calculated. GIS maps presented the locations of the various landslide risks along the corridors.

Additional discussion of various geologic hazards is provided in Section 3.14.

3.3.3 What Are the Potential Impacts Associated with Corridors Designation and Land Use Plan Amendment

3.3.3.1 No Action Alternative

Under the No Action Alternative, no Section 368 energy corridors would be designated on federal land and there would be no impact from the decision. Under this alternative, future energy transport projects would be sited in a manner similar to that currently used. Project applicants would identify potential project ROWs for crossing federal and nonfederal lands. Geologic resources associated with the selected and authorized ROWs would be most likely to be affected by project development and operation. In the absence of known ROW locations, it is not possible to identify those geologic resources.

3.3.3.2 The Proposed Action

The designation of energy corridors and land use plan amendment under the Proposed Action are not expected to affect geologic resources. These resources would be affected with the development of specific energy transport projects following corridor designation. Under the Proposed Action, about 3.3 million acres of designated corridor footprint would lie on federal land. The total miles and acreage that would be occupied by project-specific ROWs with the corridors and their associated access roads, staging areas, construction sites, and infrastructure are not known. Because soil, gravel, and crushed stone resources have not been mapped completely for the 11 western states, affected environments and future project-specific impacts will need to be addressed at the project level. Soil erosion potential is location-specific and varies dramatically over short distances. Evaluation of the potential is not appropriate at the programmatic level in this PEIS. It should be addressed at the project level.

Geologic hazards are related to safety issues. Their evaluations are presented in Section 3.14.

3.3.4 Following Corridor Designation, What Types of Impacts Could Result to Geological Resources and Hazardous Geologic Features with Project Development, and How Could Potential Impacts Be Minimized, Avoided, or Compensated?

3.3.4.1 What Are the Usual Impacts to Geologic Resources of Building and Operating Energy Transport Projects?

Any type of construction or industrial activity requires the use of sand and gravel and/or crushed rock, including building the infrastructure of energy transport projects. The materials are used in access roads, ROWs, staging areas, stream banks, and other construction sites and are for concrete, gravel pads, road beds, stream bank protection, and building materials. These materials are normally mined in areas close to the corridors to reduce construction cost.

Under either alternative, geologic resources could be affected by the construction, operation, maintenance, and decommissioning of energy infrastructures within the energy corridor ROWs. Impacts originate in the extraction and placement of the geologic material and ground disturbance. Sand and gravel are commonly mined from alluvium in river or stream valleys. When the quality of sand and gravel does not meet requirements, suitable stone is mined from quarries and crushed to proper size for use. Mining operations would disturb the ground surface, and runoff would erode fine-grained soils, increasing the sediment load farther down in streams and/or rivers. Mining on steep slopes and/or on unstable terrain without appropriate engineering measures increases the landslide potential in the mining areas.

Sand, gravel, and crushed stone would be obtained from borrow pits and quarries located up to tens of miles from access roads and construction sites. Large volumes of sand, gravel, and crushed stone would be needed to meet the construction needs of energy transport projects. These materials would also be needed for river bank protection during the construction and maintenance phase of a project. In the decommissioning phase, the used geologic material may be recycled or disposed of near the infrastructures. Since construction material is plentiful in the 11 western states, the volumes of sand, gravel, and crushed rock needed would be easily met. Locally, the location, quality, and potential competing uses for these materials should be analyzed at the project level.

Applying sand and gravel on land alters the drainage near where the material is used. The size of the area affected can range from a few hundred square feet (for a transport tower foundation) to a few hundred acres (for an access road). The impact on the natural surface drainage, therefore, depends on the size of the areas affected, local terrain rain patterns and amounts, and mitigation measures. This operation would impact the water quality of the surface water body downstream from the affected area.

Ground disturbance is unavoidable during land development and construction. The disturbance comes from clearing, grading, trenching, drilling, or blasting to construct transport towers, underground pipelines, and associated facilities, and from heavy equipment traffic near staging areas, access roads, and ROWs. The disturbance is intense during the construction phase and is expected to be temporary and local, assuming that best management practices and mitigation measures (see Section 3.3.4.2) are applied. Much less impact is expected during the operation phase.

The ground disturbance can increase soil erosion and affect the water quality of the surface water downstream from the disturbed areas, affecting both sediment load and dissolved salt content in the waters. The former is important in sloped areas, while the latter becomes an important issue in arid or semiarid environments and in areas where bedrock has a high content of soluble salts. The surface soils in arid environments generally are rich in soluble salts, and intermittent and ephemeral streams dominate there. This is exemplified by the Colorado Basin across the states of Wyoming, Colorado, Utah, Arizona, and California. The salt loading in streams and rivers within the basin is a major management issue for the Colorado River (DOI 2005a).

Soil erosion would occur along individual project sites. The erosion would be visible during the construction and decommissioning phases of a project when clearing, excavation, and fill operations are most intense. The erosion occurs in most of the related areas (e.g., borrow pits, ROWs, access roads, river crossings, staging areas, and construction sites) of the project until vegetation is reestablished. Depending on the development schedules of the energy transport projects, some parts of the project-specific ROWs within the designated corridors as well as the corridors on nonfederal lands that have not been designated may be redisturbed to install different infrastructure. Soil erosion would therefore be reactivated on the disturbed sites, creating another cycle of soil erosion and stabilization. The impacts would be localized and limited in extent and magnitude, if appropriate mitigation measures are implemented.

In the operation and maintenance phase of a project, the soil erosion near the access roads (especially in sloped areas) would continue, as drainage water is channeled to nearby surface water bodies. Buried pipes and/or control valves may need to be excavated and exposed for repair. Heavy equipment traffic also would damage the protective vegetation covers. The magnitude of the soil erosion impacts would be substantially lower than what would occur during the construction and decommissioning phases. Pesticide and herbicide use is expected for ROW maintenance, creating the potential for soil contamination. The use of pesticides and herbicides and unintentional spills would potentially cause soil contamination.

The impacts on soil erosion and potential soil contamination would be localized and limited in extent and magnitude, if appropriate mitigation measures are implemented. The impacts would occur near project sites.

The usual impacts to hazardous geologic features of building and operating energy transport projects are described in Section 3.14.

3.3.4.2 What Mitigation Is Available to Minimize, Avoid, or Compensate for Potential Project Impacts to Geological Resources?

The potential for impacts to geologic resources would occur primarily during construction and decommissioning. Impacts due to maintenance vehicle traffic also can be lower during the operation and maintenance phase of the projects. To reduce the impacts, mitigation measures for both planning and field operations should be used at the project implementation level. These measures may be incorporated into the management plans of responsible agencies.

DOI and USDA (2006) contains standards and guidelines for oil and gas exploration and development (commonly referred to as the Gold Book). The Gold Book offers comprehensive guidance on the design, construction, maintenance, and reclamation of sites and access roads. Additional guidance (e.g., FS 2000) on the more complex issues of oil and gas exploration, as well as newer state-of-the-art methods, will apply to future projects. Combined, the guidances would apply to this PEIS to reduce environmental impacts in the 11-state area.

Mitigation measures could be applied in the field to mitigate the impacts on soil; specific measures would be selected after considering factors that cause soil erosion, such as rainfall characteristics, runoff, soil erodibility, slope length, slope steepness, and vegetation cover (USDA 1996; FS 2000). Potential mitigation measures to reduce impacts for No Action and the Proposed Action are listed below:

- Soil experts should identify soils with high potential of erosion and/or soluble salt content such that precautionary measures can be planned and implemented.

- Do not excavate earthen material from, or store excavated earthen material in, any stream, swale, lake, or wetland.

- Maintain long-term ground cover and soil structure:

    – Topsoil removed during construction should be salvaged and reapplied during reclamation, and plant debris should be left on-site to serve as mulch. Disturbed soils should be reclaimed as quickly as possible, or protective covers should be applied.

    – When feasible, keep roads and trails out of wetlands. If roads or trails must enter wetlands, use bridges or raised prisms with diffuse drainage to sustain flow patterns. Set crossing bottoms at natural levels of channel beds and wet meadow surfaces. Avoid actions that may dewater or reduce water budgets in wetlands.

    – Design all ditches, canals, and pipes with at least an 80% chance of passing high flows and remaining stable during their life.

- Foundations and trenches should be backfilled with originally excavated materials as much as possible, and excavation material should be disposed of only in approved areas, to control soil erosion and to minimize leaching of hazardous constituents. If suitable, excess excavation materials may be stockpiled for use in reclamation activities.

- Limit roads and other disturbed sites to the minimum feasible number, width, and total length consistent with the purpose of specific operations, local topography, and climate:
  - Use existing roads and borrow pits as much as possible. Borrow material should be obtained only from authorized and permitted sites.
  - Construct roads on ridge tops, stable upper slopes, or wide valley terraces, if feasible. Stabilize soils on-site. End-haul soil if full-bench construction is used. Avoid slopes steeper than 70%.
  - Avoid soil-disturbing actions during periods of heavy rain or wet soils. Apply travel restrictions to protect soil and water.
  - Install cross drains to disperse runoff into filter strips and minimize connected disturbed areas. Make cuts, fills, and road surfaces strongly resistant to erosion between each stream crossing and at least the nearest cross drain. Revegetate using certified local native plants, as feasible; avoid persistent or invasive exotic plants.
  - Where feasible, construct roads with rolling grades instead of ditches and culverts.
  - Retain stabilizing vegetation on unstable soils. Avoid new roads or heavy equipment use on unstable or highly erodible soils.
  - Use existing roads unless other options will produce less long-term sediment. Reconstruct for long-term soil and drainage stability.
  - Avoid ground skidding with blades lowered or on highly erodible slopes steeper than 40%. Conduct logging to disperse runoff, as feasible.
  - Special construction techniques should be used, where applicable, in areas of steep slopes, erodible soil, and stream channel/wash crossings.

- Construct roads and other disturbed sites to minimize sediment discharge into streams, lakes, and wetlands:
  - Design all roads, trails, and other soil disturbances to the minimum standard for their use and to “roll” with the terrain, as feasible. Slope hill cuts should be minimized.
  - Erosion controls should be applied that comply with county, state, and federal standards, and practices should be implemented such as erecting jute netting, silt fences, and check dams near disturbed areas.
  - Use filter strips and sediment traps, if needed, to keep all sand-sized sediment on the land and disconnect disturbed soil from streams, lakes, and wetlands. Disperse runoff into filter strips.

  - Key sediment traps into the ground. Clean them out when 80% full. Remove sediment to a stable gentle upland site and revegetate.
  - Keep heavy equipment out of filter strips except to do restoration work or build hardened stream or lake approaches. Yard logs out of each filter strip with minimum disturbance of ground cover.
  - Design road ditches and cross drains to limit flow to ditch capacity and prevent ditch erosion and failure.

- Stabilize and maintain roads and other disturbed sites during and after construction to control erosion:
  - Do not encroach fills or introduce soil into streams, swales, lakes, or wetlands.
  - Properly compact fills and keep woody debris out of them. Revegetate cuts and fills upon final shaping to restore ground cover using certified local native plants, as feasible; avoid persistent or invasive exotic plants. Provide sediment control until erosion control is permanent.
  - Do not disturb ditches during maintenance unless needed to restore drainage capacity or repair damage. Do not undercut the cut slope.
  - Space cross drains from no more than 120 feet in highly erodible soils on steep grades to no more than 1,000 feet in resistant soils on flat grades. Do not divert water from one stream to another.
  - Empty cross drains onto stable slopes that disperse runoff into filter strips. On soils that may gully, armor outlets to disperse runoff. Tighten cross-drain spacing so gullies are not created.
  - Harden rolling dips as needed to prevent rutting damage. Ensure that road maintenance provides stable surfaces and drainage.
  - Where berms must be used, construct and maintain them to protect the road surface, drainage features, and slope integrity while also providing user safety.

- Reclaim roads and other disturbed sites when use ends, as needed to prevent resource damage:
  - Site-prepare, drain, revegetate, and close temporary and intermittent use roads and other disturbed sites within one year after use ends. Provide natural drainage that disperses runoff into filter strips and maintains stable fills. Do this work concurrently. Use native vegetation as feasible.
  - Remove all temporary stream crossings (including all fill material in the active channel), restore the channel geometry, and revegetate the channel banks using native revegetation, as feasible.

- Maintain or improve long-term levels of organic matter and nutrients on all lands:
  - On soils with topsoil thinner than 1 inch, topsoil organic matter less than 2%, or effective rooting depth less than 15 inches, retain 90% or more of the fine (less than 3 inches in diameter) logging slash in the stand after each clearcut and seed-tree harvest, and retain 50% or more

  - of such slash in the stand after each shelterwood and group-selection harvest, considering existing and projected levels of fine slash.
  - If machine piling of slash is done, conduct piling to leave topsoil in place to avoid displacing soil into piles or windrows.

- Place new sources of chemical and pathogenic pollutants where such pollutants will not reach surface or ground water:

  - Put pack and riding stock sites, sanitary sites, and well drill pads outside the water influence zone (WIZ).
  - Put vehicle service and fuel areas, chemical storage and use areas, and waste dumps on gentle upland sites. Do mixing, loading, and cleaning on gentle upland sites. Dispose of chemicals and containers in state-certified disposal areas.

- Apply runoff controls to disconnect new pollutant sources from surface and ground water. Install contour berms and trenches around vehicle service and refueling areas, chemical storage and use areas, and waste dumps to fully contain spills. Use liners as needed to prevent seepage into ground water.

- Apply chemicals using methods that minimize risk of entry to surface and ground water:

  - The BLM's standard operating procedures (SOPs) (BLM 2005a) should be followed when using pesticides and herbicides to minimize unintended impacts to soil. Common practices include, but are not limited to: (1) minimizing the use of pesticides and herbicides in areas with sandy soils near sensitive areas, (2) minimizing the use of pesticides and herbicides in areas with high soil mobility, and (3) evaluating soil characteristics prior to application, to assess the likelihood for pesticide and herbicide transport in soil.
  - Favor pesticides with half-lives of 3 months or less. Apply at lowest effective rates as large droplets or pellets. Follow label directions. Favor selective treatment. Use only aquatic-labeled chemicals in the WIZ.
  - Use nontoxic, nonhazardous drilling fluids, when feasible.

The mitigation measures to reduce potential project impacts related to geologic hazardous are described in Section 3.14.

3.4 PALEONTOLOGICAL RESOURCES

3.4.1 What Are the Paleontological Resources in the 11 Western States?

Paleontological resources are the fossilized remains of ancient life forms, their imprints, or behavioral traces (e.g., tracks, burrows, residues), and the rocks in which they are preserved. These are distinct from human remains and artifacts, which are considered archaeological or historical materials. Fossil energy resources, such as coal or oil, are also generally excluded from the definition of paleontological resources.

