APPENDIX 1

ACRONYMS AND ABBREVIATIONS

AAPG	American Association of Petroleum Geologists
AD	Associated Dissolved (natural gas)
APD	Application for Permit to Drill
ARMP	Approved Resource Management Plan
bbl	Barrels (of oil)
BLM	Bureau of Land Management
BOE	Barrels of Oil Equivalent
CBM	Coal Bed Methane
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CPAs	Citizen's Proposal Areas
CSU	Control Surface Usage
DEM	Digital Elevation Model
DOE	Department of Energy
DOI	Department of the Interior
EA	Environmental Assessment
EDZ	Extended Drilling Zone
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EPCA	Energy Policy and Conservation Act
ESRI	Environmental Systems Research Institute
EUR	Estimated Ultimate Recovery
FDGC	Federal Geographic Data Committee
FEIS	Final Environmental Impact Statement
GCDB	Geographic Coordinate Database
GGR	Greater Green River
GGRB	Greater Green River Basin
GIS	Geographic Information System
GOR	Gas to Oil Ratio
LGR	Liquids to Gas Ratio
LR	Legacy Rehost
MFP	Management Framework Plan
MMS	Minerals Management Service
NA	Non-Associated natural gas
NEPA	National Environmental Policy Act
NF	National Forest
NGLs	Natural Gas Liquids
NHRP	National Register of Historic Places
NLA	No Leasing, Administrative
NLA/LUP	No Leasing, Administrative/Land Use Planning
NLS	No Leasing, Statutory or Executive Order
NPC	National Petroleum Council

NSO	No Surface Occupancy
PLSS	Public Land Survey System
RA	Recreation Areas
RMP	Resource Management Plan
ROD	Record of Decision
ROW	Right-of-Way
RPD	Reserves and Production Division of the EIA
SLT	Standard Lease Terms
SUPO	Surface Use Plan of Operations
Tcf	Trillion cubic feet of natural gas
TL	Timing Limitation
TLS	Timing Limitation Stipulation
TPS	Total Petroleum System
URA	Ultimate recovery appreciation
USDA	United States Department of Agriculture
USDA-FS	U.S. Department of Agriculture-Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
WRAs	Wilderness Reinventory Areas

APPENDIX 2

GLOSSARY OF TERMS

-A-

Access Probability: The probability, expressed as a decimal fraction, of sufficient access (political and physical) to a particular assessment unit within a given time frame for the activities necessary to find an accumulation of minimum size and to add its volume to proved reserves. The time frame for this assessment is 30 years.

Accumulation: Consists of two types: conventional and continuous. A conventional accumulation is an individual producing unit consisting of a single pool or multiple pools of petroleum grouped on, or related to, a single structural or stratigraphic feature. A continuous accumulation is also an individual producing unit but has a really extensive pool or pools of petroleum not necessarily related to structural or stratigraphic features.

Affected Environment: Surface or subsurface resources (including social and economic elements) within or adjacent to a geographic area that could potentially be affected by oil and gas activities; the environment of the area to be affected or created by the alternatives under consideration. (40 Code of Federal Regulations (CFR) 1502.15)

Alternative: A combination of management prescriptions applied in specific amounts and locations to achieve a desired management emphasis as expressed in goals and objectives. One of several policies, plans, or projects proposed for decision-making. An alternative need not substitute for another in all respects.

Alternative, No Action: An alternative that maintains established trends or management direction.

Application: A written request, petition, or offer to lease lands for the purpose of oil and gas exploration and/or the right of extraction.

Application for Permit to Drill (APD): An application to drill a well submitted by a lessee or operator to the BLM. The APD consists of a Drilling Plan that discusses downhole specifications and procedures (reviewed by the BLM) and a Surface Use Plan of Operations (SUPO) that examines surface uses, including access roads, well site layout, cut and fill diagrams, reclamation procedures, production facility locations, etc. (reviewed by the surface-managing agency). The approved APD is a contract between the operator and the Federal government and cannot be changed or modified unless authorized by the BLM and the surface-managing agency.

Aquifer: (1.) A layer of material that contains water. (2.) The part of a water-drive reservoir that contains the aquifer.

Archeological/historic site: A site that contains either objects of antiquity or cultural values relating to history and/or prehistory that warrant special attention.

Assessment Unit Probability: Represents the likelihood, expressed as a decimal fraction, that, in a given assessment unit, at least one undiscovered accumulation of a selected minimum size

exists that has the potential for its volume to be added to proved reserves in a given time frame. The assessment unit probability is the product of the probabilities of the three geologic attributes (charge, rocks, and timing) and the probability of access.

