian habitat and tree cover and lead to higher water temperatures and sedimentation. These long-term impacts would be accelerated by the construction or maintenance of roads, stream channelization, vehicle

fords, improper design and location, and inadequate maintenance. In addition to any short-term impacts caused by construction, the placement of culverts would potentially cause long-term impacts to the waterway. Compaction of soil and impermeable road surfacing would reduce infiltration and increase overland flow, which would increase erosion and sedimentation. Impacts would be minimized by using appropriate road surfacing (which would decrease wind and water erosion on the road surface), reducing the number and extent of road systems, avoiding riparian areas and stream crossings, installing erosion control features, using proper culvert placement and design, reclaiming closed roads, and following BMPs.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

Acquired lands that improved the continuity of BLM-administered lands within a particular watershed or increased ownership along streams would increase the ecological viability of managing riparian and wetland areas.

ALTERNATIVE A

Avoiding activities on sensitive soils on slopes or highly erodible soils on slopes would decrease potential impacts to adjacent riparian and wetland areas from soil erosion and sedimentation, which would cause siltation of wetlands, degradation of water quality, and alteration of drainage patterns.

NSO stipulations for oil and gas leasing and development would protect vegetative buffers and prevent soil compaction and vegetation removal, which would protect riparian and wetland areas from erosion and sedimentation and maintain overall watershed health. These actions would protect 62,000 acres of riparian and wetland areas from additional disturbances. Limiting the number and restricting the size of permanent facilities would also contribute to this protection.

The magnitude and duration of the impacts of surface-disturbing activities such as linear underground facilities that crossed perennial streams, intermittent streams, wetlands, and riparian areas would vary depending on the method used to cross the waterbody. All methods would cause either short- or long-term surface disturbance, as described below.

- Trenching would have direct contact with riparian vegetation during all stages of construction. Impacts to stream morphology from the resulting erosion and sedimentation would impact the ability of riparian buffers to withstand high flow events until the buffer was reestablished.
- Isolated crossing methods (e.g., dam-and-pump and flume methods) would cause impacts similar to those caused by trenching, but with less severity and duration. The increases in turbidity and sedimentation would be limited to the installation and removal of dam or flume structures (up to 10 hours) (Lévesque 2007). Vegetation removal would be short term, and vegetation would have a greater chance to recover with reduced impacts of erosion and sedimentation to riparian areas.
- Bore crossing or HDD avoids contact with the waterbody and would avoid a large portion of the riparian area buffer. This method would protect the native riparian vegetation, decreasing vegetation removal and allowing the area to continue to dissipate energy during high flow events, with decreasing erosion and sedimentation. Slight impacts to riparian vegetation from heavy equipment activity on the outer edge of riparian buffers would occur in the short term.

Springs would provide additional moisture and runoff for riparian and wetland vegetation, and installing flow-control devices on troughs would limit excess water diverted from the source. Limiting this diversion would reduce soil moisture in overflow areas and increase flows from the source into the natural drainage, which would enhance the vigor and type of riparian vegetation. However, without fencing the source, trampling caused by congregating livestock would increase. Fencing springs would protect the vegetative buffer at the source and increase species vigor and composition.

Avoiding the placement of troughs and tanks in areas containing important riparian and wetland vegetation would increase species vigor and composition by limiting impacts caused by livestock trampling and congregating.

Because riparian and wetland areas are susceptible to invasive species (vegetation) invasion and often invaded by multiple species, allowing surface-disturbing activities in areas infested by invasive species (vegetation) would expand infestations in riparian and wetland areas. Invasive species infestations located outside of riparian and wetland areas would potentially invade and degrade adjacent native riparian vegetative communities. Surface disturbances in areas of invasive species would potentially disrupt existing weed infestations and allow seeds to blow or drain into riparian areas, which would reduce the ability of native riparian vegetation to stabilize streambanks.

NSO stipulations for oil and gas leasing and development within 0.25 miles of designated reservoirs with fisheries would protect riparian and wetland vegetation around the reservoir. Wetland vegetation would provide habitat for aquatic species and decrease bank erosion and instability, excess sedimentation, and habitat fragmentation.

Burying power lines would increase surface disturbance and remove vegetation within riparian and wetland areas. Depending on the crossing methods, the magnitude of the impacts to riparian and wetland vegetation would vary.

An NSO stipulation for oil and gas leasing and development within 0.25 miles of wetlands identified as piping plover or interior least tern habitat would protect 1,700 acres of riparian and wetland areas from erosion and sedimentation. Prohibiting surface occupancy would decrease the removal of vegetation and soil compaction and protect vegetative buffers important to piping plovers and interior least terns.

Allowing prescribed fire in Fire Management Categories B and C, which compose the entire planning area, would increase native riparian and wetland vegetation in watersheds. Road construction and heavy equipment use associated with prescribed fire would impact water quality, soil health, and vegetative buffers in the short term until vegetation was reestablished. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth.

Riparian and wetland areas within cultural and paleontological sites would be protected when lease terms were applied, so vegetative buffers would prevent soil compaction and vegetation removal, which would decrease erosion and sedimentation and maintain overall riparian health.

Allowing surface-disturbing activities (other than oil and gas activities with NSO stipulations) would increase erosion and sedimentation. Surface-disturbing activities outside of riparian and wetland areas would impact vegetative buffers by decreasing native plant composition and increasing erosion. Changes in vegetation composition would increase runoff and sedimentation, alter streambank and channel structure, and cause nutrient losses.

Allowing cottonwood harvest on public lands only when human safety was a factor or disease or insect infestations were threatening cottonwood stands would cause impacts similar to those caused by surface-disturbing activities. Because cottonwoods stands typically occur within riparian areas, harvesting would increase erosion and sedimentation and decrease infiltration. Harvesting cottonwoods would reduce vegetation within buffers, which would accelerate erosion and reduce the stream's ability to dissipate energy during high flow events.

Under this alternative, 440 acres of riparian and wetland areas would be closed to livestock grazing, and 1.6 million acres would be open to livestock grazing (99 percent of total riparian and wetland acres within the planning area). Improper livestock grazing and hoof disturbance would increase bank erosion and sedimentation, alter riparian vegetation, and introduce pollutants. Because behavior and feeding preferences differ between livestock species, overuse and trampling would impact the composition of native riparian and

wetland vegetation species or eliminate some species important to the system. Differing grazing intensities would alter the impacts to riparian and wetland vegetation. Congregating livestock would impact riparian and wetland vegetation, erosion, and sedimentation. Livestock grazing would potentially be compatible in riparian and wetland areas when managed in harmony with land management objectives such as meeting Standards for Rangeland Health. Managing livestock based on resource use and land health standard assessments would ensure riparian and wetland areas continue to meet standards. Those areas failing to meet standards would be adjusted to generate improving riparian and wetland conditions and trends.

If Standards for Rangeland Health were not met and livestock grazing was a causal factor for this failure, the management of riparian and wetland areas would change to ensure that allotments were moving toward PFC. (Standard 2 requires that riparian and wetland areas attain and maintain PFC.) Ensuring that riparian, wetland, and upland vegetation was properly functioning would help control erosion, stabilize banks, and filter sediment. Grazing management and activities would be adjusted to allow riparian and wetland areas to improve toward PFC.

Allowing livestock grazing during or immediately after mining or development would impact riparian and wetland areas by increasing erosion and sedimentation along streambanks caused by localized livestock congregating or trampling.

Permits would be renewed on a case-by-case basis when monitoring demonstrated that riparian and wetland area objectives were met on I allotments and maintained on M and C allotments. Meeting these resource objectives would maintain or improve PFC in riparian and wetland areas.

Geophysical exploration would temporarily disturb soil and vegetation. Prohibiting geophysical exploration would protect 72,000 acres of riparian wetland areas from this activity.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

ALTERNATIVE B

Prohibiting mineral leasing and permitting within riparian and wetland areas and prohibiting surface-disturbing activities on sensitive soils or slopes 25 percent or greater would decrease potential soil erosion and sedimentation in riparian and wetland areas. These actions would help riparian and wetland areas to maintain or improve PFC and protect vegetative buffers.

Prohibiting surface-disturbing and disruptive activities or mineral development would decrease streambank erosion, sedimentation, and vegetation removal and protect riparian and wetland areas. Riparian and wetland areas rated at PFC would be subject to disturbance if the activity maintained or improved riparian and wetland areas. Oil and gas leasing with an NSO stipulation would for riparian and wetland areas would protect 59,000 acres of riparian and wetland areas from erosion and sedimentation. Even when disturbances occurred in the uplands, short-term disturbances occurring outside of riparian and wetland areas would impact adjacent riparian vegetative buffers.

Prohibiting mineral leasing and permitting within riparian and wetland areas and for water resources and prohibiting surface-disturbing activities would decrease potential soil erosion and sedimentation in riparian and wetland areas. These actions would help riparian and wetland areas to maintain or improve PFC and protect vegetative buffers.

Springs would provide additional moisture and runoff for riparian and wetland vegetation, and installing flow-control devices on troughs would limit excess water diverted from the source. Limiting this diversion would reduce soil moisture in overflow areas and increase flows from the source into the natural drainage, which

would enhance the vigor and type of riparian vegetation. However, without fencing the source, trampling caused by congregating livestock would increase. Fencing springs would protect the vegetative buffer at the source and increase species vigor and composition. Designing spring developments to ensure riparian communities were maintained or improved would benefit overall watershed health.

Prohibiting surface-disturbing activities, disruptive activities, and permanent facilities within 0.5 miles of designated sport-fish reservoirs (unless the activity or facility would benefit aquatic wildlife habitat) would protect riparian and wetland vegetative buffers. Protecting vegetative buffers from surface-disturbing activities would decrease streambank erosion and sedimentation, which would improve riparian and wetland areas rated lower than PFC.

Because riparian and wetland areas are susceptible to invasive species (vegetation) invasion and often invaded by multiple species, prohibiting surface-disturbing activities in areas infested by invasive species (vegetation) would protect riparian and wetland areas. Surface disturbances in areas of invasive species would potentially disrupt existing weed infestations and allow seeds to blow or drain into riparian areas, which would reduce the ability of native riparian vegetation to stabilize streambanks.

Prohibiting invasive species control within riparian and wetland areas would include 14.3 miles of the designated Bighorn Sheep Range, which would allow invasive species to outcompete desired species on valuable riparian wildlife habitat such as point bars and side channels.

An NSO stipulation for oil and gas leasing and development within 0.25 miles of wetlands identified as piping plover or interior least tern habitat would protect 1,700 acres of riparian and wetland areas from erosion and sedimentation. Prohibiting surface occupancy would decrease the removal of vegetation and soil compaction and protect vegetative buffers important to piping plovers and interior least terns.

Burying low-voltage oil and gas power lines within 4 miles of a lek and within sage-grouse winter concentration areas would increase surface disturbance within riparian and wetland areas, which would increase erosion and sediment loads in the short term.

High-intensity fire would potentially impact vegetation composition and slow reestablishment of vegetation. However, fires would help to minimize some woody invasive species within a watershed, which would allow for the reestablishment of desired native species.

Short-term impacts following a prescribed fire would impact riparian and wetland health by decreasing water quality, affecting soil health, and altering vegetative riparian and wetland buffers.

Management actions that required buffers around upland cultural and paleontological sites would facilitate the functionality of riparian and wetland vegetative buffers, which would decrease erosion and sedimentation and maintain or improve riparian and wetland conditions.

Allowing cottonwood harvest on public lands only when human safety was a factor or disease or insect infestations were threatening cottonwood stands would cause impacts similar to those caused by surface-disturbing activities. Because cottonwoods stands typically occur within riparian areas, harvesting would increase erosion and sedimentation and decrease infiltration. Harvesting cottonwoods would reduce vegetation within buffers, which would accelerate erosion and reduce the stream's ability to dissipate energy during high flow events.

Under this alternative, 1,500 acres of riparian and wetland areas would be closed to livestock grazing, and 1.6 million acres would be open to livestock grazing (99 percent of total riparian and wetland acres within the planning area). Ensuring that riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment. Differing grazing intensities would alter the impacts to riparian and wetland vegetation. Congregating livestock would impact riparian and wetland vegetation, erosion, and sedimentation. Monitoring and evaluating priority allotments that contained specific nonfunctional or functional-at risk with downward trend riparian areas and

adjusting management of priority areas would help these areas to improve toward PFC. Livestock grazing would potentially be compatible in riparian and wetland areas when managed in harmony with land management objectives such as meeting Standards for Rangeland Health.

Management of riparian and wetland areas would be changed to ensure that allotments maintained or improved PFC in areas in which the Standards for Rangeland Health were not met and livestock grazing was a causal factor for the failure to meet these standards. (Standard 2 requires that riparian and wetland areas are rated PFC.) Ensuring that riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment for a properly functioning riparian and wetland area. Closing allotments to livestock grazing would speed fulfillment of riparian objectives.

Locating new livestock water developments at least 0.25 miles from riparian and wetland areas would protect 2.5 million acres from livestock trampling or congregating. Locating water developments near riparian and wetland areas would allow riparian and wetland areas to maintain or progress toward PFC. Ensuring riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment for a properly functioning riparian and wetland area.

Temporarily closing BLM-administered lands to grazing for at least 2 growing seasons after prescribed fire or non-fire vegetation treatments would promote the regrowth of desired native vegetation in riparian and wetland areas (with normal precipitation). Consecutive drought years following a prescribed fire would degrade riparian and wetland areas by slowing the reestablishment of native species' vigor and diversity. Allowing native species to sprout and regenerate would maintain or improve riparian and wetland conditions.

Suspending livestock grazing to ensure that adequate fine fuels were present to carry a prescribed fire would enable attainment of long-term objectives for riparian and wetland vegetation. Suspending livestock use during this period would increase herbaceous biomass, which would decrease potential erosion and sedimentation along streambanks.

Transferring or renewing grazing permits for C grazing allotments under this alternative would maintain or improve PFC in riparian and wetland areas.