Fossils have scientific and educational value because they are important in understanding the history of life on Earth and the biodiversity of the past, and in developing new ideas about ecology and evolution. On public lands, vertebrate and uncommon invertebrate and plant paleontological resources may only be collected for scientific and educational purposes under a permit. Common invertebrate and plant fossils may be collected for recreational use, but cannot be bartered or sold. Petrified wood is a mineral material that may be collected recreationally in limited amounts, or collected commercially under a mineral material contract.

Various statutes, regulations, and policies govern the management of paleontological resources on public lands. Primary statutes for management and protection include the FLPMA (Public Law [P.L.] 94–579, codified at 43 USC 1701–1782) for the BLM; the Organic Act of 1897 (16 USC 551) for the FS; and 18 USC 641, which penalizes the theft or degradation of property of the U.S. government. Other federal acts, the Federal Cave Resources Protection Act (P.L. 100–691, 102 Stat. 4546; codified at 16 USC 4301) and the Archaeological Resources Protection Act (16 USC 470(aa) et seq.), protect fossils found in significant caves and/or in association with archeological resources. Recently, legislators have proposed a bill to establish a national policy for preserving and managing paleontological resources on federal lands (Library of Congress 2006). A complete listing of the statutes and regulations that federal agencies use to manage fossils on the lands they administer can be found in Appendix E.

Significant paleontological resources on public lands in the western United States are predominantly associated with geologic units (formations) from the Mesozoic and Cenozoic Eras (Table 3.4-1). Fossiliferous formations of the Mesozoic Era, particularly of the Jurassic and Cretaceous Periods (65 to 206 million years ago), are found in the Rocky Mountains and along canyons of the Colorado Plateau. The geologic units are of marine and nonmarine origin, representing alternating episodes of marine transgression and regression. They yield important vertebrate fossils, including fish, frogs, salamanders, turtles, crocodiles, pterosaurs, mammals, birds, and dinosaurs, and generally have a high Potential Fossil Yield Classification (PFYC) ranking which, on a scale of Class 1 to Class 5, indicates a higher fossil yield potential and greater sensitivity to adverse impacts (see Table 3.4-2, Section 3.4.2). Invertebrate fossils (e.g., ammonites) are also abundant.

Fossiliferous formations of the Cenozoic era, particularly from the Tertiary Period (1.8 to 65 million years ago), are found in the many sedimentary basins across the West (e.g., in the Big Horn, Green River, and Uinta Basins). These formations contain important vertebrate fossils, including mammals, birds, reptiles, amphibians, and fish. Plants and invertebrates may also be important at some localities.

3.4.2 How Were the Potential Impacts of Corridor Designation to Paleontological Resources Evaluated?

Designation of energy corridors would have no impact on paleontological resources since under designation alone there would be no ground-disturbing activities. The analysis presented in this section, therefore, evaluates the paleontological resources potentially affected by the future development of energy corridors under the alternatives described in Chapter 2. Because the occurrences of paleontological resources closely correlate with the geologic units that contain them, the potential for finding important paleontological resources can be broadly predicted by the presence of particular geologic units at or near the surface. For this analysis, geologic mapping is used as a proxy for assessing the likeliness of occurrence of important paleontological resources in a given location, assuming that the potential for impacts to paleontological resources would be proportional to the number and extent of geologic units with high fossil-yielding potential that are intersected by the proposed corridor or corridor segments. Actual impacts would need to be assessed on the basis of on-the-ground surveys in the proposed areas of disturbance.

TABLE 3.4-1 Geologic Time Scale

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class)
Cenozoic	Quaternary (0–1.8)	Holocene (0–0.01)		Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
		Pleistocene (0.01–1.8)	Mammoths Bison and cows Horses Deer Squirrels and rabbits Invertebrates	Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Glaciofluvial deposits (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
	Tertiary (1.8–65.0)	Pliocene (1.8–5.3)	Mammals Birds (eggs) Warm climate plankton (marine) Invertebrates	Ogallala Formation (5) Idaho Group (3)
		Miocene (5.3–23.8)	Mammals (rodents) Birds (eggs) Invertebrates	Browns Park Formation (5) Dry Union Formation (5) Muddy Creek Formation (3) Ogallala Formation (5) Wagontongue Formation (5)
		Oligocene (23.8–33.7)	Mammals (early horses, primates, marsupials, carnivores) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bishop Conglomerate (3) Duchesne River Formation (5)

TABLE 3.4-1 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class)
Cenozoic (Cont.)		Eocene (33.7–54.8)	Mammals (early horses, primates, marsupials, carnivores, grazers) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bridger Formation (5) Duchesne River Formation (5) Green River Formation (5) Uinta Formation (5) Wasatch Formation (5) Wind River Formation (5)
		Paleocene (54.8–65.0)	Small mammals Reptiles Amphibians and fish Birds (eggs) Insects Plants and pollen	Beaverhead Conglomerate (3) Currant Creek Formation (5) Fort Union Formation (3) Nacimiento Formation (5) Ojo Alamo Formation (5)
Mesozoic	Cretaceous (65.0–144)		Terrestrial flora and fauna: – dinosaurs – birds – early mammals – diverse insects – flowering plants – freshwater fish and invertebrates Marine flora and fauna: – plankton and diatoms – cephalopods (ammonites, belemnites) – marine reptiles – fish – sharks and rays	Burro Canyon Formation (5) Castlegate Formation (2) Cliff House Sandstone (5) Lewis Shale (5) Mowry Shale (3) Niobrara Formation (5) Various volcanic units (1)

TABLE 3.4-1 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class)
Mesozoic (Cont.)	Jurassic (144–206)		Terrestrial flora and fauna: – dinosaurs – early mammals – seed plants – ferns Marine flora and fauna: – plankton – cephalopods (ammonites) – marine reptiles – fish – sharks and rays	Kayenta Formation (5) Moenave Formation (5) Morrison Formation (5) Navajo Sandstone (5) Summerville Formation (5)
	Triassic (206–248)		Terrestrial flora and fauna: – dinosaurs – early mammals – seed plants – conifers	Chinle Formation (5) Chugwater Formation (3) Moenkopi Formation (3) Thaynes Limestone (2) Wingate Formation (5)
Paleozoic	Permian (248–290)		Terrestrial flora and fauna dominate: – anapsids (turtles) – diapsids – archosaurs – gymnosperms (conifers)	Coconino Sandstone (3) Kaibab Formation (2) San Andres Formation (5) Satanka Shale (2) Toroweap Formation (3)
	Carboniferous	Pennsylvanian (290–323)	Terrestrial flora and fauna dominate: – freshwater clams – seedless plants – ferns – winged insects (dragonflies) – amniote species (lizards) – diapsids (reptiles, snakes) – archosaurs (crocodiles, dinosaurs, birds)	Beldon Formation (2) Hermit Shale (2) Minturn Formation (2) Morgan Formation (2) Oquirrh Formation (2)
		Mississippian (323–354)	Marine invertebrates (e.g., bryozoans and braciopods) dominate: – foraminifera – modern fish fauna	Brazer Formation (2) Deseret Limestone (2) Humbug Formation (2) Madison Formation (3) Redwall Limestone (2)

TABLE 3.4-1 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class)
Paleozoic (Cont.)	Devonian (354–417)		Terrestrial plants (ferns, seed plants, trees) Terrestrial insects and spiders Diverse freshwater fish Marine vertebrates and invertebrates (see below)	Jefferson Limestone (2) Madison Formation (3) Temple Butte Formation (2)
	Silurian (417–443)		Coral reefs Marine invertebrates (see below) Marine fish Freshwater fish Terrestrial plants	
	Ordovician (443–490)		Marine invertebrates: – red and green algae – bryozoans – crinoids, blastoids – corals – graptolites – trilobites – brachiopods, snails, clams – cephalopods – archaeocyathids (sponges) Marine vertebrates: – ostraderms (jawless, armored fish) Conodonts (early vertebrates) Terrestrial plants	Bighorn Dolomite (2) Fishhaven Dolomite (2) Garden City Limestone (2)
	Cambrian (490–543)		Marine invertebrates: – red and green algae – trilobites – brachiopods – echinoderms – archaeocyathids (sponges)	Bright Angel Shale (2) Park Shale (2) Meagher Limestone (2) Pilgrim Limestone (2) Tapeats Sandstone (2) Wolsey Shale (2)
Precambrian	Proterozoic (543–2,500)		Soft bodied fauna Carbon film Microbial mats (stromatolites)	Various igneous and metamorphic units (1)

TABLE 3.4-1 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class)
Precambrian (Cont.)	Archean (2,500–3,800?)		None	Various igneous and metamorphic units (1)

[a] Ma = millions of years before the present.

[b] Distinctive fossils are those characteristic of the geologic period listed and may or may not be present in the geologic units (formations) in the study area.

Sources: Adapted from Palmer and Geissman (1999) and the University of California Museum of Paleontology (2007).

The BLM and FS use the PFYC system, which was developed in 1996 by the FS's Paleontology Center of Excellence and the Region 2 Paleo Initiative to promote consistency throughout and among agencies (FS 1996). The PFYC system provides baseline guidance for assessing the relative occurrence of important paleontological resources and the need for mitigation. Specifically, it is used to classify geologic units at the formation or member level according to the probability of yielding paleontological resources of concern to land managers.

Under the PFYC system, geologic units are classified from Class 1 to Class 5 based on the relative abundance of vertebrate fossils or uncommon invertebrate or plant fossils and their sensitivity to adverse impacts. A higher classification number indicates a higher fossil yield potential and greater sensitivity to adverse impacts. Table 3.4-2 provides a description of the five PFYC classes and the corollary management direction indicated for each class.

For this analysis, the PFYC system was applied to geologic units intersecting and adjacent to the proposed corridors to identify units with a high fossil yield potential and therefore a potential for adverse impacts. Geologic formations with a PFYC class of 3, 4, or 5, or other known significant localities that occur within 2,000 feet of the centerlines of the proposed corridors or corridor segments, were identified as areas of potentially adverse impacts. For purposes of this initial assessment, all Quaternary sediments (alluvium, colluvium, etc.) were assigned to Class 3 since their fossil yield potential is unknown. Quaternary age sediments should be assessed on the ground to determine their source and potential for bearing fossils, once a specific project is under way. Areas designated as Class 3, 4, or 5 may warrant a paleontological field survey and/or mitigation measures (see Section 3.4.4.2).

Appendix N presents the PFYC classifications for geological formations intersecting or adjacent to the proposed corridors in each of the 11 western states.

3.4.3 What Are the Paleontological Resources and Potential Impacts Associated with Corridor Designation and Future Development?

3.4.3.1 No Action Alternative

Under the No Action Alternative, energy transport projects would likely be implemented independently within individual, widely spaced,

TABLE 3.4-2 Potential Fossil Yield Classification Descriptions

Class	Description	Basis	Management Direction
1	Geologic units that are not likely to contain recognizable fossil remains, including igneous and metamorphic units (excluding tuffs) and units that are Precambrian in age or older (i.e., older than 540 million years before present).	The potential for impacting any fossils is negligible. The occurrence of significant fossils is nonexistent or extremely rare. No assessment or mitigation of paleontological resources is needed.	Land manager's concern for paleontological resources is negligible or not applicable. No assessment or mitigation needed except in very rare cases.
2	Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant invertebrate fossils. These include geologic units in which vertebrate fossils or uncommon invertebrate or plant fossils are unknown or very rare, units that are younger than the Pleistocene Epoch (10,000 years before present), aeolian deposits, and units exhibiting significant diagenetic alteration.	The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is low. Localities containing important resources may exist, but would be rare and would not influence the classification. Management actions are not likely to be needed.	Land manager's concern for paleontological resources is low. No assessment or mitigation needed except in rare cases.
3	Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential. These include units in which vertebrate fossils and uncommon invertebrate or plant fossils are known to occur inconsistently (i.e., predictability is low), units of marine origin with sporadic known occurrences of vertebrate fossils, and poorly studied or poorly documented units (i.e., potential yield cannot be assessed without ground reconnaissance).	This classification encompasses a broad range of potential impacts, including geologic units of unknown potential and units of moderate or infrequent fossil occurrence.	Land manager's concern for paleontological resources is moderate, or cannot be determined from existing data. Surface-disturbing activities may require field assessment to determine a further course of action.

TABLE 3.4-2 (Cont.)

Class	Description	Basis	Management Direction
4	Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or uncommon invertebrate or plant fossils (as in Class 5), but have lowered risks of human-caused adverse impacts or natural degradation. These include units with extensive soil or vegetative cover or with limited bedrock exposures, areas in which exposed outcrop is less than 2 contiguous acres, and areas in which exposed outcrops form cliffs of sufficient height and slope to minimize impacts.	The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is moderate to high and is dependent on the proposed action. The geologic unit is considered a Class 5, but the risk of potential impacts is reduced by the presence of a protective layer of soil, thin alluvial material, or other mitigating circumstance.	Land manager's concern for paleontological resources is moderate to high, depending on the proposed action. A field survey and assessment by a qualified paleontologist are often needed to assess local conditions. Approval from the authorized officer is required for project to proceed. Resource preservation and conservation through controlled access or special management designation should be considered. Mitigation may be necessary before and/or during these actions. On-site monitoring may also be necessary during construction activities.
5	Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or uncommon invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation. Vertebrate fossils or uncommon invertebrate or plant fossils are known and documented to occur consistently, predictably, or abundantly. Units are exposed, with little or no soil or vegetative cover. Outcrop areas are extensive; exposed bedrock areas are larger than 2 contiguous acres.	The potential for impacting significant fossils is high. Vertebrate fossils or uncommon invertebrate or plant fossils are known or can be expected to occur.	Land manager's concern for paleontological resources is high. A field survey and assessment by a qualified paleontologist is required in advance of surface-disturbing activities or land tenure adjustments. Approval from the authorized officer is required for project to proceed. Resource preservation and conservation through controlled access or special management designation may be appropriate. Mitigation will often be necessary before and/or during these actions. On-site monitoring may also be necessary during construction activities.

Source: Hanson (2006).

and project-specific ROWs. As a consequence, the potential for adverse impacts to paleontological resources on federally administered lands could be greater than would be expected if the projects were colocated within a single ROW. Potential impacts to paleontological resources largely would be associated with construction activities, and could include any of the common impacts identified in Section 3.4.4.1. Although all managing agencies have procedures and policies for reducing or mitigating impacts to paleontological resources on a project-specific basis, the benefits of a coordinated approach (e.g., consistency of environmental analyses and mitigation requirements) may not be realized under No Action.