Associated/Dissolved Gas: Natural gas that occurs in an oil accumulation, either as a free gas cap or in solution; synonymous with gas in oil accumulations.

-B-

Barrels of Oil Equivalent (BOE): A unit of petroleum volume in which the gas portion is expressed in terms of its energy equivalent in barrels of oil. For this assessment, 6,000 cubic feet of gas equals 1 BOE.

Basin: 1. A depressed area with no surface outlet. 2. A low in the Earth's crust of tectonic origin in which sediments have accumulated.

Big Game: Larger species of wildlife that are hunted, such as elk, deer, bighorn sheep, and pronghorn antelope.

Big Game Winter Range: An area available to and used by big game (large mammals normally managed for sport hunting) through the winter season.

Buffer Zone: 1. An area between two different land uses that is intended to resist, absorb, or otherwise preclude developments or intrusions between the two use areas. 2. A strip of undisturbed vegetation that retards the flow of runoff water, causing deposition of transported sediment

Bureau of Land Management: The Department of the Interior agency responsible for managing most Federal onshore subsurface minerals. It also has surface management responsibility for Federal lands designated under the Federal Land Policy and Management Act of 1976.

-C-

Candidate Species: 1. A species for which substantial biological information exists on file to support a proposal to list it as endangered or threatened, but for which no proposal has yet been published in the *Federal Register*. The list of candidate species is revised approximately every two years in the Notice of Review. 2. Any species not yet officially listed, but undergoing a status review or proposed for listing according to *Federal Register* notices published by the Secretary of the Interior or the Secretary of Commerce.

Casing: Steel pipe placed in an oil or gas well to prevent the hole from caving.

Cell: A subdivision or area within an assessment unit having dimensions related to the drainage areas of wells (not to be confused with finite-element cells). Three categories of cells are recognized: cells tested by drilling, untested cells, and untested cells having potential to provide additions to reserves within the forecast span of the assessment. A continuous-type assessment unit is a collection of petroleum-containing cells.

Completion: The activities and methods to prepare a well for production. Includes installation of equipment for production from an oil or gas well.

Composite Total Petroleum System: A mappable entity encompassing all or a portion of two or more total petroleum systems. Composite total petroleum systems are used when accumulations within an assessment unit are assumed to be charged by more than one source rock.

Continuous-Type Accumulation: A petroleum accumulation that is pervasive throughout a large area, that is not significantly affected by hydrodynamic influences, and for which the chosen methodology for assessment of sizes and number of discrete accumulations is not appropriate. Continuous-type accumulations lack well-defined down-dip water contacts. The terms "continuous-type accumulation" and "continuous accumulation" are used interchangeably.

Controlled Surface Use (CSU): Allowed use and occupancy (unless restricted by another stipulation) with identified resource values requiring special operational constraints that may modify the lease rights. CSU is used as an operating guideline, not as a substitute for NSO or Timing Lease (TL) stipulations.

Conventional Accumulation: A discrete accumulation, commonly bounded by a down-dip water contact that is significantly affected by the buoyancy of petroleum in water. This geologic definition does not involve factors such as water depth, regulatory status, or engineering techniques.

Council on Environmental Quality (CEQ): An advisory council to the President established by the National Environmental Policy Act of 1969. It reviews Federal programs for their effect on the environment, conducts environmental studies, and advises the President on environmental matters.

Crucial Winter Range: Winter habitat on which a wildlife species depends for survival. Because of severe weather conditions or other limiting factors, no alternative habitat would be available.

Cultural Resources: Those fragile and nonrenewable physical remains of human activity, occupation, or endeavor reflected in districts, sites, structures, buildings, objects, artifacts, ruins, works of art, architecture, burial mounds, petroglyphs, and natural features that were of importance in past human events. These resources consist of (1) physical remains; (2) areas where significant human events occurred, even though evidence of the event no longer remains; and (3) the environment immediately surrounding the resource. Cultural resources are commonly discussed in terms of prehistoric and historic values; however, each period represents a part of the full continuum of cultural values from the earliest to the most recent.

Cumulative Petroleum Production: Reported cumulative volume of petroleum that has been produced. Cumulative oil, cumulative gas, and cumulative production are sometimes used as abbreviated forms of this term.

-D-

Directional Drilling: The intentional deviation of a wellbore from vertical to reach subsurface areas off to one side from the drilling site.

-E-

Endangered Species: As defined in the Federal Endangered Species Act, any species that is in danger of extinction throughout all or a significant portion of its range. For terrestrial species, the U.S. Fish and Wildlife Service determines *endangered* status.