Priority allotments under this alternative would increase management review to ensure criteria were met for permit renewals.

Restricting geophysical exploration would protect 71,000 acres of riparian and wetland areas from potential erosion and sedimentation. Limiting use to existing roads and trails would ensure that no new disturbances occurred outside of or along riparian and wetland areas, which would minimize degradation to these areas.

Management actions that allowed mineral materials sales and permitting on 1.2 million acres would increase potential erosion and sediment loads to riparian and wetland areas.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

ALTERNATIVE C

Avoiding surface-disturbing activities on slopes 25 percent or greater (71,000 acres of riparian and wetland areas) or on sensitive soils would decrease soil erosion potential and sedimentation within riparian and wetland areas. Soil disturbance on slopes 25 percent or greater would accelerate potential erosion from human-caused

activity, which would increase sediment loads to riparian and wetland areas and potentially alter vegetation and stream morphology.

Restricting or prohibiting surface-disturbing or disruptive activities or mineral leasing or development would protect riparian and wetland areas from additional erosion and sedimentation that would impact riparian and wetland vegetative buffers and their functioning condition. A CSU stipulation for oil and gas leasing and development in riparian and wetland areas would protect 11,000 acres of riparian and wetland areas from the erosion and sedimentation associated with surface disturbances. These stipulations would prevent vegetation removal and soil compaction, protect vegetative buffers important to some species, and maintain overall watershed health. Unless mitigation ensured the activity maintained or improved riparian and wetland conditions, allowing mineral exploration and development would cause opposite impacts.

Springs would provide additional moisture and runoff for riparian and wetland vegetation, and installing flow-control devices on troughs would limit excess water diverted from the source. Not authorizing spring developments would ensure that the riparian and wetland areas around springs would continue to maintain species' vigor and composition without disturbances. Limiting this diversion would reduce soil moisture in overflow areas and increase flows from the source into the natural drainage, which would enhance the vigor and type of riparian vegetation. However, without fencing the source, trampling caused by congregating livestock would increase. Fencing springs would protect the vegetative buffer at the source and increase species vigor and composition. Designing spring developments to ensure riparian communities were maintained or improved would benefit overall watershed health.

Locating new livestock water developments at least 0.25 miles from riparian and wetland areas would protect 2.5 million acres from livestock trampling or congregating. Locating water developments near riparian and wetland areas would allow riparian and wetland areas to maintain or progress toward PFC. Ensuring riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment for a properly functioning riparian and wetland area.

Because riparian and wetland areas are susceptible to invasive species (vegetation) invasion and often invaded by multiple species, allowing surface-disturbing activities in areas infested by invasive species (vegetation) would expand infestations in riparian and wetland areas. Invasive species infestations located outside of riparian and wetland areas would potentially invade and degrade adjacent native riparian vegetative communities. Surface disturbances in areas of invasive species would potentially disrupt existing weed infestations and allow seeds to blow or drain into riparian areas, which would reduce the ability of native riparian vegetation to stabilize streambanks.

Avoiding surface-disturbing activities within 0.25 miles of designated sport-fish reservoirs would prevent excess soil erosion, streambank erosion, and sedimentation. Approved mitigation under this alternative would ensure riparian and wetland areas would maintain or improve PFC in compliance with guidance found in the *Reclamation Appendix*.

Prohibiting domestic sheep and goat grazing for invasive species control on 11,000 acres of riparian and wetland areas within 14.3 miles of the Bighorn Sheep Range would allow invasive species (vegetation) to outcompete desired vegetative species. Invasive vegetation species would increase on point bars and side channels, which are valuable areas for wildlife habitat. Appropriate control of invasive species with targeted grazing would ensure riparian and wetland areas were maintained or progressing toward PFC.

Prohibiting surface-disturbing activities within 0.25 miles of wetlands identified as piping plover or interior least tern habitat would protect 1,700 acres of riparian and wetland areas from erosion, sedimentation, and vegetation removal. Activities occurring adjacent to the 0.25-mile buffer for wetlands would potentially increase erosion and sedimentation. Mitigation would ensure wetlands continued to be maintained or improved and functioning habitat was maintained for piping plovers and interior least tern.

Short-term disturbances associated with the burial of power lines within 3.1 miles of a lek and in sage-grouse winter concentration areas would occur in areas in which vegetation was removed in association with these activities. In the long term, recovery of vegetation in these areas would decrease erosion and sedimentation.

Allowing prescribed fire throughout the planning area would provide the most opportunities to meet objectives for native vegetation in riparian and wetland areas, particularly if environmental conditions allowed for proper regrowth.

Management actions that required buffers around upland cultural and paleontological sites would facilitate the functionality of riparian and wetland vegetative buffers, which would decrease erosion and sedimentation and maintain or improve riparian and wetland conditions. Riparian and wetland areas would assist in nonpoint source pollution by holding and using nutrients and reducing sediments in waterbodies. Decreased surface disturbance would improve riparian and wetland conditions.

Harvesting cottonwood to restore the health and resiliency of cottonwood stands or hazard tree removal would increase erosion and sedimentation and decrease infiltration in the short term. Harvesting cottonwoods would reduce vegetation within buffers, which would accelerate erosion. Over the long term, this action would maintain or improve the integrity and functionality of riparian and wetland areas by maintaining cottonwood health and providing vegetation resiliency that helped dissipated energy during high flow events.

Under this alternative, 1,400 acres of riparian and wetland areas would be closed to livestock grazing, and 1.6 million acres would be open to livestock grazing (99 percent of total riparian and wetland acres in the planning area). Ensuring that riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment. Differing grazing intensities would alter the impacts to riparian and wetland vegetation. Congregating livestock would impact riparian and wetland vegetation, erosion, and sedimentation. In the Dean S. Reservoir SRMA, excess livestock grazing would degrade wetland vegetative components, which would decrease composition and increase erosion along banks. In the Pumpkin Creek Ranch and Recreation SRMA, excess livestock grazing would cause trampling and soil compaction to 410 acres of riparian and wetland areas. Livestock grazing would potentially be compatible in riparian and wetland areas when managed in harmony with land management objectives such as meeting Standards for Rangeland Health.

If conditions were favorable, prescribed fire would accelerate nutrient cycles, sprouting, and forage availability; however, very intense burns would potentially decrease sprouting and forage growth. Closing BLM-administered lands to livestock grazing until the area attained identified vegetative objectives after wildfire, prescribed fire, or non-fire vegetative treatments would allow the shortest regrowth period for desired native riparian and wetland vegetation. Allowing species to sprout and regenerate would allow the shortest recovery period toward PFC. Intense burns would delay reestablishment of desired riparian and wetland vegetative communities, particularly if a healthy plant community were absent prior to burning. Delayed reestablishment would increase the risk of erosion and sedimentation. This alternative would protect riparian and wetland resources by expediting the recovery of plant communities.

Closing allotments that did not show progress toward meeting Standards for Rangeland Health within 5 years due to grazing would protect riparian and wetland areas from increased erosion caused by livestock trampling and congregating along streambanks. This action would allow riparian and wetland areas to improve to PFC. Impacts of erosion and increased sedimentation from livestock grazing in riparian and wetland areas would occur until allotments were closed.

Transferring or renewing grazing permits for C grazing allotments under this alternative would maintain or improve PFC in riparian and wetland areas.

Priority allotments under this alternative would increase management review to ensure criteria were met for permit renewals.

Allowing livestock grazing during or immediately after mining or development if Standards for Rangeland Health were met would increase erosion and sedimentation along streambanks through excess livestock congregating or trampling in riparian and wetland areas. Preventing vegetative recovery from mining before authorizing grazing would delay or prevent native vegetative reestablishment in riparian and wetland areas.

Restricting geophysical exploration would protect 4,300 acres of riparian and wetland areas. The remainder of the planning area would be open to geophysical exploration on existing roads or trails (which would include 10 acres of riparian and wetland areas in the Dean S. Reservoir SRMA, 30 acres in the Pumpkin Creek Ranch and Recreation SRMA, and 4 acres in the Strawberry Hill Recreation SRMA). Geophysical exploration in areas outside of riparian and wetland areas would increase erosion and sedimentation from uplands, which would impact adjacent riparian and wetland vegetative buffers.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

ALTERNATIVE D

Avoiding surface-disturbing activities on slopes 25 percent or greater (71,000 acres of riparian and wetland areas) or on sensitive soils would decrease soil erosion potential and sedimentation within riparian and wetland areas. Soil disturbance on slopes 25 percent or greater would accelerate potential erosion from human-caused activity, which would increase sediment loads to riparian and wetland areas and potentially alter vegetation and stream morphology.

Restricting or prohibiting surface-disturbing and disruptive activities or mineral leasing or development would protect riparian and wetland areas from additional erosion and sedimentation that would impact riparian and wetland vegetative buffers and their functioning condition. A CSU stipulation for oil and gas leasing and development in riparian and wetland areas would protect 11,000 acres of riparian and wetland areas from the erosion and sedimentation associated with surface disturbances. These stipulations would prevent vegetation removal and soil compaction, protect vegetative buffers important to some species, and maintain overall watershed health. Surface-disturbing activities would be mitigated to decrease erosion and sedimentation and maintain or improve riparian and wetland conditions. Unless mitigation ensured the activity maintained or improved riparian and wetland conditions, allowing mineral exploration and development would cause opposite impacts.

Mitigation that minimized the impacts of surface-disturbing and disruptive activities would protect riparian and wetland vegetative buffers, assist in erosion control, provide wildlife habitat and flood storage, decrease sedimentation, and promote progress toward PFC.

Springs would provide additional moisture and runoff for riparian and wetland vegetation, and installing flow-control devices on troughs would limit excess water diverted from the source. Limiting this diversion would reduce soil moisture in overflow areas and increase flows from the source into the natural drainage, which would enhance the vigor and type of riparian vegetation. However, without fencing the source, trampling caused by congregating livestock would increase. Fencing springs would protect the vegetative buffer at the source and increase species vigor and composition. Designing spring developments to ensure riparian communities were maintained or improved would benefit overall watershed health.

Locating new livestock water developments at least 0.25 miles from riparian and wetland areas would protect 2.5 million acres from livestock trampling or congregating. Locating water developments near riparian and wetland areas would allow riparian and wetland areas to maintain or progress toward PFC. Ensuring riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment for a properly functioning riparian and wetland area.

Because riparian and wetland areas are susceptible to invasive species (vegetation) invasion and often invaded by multiple species, allowing surface-disturbing activities in areas infested by invasive species (vegetation) would expand infestations in riparian and wetland areas. Invasive species infestations located outside of riparian and wetland areas would potentially invade and degrade adjacent native riparian vegetative communities. Surface disturbances in areas of invasive species would potentially disrupt existing weed infestations and allow seeds to blow or drain into riparian areas, which would reduce the ability of native riparian vegetation to stabilize streambanks.

Mitigation to minimize impacts of oil and gas leasing and development and geophysical exploration near designated sport-fish reservoirs would reduce the potential of streambank erosion and instability, excess sedimentation, and impacts to riparian and wetland vegetation components.

Prohibiting domestic sheep and goat grazing for invasive species control on 11,000 acres of riparian and wetland areas within 14.3 miles of the Bighorn Sheep Range would allow invasive species (vegetation) to outcompete desired vegetative species. Invasive vegetation species would increase on point bars and side channels, which are valuable areas for wildlife habitat. Appropriate control of invasive species with targeted grazing would ensure riparian and wetland areas were maintained or progressing toward PFC.

Prohibiting surface-disturbing activities within 0.25 miles of wetlands identified as piping plover or interior least tern habitat would protect 1,700 acres of riparian and wetland areas from erosion, sedimentation, and vegetation removal. Activities occurring adjacent to the 0.25-mile buffer for wetlands would potentially increase erosion and sedimentation. Mitigation would ensure wetlands continued to be maintained or improved and functioning habitat was maintained for piping plovers and interior least tern.

Burying power lines to maintain habitat functionality within 2 miles of a lek and within sage-grouse winter concentration areas would decrease vegetation alteration in riparian and wetland areas. Short-term disturbances would occur in areas in which vegetation was removed in association with these activities. In the long term, recovery of vegetation in these areas would decrease erosion and sedimentation.

Allowing prescribed fire throughout the planning area would provide the most opportunities to meet objectives for native vegetation in riparian and wetland areas, particularly if environmental conditions allowed for proper regrowth. In the short term, water quality, soil health, and vegetative buffers would be affected by fire or other disturbances until vegetation was reestablished. If conditions were favorable, prescribed fire would accelerate nutrient cycling and vegetative sprouting and forage availability; however, very intense burns would potentially decrease sprouting and forage growth.

Management actions that required buffers around upland cultural and paleontological sites would facilitate the functionality of riparian and wetland vegetative buffers, which would decrease erosion and sedimentation and maintain or improve riparian and wetland conditions. Riparian and wetland areas would assist in nonpoint source pollution by holding and using nutrients and reducing sediments in waterbodies. Decreased surface disturbance would improve riparian and wetland conditions.

Harvesting cottonwood to restore the health and resiliency of cottonwood stands or hazard tree removal would increase erosion and sedimentation and decrease infiltration in the short term. Harvesting cottonwoods would reduce vegetation within buffers, which would accelerate erosion. Over the long term, this action would maintain or improve the integrity and functionality of riparian and wetland areas by maintaining cottonwood health and providing vegetation resiliency that helped dissipated energy during high flow events.

Under this alternative, 60 acres of riparian and wetland areas would be closed to livestock grazing, and 1.6 million acres would be open to livestock grazing. Livestock grazing would potentially be compatible in riparian and wetland areas when managed in harmony with land management objectives such as meeting Standards for Rangeland Health.

Closing allotments that did not show progress toward meeting Standards for Rangeland Health within 5 years due to grazing would protect riparian and wetland areas from increased erosion caused by livestock trampling and congregating along streambanks. This action would allow riparian and wetland areas to improve to PFC. Impacts of erosion and increased sedimentation from livestock grazing in riparian and wetland areas would occur until allotments were closed.