3.4.3.2 The Proposed Action

For this analysis, geologic units with a high fossil yield potential that fall within the designated energy corridors under the Proposed Action represent areas where development has the potential to encounter and impact fossils. Table 3.4-3 lists the number of geologic formations for each PFYC class that occur within 2,000 feet of the centerlines of the proposed corridors in each of the 11 western states on the basis of the tables presented in Appendix N. It is important to note that the numbers in the tables represent the number of formations potentially affected for a given state and not the number of formation exposures.[2] The numbers in the tables are also affected by the scale and level of differentiation of geologic formations on the state geologic maps used for this analysis; therefore, those states having a high level of differentiation relative to other states may also have higher numbers of formations (and percentages) of geologic formations in the PFYC classes reported.

All 11 states have formations in each of the PFYC class categories, except Class 4, as shown in Table 3.4-3. The PFYC system ranks the highest potential fossil yielding formations as Class 4 or Class 5, but assigns the lower rank (Class 4) to those formations for which potential impacts are reduced by the presence of a protective layer of soil or other mitigating circumstance. For this assessment, formations with the highest potential fossil yield were assigned to the higher rank (Class 5); however, some of these may be downgraded to Class 4 once the project-specific potential for disturbance can be assessed.

There are at least 63 geologic units (18% of the total) that fall in the PFYC Class 5 category within the corridors proposed under the Proposed Action. One state, New Mexico, has a higher percentage of PFYC Class 5 formations relative to other PFYC classes. This is mainly the result of the high occurrence of formations dating from Jurassic to Cretaceous ages, which contain such vertebrates as dinosaurs, lizards and other reptiles, birds, mammals, and fish; and formations of Tertiary age, which contain lizards, small crocodiles, turtles, bats, birds, mammals, and fish. Arizona, Colorado, Montana, Utah, and Wyoming also have corridors or corridor segments crossing important PFYC Class 5 formations. For projects intersecting the PFYC Class 5 formations, resource preservation and conservation may necessitate mitigation and on-site monitoring during project activities. Other states, including California, Idaho, Nevada, Oregon, and Washington, have no PFYC Class 5 formations intersecting the corridors under the Proposed Action.

About 139 geologic units (40% of the total) fall in the PFYC Class 3 category under the Proposed Action. Four states have a higher percentage of PFYC Class 3 formations relative to other classes; these include Colorado, Idaho,

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[2] A geologic formation may be exposed at the surface at more than one location; therefore, the number of exposures of any formation is usually expected to be greater than one. For this analysis, only the number of formations potentially affected are counted, since the number of formation exposures can only be determined in the field.

TABLE 3.4-3 Number (and Percentage) by State of PFYC Classes for Formations Intersecting the Proposed Corridors under the Proposed Action[a]

States	Class 1	Class 2	Class 3	Class 4	Class 5
Arizona	6 (21)	7 (25)	7 (25)	0	8 (29)
California	12 (63)	0	7 (37)	0	0
Colorado	3 (10)	5 (17)	13 (43)	0	9 (30)
Idaho	4 (15)	5 (18)	18 (67)	0	0
Montana	7 (23)	12 (39)	10 (32)	0	2 (7)
Nevada	11 (46)	9 (38)	4 (17)	0	0
New Mexico	1 (5)	0	7 (33)	0	13 (62)
Oregon	29 (51)	11 (19)	17 (30)	0	0
Utah	6 (11)	7 (13)	27 (50)	0	14 (26)
Washington	4 (80)	0	1 (20)	0	0
Wyoming	0	10 (18)	28 (51)	0	17 (31)
Totals	83 (24)	66 (19)	139 (40)	0	63 (18)

[a] The numbers shown represent formations only. Formation outcrops may occur in more than one area; therefore, the number of exposures (or potential impact areas) could be higher than the number shown. Numbers in parentheses represent the percentage of a class assignment (e.g., Class 5) relative to other class assignments for formations in that state.

Utah, and Wyoming. This is most often because of the placement of corridors and corridor segments in river valleys and sedimentary basins or deserts. Examples include the corridor segments that stretch across the Snake River Plain in southern Idaho and the corridor segment in northwestern Utah that extends across the Great Salt Lake Desert. Another corridor segment in California extends south from near Mono Lake through Owens Valley along the eastern edge of the Sierra Nevada Range. PFYC Class 3 formations in these states may be fossiliferous but vary locally, or their potential to yield significant fossils is not currently known. Class 3 formations generally require additional field assessment to determine the next course of action at the project level.

A total of 149 geologic units (43% of the total) fall in either PFYC Class 1 or 2 under the Proposed Action. Six of the states have a higher percentage of PFYC Class 1 and 2 formations relative to other classes; these are Arizona, California, Montana, Nevada, Oregon, and Washington. The high percentage of PFYC Class 1 and 2 formations in these states can be attributed to the high occurrence of igneous (intrusives and volcanic flows and tuffs) and metamorphic units.

Important fossils on nonfederal land (i.e., privately owned land, Tribal and trust land, and land controlled by state and local governments) may also be affected by ground-disturbing activities associated with corridor development if they are present within a land “gap” that would connect projects on designated corridors if they were to be built. The analysis of impacts to fossil resources on nonfederal land would be conducted at the time such a project is proposed.

3.4.4 Following Corridor Designation, What Types of Impacts Could Result to Paleontological Resources with Project Development, and How Could They Be Minimized, Avoided, or Compensated?

3.4.4.1 What Are the Usual Impacts of Building and Operating Energy Transport Projects to Paleontological Resources?

Ground-disturbing activities associated with ROW clearing and construction of the transport systems and required infrastructure (e.g., access roads, compressor stations) and increased accessibility on public lands via new access roads and ROWs can impact paleontological resources. Direct adverse impacts common to all ground-disturbing activities, such as drilling rock to set transport tower footings or excavating to install underground transport pipelines, include the potential damage or destruction of fossil remains or the disruption of the context in which they are found.

Indirect adverse impacts may occur as a result of the increased accessibility to an area (associated with project-related access roads or trails and vegetation-clearing activities), which may lead to an increased risk of theft or vandalism. Increased accessibility may also occur if ground-disturbing or vegetation-clearing activities accelerate erosional processes over time and expose paleontological resources, leaving them vulnerable to theft or vandalism. Agents of erosion include wind, water, ice, downslope movement, animals and/or people walking in the area, and vehicles.

3.4.4.2 What Mitigation Is Available to Minimize, Avoid, or Compensate for Potential Project Impacts to Paleontological Resources?

The need for mitigation to protect paleontological resources would be determined on a project-specific basis, after appropriate assessments have been completed and before any construction activities associated with the proposed project begin. This approach should be based on the current fossil management practices and policy goals of the BLM, FS, NPS, USFWS, and BOR as presented in the document entitled *Collection, Storage, Preservation, and Scientific Study of Fossils from Federal and Indian Lands* (DOI 1999); and from procedures set forth in agency manuals and handbooks (e.g., BLM 1998a,b; FS 1996; NPS 2006a). Potential mitigation measures may include:

- An initial scoping assessment conducted in coordination with the appropriate agency's paleontology specialist. The assessment would determine whether the construction activities associated with the proposed project would disturb sedimentary bedrock or fossil-yielding alluvium that may contain significant paleontological resources. If the scoping assessment finds that the proposed project would not disturb sedimentary bedrock or potentially fossil-yielding alluvium, there would be no need for further analysis.

- If the scoping assessment were to find that construction activities may disturb sedimentary bedrock or potentially fossil-yielding alluvium, an analysis would be conducted of existing data, such as geologic maps, classifications of geologic units (formations), and other data (including aerial photos, GIS-based locality data, soils maps, and scientific literature). At this stage, the PFYC system or an equivalent system in use by other agencies would be used to categorize the potential for geologic units to contain important fossils within the area of the proposed project. The PFYC system categories could assist in determining the appropriate level of mitigation that may be necessary for approval of a project.

- If the analysis of existing data determines that a proposed project would disturb only geologic units (formations) with a PFYC Class 1 or 2 and no significant fossil localities are known to occur in the area, the project file would be documented and no additional characterization work would be necessary.

- An analysis of existing data that determines that a proposed project has the potential to disturb geologic units (formations) with a PFYC Class 3, 4, or 5, or potentially fossil-bearing alluvium, or other known significant fossil localities would warrant additional field surveys and/or mitigation measures. Mitigation measures could include altering the location or scope of the proposed project, conducting a field survey prior to authorizing activities, and conducting on-site monitoring to properly document and recover any fossil material and data found. The preferred course of action should be to avoid the potential impact by moving or rerouting the site of construction or removing or reducing the need for surface disturbance. When avoidance is not possible, excavation or collection (data recovery) and stabilization measures should be implemented, such as erecting protective barriers and signs or taking other physical and administrative protection measures.

- A paleontologist within the appropriate federal agency or a project paleontologist holding a valid permit granted from the appropriate federal agency should conduct all field surveys. Small projects (generally less than 10 acres or 5 miles, if linear) should be surveyed at a very intense level, focusing on the areas likely to produce fossils (PFYC Class 4 and 5) within 200 feet of the proposed construction project location. Large projects (generally greater than 10 acres or 5 miles, if linear) should be surveyed at a lower intensity level and should include a 5 to 15% sampling of lower probability exposures (PFYC Class 3 and 4) within 200 feet of the proposed construction project.

- After completion of the field survey, the project paleontologist should file a written report with the appropriate agency for approval. The report should summarize the results of the survey with supporting geological and paleontological information. The report should also make recommendations for on-site monitoring or other mitigation (e.g., rerouting). If on-site monitoring is recommended, the project paleontologist should identify the specific locations to be monitored and the level of monitoring or sampling to be conducted.

- If fossil materials are discovered during project construction, all surface-disturbing activities in the vicinity of the find must cease until notification to proceed by the authorized officer. The site must be protected to reduce the risk of damage to fossils and context. Appropriate measures to mitigate adverse effects to significant paleontological resources would be determined by the authorized officer after consulting with the operator.

- All paleontological specimens found on federal lands remain the property of the U.S. government. Specimens, therefore, may only be collected by a qualified paleontologist under a permit issued by the appropriate federal agency and curated in an approved repository.

3.5 WATER RESOURCES

3.5.1 What Are the Groundwater and Surface Water Resources in the 11 Western States?

3.5.1.1 Groundwater Resources

There are about 26 major aquifer systems in the 11 contiguous western states (Figure 3.5-1). Each of these aquifers is unique in that the source, volume, and quality of water flowing through it depends on hydrogeological conditions present within the aquifer (e.g. hydraulic conductivity, effective porosity, and hydraulic gradient) and external factors, such as the rates of precipitation, recharge, evaporation, and transpiration; the location and hydrologic connection with streams, rivers, springs, reservoirs, and wetlands; and overlaying human activities. Table 3.5-1 lists the potentially affected aquifers and summarizes their distributions in different hydrologic regions (see Section 3.5.1.2) and geographic areas, and their water quality and uses.

In addition to the 26 major aquifer systems discussed above, the study area for this PEIS also includes sole-source aquifers (Table 3.5-2). Sole-source aquifers are federally designated groundwater resources. The EPA defines a sole- or principal-source aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. EPA's criteria for sole-source aquifer designation also provide that the area have no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2007a). The EPA's Sole Source Aquifer Program was established under Section 1424(e) of the U.S. Safe Drinking Water Act (SDWA). Determination of sole-source aquifer boundaries can be difficult because the designated area includes the surface area above the aquifer and its recharge area. Depending on their extent, some sole-source aquifers can extend across state boundaries.

If designated as a sole-source aquifer, proposed federal projects that are financially assisted and that have the potential to contaminate the aquifer are subject to EPA review. In many cases, MOUs have been established by the EPA with other agencies (e.g., the Federal Highway Administration, the Department of Housing and Urban Development, and the U.S. Department of Agriculture Rural Development in Wyoming) to establish a review of responsibilities under the Sole Source Aquifer Protection Program and to list categories of projects that should or should not be referred to the EPA for review. MOUs help ensure that projects that pose serious threats to groundwater quality are referred to the EPA.

Most projects referred to the EPA for review meet all federal, state, and local groundwater protection standards and are approved without imposing additional conditions. Occasionally, site- or project-specific concerns for groundwater quality protection lead to specific recommendations or additional pollution prevention requirements as a condition of funding. In rare cases, federal funding has been denied when the applicant has been either unwilling or unable to modify the project.

Special agency stipulations may apply to lands that have been designated with sole-source aquifers. For example, no surface-disturbing activities would be allowed within sole-source aquifer designated areas on BLM lands, unless an exception is granted for activities for which it can be demonstrated that the Proposed Action would not result in a negative impact to the aquifer.

In general, groundwater is found near the surface in the vicinity of substantial surface water bodies. In other areas (e.g., mountainous regions), groundwater can occur at great depths. When located at a shallow depth (i.e., on the order of tens of feet), groundwater is more

FIGURE 3.5-1 Principal Aquifer Systems in the 11 Western States

TABLE 3.5-1 Groundwater Resources in the 11 Western States

Hydrologic Region	Geographic Area	Principal Aquifer Systems	Aquifer Types	Major Water Uses	General Groundwater Quality
Pacific Northwest	Coastal areas of Oregon and Washington; semiarid Columbia Plateau in eastern Washington, Oregon, and southern Idaho	Columbia Plateau basaltic-rock and basin-fill aquifers, Pacific Northwest basaltic-rock and basin-fill aquifers, Snake River Plain basaltic-rock and basin-fill aquifers, Willamette Lowland basin-fill aquifers, Northern Rocky Mountains Intermontane Basins aquifer system, and the Puget Sound aquifer system	Bedrock and basin sediments	Domestic and irrigation	Generally good water quality. Elevated levels of nitrates and pesticides have been detected in some aquifers in Snake River Basin and the Columbia Plateau.
California	Entire state of California and parts of southern Oregon	Basin and Range basin-fill aquifers and carbonate-rock aquifers, California Coastal Basin aquifers, and Central Valley aquifer system	Sedimentary rocks (including carbonate rock) and basin sediments	Main source of water for domestic consumption and agricultural irrigation	Elevated TDS (total dissolved solids) levels from evaporate beds in southern California. Agricultural practices in central California combined with a high evaporation rate have resulted in elevated nitrates and pesticides in shallow groundwater systems and substantial declines in shallow groundwater tables.

TABLE 3.5-1 (Cont.)