Environmental Assessment (EA): A public document for which a Federal agency is responsible that serves to: (1) briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a finding of no significant impact; (2) help an agency comply with the NEPA when no EIS is necessary; and (3) facilitate the preparation of an EIS when one is necessary. An EA includes brief discussions of the need for the proposal and of the environmental impacts of the proposed action and other alternatives.

Environmental Impact Statement (EIS): A written analysis of the impacts on the natural, social, and economic environment of a proposed project or resource management plan.

Estimated Ultimate Recovery (EUR): The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with total recovery.

-F-

Federal Land: For the purpose of the EPCA study, land owned by the United States, without reference to how the land was acquired or which Federal agency administers the surface; includes mineral estates underlying private surface.

Field: A production unit consisting of a collection of oil and gas pools that, when projected to the surface, form an approximately contiguous area that can be circumscribed.

Field Growth: The increases in known petroleum volume that commonly occur as oil and gas fields are developed and produced; synonymous with reserve growth.

Forecast Span: A specified future time span in which petroleum accumulations have the potential to provide additions to reserves. A 30-year forecast span is used in the USGS assessments, which affects (1) the minimum undiscovered accumulation size, (2) the number of years in the future that reserve growth is estimated, (3) economic assessments, (4) the accumulations that are chosen to be considered, and (5) the risking structure as represented by access risk.

Forest Plan: A plan for a unit of the National Forest system that provides for USDA-FS administered lands in the planning area included.

Forest Service (USDA-FS): The agency of the United States Department of Agriculture responsible for managing National Forests and Grasslands under the Multiple Use and Sustained Yield Act of 1960.

-G-

Gas Accumulation: An accumulation with a gas to oil ratio of 20,000 cubic feet/barrel or greater.

Gas in Gas Accumulations: Gas volumes in gas accumulations.

Gas in Oil Accumulations: Gas volumes in oil accumulations.

Gas to Oil Ratio (GOR): The ratio of gas to oil (in cubic feet/barrel) in an accumulation. GOR is calculated using known gas and oil volumes at surface conditions.

Geographic Information System (GIS): In the strictest sense, a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e., data identified according to their locations.

Geologic Province: A USGS-defined area having characteristic dimensions of perhaps hundreds to thousands of kilometers encompassing a natural geologic entity (for example, a sedimentary basin, thrust belt, or delta) or some combination of contiguous geologic entities.

Geospatial: Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from remote sensing, mapping, and surveying technologies, or from other sources.

Grown Petroleum Volume: Known petroleum volume adjusted upward to account for future reserve growth. Thirty years of reserve growth is considered for the USGS assessments.

-H-

Habitat: A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

-I-

-J-

-K-

Known Petroleum Volume: The sum of cumulative production and remaining reserves as reported in the databases used in support of an assessment. Also called estimated total recoverable volume (sometimes called "ultimate recoverable reserves" or "estimated ultimate recovery").

-L-

Landscape: A relatively large area of land with common climate, geology, and soils containing predictably occurring terrain features such as slopes, drainage channels, rock outcrops, etc.

Lease: An authorization to possess and use public land for a period of time sufficient to amortize capital investments in the land.

Lease Stipulations: See Stipulations.

Liquids to Gas Ratio (LGR): Ratio of total petroleum liquids (including oil, condensate, and natural gas liquids) to gas (in barrels/million cubic feet) in a gas accumulation. The LGR is calculated using known petroleum liquids and gas volumes at surface conditions. This ratio is used to assess the liquid co-products associated with undiscovered gas in gas accumulations.

-M-

Mineral: Organic and inorganic substances occurring naturally, with characteristics and economic uses that bring them within the purview of mineral laws; a substance that may be obtained under applicable laws from public lands by purchase, lease, or pre-emptive entry.

Minimum Accumulation Size: The smallest accumulation size (volume of oil in oil accumulations or volume of gas in gas accumulations) that is considered in the assessment process for conventional accumulations.

Minimum Petroleum System: The mappable part of a total petroleum system for which the presence of essential elements has been proved by discoveries of petroleum shows, seeps, and accumulations.

Minimum Total Recovery Per Cell: The smallest total recovery per cell (volume of oil or gas) that is considered in the assessment process for continuous-type accumulations.

Mitigation: Includes the following:

(1) Avoiding an impact altogether by not taking a certain action or parts of an action.

(2) Minimizing impacts by limiting the degree of magnitude of the action and its implementation.