Even if Standards for Rangeland Health were met, allowing livestock grazing during or immediately after mining or development would impact riparian and wetland vegetation by increasing erosion. Impacts from grazing would occur when livestock congregated in riparian and wetland areas and trampled vegetation. This action would increase sedimentation, decrease the stability of streambanks, and reduce riparian vigor.

Deferring livestock grazing on BLM-administered lands until seed matured on perennial herbaceous vegetation in the growing season following wildfire, prescribed fire, or non-fire vegetative treatments would protect riparian and wetland vegetative buffers by promoting the regrowth of desired native vegetation (during a year with normal precipitation). However, during drought years, vegetation would potentially fail to reestablish sufficiently to protect riparian and wetland health.

Prioritizing monitoring and evaluations on allotments that failed to meet Standards for Rangeland Health would ensure that these allotments met resource objectives, which would include attainment of properly functioning riparian and wetland areas.

Prohibiting geophysical exploration on BLM-administered surface acres would protect 70,000 acres of riparian wetland areas. Geophysical exploration in the remaining areas (outside of riparian and wetland areas) would increase upland erosion and sedimentation adjacent to riparian and wetland vegetative buffers.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Avoiding surface-disturbing activities on slopes 25 percent or greater (71,000 acres of riparian and wetland areas) or on sensitive soils would decrease soil erosion potential and sedimentation within riparian and wetland areas. Soil disturbance on slopes 25 percent or greater would accelerate potential erosion from human-caused activity, which would increase sediment loads to riparian and wetland areas and potentially alter vegetation and stream morphology.

NSO stipulations for oil and gas leasing and development would protect vegetative buffers and prevent soil compaction and vegetation removal on 62,000 acres of riparian and wetlands areas, which would protect these areas from erosion and sedimentation and maintain overall watershed health. Limiting the number and restricting the size of permanent facilities would contribute to this protection.

Avoiding surface-disturbing activities within 300 feet of riparian and wetland areas would protect most vegetative components of the riparian and wetland areas along waterbodies and streams. Vegetated buffers would be the most effective way of reducing or eliminating impacts by reducing sediments, nutrients, metals and other pollutants from surface-disturbing activities adjacent to water. The use of a buffer would maintain PFC in riparian and wetland areas. A 300-foot buffer would reduce sedimentation and erosion and soil compaction, increase streambank stabilization, maintain late summer stream flows, recharge aquifers, and maintain a higher water table (which would increase forage). The buffer area would allow for stream channel migration over time and protect most riparian and wetland areas by improving integrity and functionality.

Requiring spring developments designed to conserve water at the source would limit diversion, reduce soil moisture in overflow areas, and increase flows from the source into the natural drainage, which would enhance

the vigor and type of riparian vegetation. Springs would provide riparian and wetland areas with additional moisture and runoff for riparian and wetland vegetation. However, without fencing the source, trampling caused by congregating livestock would increase. Fencing springs would protect the vegetative buffer at the source and increase species vigor and composition. Designing spring developments to ensure riparian communities were maintained or improved would benefit overall watershed health.

Locating and designing new livestock water developments to maintain the integrity and functionality of riparian and wetland areas would protect these areas from excess trampling or congregating by livestock. Water developments near riparian and wetland areas would be designed to maintain riparian and wetland areas or ensure they progressed toward PFC. Ensuring riparian and wetland vegetation was in balance with upland vegetation would help control erosion, stabilize banks, and filter sediment for a properly functioning riparian and wetland area.

Because riparian and wetland areas are susceptible to invasive species (vegetation) invasion and often invaded by multiple species, allowing surface-disturbing activities in areas infested by invasive species (vegetation) would expand infestations in riparian and wetland areas. Invasive species infestations located outside of riparian and wetland areas would potentially invade and degrade adjacent native riparian vegetative communities. Surface disturbances in areas of invasive species would potentially disrupt existing weed infestations and allow seeds to blow or drain into riparian areas, which would reduce the ability of native riparian vegetation to stabilize streambanks.

Avoiding surface-disturbing activities within 0.25 miles of designated sport-fish reservoirs would avoid the impacts of surface-disturbing activities, such as excess soil erosion, streambank erosion, and sedimentation. Approved mitigation under this alternative would ensure riparian and wetland areas maintained or improved PFC in compliance with guidance found in the *Reclamation Appendix*.

Prohibiting domestic sheep and goat grazing for invasive species control on 11,000 acres of riparian and wetland areas within 14.3 miles of the Bighorn Sheep Range would allow invasive species (vegetation) to outcompete desired vegetative species. Invasive vegetation species would increase on point bars and side channels, which are valuable areas for wildlife habitat. Appropriate control of invasive species with targeted grazing would ensure riparian and wetland areas were maintained or progressing toward PFC.

Prohibiting surface-disturbing activities in wetlands identified as piping plover or interior least tern habitat (unless the habitat was maintained) would protect 1,700 acres of riparian and wetland areas from erosion, sedimentation, and vegetation removal. Activities adjacent to wetlands would potentially increase erosion and sedimentation. Mitigation would ensure wetlands continued to be maintained or improved and functioning habitat was maintained for piping plovers and interior least terns.

Short-term disturbances associated with the burial of low-voltage power lines within 2 miles of leks would occur in areas in which vegetation was removed in association with these activities. In the long term, recovery of vegetation in these areas would decrease erosion and sedimentation. If burial of low-voltage power lines was not feasible, impacts to riparian and wetlands areas would be the same as impacts from surface-disturbing activities.

Allowing prescribed fire throughout the planning area would provide the most opportunities to meet objectives for native vegetation in riparian and wetland areas, particularly if environmental conditions allowed for proper regrowth.

Prohibiting surface-disturbing activities in cultural and paleontological sites would facilitate the functionality of riparian and wetland vegetative buffers, which would decrease erosion and sedimentation. Riparian and wetland areas would assist in nonpoint source pollution by holding and using nutrients and reducing sediments in waterbodies. Decreased surface disturbance would improve riparian and wetland conditions.

Harvesting cottonwood to restore the health and resiliency of cottonwood stands or hazard tree removal would increase erosion and sedimentation and decrease infiltration in the short term. Harvesting cottonwoods would

reduce vegetation within buffers, which would accelerate erosion. Over the long term, this action would maintain or improve the integrity and functionality of riparian and wetland areas by maintaining cottonwood health and providing vegetation resiliency that helped dissipated energy during high flow events.

Under this alternative, 1,400 acres of riparian and wetland areas would be closed to livestock grazing, and 1.6 million acres would be open to livestock grazing (99 percent of total riparian and wetland acres in the planning area). Ensuring that riparian and wetland vegetation was in balance with upland vegetation and met the Standards for Rangeland Health would help control erosion, stabilize banks, and filter sediment. Differing grazing intensities would alter the impacts to riparian and wetland vegetation. Congregating livestock would impact riparian and wetland vegetation, erosion, and sedimentation. In the Dean S. Reservoir SRMA, excess livestock grazing would degrade wetland vegetative components, which would decrease composition and increase erosion along banks. In the Pumpkin Creek Ranch and Recreation SRMA, excess livestock grazing would cause trampling and soil compaction to 410 acres of riparian and wetland areas. Livestock grazing would potentially be compatible in riparian and wetland areas when managed in harmony with land management objectives such as meeting Standards for Rangeland Health.

If conditions were favorable, prescribed fire would accelerate nutrient cycles, sprouting, and forage availability; however, very intense burns would potentially decrease sprouting and forage growth. Closing BLM-administered lands to livestock grazing until the area attained identified vegetative objectives after wildfire, prescribed fire, or non-fire vegetative treatments would allow the shortest regrowth period for desired native riparian and wetland vegetation. Allowing species to sprout and regenerate would allow the shortest recovery period toward PFC. Intense burns would delay reestablishment of desired riparian and wetland vegetative communities, particularly if a healthy plant community were absent prior to burning. Delayed reestablishment would increase the risk of erosion and sedimentation. This alternative would protect riparian and wetland resources by expediting the recovery of plant communities.

Closing allotments that did not show progress toward meeting Standards for Rangeland Health within 5 years due to grazing would protect riparian and wetland areas from increased erosion caused by livestock trampling and congregating along streambanks. This action would allow riparian and wetland areas to improve to PFC. Impacts of erosion and increased sedimentation from livestock grazing in riparian and wetland areas would occur until allotments were closed.

If allotments near riparian and wetland areas met the Standards for Rangeland Health, livestock grazing would not directly affect these areas.

Priority allotments under this alternative would increase management review on specific allotments to ensure the allotments demonstrated progress toward meeting the Standards for Rangeland Health. Condition of riparian and wetland areas are one of the five standards identified when determining status of the allotments.

Renewing grazing permits and leases in areas in which the Standards for Rangeland Health were met would allow for proper management of the allotments.

Allowing livestock grazing during or immediately after mining or development if Standards for Rangeland Health were met would increase erosion and sedimentation along streambanks through excess livestock congregating or trampling in riparian and wetland areas. Preventing vegetative recovery from mining before authorizing grazing would delay or prevent native vegetative reestablishment in riparian and wetland areas.

Restricting geophysical exploration would protect 4,300 acres of riparian and wetland areas. The remainder of the planning area would be open to geophysical exploration on existing roads or trails (which would include 30 acres of riparian and wetland areas in the Pumpkin Creek Ranch and Recreation SRMA and 4 acres in the Strawberry Hill Recreation SRMA). Geophysical exploration in areas outside of riparian and wetland areas would increase erosion and sedimentation from uplands, which would impact adjacent riparian and wetland vegetative buffers.

OHV use that loosened soil would be a source of nonpoint source pollution and cause vegetation losses and accelerated erosion. Repeated crossings, particularly in riparian areas, would lead to sedimentation, soil compaction, increased overland flow, and decreased infiltration. Vehicle fords would cause localized erosion, sedimentation, and degradation of streambanks. Increased potential for weed invasion would also lead to accelerated erosion.

CUMULATIVE IMPACTS

From the 1860s to the 1890s, the military brought large numbers of domesticated animals (such as horses, mules, sheep, and cattle) to eastern Montana. This introduction contributed to heavy vegetation use, which affected riparian and wetland areas with accelerated erosion and sedimentation. As homesteaders settled during the late 19th century and early 20th century, additional surface disturbances (such as mining, agriculture, and introductions of invasive species) resulted in compaction, accelerated erosion, sedimentation, and altered vegetation competition in riparian and wetland areas. Although homesteaders were required to farm a portion of the land, it was not always suited to intensive agricultural use, and this practice, combined with uncontrolled grazing, took its toll on the native vegetation. To this day, many of the same surface disturbances continue to accelerate erosion and sedimentation and continue to impact riparian and wetland vegetative buffers, streambanks, and channels.

Prior to the homesteading days, bison roamed the area in large herds and consumed vegetation in the uplands and riparian and wetland areas, affecting vegetative buffers and trampled streambanks. Without vegetative cover, winds removed topsoil and floods and runoff removed soil, causing erosion and sedimentation within riparian and wetland areas.

Droughts in the early 20th century, in combination with cropland development, worsened wind erosion of agricultural lands. At this time, under the authority of the Bankhead-Jones Act, the federal government purchased areas of abandoned homesteads and rangelands that were sub-marginal in size and condition and operated these lands under conservation practices and management. Crested wheatgrass was planted in most of these areas while others returned the plowed ground to native vegetation.

Invasive vegetation species and altered upland vegetation became a problem in areas of disturbed soils. Invasive vegetation species changed the vegetative component of riparian and wetland areas throughout the 20th century and remain a problem today. Invasive vegetation species (particularly leafy spurge) outcompete desired riparian and wetland vegetation, decreasing soil moisture and increasing erosion and sedimentation. The Conservation Reserve Program, which began in 1985, was another effort to turn marginal, privately owned cropland back into grassland. Most lands enrolled in the Conservation Reserve Program were planted with crested wheatgrass or other introduced grasses, further altering riparian and wetland vegetation types.

OHV use and road and interstate development in the 20th century contributed to vegetation removal, increasing compaction, erosion, and sedimentation in riparian and wetland areas across the planning area. Increased vehicle use on unimproved roads (particularly during wet conditions) has caused rutting, erosive channeling, and braided or parallel roads and trails. Fire suppression and the introduction of nonnative vegetation has altered natural fire regimes and created hazardous fuels. Vegetation recovery takes several years and depends on many environmental conditions, including soil type and precipitation. Compaction and excessive vegetation removal impact the hydrology of a watershed by significantly reducing infiltration and increasing surface runoff. Faster runoff rates and increased runoff amounts result in the rapid delivery of water to stream channels, causing increased channel degradation and sedimentation.

Ongoing disturbance activities would impact riparian and wetland areas and associated vegetation buffers by increasing erosion and sedimentation. Such activities would potentially include fire suppression, excessive livestock grazing, vegetation removal, weed invasions, mineral exploration and development, OHV use, and nearby agriculture. However, activities that affected riparian and wetland areas would meet land health standards and would not cause effects to lower ratings and trends on individual reaches. Activities occurring adjacent to BLM-administered lands would potentially contribute to the functioning condition of riparian and wetland areas and enable the improvement of nonfunctional and functional-at risk with downward trend areas

toward PFC. Erosion from roads and trails has been reduced with improved road construction and maintenance methods. Continued improvement in conservation and control methods for riparian and wetland vegetation buffers in the planning area would increase the functionality of riparian and wetland areas and control accelerated erosion, compaction, and sedimentation. Grazing management and monitoring has improved or maintained properly functioning riparian and wetland areas.

INVASIVE SPECIES

ASSUMPTIONS AND METHODOLOGY

Assumptions for invasive species are described below.