Hydrologic Region	Geographic Area	Principal Aquifer Systems	Aquifer Types	Major Water Uses	General Ground Water Quality
Upper Colorado	Colorado Plateau in southern Wyoming, western Colorado, eastern Utah, northern Arizona, and New Mexico	Colorado Plateau aquifers, Denver Basin aquifer system, High Plains aquifer, and the Northern Rocky Mountains Intermontane Basins aquifer system	Sedimentary rocks	Major source of water for domestic and municipal uses	Groundwater quality is influenced by the nature of the bedrock. Elevated levels of TDS in areas of sedimentary rock. Mining may cause metal contamination in local groundwater.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Pecos River Basin alluvial aquifer, Rio Grande aquifer system, Roswell Basin aquifer system, Basin and Range basin-fill and carbonate-rock aquifers, and the Colorado Plateau aquifers	Basin sediments and bedrock	Main source of water for domestic consumption and agricultural irrigation	Groundwater quality is influenced by the nature of the bedrock. Elevated TDS and salinity in alluvium or in areas with Late Tertiary sedimentary bedrock. Elevated metals in groundwater in mining areas. Good water quality in deep, carbonate aquifers. Irrigation and mine dewatering lowered the water levels in shallow groundwater in Arizona.
Rio Grande	Central New Mexico	Rio Grande aquifer system, Colorado Plateau aquifers, and the High Plains aquifer	Basin sediments	Irrigation, livestock watering, and domestic uses	Elevated nitrate in agricultural areas such as the San Luis and Rincon Valleys. Pesticides detected in agricultural and urban areas.

TABLE 3.5-1 (Cont.)

Hydrologic Region	Geographic Area	Principal Aquifer Systems	Aquifer Types	Major Water Uses	General Ground Water Quality
Missouri	Most of Montana, northern and eastern Wyoming, and northeastern Colorado	Northern Rocky Mountains Intermontane Basins aquifer system, Colorado Plateau aquifers, and the High Plains aquifer	Igneous rocks and basin sediments	Primarily for irrigation. Other uses include municipal and domestic water supplies	Generally good water quality. Elevated levels of sulfate and metals found in local groundwater near mining areas. Elevated concentrations of nutrients and pesticides in shallow alluvial groundwater near agricultural areas.
Great Basin	Central and northern Nevada and western Utah	Basin and Range basin-fill and carbonate-rock aquifers, Colorado Plateau aquifers, and the southern Nevada volcanic-rock aquifers	Basin sediments and bedrock	Domestic consumption, irrigation, and power plant cooling	Groundwater quality is influenced by the nature of the bedrock. Good water quality in carbonate rock and sandstone aquifers. Elevated levels of salts and TDS in the central parts of basins; elevated metal concentrations in historic mining areas; and elevated nitrate and pesticide concentrations in shallow groundwater in agricultural areas.
Arkansas White-Red	Colorado, New Mexico	High Plains	Basin sediments	Irrigation	Generally good. Dissolved solid concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively large recharge rates in areas of sandy soil that contains few soluble minerals.
Texas-Gulf	New Mexico	High Plains	Basin sediments	Irrigation	Not known.[a]

[a] Data for the Texas-Gulf hydrologic region is incomplete (Jantzen 2005).

Source: BLM (2005a).

TABLE 3.5-2 Sole-Source Aquifers in the 11 Western States

Sole-Source Aquifer	Location
Spokane Valley-Rathdrum Prairie Aquifer	WA/ID
Camano Island Aquifer	WA
Whidbey Island Aquifer	WA
Cross Valley Aquifer	WA
Newberg Area Aquifer	WA
Troutdale Aquifer System	WA
North Florence Dunal Aquifer	OR
Cedar Valley Aquifer	WA
Lewiston Basin Aquifer	WA/ID
Eastern Snake River Plain Aquifer	ID/WY
Central Pierce County Aquifer System	WA
Marrowstone Island Aquifer System	WA
Vashon-Maury Island Aquifer System	WA
Guemes Island Aquifer System	WA
Upper Santa Cruz & Avra Basin Aquifer	AZ
Bisbee-Naco Aquifer	AZ
Fresno County Aquifer	CA
Santa Margarita Aquifer, Scotts Valley	CA
Campo/Cottonwood Creek	CA
Ocotillo-Coyote Wells Aquifer	CA
Glen Canyon Aquifer	UT
Castle Valley Aquifer	UT
Western Unita Arch Paleozoic Aquifer System	UT
Missoula Valley Aquifer	MT
Elk Mountain Aquifer	WY
Española Basin Aquifer System	NM

Sources: EPA (2006, 2007a,b,c,d, 2008).

susceptible to adverse impacts associated with construction, maintenance, and dismantling activities; surface spills; and changes in recharge.

3.5.1.2 Surface Water Resources

Surface Water Availability and Quality. There are nine hydrologic regions identified in the 11 contiguous western states: Pacific Northwest, California, Upper Colorado, Lower Colorado, Rio Grande, Missouri, Great Basin, Arkansas-White-Red, and Texas-Gulf (BLM 2005a). These regions are shown in Figure 3.5-2 and described in Table 3.5-3. The hydrologic landscape regions (HLRs) of each region are shown in Figure 3.5-3. HLRs are used by the USGS to group watersheds in the United States according to their similarity in landscape and climatic characteristics (USGS 2006). Additional details on HLRs are found in Section 3.5.2.2.

The quality of surface water is as important as its quantity. The quality of surface water is primarily influenced by the presence of sediment, microbes, pesticides, nutrients, metals, and radionuclides (BLM 2005a). Surface water quality is also affected by solar radiation and shade-producing vegetation that affect water

FIGURE 3.5-2 Hydrologic Regions for the 11 Western States (Source: BLM 2005a)

TABLE 3.5-3 Hydrologic Regions and Surface Water Conditions in the 11 Western States

Hydrologic Region	Geographic Area	Major River Systems	Typical Stream Types and Common HLRs[a]	Precipitation and Recharge	General Surface Water Quality
Pacific Northwest	Oregon, Washington, most of Idaho, and northwestern Montana; very small portions of northern Nevada and northwestern Wyoming	Columbia River, Willamette River, Snake River	Mountainous areas: stream Types A and G; HLRs 19 and 20 Coastal areas: stream Types C, E, and F; HLR 2	Areas west of the Cascade Mountains have medium to high rainfalls. Precipitation decreases east of the Cascades, and stream flow is driven primarily by snowmelt or groundwater discharge.	Agricultural areas degraded by nutrients (nitrates and phosphates) and pesticides from agricultural and grazing practices. Aquaculture has also contributed to elevated nutrients in Washington.
California	Most of California and very small portions of southern Washington and western Nevada	Sacramento River, San Joaquin River	Stream Types B, C, D, E, F, and G; HLRs 11, 14, and 16	Precipitation occurs primarily in winter, with prolonged summer periods of little rainfall. Stream flow derived primarily from spring snowmelt.	Elevated TDS levels from high salinity due to irrigation practices and arid climate. Agricultural practices in central California have resulted in elevated nutrients and pesticides.
Upper Colorado	Southwestern Wyoming, western and southwestern Colorado, eastern Utah, northeastern Arizona, and northwestern New Mexico	Upper Colorado River	Stream Types B, C, D, E, F, and G; HLRs 12, 14, 16, and 18	Precipitation varies with elevation and includes winter snow storms and heavy fall rainstorms, with most stream flow dominated by snowmelt in the mountains.	Generally good water quality except in historic mining areas and in agricultural areas. Areas of sedimentary rock may have high levels of TDS, radon, uranium, and other metals.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Lower Colorado River	Stream Types B, C, D, E, F, and G; HLRs 11, 12, 14, and 18	This region is arid, with precipitation limited to winter months and periods of heavy storms. Stream flow is largely absent except in winter or after major storms. High erosion rates common in areas with grazing livestock.	Elevated TDS in areas with agriculture and grazing, and metals in mining areas.

TABLE 3.5-3 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Typical Stream Types and Common HLRs[a]	Precipitation and Recharge	General Surface Water Quality
Rio Grande	Central New Mexico and a portion of south-central Colorado	Rio Grande River, Pecos River	Stream Types B, C, D, E, F, and G; HLRs 12, 14, and 18	An arid region with precipitation limited to winter months and periods of heavy storms. Stream flow derived from spring snowmelt and summer monsoon thunderstorms.	Elevated TDS, and nutrient and pesticide contamination in agriculture areas. Upper reaches of the Rio Grande have elevated levels of metals in mining areas attributed to the Creede mining district of southern Colorado.
Missouri	Most of Montana, northern and eastern Wyoming, and northeastern Colorado	Missouri River, Platte River	Stream Types B, C, D, E, F, and G; HLRs 8, 12, 13, and 18	Precipitation generally sparse in summer and fall, with stream flow derived from snowmelt in mountainous areas, and in summer and fall from groundwater discharge.	Good water quality in high Rocky Mountains. Quality degrades as streams enter plains and valleys, where agricultural practices and urban runoff impact water quality. Mining and oil extraction make locally increased TDS and metals concentrations, while grazing contributes sediments and nutrients.
Great Basin	Central and northern Nevada, western Utah, and very small portions of southwestern Wyoming; southeastern Idaho, southeastern Oregon	Humbolt River, Truckee River	Stream Types B, C, E, F, and G; HLRs 14, 15, and 18	Arid region located in rain shadow of the Sierra Nevada Mountains. Surface water flow in basins derived from rain and snow falling in mountain areas.	Poor water quality in areas near urban centers; elevated metal concentrations in historic mining areas. Near-surface rocks naturally contribute arsenic, uranium, and radon to surface waters.
Arkansas White-Red	Colorado, New Mexico	Arkansas, Canadian, and Red River	Stream types B, C, D, E, F, and G; HLRs 3, 6, 8, 10, 12, 13, 14, and 17	Sparse in summer and fall. Stream flow derived from snowmelt in the mountainous areas.	Surface water quality is typically moderate in this region, and poor in areas with extensive agricultural or livestock production.

TABLE 3.5-3 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Typical Stream Types and Common HLRs[a]	Precipitation and Recharge	General Surface Water Quality
Texas-Gulf	New Mexico	Running Water Draw, Black Water Draw, Yellow House Draw, Lost Draw, Sulphur Springs Draw, Mustang Draw, Monument-Seminole Draw[b]	Stream types B, C, D, E, F, and G; HLRs 5 and 10	An arid region with precipitation limited to winter months and periods of heavy storms. Stream flow derived from spring snowmelt and summer monsoon thunderstorms.	Not known.[c]

[a] HLRs: 2 = humid plains with highly permeable soils and permeable bedrock; 5 = arid plains with permeable soils and bedrock; 6 = subhumid plains with impermeable soils and bedrock; 8 = semiarid plains with impermeable soils and bedrock; 10 = arid plateaus with impermeable soils and permeable bedrock; 11 = humid plateaus with impermeable soils and bedrock; 12 = semiarid plateaus with permeable soils and impermeable bedrock; 13 = semiarid plateaus with impermeable soils and bedrock; 14 = arid playas with permeable soils and bedrock; 15 = semiarid mountains with impermeable soils and permeable bedrock; 16 = humid (low relief) mountains with permeable soils and impermeable bedrock; 17 = semiarid mountains with impermeable soils and bedrock; 18 = semiarid mountains with permeable soils and impermeable bedrock; 19 = very humid mountains with permeable soils and impermeable bedrock; 20 = humid (high-relief) mountains with permeable soils and impermeable bedrock (USGS 2006).

See Section 3.5.2.2 for a description of stream types.

[b] Source: New Mexico State University (2007).

[c] Data for the Texas-Gulf hydrologic region is incomplete (Jantzen 2005).

FIGURE 3.5-3 Hydrologic Landscape Regions for the 11 Western States (Sources: BLM 2005a; USGS 2006)

temperature, flow, total suspended solids (TSS), TDS, turbidity, and changes in dissolved oxygen, salinity, and acidity. Because of the spatial extent of the affected environment, water quality can vary considerably within the 11 contiguous western states. Figure 3.5-4 shows a map of water quality on BLM lands in the West, and Table 3.5-3 summarizes water quality within each hydrologic region of the 11 western states.

Susceptibility of Surface Water Resources to Change. Surface water resources can be described in general terms regarding the susceptibility or sensitivity of the resources to changes in channel morphology or quality. The sensitivity of a surface water resource can be characterized by combining information provided by HLR data and the Rosgen classification system (EPA 1996). The Rosgen classification system describes stream types using three parameters: Valley Type, Level I classification, and Level II classification. Classifying streams using this system aids the understanding of stream conditions and potential behavior under the influence of different types of changes, such as those that would occur during construction, operation, maintenance, and decommissioning and dismantling of energy infrastructures such as oil and gas pipelines, electricity transmission lines, and other energy infrastructures.

The Rosgen classification system can be used to provide insight into the susceptibility of surface water resources to changes in channel morphology produced by future construction, maintenance, and decommissioning of energy transport projects. In general, stream types C, D, E, F, and G are the most susceptible to change (e.g., changes in stream morphology, rates of bed and bank erosion and aggradation, etc.). These stream types are often found in Valley Types 3 through 11 (Table 3.5-4). Stream Type G is also found in Valley Types 1 and 2. Additional details on the Rosgen classification system are discussed in Section 3.5.2.2.

Wild and Scenic Rivers. Surface water that are classified as wild and scenic rivers are of particular concern with regard to impacts. The Wild and Scenic Rivers Act (P.L. 90–542 as amended; 16 USC 1271–1287), enacted in October 1968, provides a national policy and program to preserve and protect selected rivers, or segments of rivers, in their free-flowing condition in the national system. The Act states that certain selected rivers of the nation, which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. Proposed energy corridors licensed other than under the Federal Power Act are not automatically precluded. However, any other federally assisted water resources project (e.g., a project with proposed construction within a river's bed or its banks) is subject to review and an affirmative determination that such proposal may proceed by the federal river-administering agency. The Act also states that each component of the National Wild and Scenic Rivers System shall be administered in such a manner as to protect and enhance its values, without limiting other uses that do not substantially interfere with public use and enjoyment of these values.

The protection of a designated wild and scenic river depends on the administrating agency of the river and the administrating agency of the land where the river is located (USFS 2008). For rivers designated using Section 2(a)(ii) of the Wild and Scenic Rivers Act, the state is responsible for providing protection except on federally administered lands.

For federally administered rivers, the federal agency is responsible for providing the protection. A state's responsibilities include:

- Regulating and enforcing fishing and hunting regulations.