(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(5) Compensating for the impact by replacing or providing substitute resources or environments.

Monitoring: The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting resource management objectives.

-N-

National Environmental Policy Act (NEPA): The law that requires a process to assess and document the environmental and social impacts of federal actions. This act establishes policy, sets goals, and provides different ways to carry out the policy.

National Forest: A forest or weathershed reservation that is administered by the United States Department of Agriculture-Forest Service for multiple uses, including grazing, logging, and recreation.

National Register of Historic Places (NRHP): A Federal Government list of " . . .districts, sites, buildings, structures, and other objects significant in American history, architecture, archeology, and culture." The National Register is maintained by the National Park Service, U.S. Department of the Interior, and is published in its entirety in the *Federal Register* each year in February.

Natural Gas Liquids (NGL): Petroleum that occurs naturally as a gas in the reservoir, but that is a liquid under surface conditions. Natural gas liquids are typically reported separately from crude oil.

Natural Gas Liquids to Gas Ratio (for oil accumulations): Ratio of natural gas liquids to gas (in barrels/million cubic feet) in an oil accumulation, calculated using known natural gas liquids and gas volumes at surface conditions. This ratio is used to assess the natural gas liquids associated with undiscovered gas in oil accumulations.

Non-Associated Gas: Natural gas that occurs in a gas accumulation; synonymous with gas in gas accumulations.

No Surface Occupancy (NSO): A no surface occupancy area where no surface-disturbing activities *of any nature or for any purpose* are allowed. For example, construction or the permanent or long-term placement of structures or other facilities for any purpose would be prohibited in an NSO area. It is also used as a stipulation or mitigation requirement for controlling or prohibiting selected land uses or activities that would conflict with other activities, uses, or values in a given area. When used in this way, the NSO stipulation or mitigation requirement is applied to prohibit one or more specific types of land and resource development activities or surface uses in an area, while other—perhaps even similar— types of activities or uses (for other purposes) would be allowed. For example, protecting important rock art relics from destruction may require closing the area to the staking of mining claims and surface mining, off-road vehicle travel, construction or long-term placement of structures or pipelines, power lines, general purpose roads, and livestock grazing. Conversely, the construction of fences (to protect rock art from vandalism or from trampling or breakage by livestock), an access road or trail, and other visitor facilities to provide interpretation and opportunity for public enjoyment of the rock art would be allowed. Additionally, if there were potential and interest for leasing and development of leasable minerals in the area, then leases for gas and oil, coal, etc., could be issued with a "no surface occupancy" stipulation or mitigation requirement for the rock art site, which would still allow access to the leasable minerals from adjacent lands and underground. The term "no surface occupancy" has no relationship or relevance to the presence of people in an area.

Notice: The communication of a pending Federal action; the notification to parties of Federal actions about to the taken. This is a part of due process.

-O-

Occupancy: Actual possession and use of land in something more than a slight or sporadic manner. As defined as a multiple use component, it is the management of public lands for

occupancy involving the protection, regulated use, and development of lands as sites for economically and socially useful structures, either publicly or privately owned.

Oil Accumulation: An accumulation with a gas to oil ratio of less than 20,000 (in cubic feet/barrel).

Oil in Gas Accumulations: Oil volumes in gas accumulations. For this assessment, oil in gas accumulations were calculated along with other liquids rather than separately.

Oil in Oil Accumulations: Oil volumes in oil accumulations.

Operator: An individual, group, association, or corporation authorized to conduct, for example, livestock grazing or oil and gas drilling on public lands.

-P-

Petroleum: A collective term for oil, gas, natural gas liquids, and tar.

Play: A set of known or postulated oil and gas accumulations sharing similar geologic, geographic, and temporal properties, such as source rock, migration pathway, timing, trapping mechanism, and hydrocarbon type. A play may or may not differ from an assessment unit; an assessment unit can include one or more plays.

Proposed Species: A species of plant or animal formally proposed by the U.S. Fish and Wildlife Service (USFWS) to be listed as threatened or endangered under the Endangered Species Act.

Proved Reserves: Quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as 90 percent or more probable) to be recoverable in future years from known reservoirs under existing economic and operating conditions.

Public Lands: Any land and interest in land owned by the United States that are administered by the Secretary of the Interior through the BLM, without regard to how the United States acquired ownership, except for (1) lands located on the Outer Continental Shelf and (2) lands held for the benefit of Indians, Aleuts, and Eskimos; includes public domain and acquired lands (see definitions). Vacant, unappropriated, and unreserved public lands, or public lands withdrawn by Executive Order 6910 of November 26, 1934, as amended, or by Executive Order 6964 of February 5, 1935, as amended, and not otherwise withdrawn or reserved, or public lands within grazing district established under Section 1 of the Act of June 28, 1934 (48 Stat. 1269), as amended, and not otherwise withdrawn or reserved.