- Constant seed sources from wildlife movement, rivers, recreationists, and general public land use would prevent eradication of invasive species over the life of the RMP. Domestic animals, wildlife, recreationists, clothing, pets, and hay contribute to the spread of invasive species as do many other activities in daily life (such as water, air, and vehicle travel and animal transportation).
- Invasive vegetation species not known to occur in the planning area would occur.
- Increases in invasive vegetation species would reduce habitat quality and quantity.
- The demand for control of weeds is expected to increase as general public knowledge of the detrimental impacts of invasive species increases.
- Control of invasive vegetation species would continue to be a combination of mechanical, chemical, biological, or manual methods.
- The BLM would manage invasive species designated noxious by the State of Montana and prioritize treatments.

MANAGEMENT COMMON TO ALL ALTERNATIVES

Reclamation plans for approved surface-disturbing activities would reduce invasive species seed spread with weed-seed-free seed mixtures.

Vegetation management that met Rangeland Health Standards and supported endangered species, wildlife, water quality, and fisheries would support native vegetation and enhance its ability to outcompete invasive species infestations. These actions would reduce invasive species development and the spread of invasive species.

Maintaining consistency for vegetative manipulation (or prescriptive) treatments (including chemical, fire, biological, manual, and mechanical methods) with the guidelines stated in specific plans under Vegetation, Invasive Species actions would support minimal invasive species spread and move toward invasive species treatment using an Integrated Weed Management approach.

Establishing riparian buffer zones to trap silt from surface runoff and prevent it from entering and affecting the riparian wetland system would prevent the spread of weed seeds that may be dispersed with the silt.

Using temporary or permanent enclosures (i.e., in woody draw or riparian areas) to promote species diversity, recruitment, and functionality would allow for stronger species competition and decrease the potential for invasive species infestations.

Allowing woody and non-woody vegetation mechanical thinning, biomass removal, and chemical and biological treatments to reduce hazardous fuels would also aid in invasive species treatments by removing dense vegetation and permitting access to these areas.

Allowing the removal of woody and non-woody biomass products, commercial or personal use in forest and woodlands, or the salvage of dead and dying timber would spread invasive species seed during the removal process. An invasive species prevention plan would need to be in place prior to these activities.

Limited OHV use would reduce the spread of invasive species in these areas.

Implementing new travel management areas would increase the probability of spreading invasive species through vehicle use (weed seeds falling from vehicles that passed through infestations in other areas).

Climate change is likely to combine with other human-induced stress to further increase the vulnerability of ecosystems to other pests, invasive species, and loss of native species.

ALTERNATIVE A

Treating invasive species infestations on a case-by-case basis, which is not the most cost-efficient method, would not allow for an overall holistic approach in managing the program. Treating invasive species in the northern part of the planning area and then treating invasive species in the southern part of the planning area the next day would increase the overall cost of treatment per acre.

Allowing surface-disturbing activities in areas of invasive species infestations would increase the potential of weed-seed spread. An operation plan for washing equipment would need to be in place.

Allowing prescribed fire in Category B and C Fire Management Categories (the entire planning area), would impact vegetation through disturbance. Commonly, invasive species appear in the short term following prescribed fire. Road construction and heavy equipment use associated with prescribed fire would impact soil health and vegetative buffers in the short term until reestablishment of vegetation. Favorable conditions would allow prescribed fire to accelerate nutrient cycling, sprouting, and forage availability. Very intense burning would decrease sprouting and forage growth and increase the possibility of invasive species.

ALTERNATIVE B

Prioritizing treatment areas in which Montana-designated invasive species were present would not allow for project-level treatments. This action would be inefficient and economically ineffective.

Prohibiting surface-disturbing activities in areas of invasive species infestations would limit the spread of weed seeds, which would assist in meeting BLM goals.

Restricting grazing of domestic sheep or goats for invasive species control in or near the Bighorn Sheep Range would prevent use of the most cost-effective method of invasive species control along the Powder River.

Closing livestock grazing allotments that failed to meet Standard for Rangeland Health 5 and in which the BLM administered 51 percent or more of the lands in a pasture would limit grazing and Integrated Weed Management (which is the best and most cost-effective tool for combating invasive species). Domestic sheep grazing for invasive species control would not be allowed under this alternative.

ALTERNATIVE C

Under this alternative, invasive species treatments would not be allowed across the entire planning area.

Allowing surface-disturbing activities within areas of invasive species infestations only with approved mitigation measures would limit the possibility of seed spread through timing stipulations or equipment washing.

Using Early Detection Rapid Response to designate priority treatment areas would emphasize the newest, most efficient technological system for invasive species treatments. Because the majority of invasive species are spread in publicly accessible areas, primary invasive species control in these areas would minimize impacts.

Allowing disruptive activities within 2 miles of sharp-tailed grouse leks with specialized design features, which would most likely consist of timing stipulations, would allow invasive vegetation species (weed) treatments in these areas and improve the habitat.

Closing livestock grazing allotments that failed to meet Standard for Rangeland Health 5 and in which the BLM administered 51 percent or more of the lands in a pasture would limit grazing and Integrated Weed Management (which is the best and most cost-effective tool for combating invasive species).

Domestic sheep grazing for invasive species control would be allowed within 14.3 miles of the Bighorn Sheep Range under this alternative with specialized design features (such as an on-site, round-the-clock sheepherder). Domestic sheep grazing is an important tool for controlling invasive species and the most cost-effective, integrated approach.

Allowing prescribed fire throughout the planning area would increase the spread of invasive species through vegetation disturbance.

Closing allotments to cattle grazing if Standards for Rangeland Health were not improved after 5 years would potentially cause a short-term increase in invasive species but should decrease invasive species over the long term.

Allowing big game retrieval would promote invasive species seed spread onto BLM-administered lands via vehicles.

ALTERNATIVE D

Although allowing surface-disturbing activities would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would affect the relative abundance, distribution, and occurrence of seral stages. Surface-disturbing activities would create desirable conditions for invasive species infestations.

Allowing surface-disturbing activities within areas of invasive species infestations only with approved mitigation measures would limit the possibility of seed spread through timing stipulations or equipment washing.

Treating invasive weed species only in areas in which landowners were actively controlling invasive species would not represent a holistic approach. Although cooperating with landowners is beneficial, it is not cost effective or the most efficient method when treating invasive species with a landscape approach.

Domestic sheep grazing for invasive species control would be allowed under this alternative with specialized design features (such as an on-site, round-the-clock sheepherder). Domestic sheep grazing is an important tool for controlling invasive species and the most cost-effective, integrated approach.

Allowing prescribed fire throughout the planning area would increase the spread of invasive species through vegetation disturbance.

Allowing big game retrieval would promote invasive species seed spread onto BLM-administered lands through vehicle traffic.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Although allowing surface-disturbing activities would not result in the complete elimination of a plant species, plant community, or seral stage, these activities would affect the relative abundance, distribution, and occurrence of seral stages. Surface-disturbing activities would create desirable conditions for invasive species infestations.

Using Early Detection Rapid Response to designate priority treatment areas would emphasize the newest, most efficient technological system for invasive species treatments. Because the majority of invasive species are spread in publicly accessible areas, primary invasive species control in these areas would minimize impacts.

Domestic sheep grazing for invasive species control would be allowed under this alternative with specialized design features (such as an on-site, round-the-clock sheepherder). Domestic sheep grazing is an important tool for controlling invasive species and the most cost-effective, integrated approach.

Allowing prescribed fire throughout the planning area would increase the spread of invasive species through vegetation disturbance.

Limiting OHV use to existing roads in the camping and boating ramp area and closing OHV use on the east side of the walking trail through the island in the Howrey Island ACEC would assist in controlling the spread of invasive species.

CUMULATIVE IMPACTS

Management of invasive species would not reduce the total number of invasive-species-infested acres within the planning area because treatments would not exceed the rate of expansion under any alternative. Natural expansion of previous biological releases without treatments would occur at a rate of approximately 14 percent per year (BLM 1996). Alternative prescriptions would affect the locations and quantity of invasive species (vegetation) treatments, and invasive species populations would decline in vigor and extent on treated sites. Coordination of invasive species management with federal, state, county, and private landowners and organizations would result in more effective and cost-efficient invasive species control because treatments would address the natural boundaries of the infestations and management resources could be shared between partners, which would protect more acres from new infestations and control more acres of existing weed infestations. Using Integrated Weed Management would also assist with invasive species (vegetation) control by focusing the multiple methods of invasive species management on the conditions that affect invasive species population size and outbreak of new infestations.

Increases in invasive species (vegetation) acreage within the planning area would result primarily from expansion of existing invasive species infestations supplemented by new infestations. Invasive species (vegetation) population size is dependent on three conditions: the relative amount of invasive species seed or root sources for reproduction, the availability of safe sites for germination or propagation, and access to the necessary resources for plant growth, which are sunlight, water, and nutrients.

Management actions that reduced these conditions would decrease or control invasive species population size while actions that produced these conditions would usually increase invasive species population size. Promoting healthy desired vegetation is the most common and long-term reducer of invasive species populations because the desired plants continually compete with weeds in producing seeds, occupying germination sites, and acquiring resources for growth. Vegetation restoration and fire rehabilitation activities, including revegetation and protection of post-fire plantings, would be effective methods for improving desired vegetation populations, although vegetation treatments would potentially initially cause weeds to increase through associated ground disturbance. Vegetation treatments that restore grasslands, shrublands, and riparian areas would be particularly effective in reducing potential invasive species spread because most invasive species occur in these habitats. Using weed-seed-free forage and cleaning vehicles and equipment would decrease invasive species seed and root sources; thereby reducing the number of new infestations. Education and outreach would reduce invasive species establishment and spread because people often act once informed about the impacts of invasive species on ecosystem health and economics. Education about methods for invasive species management would also assist.

Ground-disturbing activities would be the biggest increase of both new and existing weed infestations because they often bring in seeds on equipment and vehicles, create bare spots for seed germination, and reduce

competition for resources by removing desired vegetation. Fire retardant and burning of natural fuels release compounds useful for plant growth, thereby benefiting colonizing plants, particularly invasive species, by providing a surplus of nutrients. Therefore, forest management designed to reduce unnaturally large and severe wildfires would reduce the potential for increased invasive species populations. Motorized public travel and camping within 300 feet of existing roads, acquisition of easements and exchanges to improve access to public lands, and use of SRMAs could potentially increase human use through hiking, camping, hunting, horseback riding, and driving for pleasure; thereby increasing both disturbance and the risk of igniting wildfires, which could lead to expansions in invasive species populations. Other management activities that caused surface disturbances would also increase the potential for new invasive species infestations, although most activities incorporate methods to reduce introduction and expansion of invasive species infestations like minimizing new road construction in invasive-species infested areas, reseeding disturbed and exposed soils where necessary, and locating new utility facilities in existing ROWs.

The degree to which invasive species populations impact their environments depends on the cumulative effect of infestations on the resiliency and sustainability of the desired plant community. Infestations that are a non-dominant part of a diverse, otherwise healthy desired plant community that controls the size and density of the infestations would cause reduced impacts. Infestations would have a high impact when they dominate the plant community and are substantially reducing its sustainability and resiliency by negatively affecting the water cycle, erosion potential, nutrient cycling, and forage availability for wildlife and livestock. Infestations that affect some or all of these things but do not yet substantially reduce the community's sustainability or resiliency would have a medium, or moderate, impact.

Alternative A

The spread of invasive species caused by equipment movement under Alternative A would potentially impact the ecological status of vegetation in the planning area. With 4,500 public acres infested by leafy spurge alone and limited funding for weed control, invasive species would continue to spread under this alternative.

Scattered patches of knapweed, which has a high potential to spread, have been found in the planning area. Tamarisk or salt-cedar, an introduced ornamental, has had devastating impacts in the southwest, has outcompeted native riparian plants, and completely eradicated some riparian areas because it requires large volumes of water. Tamarisk has been observed along isolated waterbodies; the Fort Peck Reservoir; and the Yellowstone, Tongue, and Powder rivers and their tributaries.

Under this alternative, the spread of invasive plant species, including invasive species, would be controlled in some areas but spread more rapidly in others. Factors affecting the spread or control of invasive species would include the frequency and amount of motorized traffic and recreational use on public lands in the planning area, development occurring on private lands adjacent to BLM-administered lands, and the type of actions occurring on federal, state, and private lands. Any actions that limited the treatment of invasive species on public lands would potentially limit the efficacy of treatments on lands with other ownership or administration. The cumulative impacts of reducing the efficacy of control on invasive species and invasive species would potentially decrease the amount and availability of native forage for livestock and wildlife and contribute to soil erosion and increased sediment loads in streams.

Alternative B

The spread of invasive species caused by restrictions to sheep grazing under Alternative B would potentially impact the ecological status of vegetation in the planning area. With 4,500 public acres infested by leafy spurge alone and limited funding for weed control, invasive species would continue to spread. Leafy spurge has been observed along isolated waterbodies and the Yellowstone, Tongue, and Powder rivers and their tributaries. Sheep grazing would be the best method for controlling leafy spurge along waterways.

Alternative C

Allowing sheep grazing with specialized design features under Alternative C would reduce the impacts to the ecological status of vegetation in the planning area. With 4,500 public acres infested by leafy spurge alone and limited funding for weed control, invasive species would continue to spread. Leafy spurge has been observed along isolated waterbodies and the Yellowstone, Tongue, and Powder rivers and their tributaries. Sheep grazing would be the best method for controlling leafy spurge along waterways.

Alternative D

The spread of invasive species caused by equipment movement under Alternative D would potentially impact the ecological status of vegetation in the planning area. With 4,500 public acres infested by leafy spurge alone and limited funding for weed control, invasive species would continue to spread.

Scattered patches of spotted and Russian knapweed have been found in the planning area. Tamarisk or salt-cedar, an introduced ornamental, has had devastating impacts in the southwest, outcompeted native riparian plants, and completely eradicated some riparian areas because with its need for large volumes of water. Tamarisk and spotted knapweed have been observed along isolated waterbodies and the Yellowstone, Tongue, and Powder rivers and their tributaries.