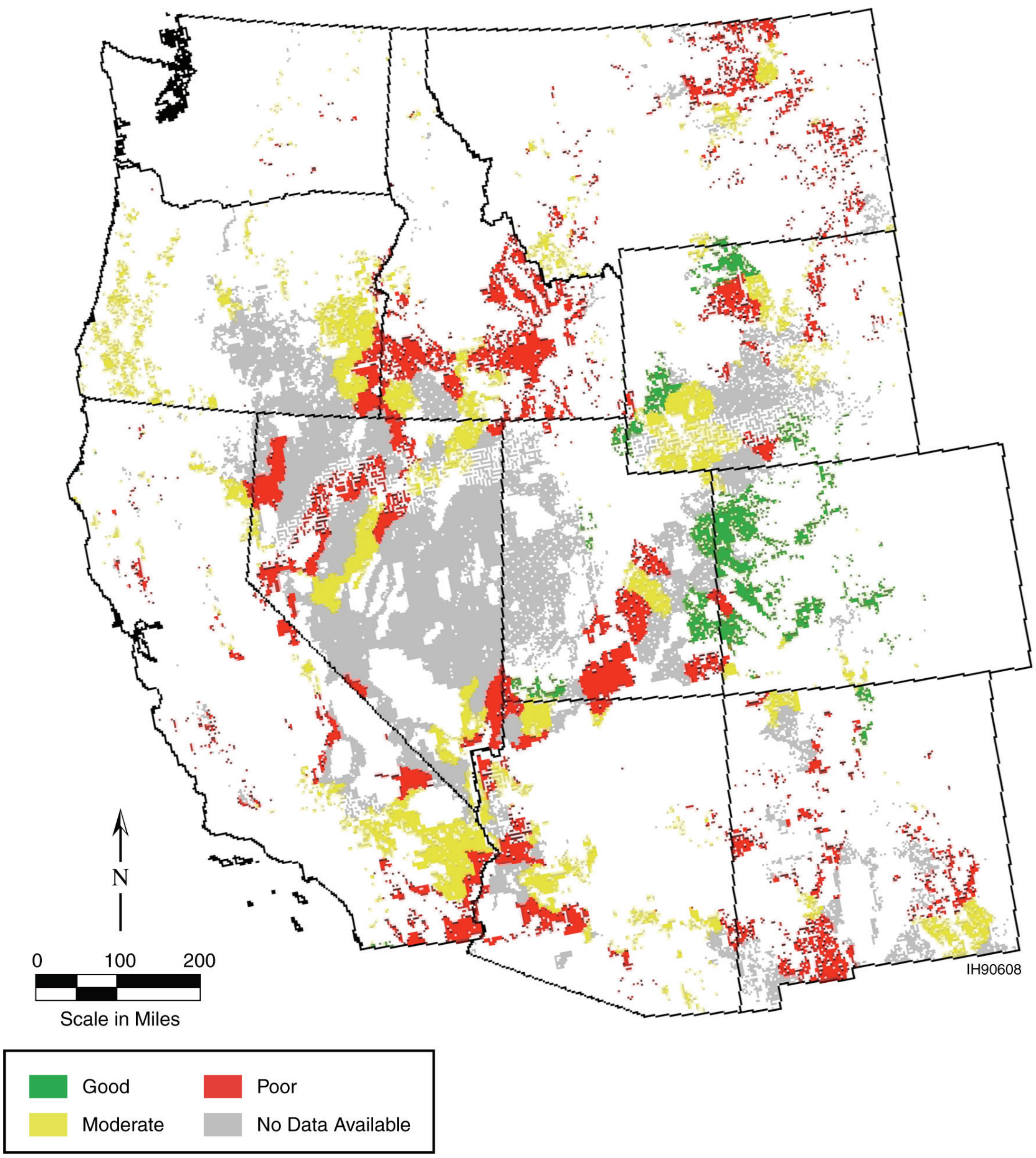

FIGURE 3.5-4 Water Quality on BLM Lands in the 11 Western States (Source: BLM 2005a)

TABLE 3.5-4 Valley Types for Stream Classification

Valley Type	Characteristics	Level I Stream Types
1	V-shaped, confined, and often structurally controlled and/or associated with faults. Elevation relief is high, valley floor slopes are greater than 2%, and landforms may be steep, glacially scoured lands and/or highly dissected fluvial slopes.	Aa^{+}, A, and G
2	Moderate relief, relatively stable, moderate side slope gradients, and valley floor slopes that are often less than 4% with soils developed from parent material (residual soils), alluvium, and colluvium.	B (sometimes G in transition)
3	Debris-colluvial or alluvial fan landforms, and valley-floor slopes that are moderately steep or greater than 2%.	A, B, G, and D
4	Classic meandering, entrenched, or deeply incised and confined landforms directly observed as canyons and gorges with gentle elevation relief and valley-floor gradients often less than 2%.	F and C
5	Product of a glacial scouring process in which the resultant trough is now a wide, “U”-shaped valley, with valley-floor slopes generally less than 4%.	C, D, and G
6	Termed a fault-line valley, is structurally controlled and dominated by colluvial slope-building processes. The valley-floor gradients are moderate, often less than 4%.	B, C, F, and G
7	Steep to moderately steep landform, with highly dissected fluvial slopes, high drainage density, and a very high sediment supply. Streams characteristically are deeply incised in either colluvium and alluvium or residual soils.	A and G
8	Presence of multiple river terraces positioned laterally along broad valleys with gentle, down-valley elevation relief. Alluvial terraces and floodplains are the predominant depositional landforms, which produce a high sediment supply.	C and E
9	Glacial outwash plains and/or dunes, where soils are derived from glacial, alluvial, and/or aeolian deposits.	C and D
10	Very wide, with very gentle elevation relief. Mostly constructed with alluvial materials originating from both riverine and lacustrine deposition processes.	C, E, and DA
11	A unique series of landforms consisting of large river deltas and tidal flats constructed of fine alluvial materials originating from riverine and estuarine depositional processes.	DA and D

Source: EPA (1996).

- Adjudicating water rights and appropriation.
- Developing and administrating water quality standards.
- Administering state land use regulations on nonfederal lands.
- Managing state lands and facilities along the river (state highways, parks, forests, etc.).

Designated Rivers. The National Wide and Scenic Rivers System is comprised of selected rivers that Congress authorizes for inclusion (designation by Congress) or that are designated as wild, scenic, or recreational rivers by the state legislatures through which they flow and approved by the Secretary of the Interior (Section 2(a)(ii) of the Act). The former is assigned to be administrated either to the Secretary of the Interior or the Secretary of Agriculture through its agencies (e.g., BLM, BOR, FS, etc.), while the latter is administered by the state. If a river or a segment of river is included in the system, it must be classified, designated, and administered as a wild, scenic, or a recreational river area. A comprehensive management plan would be installed.

Figure 3.5-5 shows a map of wild and scenic river segments within the 11 contiguous western states. These rivers and segments are listed in Table O-1 and O-2 in Appendix O. Table O-2 identifies the specific classifications (wild, scenic, and recreational) for each designated river segment.

Congressionally Authorized Wild and Scenic Study Rivers. Besides the directly designated rivers, the Secretary of the Interior, or the Secretary of Agriculture, or the Secretaries jointly could submit to the President additional rivers suitable for addition to the National Wild and Scenic Rivers System. The President must make recommendations and proposals to Congress for the rivers as potential additions. Among these potential additions, those authorized by Congress for studies would be provided statutory protection under the National Wide and Scenic Rivers System (NWSRS 2003). Congressionally authorized study rivers are afforded statutory protection under Section 7(b) of the NWSRS for a 3-year period after the report is submitted to the Congress. Analogous to designated rivers, this provision protects the congressionally authorized study rivers from the harmful effects of water resources projects (for any part of a project proposed for construction within a study river's bed or its banks). While there are 15 such rivers in the affected states (a list of the study rivers is provided in Table O-4), no energy crossings are proposed or proximate (within 5 miles) to these rivers (Diedrich 2008).

Federal Agency Protected Rivers. Section 5(d)(1) of the NWSRS directs each federal agency to identify potential additions to the National Wild and Scenic Rivers System through agency planning processes. Such rivers are not, however, provided statutory protection through the NWSRS. Each federal agency provides protection to the study river's free-flowing condition, outstandingly remarkable values, and classification through guidance in its respective policy and through other authorities. Forest Service policy is located in Forest Service Handbook 1909.12, Chapter 80.

Floodplains and Ephemeral Streams. Surface water resources of the affected environment also include numerous floodplains and ephemeral streams (i.e., streams that carry water only briefly in direct response to precipitation). Floodplain maps are usually prepared for populated areas that can experience flooding. These maps are generally prepared by the Federal Emergency Management Agency (FEMA) for floods that statistically have a 1% chance of occurring each year (i.e., 100-year flood events). Such maps are used for property insurance purposes (FEMA 2006). Because the

NO.	NAME
1	Big Marsh Creek Wild and Scenic River
2	Big Sur Wild and Scenic River
3	Cache la Poudre Wild and Scenic River
4	Chetco Wild and Scenic River
5	Clackamas Wild and Scenic River
6	Clarks Fork of the Yellowstone Wild and Scenic River
7	Crescent Creek Wild and Scenic River
8	Crooked Wild and Scenic River
9	Deschutes Wild and Scenic River
10	Donner Und Blitzen Wild and Scenic River
11	Eagle Creek Wild and Scenic River
12	East Fork Jemez Wild and Scenic River
13	Eel Wild and Scenic River
14	Elk Wild and Scenic River
15	Elkhorn Creek Wild and Scenic River
16	Flathead Wild and Scenic River
17	Grande Ronde Wild and Scenic River
18	Illinois Wild and Scenic River
19	Imnaha Wild and Scenic River
20	John Day Wild and Scenic River
21	Joseph Creek Wild and Scenic River
22	Kern Wild and Scenic River
23	Kings Wild and Scenic River
24	Klamath Wild and Scenic River
25	Klickitat Wild and Scenic River
26	Little Deschutes Wild and Scenic River
27	Lostine Wild and Scenic River
28	Lower American Wild and Scenic River
29	Malheur Wild and Scenic River
30	McKenzie Wild and Scenic River
31	Merced Wild and Scenic River
32	Metolius Wild and Scenic River
33	Middle Fork Clearwater Wild and Scenic River
34	Middle Fork Feather Wild and Scenic River
35	Middle Fork Salmon Wild and Scenic River
36	Minam Wild and Scenic River
37	Missouri Wild and Scenic River
38	North Fork American Wild and Scenic River
39	North Fork Crooked Wild and Scenic River
40	North Fork John Day Wild and Scenic River
41	North Fork Malheur Wild and Scenic River
42	North Fork Owyhee Wild and Scenic River
43	North Fork Sprague Wild and Scenic River
44	North Fork of Middle Fork Willamette Wild and Scenic River
45	North Powder Wild and Scenic River
46	North Umpqua Wild and Scenic River
47	Owyhee Wild and Scenic River
48	Pecos Wild and Scenic River
49	Powder Wild and Scenic River
50	Quartzville Creek Wild and Scenic River
51	Rapid Wild and Scenic River
52	Rio Chama Wild and Scenic River
53	Rio Grande Wild and Scenic River
54	Roaring Wild and Scenic River
55	Rogue Wild and Scenic River
56	Saint Joe Wild and Scenic River
57	Salmon Wild and Scenic River
58	Sandy Wild and Scenic River
59	Sespe Creek Wild and Scenic River
60	Sisquoc Wild and Scenic River
61	Skagit Wild and Scenic River
62	Smith Wild and Scenic River
63	Snake Wild and Scenic River
64	South Fork John Day Wild and Scenic River
65	Squaw Creek Wild and Scenic River
66	Sycan Wild and Scenic River
67	Trinity Wild and Scenic River
68	Tuolumne Wild and Scenic River
69	Upper Rogue River Wild and Scenic River
70	Verde Wild and Scenic River
71	Wallowa Wild and Scenic River
72	Wenaha Wild and Scenic River
73	West Little Owyhee Wild and Scenic River
74	White Salmon Wild and Scenic River
75	White Wild and Scenic River

FIGURE 3.5-5 Wild and Scenic River Segments in the 11 Western States

11 western states under study in this PEIS have large areas that have not been evaluated for 100-year flood potential, affected environments and future project-specific impacts will need to be addressed during site-specific project work. As with floodplains, stream channels for ephemeral surface water resources have not been mapped completely for the 11 western states.

3.5.2 How Were the Potential Impacts of Corridor Designation and Land Use Plan Amendment on Water Resources Evaluated?

3.5.2.1 How Were Potential Impacts on Groundwater Evaluated?

The first step used to evaluate potential impacts to groundwater resources was to identify groundwater resources (aquifers) in the 11 western States (Section 3.5.1.1). This identification was made at a regional scale using USGS data available in Anderson and Woosley (2005) and a USGS database (USGS 2003). Next, aquifers that would be crossed by the designated energy corridors under the Proposed Action were identified by overlaying the designated corridors onto the aquifer locations. Intercepts for the groundwater resources were performed only for the 26 major aquifer systems discussed in Section 3.5.1.1. Intercepts with sole-source aquifers in the western states were not identified because maps showing the extent of sole-source aquifers and their recharge areas were not available for all of the states concerned.

The analysis performed for this PEIS identified which aquifers would underlay the proposed corridors and could thus be potentially affected by surface activities associated with the development of energy transport systems in the corridors. In addition, the analysis estimated the area of each aquifer that would be affected. The potential area of impact is an important metric for each aquifer because it can be used as a measure of potential contamination produced by surface activities. Under the No Action Alternative, transport project ROWs might be located throughout the West; it is, therefore, not possible at the programmatic level to identify specific aquifer systems that would be crossed by future project ROWs.

Next, impacting factors were determined for three general corridor development activities: construction (e.g., groundwater extraction, land disturbance caused by trenching operations, clearing operations, compaction produced by vehicular traffic, material storage, accidental spills, etc.), normal operations and maintenance (including unintentional spills), and decommissioning and dismantling. To provide conservative results (i.e., impacts that would be greater than those under actual field conditions), all potential projects were assumed to occur at the same time.

The potential effects of corridor development on groundwater resources were then qualitatively evaluated for each of the alternatives. Quantitative evaluations of impacts to groundwater were not possible for this PEIS because such evaluations would require site-specific and project-specific information that would be obtainable only during an associated project phase. It should be noted that energy transport projects might cross federal and nonfederal lands that are not designated in the Proposed Action. Potential impacts from these areas are not evaluated in this PEIS because their locations have not been determined. They should be evaluated at the project level.

3.5.2.2 How Were the Potential Surface Water Impacts Evaluated?

As with the groundwater analysis, the first step used to evaluate impacts to surface water was to identify surface water resources that would occur within the designated corridors under the Proposed Action. These surface water resources were identified by using hydrologic region information available from the BLM

(BLM 2005a) and other appropriate databases (ESRI 2004). As with groundwater resources discussed in Section 3.5.2.1, energy transport projects might cross federal and nonfederal lands that are not designated in the Proposed Action. Potential impacts from these areas are not evaluated in this PEIS because their locations have not been determined. They should be evaluated at the project level.

HLRs (Wolock et al. 2004; USGS 2006) were used to identify surface water resources in the 11 western states that have similar characteristics. The USGS (USGS 2006) has used HLRs to classify landforms on the basis of land-surface form, geologic texture, and climate. The 20 HLRs in the 11 western states are shown in Figure 3.5-3.

Surface water resources can be further delineated using the Rosgen stream type classification system to evaluate the susceptibility of the resources to change (EPA 1996). The Rosgen system describes stream types with three designators: valley type, Level I classification, and Level II classification. Only the first two designators were used in this study. Level II identifiers within the Rosgen classification system provide more detailed morphological descriptions of stream types from field measurements of channel form and bed composition. Level II classifications are better suited for project-specific analyses that would be used for future project development work.