-Q-

-R-

Remaining Petroleum Reserves: Volume of petroleum in discovered accumulations that has not yet been produced. Remaining reserves is sometimes used as an abbreviated form of this term.

Reserve Growth: The increases in known petroleum volume that commonly occur as oil and gas accumulations are developed and produced; synonymous with field growth.

Resource Management Plan (RMP): A plan that provides the basic, general direction and guidance for BLM-administered public lands in the planning area involved.
Right-of-Way (ROW): A permit or easement which authorizes the use of public land for certain specified purposes, commonly for pipelines, roads, telephone lines, etc.; also, the lands covered by such an easement or permit. Does not grant an estate or any kind, only the right of use. May also include a site.

Riparian Areas: The vegetation along the banks of rivers and streams and around springs, bogs, wet meadows, lakes, and ponds.

Roadless: Refers to an absence of roads that have been constructed and maintained by mechanical means to ensure regular and continuous use.

Roads: Vehicle routes that have been improved and maintained by mechanical means to ensure relatively regular and continuous use. (A way maintained strictly by the passage of vehicles does not constitute a road.)

-S-

Sense of Place: Sense of place offers a holistic interpretation of a geographic place. It synthesizes a complex grouping of meanings, symbols, values, and feelings associated with a particular locality. It can include social, political, economic, aesthetic, occupational, biological, physical, etc. information, which can be drawn on an individual, community, and/or regional basis. Sense of place combines (1) contemporary (present-day) attachment, (2) traditional cultural use and attachment (perhaps by American Indians or other cultural/ethnic groups), and (3) cultural and heritage sites, properties, and districts.

Shapefile: GIS file format usable with ESRI (such as ArcView) and other commercial GIS software. It is a nontopological data structure that does not explicitly store topological relationships. However, unlike other simple graphic data structures, one or more rings represent shapefile polygons. A ring is a closed, non-self-intersecting loop. This structure can represent complex structures, such as polygons, that contain "islands." The vertices of a ring maintain a consistent, clockwise order so that the area to the right, as one "walks" along the ring boundary, is inside the polygon, while the area to the left is outside the polygon.

Split Estate: Federal mineral estate administered by the BLM, which is under either private lands, State lands, or lands administered by another Federal agency. On split estate lands, the surface owner or managing agency controls the surface uses but the mineral estate is the dominant estate. However, the BLM coordinates with surface owners on mineral leasing and development. In a few cases, the BLM administers the surface, but the minerals are owned by the State or a private entity.

Stipulations[1]: Conditions, promises, or demands added to a lease when the environmental and planning record demonstrates the necessity for the stipulations. Stipulations, as such, are neither "standard" nor "special"; they are a necessary modification of the terms of the lease. In order to accommodate the variety of resources encountered on Federal lands, stipulations are categorized as to how the stipulation modifies the lease rights, not by the resource(s) to be protected. What, why, and how this mitigation/protection is to be accomplished is determined by the land management agency through land use planning and NEPA analysis.

If, upon weighing the relative resource values, uses, and/or users, conflict with oil and gas operations is identified that cannot be adequately managed and/or accommodated on other lands, then a lease stipulation is necessary. Land use plans serve as the primary vehicle for determining the necessity for lease stipulations. Documentation of the necessity for a stipulation is disclosed in planning documents or through site-specific analysis. Land use plans and/or NEPA documents also establish the guidelines under which future waivers, exceptions, or modifications may be granted.

Substantial modification or waiver of stipulations subsequent to lease issuance is subject to public review for at least a 30-day period in accordance with Section 5102.f of the Federal Onshore Oil and Gas Leasing Reform Act of 1987 (FOLRA). Stipulations may be necessary if the authority to control the activity on the lease does not already exist under laws, regulations, or orders. An authorized Federal officer has the authority to modify the site location and design of facilities, control the rate of development and timing of activities, and require other mitigation under standard lease term. The necessity for individual lease stipulations is documented in the lease-file record with reference to the appropriate land use plan or other leasing analysis document. The necessity for exceptions, waivers, or modifications is documented in the lease-file record through reference to the appropriate plan or other analysis.

Study Areas: The Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River Basins, and the Montana Thrust Belt, which were selected as the resource provinces of the study and comprise the areas of these resource provinces underlain by oil and/or natural gas resources based upon USGS analysis.