Alternative E (Preferred Alternative)

Allowing sheep grazing with specialized design features under Alternative C would reduce impacts to the ecological status of vegetation in the planning area. With 4,500 public acres infested by leafy spurge alone and limited funding for weed control, invasive species would continue to spread. Leafy spurge has been observed along isolated waterbodies and the Yellowstone, Tongue, and Powder rivers and their tributaries. Sheep grazing would be the best method for controlling leafy spurge along waterways.

Scattered patches of spotted and Russian knapweed have been found in the planning area. Tamarisk or salt-cedar, an introduced ornamental, has had devastating impacts in the southwest, outcompeted native riparian plants, and completely eradicated some riparian areas with its need for large volumes of water. Tamarisk and spotted knapweed have been observed along isolated waterbodies and the Yellowstone, Tongue, and Powder rivers and their tributaries.

FISH AND WILDLIFE, AQUATICS (INCLUDING SPECIAL STATUS SPECIES)

ASSUMPTIONS AND METHODOLOGY

Restoration projects in prairie streams would focus on restoring the riparian area and in-stream attributes that promote quality native fish and aquatic wildlife habitat and communities.

In sport-fish reservoirs, a 0.25-mile buffer would include 3,834 acres of sport-fish habitat.

There would be 1 to 5 aquatic wildlife projects constructed each year, disturbing a total of 10 to 100 acres per year.

There would be changes in listed and special status species in the future.

MANAGEMENT COMMON TO ALL ALTERNATIVES

Actions that minimized the potential impacts of climate change would have the potential to maintain or enhance aquatic wildlife habitat.

Potential changes in climate that would increase surface water temperature, dramatically alter precipitation and runoff patterns, and alter growth of riparian vegetation would have deleterious effects to aquatic wildlife habitat.

Surface-disturbing activities associated with soils management actions would have the potential to cause increased soil erosion in both uplands and riparian areas, which would reduce aquatic wildlife habitat and cause accelerated erosion, increased overland flow, decreased infiltration, and degradation of water quality associated with increased sedimentation, turbidity, eutrophication, metals, and other pollutants in waterbodies. Ultimately, all of these chemical-physical impacts would degrade or reduce aquatic wildlife habitat, instigate toxicological impacts, isolate populations, and disrupt or destroy nutrient cycling and the aquatic food web. Because there is an intrinsic connection between uplands and riparian areas and aquatic wildlife habitat, following the *Reclamation Appendix* for Soils management actions would minimize impacts to aquatic wildlife by decreasing the amount of soil erosion degrading habitat for aquatic wildlife.

Following the Watershed Protection and Flood Control Act and Clean Water Act and minimizing nonpoint source pollution would maintain water quality and maintain or improve aquatic wildlife habitat. Meeting or exceeding water quality standards would maintain or enhance aquatic wildlife habitat.

Emphasizing native plant reestablishment under vegetation management actions would improve aquatic resources by helping stabilize soils and stream-banks. Additionally, replacing nonnative plant communities would minimize unwanted impacts (e.g., excessive transpiration by salt-cedar and Russian olive) to aquatic resources.

Approximating a natural disturbance regime in hardwood draws would benefit aquatic resources in the long term. Hardwood draws are typically arranged in ephemeral or headwater reaches of watersheds, and, because physical, chemical, and biological attributes and processes of rivers and streams constantly occur on a longitudinal scale, moving downstream from headwaters to large rivers (Vannote, Minshall, Cummins, Sedell, and Cushing 1980; Ward and Stanford 1995; Dodds et al. 2004), the ephemeral portions of streams are connected to aquatic wildlife habitat.

Protection and mitigation of special status plants would maintain or improve aquatic wildlife habitat, particularly in riparian areas.

Because riparian, wetland, and aquatic resources are inherently connected, actions that maintained or enhanced riparian and wetland areas have the potential to benefit aquatic resources. Vegetated riparian buffer zones would provide shade to streams, enhance thermal cover, provide food substrate (e.g., habitat for invertebrates) and food sources to aquatic wildlife (Saunders and Fausch 2007), and trap sediment that would otherwise alter or eliminate habitat for aquatic wildlife. Improving riparian areas to meet PFC standards would not, necessarily, improve aquatic wildlife habitat.

Enclosures around riparian areas would improve aquatic wildlife habitat. However, it could take many years (on the order of 5 to 20 or more years) and active restoration efforts (riparian plantings, bank stabilization, etc.) to realize an improvement to the riparian area and aquatic wildlife habitat.

Although PFC is a minimum ecological threshold for riparian areas, this concept has not been empirically demonstrated to have an influence on aquatic wildlife habitat. Managing riparian areas to meet PFC will not universally improve aquatic wildlife habitat.

Controlling and decreasing the spread of invasive species, particularly in riparian areas, would improve habitat for aquatic wildlife.

Proactive management of threatened and endangered species would improve habitat conditions for threatened and endangered aquatic wildlife in those habitats where threatened and endangered aquatic species thrive. Improved habitat for threatened and endangered species would also provide improved habitat for a suite of other aquatic wildlife species.

Managing prairie streams to meet PFC standards would maintain a minimum ecological threshold for riparian areas but not necessarily improve aquatic wildlife habitat. Prairie streams already exist in a precarious balance between flooding and drying, and a legacy of various land use impacts has rendered them a resource "living on the edge" (Dodds et al. 2004). As a result, additional surface disturbance across the prairie landscape of the planning area would impact stream channel morphology, which would lead to gullying or sloughing that would compromise aquatic wildlife habitat. Finally, this additional surface disturbance would lead to a decrease in abundance and diversity of fish and other aquatic organisms. Many intermittent and ephemeral streams are not recognized as important components of viable aquatic wildlife habitat. Recent evidence (Franssen et al. 2006; Ostovar 2007; Scheurer, Fausch, and Bestgen 2003) demonstrates that the dynamic nature of prairie streams and the large spatial scale over which some native prairie fish species carry out their life cycle requires conservation and management at the landscape or river-scape scale (an ecosystem or watershed perspective), beyond the local habitat scale (Fausch, Torgersen, Baxter, and Li 2002).

Actions that improved habitat for terrestrial wildlife, particularly in riparian areas, would generally maintain or enhance aquatic wildlife habitat.

Participating in and developing recovery plans, management plans, and conservation strategies, particularly from an ecosystem form and function theory, for special status species would indirectly maintain or enhance aquatic wildlife habitat.

Reducing fuel or woody debris within riparian zones would reduce habitat for aquatic resources. There is not conclusive empirical evidence that thinning in riparian areas is necessary for resource health, particularly in the Northern Great Plains Ecoregion of the planning area.

Although the *Policy for Aerial Delivery of Wildland Fire Chemicals near Waterways* (USFS et al. 2000) suggests 300-foot buffers on all waterways, recent evidence demonstrates that fire retardant that does end up in waterways through overland flow (or other methods) would cause toxic impacts to aquatic wildlife (Little and Calfee 2004). Subsequently, the use of fire retardant chemicals near all streams and rivers would have the potential to impact aquatic systems.

Intense fires in uplands would have the potential to increase erosion and sediment loads to streams, which would degrade aquatic wildlife habitat. Climate change is increasing wildfire frequency and intensity. Heavy equipment use and road construction for fire suppression activities would cause erosion and subsequent increased sediment to streams, which would alter habitat for aquatic resources. However, following fire management protocol to mitigate for these impacts would typically alleviate impacts from wildland fire suppression.

Prescribed fire would not generally cause deleterious impacts to aquatic wildlife habitat, provided infrastructure (roads and other structures) and equipment used to accomplish the tasks were used in a manner that did not contribute to excessive long term sedimentation and accidental spills that compromised water quality were avoided.

Reducing live or dead trees within riparian zones would reduce habitat for aquatic resources. There is not conclusive empirical evidence that thinning or harvest in riparian areas is necessary for resource health, particularly in the Northern Great Plains Ecoregion of the planning area.

Forestry and woodland products practices would not generally cause deleterious impacts to aquatic wildlife habitat, provided infrastructure (roads and other structures) and equipment used to accomplish the tasks were used in a manner that did not contribute to excessive long-term sedimentation and accidental spills that compromised water quality were avoided.

Although grazing management that meets Standards for Rangeland Health and guidelines would reduce the sum and extent of impacts to uplands, the same reduction would not necessarily occur in riparian areas and aquatic wildlife habitat. Grazing in riparian areas and streams would cause impacts different from those caused by

grazing in uplands. Additionally, managing riparian areas to meet PFC requires only a minimum ecological threshold for riparian areas and does not specifically address water quality, water quantity, food-web dynamics, and other important factors for aquatic wildlife habitat. Riparian areas and uplands have vastly different physical characteristics, and livestock often spend a disproportionate amount of time in riparian areas. In a literature review of grazing in riparian areas and streams, Belsky et al. (1999) stated that grazing activities had no ecological benefits for aquatic wildlife, riparian areas, or stream ecosystems in general. Belsky et al. (1999) also found that degradation of aquatic wildlife habitat in streams and rivers caused by livestock continues to the present day. The magnitude of the impacts from livestock grazing would vary based on utilization, location in the watershed, duration, season of use, history of land use for that allotment and watershed, and physical-chemical characteristics of the particular watershed or riparian ecosystem (Green and Kauffman 1995; Henley et al. 2000). Alternate grazing schedules (other than season long grazing) or buffers are a proven tool to prevent impacts to the riparian areas, river and stream habitat, and aquatic wildlife (Magilligan and McDowell 1997; Henley et al. 2000; Saunders and Fausch 2007).

Coal mining activities (e.g., surface disturbance, road construction, overburden removal, rerouting of stream systems, and the presence of sediment ponds) would disrupt surface water and reduce streamflow and habitat-forming peak flows. During mining, sedimentation would be reduced by sedimentation ponds. Discharge of produced water during operations and discharge of groundwater with leached salts or metals (or both) following operations would cause toxic impacts to aquatic wildlife.

In general, impacts to streams and aquatic wildlife would increase as mineral extraction activity and well, road, and facility density increased. The increase in roads and construction would cause a parallel increase in erosion, which would impact stream channel morphology and habitat quality and ultimately decrease aquatic wildlife populations. An increase in stream crossings would cause habitat fragmentation, which would lead to isolation of populations and block dispersal and migration. Following BMPs, following guidance in the *Reclamation Appendix,* and installing fish-passable culverts would minimize these impacts.

Recreation management actions would not directly impact aquatic resources. However, various recreation actions associated with particular locations would impact aquatic wildlife habitat if a particular recreation use contributed to erosion into streams or destruction of riparian vegetation. For example, OHV areas would impact aquatic wildlife habitat through erosion and sedimentation of habitat. Livestock grazing in particular recreation areas would cause the impacts described in the grazing and aquatics discussions of this section. Road construction would cause increased sedimentation in aquatic wildlife habitat. Following BMPs, following guidance in the *Reclamation Appendix,* and installing fish-passable culverts would minimize these impacts.

Exploration for renewable energy, installation of renewable energy facilities, and the subsequent increase in road and facility density would increase erosion, which would impact stream channel morphology, habitat quality, and, ultimately, aquatic wildlife habitat and populations. Following BMPs, following guidance in the *Reclamation Appendix,* and installing fish-passable culverts would minimize these impacts.

Roads would cause impacts similar to those caused by surface-disturbing activities; however, installing fish-passable culverts and following guidance found in the *Reclamation Appendix* during road construction would minimize these impacts. The redesign, rerouting, closure, or decommissioning of roads already causing impacts to resources would improve aquatic wildlife habitat.

Aquatic wildlife habitat adjacent to or downstream of OHV areas would be affected by erosion and sedimentation of habitat. Although stream crossings would be immediately affected in the localized crossing area, downstream areas would also be affected by erosion and sedimentation of aquatic wildlife habitat. Following BMPs, following guidance in the *Reclamation Appendix,* and installing fish-passable culverts would minimize these impacts.

Acquired lands that improved continuity of BLM-administered lands within a particular watershed or increased ownership along streams would make management of aquatic wildlife more ecologically viable.

Extensive Recreation Management Areas (ERMAs), SRMAs, and ACECs with aquatic wildlife habitat would include Powder River Depot, Calypso, Howrey Island, Matthews Recreation Area, Dean S. Reservoir, and Pumpkin Creek Ranch and Recreation Area. Additionally, Powder River Depot, Calypso, Howrey Island, and Matthews Recreation Area are adjacent to the Yellowstone River, which is habitat for the endangered pallid sturgeon and other fish species of special concern.

Maintaining wilderness values of WSAs would maintain water quality, and, consequently, aquatic wildlife habitat, in these watersheds.

ALTERNATIVE A

Sedimentation is one of the most frequently occurring physical and chemical pollutants in aquatic wildlife habitat (Wenger 1999). Aquatic wildlife habitat in areas in which surface disturbance would be allowed would be degraded by sediment input to streams.

An NSO stipulation for 100-year floodplains of major rivers would maintain floodplains of major rivers and not necessarily aquatic wildlife habitat. Although NSO stipulations for oil and gas leasing would be designated for waterbodies and streams, no specific aquatic wildlife habitat would be closed to surface-disturbing and disruptive activities under this alternative, and aquatic wildlife habitat would be subjected to impacts of surface-disturbing activities, which would include erosion and sedimentation of habitat, physical and chemical pollution of water by sedimentation and pollutants, habitat fragmentation resulting from road and facility development (and other activities), alteration of the normative flow regime through increased product water, and displacement or extirpation of aquatic wildlife. Aquatic wildlife habitat does not occur only where water occurs; this habitat is intrinsically connected to riparian area and even uplands via physical, biological, and chemical associations. Subsequently, buffers are the best way to protect aquatic wildlife habitat in relationship to water resources.