Valley type, the first Rosgen identifier, is based on the physical characteristics of a valley including such parameters as relief, valley-floor slope, scouring, drainage, and soil type. There are 11 valley types defined in the Rosgen stream type classification system (EPA 1996). Valley type can provide a basis for an initial indication of river morphology within a valley. Table 3.5-4 lists the 11 valley types in the Rosgen stream type classification system and their identifying characteristics.

The second identifier in the Rosgen stream type classification system is Level I. The Level I characterization is based on stream characteristics that result from relief (i.e., topography), landform, and valley morphology. Nine major stream categories are included in the Level I classification. These stream types are shown in Figure 3.5-6 and linked to valley types in Table 3.5-4.

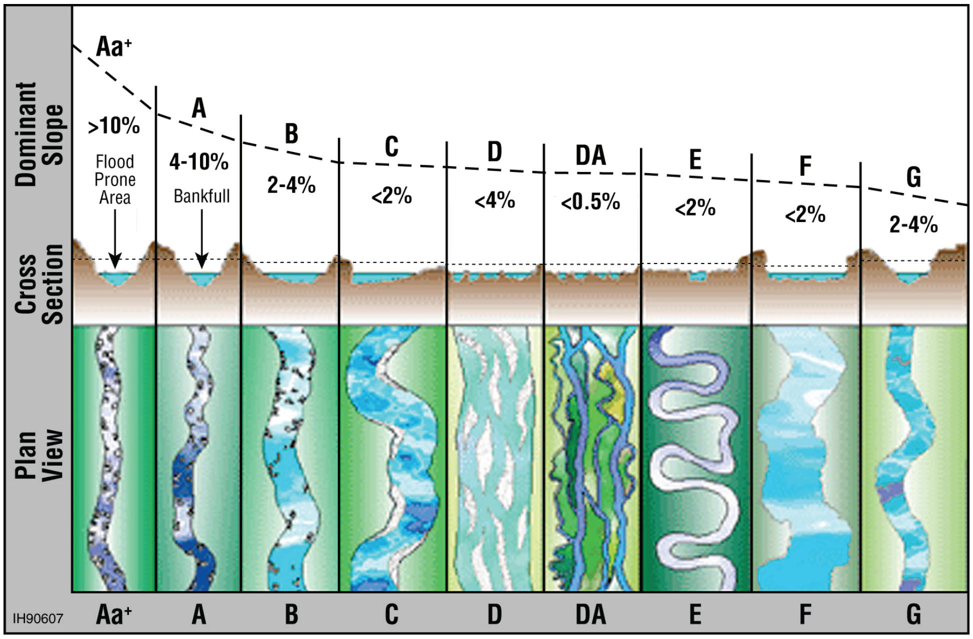

FIGURE 3.5-6 Nine Categories of Level I Streams (Source: EPA 1996)

Stream types Aa^+, A, and B are relatively stable with respect to changes in aggradation (i.e., build up in bed or bank material due to deposition of sediment) and erosion. The channel aggradation/degradation and lateral extension processes, notably active in C-type streams, depend inherently on the natural stability of stream banks, the existing upstream watershed conditions, and the flow and sediment regime. C-type channels can be significantly altered and rapidly destabilized when the effects of imposed changes in bank stability, watershed condition, or flow regime are combined to cause an exceedance of a channel stability threshold. In D-type streams, bank erosion rates are characteristically high, and meander width ratios are very low.

Sediment supply is generally unlimited, and bed features are the result of a convergence/ divergence process of local bed scour and sediment deposition. Aggradation and lateral extension are dominant channel adjustment processes occurring within a range of landscapes from desert to glacial outwash plains. The DA stream type is a multiple-thread channel system that has a very low stream gradient and a bank-full width that is very variable. Such stream types are not seen often. DA stream banks are frequently composed of fine-grained cohesive materials, support dense-rooted vegetation species, and are extremely stable. Channel slopes are very gentle, commonly found to be at or less than 0.0001. Lateral migration rates of the individual channels are very low except for infrequent avulsion. Relative to the D stream type, the DA stream type is considered to be a stable system composed of multiple channels. E-type streams (i.e., evolutionary) are considered highly stable systems, provided that the floodplain and low channel width/depth characteristics are maintained; they are very sensitive to disturbance and can rapidly adjust and convert to other stream types in relatively short time periods.

F-type stream channels can develop very high bank erosion rates, lateral extension rates, significant bar deposition, and accelerated channel aggradation and/or degradation while providing for very high sediment supply and storage capacities. The G-type streams (i.e., gullies) have very high bank erosion rates and a high sediment supply. Channel degradation and side slope rejuvenation processes are typical.

Next, streams and other surface water features that would be crossed by federal energy corridors under the Proposed Action were identified by overlaying the proposed corridors onto the locations of the surface water features. This analysis identified those surface water features that would fall within the proposed corridors and thus could be affected by energy transport systems in the corridors, should such development occur (e.g., Tables 3.5-6 and 3.5-7). A second overlay was made to identify the associated HLR at the point of stream interception (e.g., Appendix O, Table O-3). Because under No Action, ROWs may be located throughout the West, it is not possible at the programmatic level to identify which surface waters could be crossed by potential project ROWs.

Given the HLR at the point of stream interception, potential stream types can be approximately estimated combining information presented in Table 3.5-3 and the crossing streams (e.g., Table O-3 under the Proposed Action). Stability characteristics for the streams can then be characterized and used to assess potential impacts of construction, operation, maintenance, and decommissioning and dismantling of energy infrastructure in Section 368 energy corridors in the 11 contiguous western states. More accurate results could be obtained if Rosgen valley type and Level I classification were made for the point of stream interception. Presently, no detailed maps are available at the scale needed to make such evaluations. However, such analyses should be incorporated for project-specific analyses that would be used for future project development work.

Next, impacting factors were determined for activities that could occur, should an energy transport project be developed within a designated corridor. These activities include construction (e.g., land disturbance caused by trenching operations, clearing operations, channelization, water extraction, inter/intra-basin water transfer, river bank structures, in-stream structures, compaction produced by vehicular traffic, material storage, accidental spills, etc.), normal operations and maintenance (including unintentional spills), and decommissioning and dismantling. To provide conservative results (i.e., impacts that would be greater than those under actual field conditions), all potential projects were assumed to occur at the same time.

The effects of potential corridor development on surface water resources were qualitatively evaluated, as described in the previous three paragraphs. It should be noted that the effects might extend to areas near energy transport project sites on federal and nonfederal lands that are not designated in the alternatives. Quantitative evaluations of impacts to surface water were not conducted, because such evaluations would require project- and site-specific information that would be obtainable only during an associated project phase.

3.5.3 What Are the Potential Impacts Associated with Corridor Designation and Land Use Plan Amendment?

3.5.3.1 No Action Alternative

Under No Action, there would be no impacts to water resources on federal or nonfederal lands from not designating Section 368 energy corridors on federal land.

If energy transport projects were developed and operated under No Action, water resources could be affected on federal and nonfederal lands where energy transport project-specific ROWs may be sited. Environmental impacts would be evaluated by each federal agency on an individual, case-by-case basis. The current application-permitting processes on federal lands would still require conducting environmental analyses to identify potential environmental impacts and developing mitigation measures that address any identified adverse impacts.

Groundwater. Under No Action, energy transport projects and their ROWs, if implemented, could occur throughout the 11 contiguous western states. Each project could adversely impact associated groundwater resources. A number of common impacts (Section 3.5.1) could occur along each individual project ROW as a result of construction (e.g., groundwater extraction, land disturbance caused by trenching and clearing operations, compaction produced by vehicular traffic, material storage, waste disposal, accidental spills, etc.), normal operations and maintenance (including unintentional spills), and decommissioning and dismantling. These activities could affect recharge to underlying aquifers, groundwater flow direction and volume, depth to groundwater, and degradation of groundwater quality in the event of inadvertent chemical spills or accidental pipeline releases of hazardous liquids.

In general, these impacts would be expected to be small, local, and temporary on the scale of this PEIS. However, impacts from a large hazardous material spill could produce groundwater impacts of greater magnitude and duration. The identification of the potential impacts would require site-specific analyses at the project level.

Surface Water. Implementation of each project under No Action could adversely impact surface water resources. Construction, normal operations and maintenance, and decommissioning and dismantling activities associated with each hypothetical project ROW could affect the volumetric flow of nearby surface water features; alter stream hydrographs (i.e., time-dependent flow patterns); increase channelization, erosion aggradation, and avulsion; and degrade water quality (e.g., by causing increases or decreases in sediment load, introducing soluble contaminants, causing changes in temperature, etc.). In general, these impacts would be expected to be small, local, and temporary on the scale of this PEIS. A large spill could result in impacts with a greater extent and magnitude, but identification of the impacts would require site-specific analyses at the project level.

3.5.3.2 Proposed Action

The designation of energy corridors under the Proposed Action is not expected to affect water resources in the 11 western states, although water resources could be impacted by development of energy transport projects within designated corridors. The following impact discussion addresses potential impacts to water resources from project development within the proposed corridors at the programmatic level. Potential impacts to water resources from future energy transport projects, if developed, would be addressed in detail in project-specific environmental analyses, and are outside the scope of this PEIS. It should be noted that energy transport project sites that are not designated in the Proposed Action might exist on federal and nonfederal lands. Potential impacts from these project sites are not evaluated in this PEIS because their locations have not been determined. They should be evaluated at the project level.

Groundwater. The energy corridors designated under the Proposed Action would overlay approximately 5,173 square miles of major aquifer systems on the 11 western states (Table 3.5-5). This area represents about 0.51% of total aquifer area in the 11 western states. The percentage of aquifers falling within the footprint of the corridors designated under the Proposed Action varies by state (Table 3.5-5), ranging from 0.01% of Paleozoic aquifers in Montana to about 2.65% of the Basin and Range basin-fill aquifers in Oregon. Because groundwater resources and characteristics beneath the corridors designated under the Proposed Action are very variable, potential impacts to groundwater resources from the development of the projects can be quantified only at the project-specific level.

In general, the potential impacts that could occur with future project construction activities, normal operations and maintenance, and decommissioning of the projects under the Proposed Action would be expected to be small, local, and temporary on the scale of this PEIS and similar to impacts experienced previously during similar construction activities on federal lands. However, impacts from a large accidental pipeline spill of hazardous liquids could be large and long-lasting.

Surface Water. Surface water resources that could be intersected by the energy corridors designated under the Proposed Action include perennial rivers and streams, man-made canals (e.g., the Los Angeles Aqueduct and the All American and Coachella Canals in California), lakes, reservoirs, ephemeral streams, and associated floodplains.

Under the Proposed Action, there could be 273 individual streams, rivers, man-made channels, and intermittent streams intersected by the energy corridors (Table 3.5-6). These intercepts are noncontiguous and can be widely spaced. All surface water intercepts could encompass about 412 linear miles of surface water features (Table 3.5-6). The greatest number of intercepted miles would occur in Nevada (93 linear miles); the least would occur in Washington (4 linear miles).

In addition to streams, rivers, and man-made canals, 30 lakes or reservoirs would be directly

TABLE 3.5-5 Major Western Aquifer Systems Intersected by Proposed Section 368 Energy Corridors

Major Aquifer of the 11 Western States	State	In-State Aquifer Area (square miles)	Area (square miles) of Aquifer within the Proposed Corridor Footprint	Percentage of In-State Aquifer Area within the Proposed Corridor Footprint
Basin and Range basin-fill aquifers	Arizona	37,673	304	0.81
	California	26,320	705	2.68
	Idaho	1,236	2	0.13
	Nevada	55,625	1,018	1.83
	Oregon	947	25	2.65
	Utah	24,453	179	0.73
Basin and Range carbonate-rock aquifers	Arizona	550	8	1.46
	California	861	3	0.39
	Nevada	9,777	82	0.84
	Utah	3,969	17	0.44
California Coastal Basin aquifers	California	10,165	2	0.02
Colorado Plateaus aquifers	Arizona	27,818	41	0.15
	Colorado	27,573	326	1.18
	New Mexico	24,617	51	0.21
	Utah	42,830	328	0.77
	Wyoming	18,634	173	0.93
Lower Cretaceous aquifers	Montana	2,723	1	0.03
	Wyoming	4,924	2	0.04
Lower Tertiary aquifers	Wyoming	22,409	72	0.32
Northern Rocky Mountains Intermontane Basins aquifer system	Idaho	6,380	4	0.07
	Montana	8,632	8	0.09
Pacific Northwest basaltic-rock aquifers	California	6,584	45	0.68
	Idaho	13,943	38	0.27
	Nevada	2,541	23	0.89
	Oregon	41,964	250	0.60
Pacific Northwest basin-fill aquifers	California	3,899	18	0.46
	Idaho	5,598	10	0.18
	Nevada	380	1	0.24
	Oregon	9,913	34	0.35
Paleozoic aquifers	Montana	3,274	0	0.01
	Wyoming	4,290	2	0.05

TABLE 3.5-5 (Cont.)