Subsurface Allocation: An allocation of potential additions to reserves to land entities based on subsurface ownership of mineral rights.

Surface Allocation: An allocation of potential additions to reserves to land entities based on surface ownership.

Sweet Spot: An area within a continuous-type deposit where production characteristics are relatively more favorable.

-T-

[1] Taken from the booklet, "Uniform Format for Oil and Gas Lease Stipulations," prepared by the Rocky Mountain Regional Coordinating Committee in March 1989. These guidelines were developed by the BLM and USDA-FS.

Technically Recoverable Resources: In-place resources that are producible using current recovery technology but without reference to economic profitability. These are oil and natural gas resources that may be produced at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface, and the maintenance of reservoir pressure by fluid injection. These resources are generally conceived as existing in accumulations of sufficient size to be amenable to the application of existing recovery technology.

Timing Limitation: Prohibits surface use during specified time periods to protect identified resource values. The stipulation does not apply to the operation and maintenance of production facilities unless the findings of analysis identify the continued need for such mitigation and demonstrate that less stringent, project-specific mitigation measures would be insufficient. Also called a Seasonal Restriction.

Total Petroleum System (TPS): A mappable entity encompassing genetically related petroleum that occurs in seeps, shows, and accumulations (discovered or undiscovered) that have been generated by a pod or by closely related pods of mature source rock, together with the essential mappable geologic elements (source, reservoir, seal, and overburden rocks) that controlled fundamental processes of generation, migration, entrapment, and preservation of petroleum.

Total Recovery: The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with estimated ultimate recovery.

-U-

Ultimate Recovery Appreciation (URA): The generally observed increase of Estimated Ultimate Recovery (EUR) over time.

Undiscovered Petroleum Resources: Resources postulated from geologic information and theory to exist outside of known oil and gas accumulations.

USGS-Assessed Petroleum Volumes: The quantities of oil, gas, and natural gas liquids that have the potential to be added to reserves within some future time frame, which for this assessment is 30 years. The USGS assessed petroleum volumes include both those from undiscovered accumulations, whose sizes are greater than or equal to the selected minimum accumulation size, and those from the reserve growth of fields already discovered.

-V-

-W-

Wetlands: Permanently wet or intermittently flooded areas where the water table (fresh, saline, or brackish) is at, near, or above the soil surface for extended intervals; where hydric wet soil conditions are normally exhibited; and where water depths generally do not exceed two meters. Marshes, shallows, swamps, muskegs, lake bogs, and wet meadows are examples of wetlands.

Wilderness: A Congressionally designated area of undeveloped Federal land retaining its primeval character and influence, without permanent improvement or human habitation, that is

protected and managed so as to preserve its natural conditions and that (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and, (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Wildlife: All living vertebrate and invertebrate fauna that exist or potentially exist in an area.

Withdrawal: An action that restricts the disposition of public lands and that holds them for specific public purposes; also, public lands that have been dedicated to public purposes (for example, recreation sites, office or warehouse sites, etc.).

APPENDIX 3

LAND STATUS METHODOLOGY

For purposes of the EPCA project, spatial data themes were created that define various ownership characteristics and categories for lands within the play boundaries. The final data sets were rendered to delineate both surface and subsurface U.S. rights. To accomplish this, ownership cases, extracted from the BLM's LR-2000 Case Recordation and Status Databases, were processed and used to created polygon themes for the project (Figure A3-1).