Water impoundments on any stream (ephemeral, intermittent, or perennial) would compromise or decrease aquatic wildlife habitat by increasing erosion and sediment transport and altering the connectivity of hydrologic flows, nutrient cycling and food web dynamics, and riparian vegetation recruitment and succession. Impoundments would disrupt or disconnect both the linear landscape of streams and organisms within the streams (Dodds et al. 2004). The open water of a reservoir would lead to altered thermal regimes and large-scale evaporation, which would further impact the hydrologic cycle by decreasing overall water quantity. Some reservoirs contain habitat for nonnative fishes or other predators, which would impact sensitive native fish and other aquatic wildlife populations in prairie streams. Impoundments constructed on streams would limit dispersal and migration between habitats, which are key life history strategies for prairie fishes and other aquatic wildlife.

An NSO stipulation for oil- and gas-associated surface-disturbing activities in riparian areas and wetlands would provide protection of key aquatic wildlife attributes. However, discretionary buffers would ensure protection of aquatic wildlife habitat. Ongoing inventory efforts to determine the extent and condition of riparian areas in the planning area would elucidate critical information for this action. Riparian areas provide stability; thermal and protective cover; food resources and key food web items and connections; thermal buffering; habitat components and structure (e.g., wood); and key ecosystem physical, chemical, and biological processes important to aquatic wildlife habitat.

Allowing livestock tanks or troughs in riparian areas would lead to trampling of riparian soils and plants. These actions would impact aquatic wildlife habitat by causing excessive sedimentation (Belsky et al. 1999); thermal and protective cover losses; food resource losses; and alteration or disruption of key physical, chemical, or biological ecosystem processes.

Fencing spring developments would minimize impacts to aquatic wildlife but complete fencing of riparian areas near the water development would help decrease impacts.

Allowing livestock tanks or troughs in riparian areas would lead to trampling of riparian soils and plants. These actions would impact aquatic wildlife habitat by causing excessive sedimentation (Belsky et al. 1999); thermal and protective cover losses; food resource losses; and alteration or disruption of key physical, chemical, or biological ecosystem processes.

Although this alternative would require a 0.25-mile buffer with an NSO stipulation for oil- and gas-associated surface-disturbing and disruptive activities for leasing in sport-fish reservoirs, sport-fish reservoirs would not be protected from other surface-disturbing activities under this alternative. Many of these reservoirs are already constrained by low water due to current climate conditions and trampling of banks by livestock; collectively, these two conditions have decreased riparian and aquatic vegetation near shores, increased erosion, reduced shade for thermal buffering and cover habitat, decreased water quality, and reduced food resources for fish and the aquatic food web.

Stream-crossing structures that restricted fish passage would cause habitat fragmentation, isolation of populations, and contribute to disrupted life cycles patterns of fish and other aquatic wildlife. Although many prairie streams in the planning area are intermittent, aquatic wildlife historically thrived in these intermittent pools and depended on periods of high flow to redistribute; subsequently, fish-passable, stream-crossing structures would be important in the many prairie streams throughout the planning area. Additionally, fish-passable structures, by design, would contribute less to erosion than other stream-crossing structures.

Pallid sturgeon habitat under this alternative would be exposed to excessive sedimentation through surface-disturbing activities. Floodplain and riparian habitat important to pallid sturgeon (e.g. large cottonwood trees and snags) would have the potential to be eliminated. Water quality would be degraded, and the potential for toxic impacts and impairment of the food web would increase.

Infrequent cottonwood harvest would cause minimal impacts to aquatic wildlife habitat. However, because cottonwood decline is a rampant problem throughout the Great Plains (Rood and Mahoney 1990; Lytle and Merritt 2004), harvesting of cottonwoods would contribute to the decline of this important riparian species. Cottonwood stands are important physical modifiers of aquatic wildlife habitat and provide thermal protection, cover, and food resources in the form of leaves and organic matter; subsequently, a loss of these attributes through cottonwood harvest would degrade aquatic wildlife habitat.

Where grazing allotments failed to meet Standards for Rangeland Health and grazing was a causal factor, impairment of riparian areas and aquatic wildlife habitat would occur through continued permitted grazing. Because recovery of riparian zones and streams from livestock grazing would require total rest from grazing (Belsky et al. 1999; Henley et al. 2000), allowing grazing without resting these allotments would continue to degrade aquatic wildlife habitat and degrade some areas beyond recovery to historical potential. In a review of grazing and stream ecosystems, Belsky et al. (1999) found that the impacts from livestock trampling soils and vegetation included poor water quality, decreased seasonal water quantity, unstable stream channel morphology (e.g., eroding banks), altered hydrology, unstable riparian soils and vegetation, and decreased aquatic wildlife populations. Although Rangeland Health Standards and PFC guidelines address riparian areas qualitatively, they do not specifically address aquatic wildlife habitat, which is strongly linked to riparian health and vigor. Current Rangeland Health Standards do not specifically address the grazing, the history of land use, and the cumulative impacts on streams and aquatic wildlife habitat from an ecosystem perspective. The specific impacts of grazing would depend on the particular environmental location, history of land use, and aquatic wildlife communities present.

Allowing livestock grazing during or immediately after locatable mining would impact aquatic wildlife habitat. Collective impacts from successive multiple erosive land use activities would cause extreme sedimentation in streams and aquatic wildlife habitat, instability and mass wasting of streambanks, decreased water quality, decreased riparian vigor, and, accordingly, degraded aquatic habitat, food webs, and ecosystem processes.

Allowing livestock grazing during or immediately after oil and gas development would degrade aquatic wildlife habitat, particularly in light of the widespread oil and gas development already in progress and the potential for increased activities. Collectively, impacts from both activities have the potential to cause extreme sedimentation

in streams and aquatic wildlife habitat, instability and mass wasting of streambanks, decreases in water quality and riparian vigor, and, accordingly, degraded aquatic habitat, food webs, and ecosystem processes.

Deferring livestock grazing for 1 growing season following a wildfire or prescribed fire would help facilitate vegetative reestablishment and minimize impacts to aquatic wildlife habitat from soil erosion common after wildfires. However, if wildfires were intense, trampling of soils and plants and herbivory in upland and riparian areas 1 season after a wildfire would cause erosion and excessive sedimentation in aquatic wildlife habitat. In a review of post-fire activities in the western United States, Beschta et al. (2004) found several activities, including livestock grazing, would generally inhibit restoration of ecosystem functions. As a result, exclusion of livestock for 1 season post-fire would not allow sufficient time to prevent severe erosion in some cases. Specific climatic conditions and each fire situation, riparian area, and local history of land use in the watershed would best determine the resting period that would allow riparian vegetative reestablishment and subsequently protect aquatic wildlife habitat.

ALTERNATIVE B

Not allowing surface-disturbing activities that did not benefit the functionality of the soil resource on sensitive soils and slopes 25 percent or greater would decrease the amount of sediments that entered streams, which would help maintain aquatic wildlife habitat.

For Alternative B, surface-disturbing activities that did not benefit floodplain functionality would not be allowed and an NSO stipulation for oil and gas leasing would be required within 100-year floodplains. Similarly, under this alternative, surface-disturbing activities that did not benefit floodplain functionality would not be allowed and an NSO stipulation for oil and gas leasing would be required in waterbodies and streams. However, buffers would better protect aquatic wildlife habitat in prairie streams because there is an intrinsic connection between adjacent uplands, riparian areas, streams, and aquatic wildlife habitat because and defining floodplain boundaries and aquatic wildlife habitat of intermittent prairie streams in the planning area is complex. The lack of buffers on most prairie streams would impact aquatic wildlife. Sedimentation, which is one of the most frequently occurring chemical and physical pollutants in many streams and rivers, would occur (Wenger 1999) if buffers were not implemented; subsequently, stream buffers should be applied to all streams, including intermittent and ephemeral streams. Impacts would include erosion and excessive sedimentation in aquatic wildlife habitat, bank instability, habitat fragmentation, and, ultimately, displacement or extirpation of aquatic wildlife.

Impacts caused by surface water impoundments under this alternative would be similar to impacts caused by impoundments under Alternative A. Water impoundments on any stream (ephemeral, intermittent, or perennial) would impact aquatic wildlife habitat by altering connectivity of hydrologic flows, nutrient cycling and food web dynamics, and riparian vegetation recruitment and succession and by increasing erosion and sediment transport, all of which would compromise or decrease aquatic wildlife habitat. Impoundments would disrupt or disconnect both the linear landscape of streams and the organisms within the streams (Dodds et al. 2004). The open water of a reservoir would lead to altered thermal regimes and large-scale evaporation, which would further impact the hydrologic cycle by decreasing overall water quantity. Some reservoirs contain habitat for nonnative fishes or other predators, which would impact sensitive native fish and other aquatic wildlife populations in prairie streams. Impoundments constructed on streams would limit dispersal and migration between habitats, which are key life history strategies for prairie fishes and other aquatic wildlife.

Prohibiting surface-disturbing and disruptive activities in riparian areas and wetlands would provide protection of key aquatic wildlife attributes. However, mandatory buffers would ensure protection of aquatic wildlife habitat. Riparian areas provide stability; thermal and protective cover; food resources and key food web items and connections; thermal buffering; habitat components and structure (e.g., wood); and key ecosystem physical, chemical, and biological processes important to aquatic wildlife habitat.

Prohibiting spring development in riparian and wetland areas would benefit aquatic wildlife habitat. Locating livestock wells and troughs at least 0.25 miles from riparian and wetland areas would protect, restore, and maintain the riparian area and aquatic wildlife habitat. This action would protect aquatic wildlife habitat

from excessive sedimentation (Belsky et al. 1999); cover and food resource losses; and alteration or disruption of key physical, chemical, and biological ecosystem processes.

Under Alternative B 10,000 acres of sport-fish reservoirs would be closed to surface-disturbing and disruptive activities. These actions would protect these sport-fish reservoir acres from the impacts of surface-disturbing and disruptive activities, including erosion and sedimentation of habitat, physical and chemical pollution of water by sedimentation and pollutants, habitat fragmentation from road and facility development, and displacement or extirpation of aquatic wildlife.

Management actions that required fish-passable culverts would be economically responsible and ensure that aquatic wildlife habitats remained intact. In Oregon and Washington, the Government Accountability Office (2001) found 2,600 culverts (and estimated that up to 5,500) were impeding fish passage on USFS and BLM-administered lands. The cost of replacing these structures was estimated at over $375 million. Given the dynamic patterns of drying and flooding and the colonization and emigration patterns of prairie fish and aquatic wildlife, constructing fish passable structures would alleviate future resource and economic problems associated with stream-crossing structures impassable by fish. Designing new structures so that they would not contribute to erosion would protect and enhance aquatic wildlife habitat (see the *Reclamation Appendix*).

This alternative would protect pallid sturgeon habitat through the implementation of a non-discretionary buffer. Because pallid sturgeon habitat occurs in large river systems and because interaction of river-floodplain and riparian area-adjacent uplands occurs on a landscape scale, impacts to pallid sturgeon would potentially occur from a variety of factors. A 0.5-mile buffer would ensure that an accidental oil spill from a well, for example, would have less probability of harming this species that is already on the brink of extinction.

Infrequent cottonwood harvest would cause minimal impacts to aquatic wildlife habitat. However, because cottonwood decline is a rampant problem throughout the Great Plains (Rood and Mahoney 1990; Lytle and Merritt 2004), harvesting of cottonwoods would contribute to the decline of this important riparian species. Cottonwood stands are important physical modifiers of aquatic wildlife habitat and provide thermal protection, cover, and food resources in the form of leaves and organic matter; subsequently, a loss of these attributes through cottonwood harvest would degrade aquatic wildlife habitat.

Closing grazing allotments in which Standards for Rangeland Health were not met and grazing was a causal factor would improve riparian areas and aquatic wildlife habitat.

Suspending livestock grazing during locatable mining, coal mining, and oil and gas development would reduce the potential for compounded impacts on aquatic wildlife habitat from multiple resource uses, which would include extensive sedimentation and degradation beyond recovery to historical potential.

Deferring livestock grazing for 2 growing seasons following a wildfire, prescribed fire, or non-fire vegetative treatment would facilitate vegetative reestablishment and subsequently minimize impacts to aquatic wildlife habitat caused by soil erosion, trampling of upland and riparian areas, and livestock herbivory. Specific climatic conditions and each fire situation, riparian area, and local history of land use in the watershed would best determine the resting period that would allow riparian vegetative reestablishment and protect aquatic wildlife habitat.

ALTERNATIVE C

Avoiding surface-disturbing activities on slopes 25 percent or greater and sensitive soils would decrease the amount of soil that entered streams and affected aquatic wildlife habitat. However, if these activities were allowed with mitigation (and depending on the activity's proximity to streams), there would be at least an initial period in which sedimentation in streams and impacts to aquatic wildlife habitat occurred.

For Alternative C, surface-disturbing activities that did not benefit floodplain functionality would be avoided unless no other practicable alternative existed, and an NSO stipulation for oil and gas leasing would be required within 100-year floodplains. Similarly, under this alternative, surface-disturbing activities that did not benefit

functionality of streams and waterbodies would be avoided unless no other practicable alternative existed, and a CSU stipulation for oil and gas leasing would be required. Allowing surface-disturbing activities in these areas when no other practicable alternative existed would be subject to multiple interpretations and would provide very little protection to the water resource. Additionally, buffers would better protect aquatic wildlife habitat in prairie streams because there is an intrinsic connection between adjacent uplands, riparian areas, streams, and aquatic wildlife habitat. The lack of buffers on most prairie streams would impact aquatic wildlife. Sedimentation, which is one of the most frequently occurring chemical and physical pollutants in many streams and rivers, would occur (Wenger 1999) if buffers were not implemented; subsequently, stream buffers should be applied to all streams, including intermittent and ephemeral streams. Impacts would include erosion and excessive sedimentation in aquatic wildlife habitat, bank instability, habitat fragmentation, and, ultimately, displacement or extirpation of aquatic wildlife.

Allowing surface water impoundments with design features that maintained the natural flow regime and watershed functionality, and, in particular, flows that allowed the maintenance and formation of pool habitats would minimize impacts to aquatic wildlife habitat. Avoiding habitat fragmentation and ensuring fish passage would maintain habitat for aquatic wildlife by maintaining the natural flow regime and watershed functionality.