Major Aquifer of the 11 Western States	State	In-State Aquifer Area (square miles)	Area (square miles) of Aquifer within the Proposed Corridor Footprint	Percentage of In-State Aquifer Area within the Proposed Corridor Footprint
Pecos River Basin alluvial aquifer	New Mexico	512	2	0.37
Rio Grande aquifer system	New Mexico	21,546	81	0.38
Snake River Plain basaltic-rock aquifers	Idaho	9,488	67	0.70
	Oregon	96	0	0.02
Snake River Plain basin-fill aquifers	Idaho	4,732	62	1.32
Southern Nevada volcanic-rock aquifers	Nevada	1,952	3	0.13
Upper Cretaceous aquifers	Wyoming	4,818	13	0.26
Willamette Lowland basin-fill aquifers	Oregon	3,393	1	0.03
Other rocks	Arizona	47,951	252	0.52
	California	89,846	278	0.31
	Colorado	51,611	82	0.16
	Idaho	38,145	9	0.02
	Montana	92,051	68	0.07
	Nevada	40,285	288	0.71
	New Mexico	61,889	55	0.09
	Oregon	25,589	50	0.19
	Utah	13,331	54	0.40
	Washington	28,900	10	0.03
	Wyoming	30,615	28	0.09
Totals		1,017,254	5,173	0.51

TABLE 3.5-6 Named Streams and Canals Intersected by the Proposed Energy Corridors[a]

State	No. of Streams Intersected	Stream Names	Total Stream Length Intersected (miles)
AZ	36	Agua Fria R., Beaver Dam Wash, Big Bug Cr., Big Sandy R., Boulder Cr., Buck Mountain Wash, Burro Cr., Castanada Wash, Castle Dome Wash, Centennial Wash, Chevelon Canyon, Clayhole Wash, Colorado R., Copper Wash, Crozier Wash, Detrital Wash, Dutchman Draw, Fourth of July Wash, Gila Gravity Main Canal, Hualapai Wash, Hurricane Wash, Jackrabbit Wash, Johnson Wash, Kanab Cr., Miller Wash, Red Horse Wash, Sacramento Wash, Sycamore Cr., Tonto Cr., Tyson Wash, Vekol Wash, Verde R., Waterman Wash, West Chevelon Canyon, White Sage Wash, Willow Cr.	55
CA	24	All American Canal, Bear R., Carrizo Cr., Coachella Canal, Colorado River Aqueduct, Cottonwood Cr., Coyote Wash, Deep Cr., East Highline Canal, Homer Wash, La Posta Cr., Little Dixie Wash, Los Angeles Aqueduct, Lytle Cr., Mad R., Mojave R., Owens R., Palm Canyon Wash, Piute Wash, Sacramento R., Schulyler Wash, Secret Cr., South Fork Trinity R., Westside Main Canal	75
CO	41	Arkansas R., Badger Cr., Beaver Cr., Big Blue Cr., Blue R., Cebolla Cr., Cedar Cr., Clear Cr., Colorado R., Cottonwood Cr., Crooked Wash, Currant Cr., Deception Cr., Deep Channel Cr., Dolores R., Dripping Rock Cr., Dry Cr., Dry Fork Piceance Cr., East Fork Dry Cr., Fourmile Cr., Gunnison R., Hamilton Cr., Little Snake R., Lost Canyon Cr., Morapos Cr., Naturita Cr., Piceance Cr., Plateau Cr., Red Wash, Roan Cr., Rock Cr., Roubideau Cr., San Miguel R., South Arkansas Cr., Spring Cr., Stinking Water Cr., West Mancos R., White R., Williams Fork, Willow Cr., Wolf Cr.	52
ID	15	Beaver Cr., Birch Cr., Canyon Cr., Catherine Cr., Deep Cr., Milner Gooding Canal, North Cottonwood Cr., Picket Cr., Rabbit Cr., Sailor Cr., Salmon Falls Cr., Snake R., South Fork Coeur d'Alene R., Squaw Cr., X Canal	12
MT	14	Big Beaver Cr., Big Hole R., Big Pipestone Cr., Boulder R., Clark Fork, Flint Cr., Frying Pan Gulch, Junction Cr., Moose Cr., Prickly Pear Cr., Rock Cr., Sage Cr., Saint Regis R., Willow Cr.	21
NM	11	Betonnie Tsosie Wash, Burro Cienaga, Burro Draw, Cow Springs Draw, Escavada Wash, Farmington Glade, Nogal Canyon, Pecos R., Rio Puerco, Rio Salado, San Jose Arroyo	4

TABLE 3.5-6 (Cont.)

State	No. of Streams Intersected	Stream Names	Total Stream Length Intersected (miles)
NV	41	Big Spring Wash, Boulder Cr., California Wash, Carson R., Coal Mine Cr., Cottonwood Cr., Coyote Cr., Coyote Wash, Deer Cr., Duck Cr., Ellison Cr., Fortymile Wash, Granite Spring Wash, Gypsum Wash, Humboldt R., Jackson Wash, Jumbo Wash, Kane Springs Wash, Lava Beds Cr., Marys R., McDermitt Cr., Muddy R., Nelson Cr., Pahranagat Wash, Quinn R., Ragan Cr., Rock Cr., Rock Valley Wash, Salmon Falls Cr., Spring Cr., Steptoe Cr., Susie Cr., Tabor Cr., Topopah Wash, Toquop Wash, Town Cr., Truckee Canal, Truckee R., Washburn Cr., White R., Willow Cr.	93
OR	18	Burnt R., Clackamas R., Clear Cr., Cow Cr., Crooked Cr., Deep Cr., East Fork Dairy Cr., Evans Cr., Grave Cr., Jordan Cr., Malheur R., Oregon Canyon Cr., Owyhee R., Rattlesnake Cr., South Myrtle Cr., Succor Cr., Sycan R., Trout Cr.	16
UT	31	Bear Cr., Browns Wash, Brush Cr., Cliff Cr., Cottonwood Wash, East Canyon Wash, Floy Wash, Grassy Trail Cr., Green R., Hatch Wash, Johnson Wash, Kaibab Gulch, Little Grand Wash, Lost Spring Wash, Mill Cr., Moody Wash, Mud Spring Wash, Pack Cr., Paria R., Pine Valley Wash, Price R., Saleratus Wash, Sevier R., Soap Wash, Soldier Cr., Spanish Fork, Swasey Wash, The Big Wash, Thompson Wash, Virgin R., Wah Wah Wash	46
WA	6	Beckler R., Deception Cr., Entiat R., Nason Cr., South Fork Skykomish R., Tye R.	4
WY	36	Alkali Cr., Barrel Springs Draw, Bitter Cr., Black Butte Cr., Black Rock Cr., Blacks Fork, Bridger Cr., Casper Cr., Currant Cr., Deadman Wash, Dry Cr., East Fork Nowater Cr., Fivemile Cr., Foster Gulch, Greasewood Wash, Green R., Greybull R., Killpecker Cr., Kirby Cr., Little Bitter Cr., Medicine Bow R., Muddy Cr., North Barrel Springs Draw, Nowater Cr., Saint Marys Cr., Salt Sage Cr., Salt Wells Cr., Sand Cr., Sand Spring Cr., Separation Cr., Sevenmile Gulch, Smiths Fork, South Fork Casper Cr., South Fork Powder R., Sugar Cr., West Branch Willow Cr.	34
Totals	273	NA[b]	412

[a] Unnamed streams are not listed. Includes perennial and intermittent streams and canals completely crossed by a corridor, as well as those that may occur within the 3,500-ft corridor width but do not cross the corridor centerline.

[b] NA = not applicable.

intercepted by the proposed corridor footprints (Table 3.5-7). A few of them, such as the reservoirs of the Colorado River, may have multiple intercepts. Of these lakes and reservoirs, two potential intercepts are in Arizona (Bartlett Reservoir), 11 are in California, one in Colorado (Blue Mesa Reservoir), one in Idaho, one each in Montana and New Mexico, eight in Nevada, two in Oregon, four in Utah, and one in Wyoming (Flaming Gorge Reservoir).

Crossings of designated wild and scenic rivers by proposed energy corridors are of particular concern. The national wild and scenic rivers are classified and administered as one of the following (P.L. 90−542, as amended, 16 USC 1271−1287):

1. *Wild river areas.* Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

2. *Scenic river areas.* Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

3. *Recreational river areas.* Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

Three such crossings would occur under the Proposed Action (Figure 3.5-7). Two crossings would occur in Oregon (a scenic segment of the Clackamas River, and a scenic segment of the Sycan River) and one in California (a wild segment of the South Fork Trinity River). In Oregon, the total length of the wild and scenic rivers to be crossed would be about 1.5 miles, including about 0.70 and 0.76 miles on the Clackamas and Sycan Rivers, respectively. In California, the length of the South Fork Trinity River to be crossed would be 0.44 miles. The three wild and scenic river crossings are not in locally designated corridors.

Surface water bodies intercepted by the proposed corridor footprints could be subject to adverse impacts due to construction, operation, maintenance, and decommissioning and dismantling activities of any future projects. The degree of impact would be determined by existing conditions within the surface water body, the level classification and valley type for the stream, and the magnitude and type of impact resulting from the activity. Mitigation measures should protect the free-flowing condition, water quality, and outstandingly remarkable values of each designated river or congressionally authorized study river, consistent with the WSRA.

Under the Proposed Action, 273 potential intercepts of rivers, streams, man-made canals, and intermittent streams and another 30 intercepts of lakes and reservoirs would occur. These interceptions occur in a wide range of locations that have differing hydrologic, topographic, and physical properties, in addition to a number of different HLRs (see Appendix O). As shown in Figure 3.5-3, seven HLRs dominate stream intercepts in the 11 continuous western states: 5 arid plains with permeable soils and bedrock — about 9.83%, 10 acrid plateaus with impermeable soils and permeable bedrock — about 5.06%, 12 semiarid plateaus with permeable soils and impermeable bedrock — about 19.10%, 14 arid playas with permeable soils and bedrock — approximately 22.22%, 15 semiarid mountains with impermeable soils and permeable bedrock — about 10.39%, 17 semiarid mountains with permeable soils and bedrock — about 16.29%, and 18 semiarid mountains with permeable soils and impermeable bedrock — approximately 12.64%. The seven HLRs are generally located in semiarid/arid and/or moderate to steep relief (plateaus to mountains)

TABLE 3.5-7 Lakes and Reservoirs Intersected by the Proposed Energy Corridors[a]

State	Feature Name	Acres Intersected
Arizona	Bartlett Reservoir	102
	Colorado River (impounded)	153
California	Bristol Lake[b]	19
	Colorado River (impounded)	205
	Ford Dry Lake[b]	843
	Imperial Reservoir	92
	Ivanpah Lake[b]	2,122
	Loveland Reservoir	11
	Rollins Reservoir	4
	Shasta Lake	331
	Silver Lake[b]	94
	Stampede Reservoir	13
	Troy Lake[b]	1,140
Colorado	Blue Mesa Reservoir	204
Idaho	Coeur d'Alene Lake	3
Montana	Clark Canyon Reservoir	101
Nevada	Colorado River (impounded)	40
	Delamar Lake[b]	484
	Dry Lake[b]	777
	Great Salt Lake Desert[b]	954
	Lahontan Reservoir	289
	Unnamed Dry Lake[b]	255
	Walker Lake	59
	Winnemucca Lake[b]	43
New Mexico	Unnamed Dry Lake[b]	1,300
Oregon	Guano Lake[b]	602
	Warm Springs Reservoir	68
Utah	Great Salt Lake	8
	Great Salt Lake Desert[b]	9,046
	Pruess Lake	3
	Unnamed Intermittent Lake[b]	1,845
Wyoming	Flaming Gorge Reservoir	139

[a] Includes lakes and reservoirs completely crossed by a corridor, as well as those that may occur within the 3,500-ft corridor width but do not cross the corridor centerline.

[b] Dry or intermittent lake.

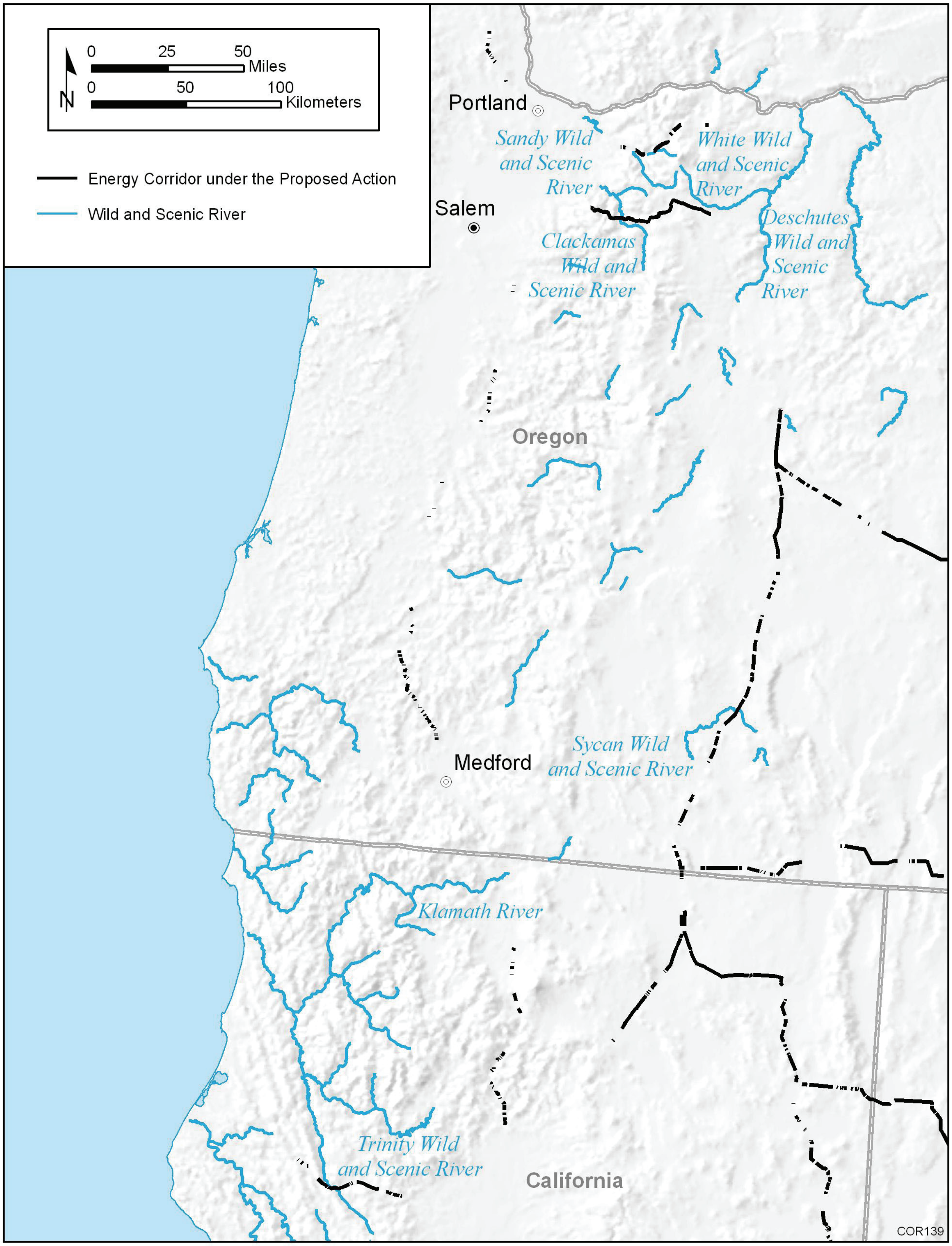

FIGURE 3.5-7 Wild and Scenic River Segments Intercepted by the Proposed Energy Corridors

terrains. Potential Level 1 stream types for these HLRs include B, C, D, E, F, and G. Of these stream types, C, D, E, F, and G are sensitive to change and can be impacted by activities in the energy transport corridor.

The magnitudes of potential impacts that could be incurred with development of the projects in the proposed corridors would be related to the existing characteristics of the surface water resource affected, its sensitivity to change, the size of the change made to runoff, and the magnitude of installation activities. For similar properties and without implementing any mitigation measures, the largest areas of disturbance would produce the largest impacts. The lengths of the potential disturbed areas (that a river intercepts the proposed corridor including its buffer zone) under the Proposed Action range from less than 10 feet for the Rattlesnake Creek in Oregon to about 23 miles for the All American Canal in California (see Appendix O).