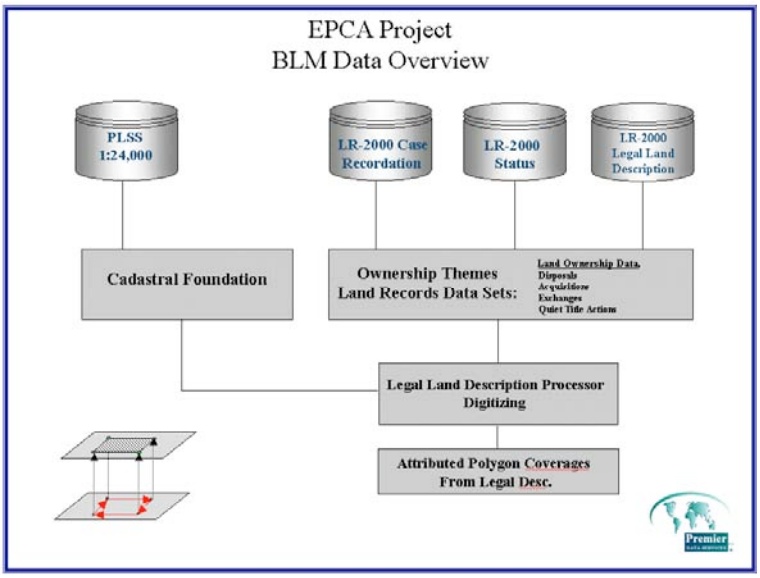

Figure A3-1 Schematic of BLM's Primary Land Records Databases

The primary information that defines U.S. interests in parcels of land are data elements associated with various case categories and land transactions recorded and maintained in the BLM's LR-2000 Case Recordation and Status Databases. The mapped case land records extracted fall within four general categories:

- Land Disposals, including patents, grants, deeds, land sales, and all other transactions that conveyed Federal ownership rights in lands from the Federal Government.

- Acquired Lands, including lands that were re-acquired by the United States under various legal authorities.

- Land Exchanges, including lands exchanged between the Federal Government and other parties.

- Quiet Title Cases, including all records established to cure title and quiet adverse claims.

These four major categories formed the basis to extract records from the BLM's databases. The four queries were processed against both the Status and Case Recordation Systems. Due to formatting differences between the two databases, the resulting polygon attributes contained in

the GIS shape files varied slightly. Additionally, in some case records extracted from the Case Recordation system, U.S. rights were not readily available but were determined as accurately as possible through interpretation from land records obtained at BLM State and field offices.

The polygon boundaries created through processing reflect the geometry as described by aliquot part description. Lands described by lot or tract surveys were processed against the BLM Legal Land Description (LLD) file to convert the lot references to nominal aliquot descriptions for mapping purposes. Depending on the actual survey type and geometry, the resulting polygon may contain a degree of generalization. Additionally, the BLM record systems do not contain individual records for public domain lands. The location of these lands was determined through various polygon-processing steps described below. The data elements for the attribute fields contained in the shape files produced from each of the LR-2000 databases are shown in Table A3-1.

Status Data Attributes*	Case Recordation Attributes*
Shape	Meridian
Meridian	Township
Township	Range
Range	Section
Section	Surveytype
Survey Type	Aliquot
Aliquot	Serialnumb
Adminagenc	Surveynumb
County	Name
State	Percentint
Serialnumb	Price
Docid	Acres
Patent_num	Dispositio
Case_type	Casetype
Usright1	Commodity
Usright2	Expiredate
Usright3	Expireyear
Usright4	Effectdate
Patentissu (mm/dd/yy)	Royaltyrt
Patentiss1 (year)	Geoname
Acres	Hbp
Patentee	Or
Id	Id
*Note: Data fields were populated if data is entered in the Status or Case Recordation database. If U.S. rights are recorded in the US Rights field, they were included in the Commodity field.	

Table A3-1 Data Elements, LR-2000 Database

The data simplification process was completed through numerous steps that combined data associated with each of the four broad record categories referenced above using the following processing steps, shown for an example from the Powder River Basin:

1. A Public Land Survey System (PLSS) grid digitized from USGS 7.5-minute quadrangle maps was used as the cadastral reference framework and contains shapefile coverages that define both townships and sections. For example, lands that fall within the geographic extent of the Powder River Basin were acquired in 1803 under the Louisiana Purchase. All surface and subsurface rights belonged to the United States of America.

After the PLSS base was loaded, a master polygon (Figure A3-2) was created to represent the disposition of the lands at the time of the original purchases and annexations by which the United States acquired land.