Management actions that allowed surface-disturbing or disruptive activities in riparian and wetland areas subject to PFC and approved specialized design features would potentially minimize aquatic wildlife habitat in perennial and intermittent streams.

Not allowing spring development in riparian and wetland areas would benefit aquatic wildlife habitat.

Management actions that allowed livestock tanks or troughs in ephemeral portions of streams would impact aquatic wildlife habitat in downstream intermittent and perennial reaches. Headwaters, which include ephemeral channels in the planning area, are key components of physical, chemical, and biological processes of watersheds and interact in a longitudinal manner, upstream to downstream (Vannote et al. 1980; Belsky et al. 1999; Fausch et al. 2002), to influence aquatic wildlife habitat. Allowing tanks or troughs on sport-fish reservoirs without a buffer would cause erosion and trampling of the banks, which would degrade aquatic wildlife habitat.

The NSO stipulation for oil and gas leasing and development for sport-fish reservoirs would protect habitat and water quality. A 0.25-mile buffer would protect approximately 3,800 acres of sport-fish reservoir habitat. In this situation, the 0.25-mile buffer would help to eventually reestablish the littoral zone (shallow shoreline area), decrease erosion, lower evaporation rates, provide shade, decrease water temperature, and provide additional food resources for fish and the aquatic food web within these reservoirs. Many of these reservoirs are already constrained by low water due to current climate conditions and livestock trampling of banks.

Management actions that required fish-passable culverts would be economically responsible and ensure that aquatic wildlife habitats remained intact. In Oregon and Washington, the Government Accountability Office (2001) found 2,600 culverts (and estimated that up to 5,500) were impeding fish passage on USFS and BLM-administered lands. The cost of replacing these structures was estimated at over $375 million. Given the dynamic patterns of drying and flooding and the colonization and emigration patterns of prairie fish and aquatic wildlife, constructing fish passable structures would alleviate future resource and economic problems associated with stream-crossing structures impassable by fish. Designing new structures so that they would not contribute to erosion would protect and enhance aquatic wildlife habitat (see the *Reclamation Appendix*). Installing fish screens on all diversions would ensure fishes and aquatic wildlife were not stranded in irrigation ditches or deposited on agricultural fields.

This alternative would protect pallid sturgeon habitat through the implementation of a non-discretionary buffer. Because pallid sturgeon habitat occurs in large river systems and because interaction of river-floodplain and riparian area-adjacent uplands occurs on a landscape scale, impacts to pallid sturgeon would potentially occur from a variety of factors. A 0.5-mile buffer would ensure that an accidental oil spill from a well, for example, would have less probability of harming this species that is already on the brink of extinction.

Management actions that allowed cottonwood harvest would impact aquatic wildlife habitat. Cottonwood stands are important physical modifiers of aquatic wildlife habitat and provide thermal protection, cover, and food resources in the form of leaves and organic matter; subsequently, a loss of these attributes through cottonwood harvest would degrade aquatic wildlife habitat. Large cottonwood trees would also provide seed sources for future cohorts of cottonwood trees. Various cohorts of cottonwoods and other riparian woody species provide a physical template within which streams and rivers interact to form various habitat patches upon which aquatic wildlife depend. Additionally, cottonwoods provide an important habitat component to the endangered pallid sturgeon in the Missouri and Yellowstone rivers. Furthermore, there have been numerous cases in which cottonwoods have declined throughout the Great Plains because of mature tree mortality without adequate regeneration (Rood and Mahoney 1990; Lytle and Merritt 2004). Although this occurrence is due primarily to hydrologic alterations, harvesting mature cottonwoods would exacerbate these impacts and alter the important patchy habitat mosaic (Pringle et al. 1988; Stanford, Lorang, and Hauer 2005) in riparian areas and aquatic wildlife habitat. Finally, there is no empirical evidence that harvesting of cottonwoods is necessary for resource health.

Where grazing allotments failed to meet Standards for Rangeland Health and grazing was a causal factor, impairment of riparian areas and aquatic wildlife habitat would occur through continued permitted grazing. However, if impairment continued and the allotment closed after 5 years of non-compliance, recovery would then begin. That additional 5 years, if impairment continued, would cause severe impacts to the upland, riparian areas, and consequently aquatic wildlife habitat. Recovery of riparian zones and streams from livestock grazing would require total rest from grazing (Belsky et al. 1999; Henley et al. 2000), and allowing grazing without resting these allotments would continue to degrade aquatic wildlife habitat and degrade some areas beyond recovery to historical potential.

Suspending livestock grazing in areas of active locatable mining and coal development, and resuming after reclamation would decrease potential for effects such as sedimentation from compounding multiple land-use activities.

Allowing livestock grazing during or immediately after oil and gas development would degrade aquatic wildlife habitat, particularly in light of the widespread oil and gas development already in progress and the potential for increased activities. Collectively, impacts from both activities have the potential to cause extreme sedimentation in streams and aquatic wildlife habitat, instability and mass wasting of streambanks, decreases in water quality and riparian vigor, and, accordingly, degraded aquatic habitat, food webs, and ecosystem processes.

Deferring livestock grazing until identified vegetative conditions are met following a wildfire or prescribed fire would help facilitate vegetative reestablishment and minimize impacts to aquatic wildlife habitat from soil erosion common after wildfires. However, if wildfires were intense, trampling of soils and plants and herbivory in upland and riparian areas would cause erosion and excessive sedimentation in aquatic wildlife habitat. In a review of post-fire activities in the western United States, Beschta et al. (2004) found several activities, including livestock grazing, would generally inhibit restoration of ecosystem functions. Post-fire exclusion of livestock would need to incorporate climatic conditions and each fire situation, riparian area, and local history of land use in the watershed to understand and ensure there were no impacts to aquatic wildlife habitat.

ALTERNATIVE D

Avoiding surface-disturbing activities on slopes 25 percent or greater and sensitive soils would decrease the amount of soil that entered streams and affected aquatic wildlife habitat. However, if these activities were allowed with mitigation (and depending on the activity's proximity to streams), there would be at least an initial period in which sedimentation in streams and impacts to aquatic wildlife habitat occurred.

For Alternative D, surface-disturbing activities that did not benefit floodplain functionality would be avoided unless no other practicable alternative existed, and an NSO stipulation for oil and gas leasing would be required within 100-year floodplains. Similarly, under this alternative, surface-disturbing activities that did not benefit functionality of streams and waterbodies would be avoided unless no other practicable alternative existed, and a CSU stipulation for oil and gas leasing would be required. Allowing surface-disturbing activities in these areas

when no other practicable alternative existed would be subject to multiple interpretations and would provide very little protection to the water resource. Additionally, buffers would better protect aquatic wildlife habitat in prairie streams because there is an intrinsic connection between adjacent uplands, riparian areas, streams, and aquatic wildlife habitat. The lack of buffers on most prairie streams would impact aquatic wildlife. Sedimentation, which is one of the most frequently occurring chemical and physical pollutants in many streams and rivers, would occur (Wenger 1999) if buffers were not implemented; subsequently, stream buffers should be applied to all streams, including intermittent and ephemeral streams. Impacts would include erosion and excessive sedimentation in aquatic wildlife habitat, bank instability, habitat fragmentation, and, ultimately, displacement or extirpation of aquatic wildlife.

Allowing surface water impoundments with design features that maintained the natural flow regime and watershed functionality, and, in particular, flows that allowed the maintenance and formation of pool habitats would minimize impacts to aquatic wildlife habitat. Avoiding habitat fragmentation and ensuring fish passage would maintain habitat for aquatic wildlife by maintaining the natural flow regime and watershed functionality.

Management actions that allowed surface-disturbing or disruptive activities in riparian and wetland areas subject to PFC and approved specialized design features would potentially minimize aquatic wildlife habitat in perennial and intermittent streams.

Not allowing spring development in riparian and wetland areas would benefit aquatic wildlife habitat.

Management actions that allowed livestock tanks or troughs in ephemeral portions of streams would impact aquatic wildlife habitat in downstream intermittent and perennial reaches. Headwaters, which include ephemeral channels in the planning area, are key components of physical, chemical, and biological processes of watersheds and interact in a longitudinal manner, upstream to downstream (Vannote et al. 1980; Belsky et al. 1999; Fausch et al. 2002), to influence aquatic wildlife habitat. Allowing tanks or troughs on sport-fish reservoirs without a buffer would cause erosion and trampling of the banks, which would degrade aquatic wildlife habitat.

Allowing surface-disturbing and disruptive activities adjacent to sport-fish reservoirs would cause sedimentation, decreasing the overall life of the sport-fish reservoir. Excessive sedimentation on reservoirs in this region would fill in the reservoir more quickly than without surface disturbance adjacent to the reservoir.

Stream-crossing structures that restricted fish passage would cause habitat fragmentation, isolation of populations, and contribute to disrupted life cycles patterns of fish and other aquatic wildlife. Although many prairie streams in the planning area are intermittent, aquatic wildlife historically thrived in these intermittent pools and depended on periods of high flow to redistribute; subsequently, fish-passable, stream-crossing structures would be important in the many prairie streams throughout the planning area. Additionally, fish-passable structures, by design, would contribute less to erosion than other stream-crossing structures.

This alternative would protect pallid sturgeon habitat through the implementation of a non-discretionary buffer. Because pallid sturgeon habitat occurs in large river systems and because interaction of river-floodplain and riparian area-adjacent uplands occurs on a landscape scale, impacts to pallid sturgeon would potentially occur from a variety of factors. A 0.5-mile buffer subject to habitat functionality would ensure that an accidental oil spill from a well, for example, would have less probability of harming this species that is already on the brink of extinction.

Management actions that allowed cottonwood harvest would impact aquatic wildlife habitat. Cottonwood stands are important physical modifiers of aquatic wildlife habitat and provide thermal protection, cover, and food resources in the form of leaves and organic matter; subsequently, a loss of these attributes through cottonwood harvest would degrade aquatic wildlife habitat. Large cottonwood trees would also provide seed sources for future cohorts of cottonwood trees. Various cohorts of cottonwoods and other riparian woody species provide a physical template within which streams and rivers interact to form various habitat patches upon which aquatic wildlife depend. Additionally, cottonwoods provide an important habitat component to the endangered pallid sturgeon in the Missouri and Yellowstone rivers. Furthermore, there have been numerous cases in which cottonwoods have declined throughout the Great Plains because of mature tree mortality without adequate

regeneration (Rood and Mahoney 1990; Lytle and Merritt 2004). Although this occurrence is due primarily to hydrologic alterations, harvesting mature cottonwoods would exacerbate these impacts and alter the important patchy habitat mosaic (Pringle et al. 1988; Stanford, Lorang, and Hauer 2005) in riparian areas and aquatic wildlife habitat. Finally, there is no empirical evidence that harvesting of cottonwoods is necessary for resource health.

Where grazing allotments failed to meet Standards for Rangeland Health and grazing was a causal factor, impairment of riparian areas and aquatic wildlife habitat would occur due to continuing to allow grazing. However, if impairment continued and it was closed after 5 years of non-compliance, recovery would then begin. That additional 5 years, if impairment continued, would cause severe impacts to the upland, riparian areas, and consequently aquatic wildlife habitat. Recovery of riparian zones and streams from livestock grazing would require total rest from grazing (Belsky et al. 1999; Henley et al. 2000), allowing grazing without resting these allotments would continue to degrade aquatic wildlife habitat and degrade some areas beyond recovery to historical potential.

Suspending livestock grazing in areas of active locatable mining and coal development, and resuming after reclamation would decrease potential for localized effects such as sedimentation from compounding multiple land-use activities.

Allowing livestock grazing during or immediately after oil and gas development would degrade aquatic wildlife habitat, particularly in light of the widespread oil and gas development already in progress and the potential for increased activities. Collectively, impacts from both activities have the potential to cause extreme sedimentation in streams and aquatic wildlife habitat, instability and mass wasting of streambanks, decreases in water quality and riparian vigor, and, accordingly, degraded aquatic habitat, food webs, and ecosystem processes.

Deferring livestock grazing until the seed set the following season would not protect aquatic wildlife. In a review of post-fire activities in the western United States, Beschta et al. (2004) found several activities, including livestock grazing, would generally inhibit restoration of ecosystem functions. Post-fire exclusion of livestock would need to incorporate climatic conditions and each fire situation, riparian area, and local history of land use in the watershed to understand and ensure there were no impacts to aquatic wildlife habitat.

ALTERNATIVE E (PREFERRED ALTERNATIVE)

Avoiding surface-disturbing activities on slopes 25 percent or greater and sensitive soils would decrease the amount of soil that entered streams and affected aquatic wildlife habitat. However, if these activities were allowed with mitigation (and depending on the activity's proximity to streams), there would be at least an initial period in which sedimentation in streams and impacts to aquatic wildlife habitat occurred.

For Alternative E, specialized design features to maintain functionality and resiliency of the floodplain would maintain aquatic wildlife habitat provided water quality was not affected, flows were not altered, the ability of the river or stream to interact with the floodplain and riparian area was not altered, sedimentation did not increase substantially, and exotic species were not unintentionally introduced.

For Alternative E, impacts to stream and waterbodies would be similar to Alternative A. A loss of protection to ephemeral drainages would have substantial, degrading impacts to aquatic wildlife habitat. Water moves downstream from ephemeral or headwater areas, causing impacts downstream to intermittent and perennial portions of watersheds. If water quality was degraded in ephemeral portions of a stream, associated impacts would potentially occur downstream. Additionally, buffers would better protect aquatic wildlife habitat because there is an intrinsic connection between adjacent uplands, riparian areas, streams, and aquatic wildlife habitat. The lack of buffers on most prairie streams would impact aquatic wildlife. Sedimentation, which is one of the most frequently occurring chemical and physical pollutants in many streams and rivers, would occur (Wenger 1999) if buffers were not implemented; subsequently, stream buffers should be applied to all streams, including intermittent and ephemeral streams. Impacts would include erosion and excessive sedimentation in aquatic wildlife habitat, bank instability, habitat fragmentation, and ultimately, displacement or extirpation of aquatic wildlife.