Surface water quality could also be affected during operation of the projects within the proposed corridors. Contaminants from surface spills, improperly stored material, and wastewater discharge could enter nearby surface waters and adversely affect their quality. In addition, sediment load in the receiving water could be affected by increases in runoff, and water temperatures could be altered by modified runoff characteristics and land-clearing operations.

The magnitudes of the impacts would be related to the types of constituents present in runoff water, their toxicity, preexisting concentrations in the receiving water, the quantity spilled or transported to the nearby surface water body, the flow in the receiving body of water, the types and quantities of bed and bank material present, and the effectiveness and timeliness of remediation activities. In general, impacts would be greatest in streams that have a small flow, streams that have little transverse and vertical mixing, and streams that have existing contamination levels that are near threshold values for environmental concern. In general, these impacts would be expected to be small, local, and temporary on the scale of this PEIS and similar to impacts observed previously from similar construction activities on federal lands. However, impacts from a large hazardous liquid spill could be large and long-lasting.

3.5.4 Following Corridor Designation, What Types of Impacts Could Result to Water Resources with Project Development, and How Could These Impacts Be Minimized, Avoided, or Compensated?

3.5.4.1 What Are the Usual Impacts to Water Resources from Building and Operating Energy Transport Projects?

Groundwater and surface water resources could be similarly affected in the future following implementation of either of the two alternatives, by the construction, normal operation, maintenance, and decommissioning and dismantling of energy infrastructures within the energy corridors designated under the Proposed Action and the No Action ROWs.

Groundwater Resources. The development of energy transport projects within the energy corridors or the No Action ROWs could affect groundwater as a result of changes in the physical characteristics of affected aquifers and changes in the quality of the groundwater. Shallow groundwater (i.e., water on the order of tens of feet deep) would be affected most; deep groundwater would be affected least. Physical changes to groundwater are directly linked with the amount of recharge that an aquifer receives. Decreasing an aquifer's recharge could increase the depth of its water table (i.e., the top of the zone of saturation), change the direction of flow of the groundwater by altering the hydraulic head available, and change the volume of water flowing in the system. Similarly, increasing recharge to an aquifer could decrease the depth of the water table and change the direction and magnitude of flow in the system. The magnitudes of the impacts would be related to the hydrogeological characteristics of the aquifer (e.g., hydraulic conductivity, aquifer thickness, effective porosity [i.e., degree of connection between void spaces in the aquifer], heterogeneity, anisotropy [i.e., aquifer property that produces directionally dependent flow, etc.]), the site-specific values of recharge, and the size of the change made to the existing recharge.

Project-specific activities might also affect the quality of water in an aquifer. Dissolved contaminants from surface spills, improperly stored material, and wastewater discharge could percolate downward with infiltrating water and adversely affect underlying water quality. The magnitudes of the impacts would be related to the types and toxicity of dissolved constituents present in the infiltrating water, preexisting water quality in the aquifer, the quantity of liquids spilled, the geochemical makeup of the aquifer, and the effectiveness and timeliness of spill-control and cleanup activities. The last factor is especially important if a large spill caused by pipeline ruptures occurs.

In general, physical and chemical impacts to groundwater resources would be directly associated with the size of the disturbance. Larger impacts would be expected to be produced by corridors that have a larger footprint (i.e., area overlying the potentially affected aquifer) and a longer region of interception.

Surface Water. Surface water resources could be affected by the future development of energy transport projects within designated corridors or No Action ROWs by changes in the physical characteristics of surface water features and changes in water quality.

Physical changes to surface water resources from future project development are directly linked with runoff from the land surface. An increase in surface runoff to an unstable stream or river could produce the following impacts:

- An increase in downstream flow,
- An increase in channel width or depth,
- Erosion of the stream's bed (e.g., armoring, that is, the removal of fine material by moving water that leaves more coarse material on the stream's bed),
- Erosion of the stream's banks (e.g., bank slumping),
- Alteration of the channel morphology (e.g., avulsion, that is, a sudden change in the course of a stream or river),
- Changes in the stream's hydrograph (i.e., time-dependent flow history), and
- Changes in downstream aggradation (i.e., build up of sediment in a stream or in its banks).

Similarly, a decrease in surface runoff would decrease downstream flow, channel width, and depth; alter the stream's hydrograph; and increase downstream aggradation.

Physical changes to surface water could also be produced by directly disturbing a stream's bed. These changes could include erosion of the stream bed, alteration of the channel's morphology, and modification to downstream aggradation. Such disturbance would occur if direct burial of a pipeline occurred in the stream or could occur during directional boring at a stream crossing. The magnitude of an impact would be related to the physical characteristics of the surface water resource affected (e.g., width, depth, bed and bank materials, existing flow, stream morphology, and existing stability), the size of the change made to the existing runoff, and the degree of disturbance produced by installation activities.

Surface activities associated with the development, operation, and decommissioning of an energy transport project could also affect the quality of water in a surface water feature. Contaminants from surface spills (both particulate and dissolved), improperly stored material, and wastewater discharge could enter nearby surface waters, adversely affecting their quality. In addition, increases in runoff could affect sediment load in the receiving water, and modified runoff characteristics could alter water temperatures. The magnitudes of the impacts would be related to the types of constituents present in runoff water, their toxicity, preexisting concentrations in the receiving water, the quantity spilled or transported to the nearby surface water body, the type and quantity of bed and bank material present, and the effectiveness and timeliness of remediation activities.

The construction and placement of some pipelines, electricity transmission line support structures, and access roads, along with the establishment of temporary work areas, could occur within 100-year floodplains. Executive Order (E.O.) 11988 requires all federal agencies to restore and preserve the natural and beneficial values served by floodplains. Permanent facilities, such as pump stations, compressor stations, or substations, would likely be located outside of floodplains. The presence of support structures and excavated soils from footings would result in the displacement of a small amount of floodplain volume and flood storage capacity of 100-year floodplains. A further assessment of potential impacts to floodplains is included in Appendix P.

As with groundwater resources, physical and chemical impacts to surface water resources would be directly associated with the size of the disturbance. Larger impacts would be expected to be produced by corridors that have a larger footprint (i.e., area intercepting surface water resources) and a longer region of interception.

3.5.4.2 What Mitigation Is Available to Minimize, Avoid, or Compensate for Potential Project Impacts to Water Resources?

Except for accidental spills, most project-specific impacts to groundwater and surface water resources would be produced by construction and dismantling activities regardless of the alternative under which a project is developed. The FERC regulates the construction of hazardous liquid pipelines within the United States; federal regulatory approval is required for developing such pipelines if they cross federal lands. Minimum standards for construction have been established to minimize impacts to the affected environment (PHMSA 2006). Similarly, mitigation measures for construction have been defined by individual states to minimize impacts to both groundwater and surface water resources from construction activities. Often, stormwater construction permits and/or pollution prevention plans must be developed prior to construction.

Some possible mitigation measures are listed below. Mitigation measures should be selected with care, particularly when potential impacts are to wild and scenic river segments or sole-source aquifers. For the wild and scenic rivers, protect rivers' free-flowing condition, water quality, and outstandingly remarkable values, consistent with the WSRA. Mitigation measures may be specified in the comprehensive river management plans of the managing agency or, as appropriate, from the measures described below. The measures provided in the management plans address the protection and enhancement of the free-flowing nature of the wild and scenic river segment and its outstandingly remarkable values (ORVs) that represent rare, unique, or exemplary qualities that set it apart from all other rivers in the nation. They can relate to scenic, recreational, geologic, fish, wildlife, historic, cultural, or other similar features. The ORVs are river-related and site-specific values that make the river segment unique and worthy of special protection. The river-administering agency works with its partners to identify and resolve any activities adversely affecting the ORVs through a management plan. For sole-source aquifers, protection of the aquifers from being contaminated is emphasized.

The selection of mitigation measures for specific energy transport projects would be determined by specialists of the land managing agency who will be using site-specific information. The selection process should consider such factors as mitigation effectiveness, cost, availability, feasibility, and suitability for the site. Important site conditions to consider in the selection process include the amount of soil disturbance expected, anticipated weather conditions, soil type and erodibility, flow path length, the slope of the exposed soil, and conditions in the receiving waters (SCGC 2002). The mitigation measures listed here could be used to mitigate adverse impacts under No Action and the Proposed Action:

- Silt fences could be used along edges of streams and wetlands to prevent erosion and transport of disturbed soil, including spoil piles (TVA 2002). Silt fences are made of a filter fabric that has been entrenched and attached to supporting poles (and sometimes is backed by a plastic or wire mesh for support). Silt fences detain sediment-laden water and promote sedimentation behind the fence (CASQA 2003).

- Synthetic membranes or other material could be placed at the bottom of spoil piles to prevent or minimize infiltration of possibly contaminated water to underlying aquifers (PHMSA 2006).

- Removal of desirable vegetation should be minimized near residential and domestic water sources.

- Equipment or vehicles should not be washed in streams and wetlands, as doing so increases their sediment loads.

- When an herbicide/pesticide is used to control vegetation, the climate, soil type, slope, and vegetation type should be considered in determining the risk of herbicide/pesticide contamination (BLM 2006a).

- Herbicide/pesticide spray tanks should not be rinsed in or near water bodies, as doing so would contaminate the water (BLM 2006a).

- Herbicide/pesticide pellets should not be broadcast/distributed where there is danger of contaminating water supplies (BLM 2006a).

- Herbicide/pesticide treatment of areas with a high risk for groundwater contamination should be minimized (BLM 2006a).

- Appropriate herbicide-free/pesticide-free buffer zones should be used for herbicides not labeled for aquatic use, based on BLM/FS risk assessment guidance, which has minimum widths of 100 feet for aerial applications, 25 feet for applications dispersed by vehicle, and 10 feet for hand-spray applications (BLM 2006a).

- Federal regulations require that hazardous liquid pipelines be buried at least 30 inches below the surface in rural areas and deeper in more populated areas. In addition, pipelines must be buried deeper in some locations, such as at road crossings and crossings of bodies of water, and may be buried less deeply in other locations, such as when being installed in consolidated rock. The depth of burial of the line must be in accordance with federal pipeline safety regulations (PHMSA 2006).

- Cathodic protection systems should be installed along the pipeline to mitigate pipeline corrosion that could produce future environmental spills contaminating surface and/or ground water. Corrosion can be a major source of pipeline failure. The cathodic protection system imparts a current to the pipeline to offset natural soil and moisture corrosion potential. Cathodic protection systems should be inspected to ensure proper operating conditions for corrosion mitigation (TVA 2002).

- Entry and exit pits should be constructed to trap sediments from entering into streams at stream crossings. Prerequisites to excavating the entry and exit pits should include:

  - Locating the entry and exit pits far enough from stream banks and at a sufficient elevation to avoid inundation by storm flow stream levels and to minimize excessive migration of groundwater into the entry or exit pits.

  - Isolating the excavation for the entry and exit pits from the surface water by using silt fencing to avoid sediment transport by stormwater.

  - Isolating the spoils storage resulting from excavation of the entry and exit pits by using silt fencing to avoid sediment transport by stormwater.

- Sandbag trench plugs should be constructed uphill of each stream bank in the pipeline trench to prevent stormwater sediment transport from the upland trenches to the stream.

- Pipeline crossings of perennial, intermittent, and ephemeral stream channels should be constructed to withstand floods of extreme magnitude to prevent breakage and accidental contamination of runoff during high-flow events. Surface crossings must be constructed high enough to remain above the highest possible stream flows at each crossing. At a minimum, pipelines must be located above the 100-year flood elevation, and preferably above the 500-year flood elevation. Subsurface crossings must be buried deep enough to remain undisturbed by scour throughout passage of peak flows (BLM 2005b).

- Vegetated buffers on slopes could be used to trap sediment and promote groundwater recharge. The buffer width that is needed to maintain water quality ranges from 15 to 100 feet. On gradual slopes, most of the filtering occurs within the first 30 feet. Steeper slopes require a greater width of vegetative buffer to provide water quality benefits (CASQA 2003).

- Riparian vegetation could be planted and used to stabilize stream banks by increasing the tensile strength in the soil. The presence of vegetation modifies the moisture condition of slopes (i.e., infiltration, evapotranspiration, interception) and increases bank stability. Similarly, hydroseeding of banks could be used to stabilize stream banks (CASQA 2003).

- Geotextiles and mats could be used to stabilize disturbed channels and stream banks (CASQA 2003).

- Earth dikes, swales, and lined ditches could be used to divert work-site runoff that would otherwise enter a disturbed stream (CASQA 2003).

- Fiber rolls could be installed along slopes above the high-water level to intercept runoff, reduce flow velocity, release the runoff as sheet flow, and remove sediment from the runoff (CASQA 2003).

- Certified weed-free straw bale barriers could be installed to control sediment in runoff water. Straw bale barriers should only be installed where sediment-laden water can pond, thus allowing the sediment to settle out (CASQA 2003).

- Check dams (i.e., small barriers constructed of rock, gravel bags, sandbags, fiber rolls, or reusable products) could be placed across a constructed swale or drainage ditch to reduce the velocity of flowing water, allowing sediment to settle and reducing erosion (CASQA 2003).

- Padding could be placed in a stream below the work site to trap some solids that are deposited in the stream during construction. After work is done, the padding is removed from the stream and placed on the bank to assist in revegetation (CASQA 2003).

- Clean, washed gravel could be used in construction activities to reduce solid suspension in adjacent surface waters (CASQA 2003).

- Non-stormwater management IOPs should be adopted, which are source control actions that prevent pollution by limiting or reducing potential pollutants at their source before they come in contact with stormwater. These practices involve day-to-day operations of the construction site and are usually under the control of the contractor. These IOPs are also referred to as "good housekeeping practices," which involve keeping a clean, orderly construction site (NDOT 2004).

- Waste management should be adopted for handling, storing, and disposing of wastes generated by a construction project to prevent the release of waste materials into stormwater discharges. Waste management includes the following IOPs: spill prevention and control, construction debris and litter management, concrete waste management, sanitary/septic waste management, and liquid waste management (NDOT 2004).

- Successful reclamation could ensure that construction and dismantling impacts are not permanent. During the life of the development, all disturbed areas not needed for active support of production operations should undergo "interim" reclamation in order to minimize the environmental impacts of development on other resources and uses. At final abandonment, pipelines, compressors, powerlines, and access roads must undergo "final" reclamation so that the character and productivity of the land and water are restored (DOI and USDA 2006).

3.6 AIR QUALITY

3.6.1 What Air Quality Resources Are Associated with Section 368 Energy Corridors in the 11 Western States?

3.6.1.1 What Are the Existing Climate and Meteorology?

Climate varies substantially across the 11-state area, influenced by variations in elevation, topographic features, latitude, and proximity to the ocean. In Arizona, the average number of days with measurable precipitation per year varies from nearly 70 in the Flagstaff area to 15 at Yuma. A large portion of Arizona is classed as semiarid, and long periods often