Similarly, under this alternative, surface-disturbing activities that did not benefit functionality of streams and waterbodies would be avoided unless no other practicable alternative existed, and a CSU stipulation for oil and gas leasing would be required. Allowing surface-disturbing activities in these areas when no other practicable alternative existed would be subject to multiple interpretations and would provide very little protection to the water resource.

Allowing surface water impoundments with design features that maintained the natural flow regime, water quality, and watershed or riparian functionality would minimize impacts to aquatic wildlife habitat if the activities succeeded in maintaining flows that allowed for natural scouring events, which maintain pool habitat and encourage groundwater-surface water interactions. Avoiding habitat fragmentation and ensuring fish passage would maintain habitat for aquatic wildlife.

Management actions that allowed surface-disturbing or disruptive activities with approved specialized design features in riparian and wetland areas would still potentially impact aquatic wildlife and their habitat. A 300-foot buffer from riparian areas and wetlands would help ensure that impacts to riparian area and wetlands, (and consequently aquatic wildlife and their habitat) were minimal.

Management actions that allowed spring developments and livestock water developments in riparian areas and wetlands would impact aquatic wildlife habitat even if they were designed to maintain functionality of wetlands, riparian areas, waterbodies, or creeks. Complete fencing of riparian areas near the water development would help decrease impacts. Water developments or livestock water access on sport-fish reservoirs without a buffer would cause erosion and trampling of the banks, which would degrade aquatic wildlife habitat.

Alternative E would provide some protection for sport-fish reservoirs. In this situation, the 0.25-mile buffer would help to eventually reestablish the littoral zone (shallow shoreline area), decrease erosion, lower evaporation rates, provide shade, decrease water temperature, and provide additional food resources for fish and the aquatic food web within these reservoirs. Many of these reservoirs may be constrained by low water due to current climate conditions and also experience livestock trampling of banks.

Management actions that required fish-passable culverts would be economically responsible and ensure that aquatic wildlife habitats remained intact. In Oregon and Washington, the Government Accountability Office (2001) found 2,600 culverts (and estimated that up to 5,500) were impeding fish passage on USFS and BLM-administered lands. The cost of replacing these structures was estimated at over $375 million. Given the dynamic patterns of drying and flooding and the colonization and emigration patterns of prairie fish and aquatic wildlife, constructing fish passable structures would alleviate future resource and economic problems associated with stream-crossing structures impassable by fish. Designing new structures so that they would not contribute to erosion would protect and enhance aquatic wildlife habitat (see the *Reclamation Appendix*). Installing fish screens on all diversions would ensure fishes and aquatic wildlife were not stranded in irrigation ditches or deposited on agricultural fields.

This alternative would protect pallid sturgeon habitat through the implementation of a non-discretionary buffer. Because pallid sturgeon habitat occurs in large river systems and because interaction of river-floodplain and riparian area-adjacent uplands occurs on a landscape scale, impacts to pallid sturgeon would potentially occur from a variety of factors. A 0.5-mile buffer subject to the requirements under this alternative would ensure that an accidental oil spill from a well, for example, would have less probability of harming this species that is already on the brink of extinction.

Management actions that allowed cottonwood harvest would impact aquatic wildlife habitat. Cottonwood stands are important physical modifiers of aquatic wildlife habitat and provide thermal protection, cover, and food resources in the form of leaves and organic matter; subsequently, a loss of these attributes through cottonwood harvest would degrade aquatic wildlife habitat. Large cottonwood trees would also provide seed sources for future cohorts of cottonwood trees. Various cohorts of cottonwoods and other riparian woody species provide a physical template within which streams and rivers interact to form various habitat patches upon which aquatic wildlife depend. Additionally, cottonwoods provide an important habitat component to the endangered pallid

sturgeon in the Missouri and Yellowstone rivers. Furthermore, there have been numerous cases in which cottonwoods have declined throughout the Great Plains because of mature tree mortality without adequate regeneration (Rood and Mahoney 1990; Lytle and Merritt 2004). Although this occurrence is due primarily to hydrologic alterations, harvesting mature cottonwoods would exacerbate these impacts and alter the important patchy habitat mosaic (Pringle et al. 1988; Stanford, Lorang, and Hauer 2005) in riparian areas and aquatic wildlife habitat. Finally, there is no empirical evidence that harvesting of cottonwoods is necessary for resource health.

Where grazing allotments failed to meet Standards for Rangeland Health and grazing was a causal factor, impairment of riparian areas and aquatic wildlife habitat would occur through continued permitted grazing. However, if impairment continued and the allotment closed after 5 years of non-compliance, recovery would then begin. That additional 5 years, if impairment continued, would cause severe impacts to the upland, riparian areas, and consequently aquatic wildlife habitat. Recovery of riparian zones and streams from livestock grazing would require total rest from grazing (Belsky et al. 1999; Henley et al. 2000), and allowing grazing without resting these allotments would continue to degrade aquatic wildlife habitat and degrade some areas beyond recovery to historical potential.

Suspending livestock grazing in areas of active locatable mining, and resuming after reclamation would decrease potential for localized effects such as sedimentation from compounding multiple land-use activities.

Allowing livestock grazing during or immediately after oil and gas development would degrade aquatic wildlife habitat, particularly in light of the widespread oil and gas development already in progress and the potential for increased activities. Collectively, impacts from both activities have the potential to cause extreme sedimentation in streams and aquatic wildlife habitat, instability and mass wasting of streambanks, decreases in water quality and riparian vigor, and, accordingly, degraded aquatic habitat, food webs, and ecosystem processes.

Deferring livestock grazing until the area attained treatment or rehabilitation plan resource objectives following a wildfire or prescribed fire would help facilitate vegetative reestablishment and minimize impacts to aquatic wildlife habitat from soil erosion common after wildfires. However, if wildfires were intense, trampling of soils and plants and herbivory in upland and riparian areas would cause erosion and excessive sedimentation in aquatic wildlife habitat. In a review of post-fire activities in the western United States, Beschta et al. (2004) found several activities, including livestock grazing, would generally inhibit restoration of ecosystem functions. Post-fire exclusion of livestock would need to incorporate climatic conditions and each fire situation, riparian area, and local history of land use in the watershed to understand and ensure there were no impacts to aquatic wildlife habitat.

CUMULATIVE IMPACTS

River and stream aquatic wildlife habitat has been affected by past land use, dams and reservoirs, natural events, changes in local and global climatic patterns, and current management actions and land uses. Historically, prairie streams, in which species thrived in perennial pools of intermittent streams with intact riparian zones, contained warm-water fish and other aquatic wildlife species adapted to a flow regime that straddled a delicate balance of drying and flooding. Aquatic wildlife in the larger perennial streams and rivers were generally adapted to free-flowing river systems in which some species, such as the endangered pallid sturgeon and the paddlefish, required unimpeded access to hundreds of miles of river habitat to complete their life cycles.

Prior to European settlement, disturbances caused by fire, occasional or patchy bison and large ungulate grazing (McNaughton 1984; Knapp et al. 1999), and flooding were common across the landscape. These disturbances were an integral part of the ecology of prairie ecosystems and established a diverse habitat template that created niches for a biodiverse flora and fauna. Although bison grazing was prevalent, these animals were nomadic, unconfined by fences or other measures, and likely did not cause dramatic impacts to streams and aquatic wildlife on a landscape scale. Conversely, livestock grazing from the late 1800s through the mid-1900s dramatically damaged stream and river ecosystems (Armour, Duff, and Elmore 1991; Armour, Duff, and Elmore 1994; Belsky et al. 1999; Magilligan and McDowell 1999).

Bison typically spend more time in uplands or open landscapes in which they specifically target grasses instead of forbs and woody species, while cattle often pass longer periods in areas with moist soils such as swales and riparian areas (Knapp et al. 1999; Peden, Van Dyne, Rice, and Hansen 1974; Steuter and Hidinger 1999). Knapp et al. (1999) suggested that bison might have used moist sites or riparian areas in late summer when uplands became very dry, causing localized and seasonal impacts. Fritz et al. (1999) found that bison crossed creeks at specific locations (crossings) of less than 2 meters of stream length and that impacts to aquatic macroinvertebrates at bison creek crossings was minimal and localized, which indicates that bison crossings created a small spatial and temporal disturbance in which recovery from the disturbance occurred quickly. This pattern is in accordance with the nature of patchy habitat types important to the enhancement of habitat diversity and biodiversity.

Similarly, McNaughton (1984) and Fritz et al. (1999) discussed the historical maintenance of "grazing lawns" in prairie uplands, in which large ungulates (including bison) grazed upland patches while adjacent areas were left untouched as these animals moved, encouraged by predators to travel great distances across the landscape. In contrast, because livestock spend a disproportionate amount of time in riparian areas, livestock grazing directly impacts riparian areas and aquatic wildlife (Belsky et al. 1999; Henley et al. 2000). The result has been widespread loss of riparian cover and subsequent dramatic changes, including streambank erosion, loss of streambank stability, and alteration of in-stream habitat and food webs. McEldowney, Flenniken, Frasier, Trlica, and Leininger (2002) found decreased stem density and aboveground biomass in grazed riparian areas retarded the ability of riparian areas to filter and trap sediments. Similarly, Saunders and Fausch (2007) demonstrated that the aboveground riparian biomass and terrestrial invertebrate input to streams was 2 to 3 times higher and fish biomass was more than twice as high in high-intensity, short duration (14 days) treatments, in comparison to seasonal treatments.

Aquatic wildlife in prairie streams are adapted to harsh conditions, including warm to hot summers and near-freezing winter water temperatures. These species are also adapted to turbid conditions because the Northern Great Plains Ecoregion, which includes a large portion of the planning area, is naturally erosive. However, cumulative impacts from land use activities have dramatically increased erosion, altered thermal and hydrologic regimes, decreased riparian vigor and riparian connections with streams, and increased the numbers and impacts of exotic species, subsequently pushing some prairie aquatic wildlife to the edge of tolerance or even to localized extinctions. Although improved livestock grazing management has resulted in better habitat conditions in some stream systems, unless innovative (Green and Kauffman 1995; Saunders and Fausch 2007), but mostly unpracticed, grazing management strategies are employed, there is potential for widespread deleterious impacts to riparian areas and aquatic wildlife. Although the Clean Water Act of 1972, the ESA of 1973, and better grazing management have improved conditions in some stream and river systems, oil and gas development, road construction, urban expansion, the spread of introduced species, drought and climate change, continued reservoir development, and obstruction of aquatic wildlife migration patterns have compounded the impacts of already constrained prairie stream and river ecosystems in the planning area. Although prairie streams are already considered an endangered resource (Dodds et al. 2004), they receive much less political and social attention than streams and rivers since the latter conservation focus is driven by sport-fishing demands.

Streams are complex systems connected physically, chemically, and biologically where they interact with their respective watershed. They operate in four-dimensional scales:

- longitudinally, from headwaters (or ephemeral streams) to the large rivers to oceans;
- laterally, through interactions with riparian areas and uplands;
- vertically, through interactions with the substrate and groundwater or hyporheic water; and
- temporally.

Although scattered land ownership and the absence of an ecosystem or watershed discipline have made management at an appropriate (watershed) scale difficult, aquatic resources in the planning area would benefit from this holistic or ecosystem-level perspective.

Alternative A

Alternative A would contribute to a general declining trend in habitat conditions of prairie streams and rivers. This alternative would decrease riparian vigor, continue erosion and sedimentation of aquatic wildlife habitat, and fail to protect aquatic wildlife passage and migration patterns at road and trail crossings. This alternative would lead to increased designations of state and federally listed sensitive aquatic wildlife species and ESA species in the future.

Alternative B

Alternative B would enable habitat conditions of prairie stream and rivers in the planning area to plateau or even improve through the implementation of buffers and NSO stipulations for oil and gas leasing and development in riparian areas and aquatic wildlife habitat. This alternative would decrease excessive erosion and sedimentation or physical pollution of aquatic wildlife habitat; repair and protect aquatic wildlife passage and migration patterns at stream-road crossings (where feasible); and increase riparian vigor, which would restore physical and biological connections between the riparian zone and stream. This alternative would also help to protect endangered (pallid sturgeon) and sensitive fish (seven species), amphibian (three), and reptile (four) species in the planning area.

Alternative C

Alternative C would enable habitat conditions of prairie stream and rivers in the planning area to plateau, rather than continue to decline, through the use of buffers and NSO stipulations for oil and gas leasing and development in riparian areas and aquatic wildlife habitat. This alternative would increase riparian vigor, decrease excessive erosion and sedimentation or physical pollution of aquatic wildlife habitat, and repair and protect aquatic wildlife passage and migration patterns at stream-road crossings, where feasible.

Alternative D

Alternative D would contribute to a general declining trend in habitat conditions of prairie streams and rivers. This alternative would decrease riparian vigor, continue erosion and sedimentation of aquatic wildlife habitat, and fail to protect aquatic wildlife passage and migration patterns at road and trail crossings. This alternative would lead to increased designations of state and federally listed sensitive aquatic wildlife species and ESA species in the future.

Alternative E (Preferred Alternative)

Alternative E would slowly enable habitat conditions of some prairie streams and rivers in the planning area to plateau, rather than continue to decline, through the use of buffers and NSO stipulations for oil and gas leasing and development in streams, waterbodies, riparian areas, and wetlands. This would occur, if and only if, the NSO stipulations for oil and gas leasing and development were actively applied. However, livestock grazing would continue to degrade habitat conditions for aquatic wildlife in some streams. In some areas, this alternative would lead to decreased habitat fragmentation and increased migratory ability of aquatic wildlife by requiring fish passage on all newly constructed and replacement culverts and stream-crossing structures.

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