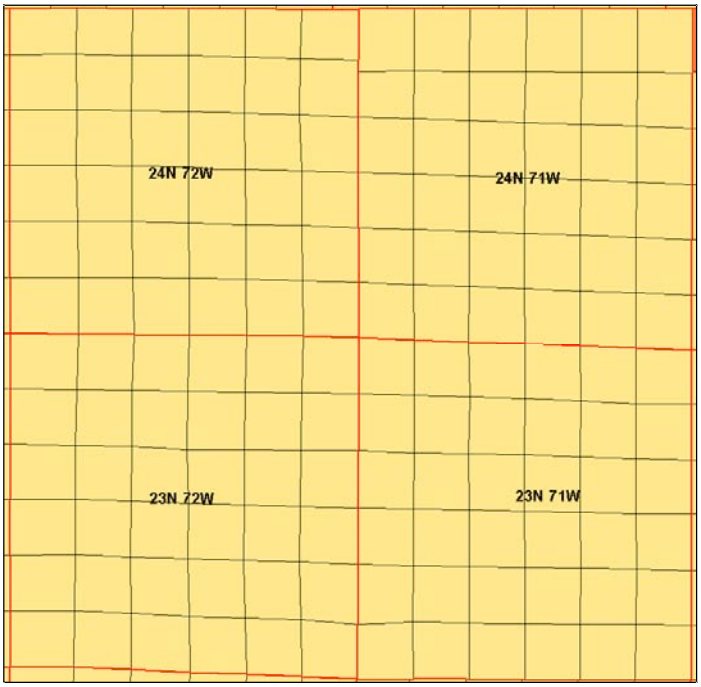

Figure A3-2 Master Polygon

2. The next step involved processing textual legal land descriptions against the section shape file by subdividing according to the survey rules embedded in the CarteView product[1]. Table A3-2 shows a typical input file.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Status	Generic	USRight1	SerialNumber								
2	Meridian	Township	Range	Section	SurveyTy	Aliquot	County	State	SerialNumber	DocID	Case_Type	USRight1
1348	6	0160N	0920W	28	T	NWNW,NWSW,SWNW;	7	WY	WYC 0001269	165770	HE ORIGINAL	Coal
1349	6	0160N	0920W	29	T	NENE,NESE,NWNE,NWSE,SENE,SW	7	WY	WYC 0001269	165770	HE ORIGINAL	Coal
1350	6	0160N	0920W	20	T	NESE,NWSE,SESE,SWSE;	7	WY	WYC 0001270	163248	HE ORIGINAL	Coal
1351	6	0160N	0920W	21	T	NWSW,SWSW;	7	WY	WYC 0001270	163248	HE ORIGINAL	Coal
1352	6	0160N	0920W	28	T	NWNW;	7	WY	WYC 0001270	163248	HE ORIGINAL	Coal
1353	6	0160N	0920W	29	T	NENE,NWNE;	7	WY	WYC 0001270	163248	HE ORIGINAL	Coal

Table A3-2 Typical CarteView Input File

3. After the records from the Status and Case Recordation databases were processed, the resulting polygon themes were re-attributed to allow for a merge between the two data sets. The polygons were then overlaid on the Master Polygon to establish the location of lands where ownership left

[1] A product available through Premier Data Services, Inc.

the Federal government by virtue of patent, grant, or other title transfer authority. The resulting coverages are represented in Figure A3-3.

The yellow polygons shown on Figure A3-3 represent lands that remain in the public domain with all surface and subsurface rights managed by the BLM. These public domain lands were then converted to a polygon and attributed to show the current disposition of the U.S rights.

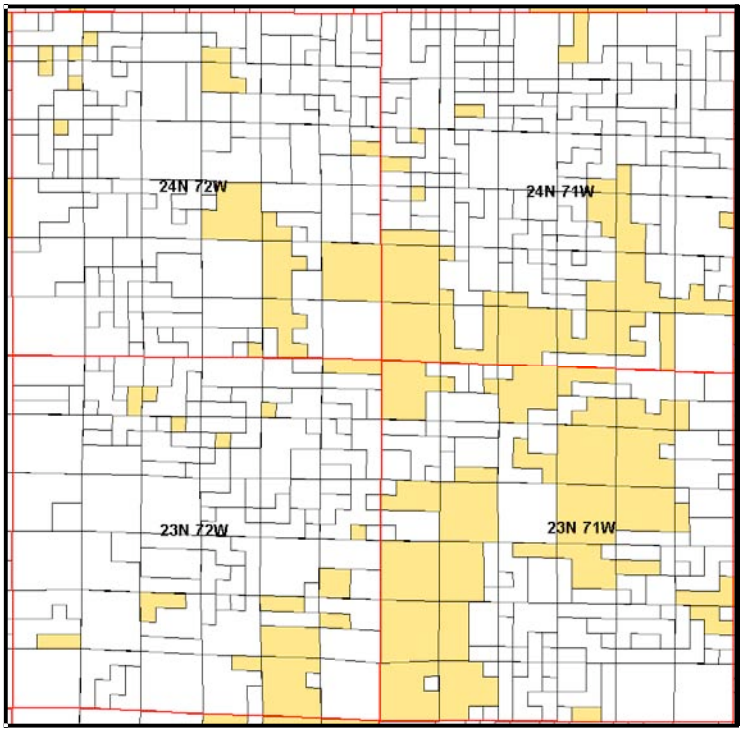

Figure A3-3 Public Domain Lands

4. The next step involved constructing a series of queries against the U.S. rights data associated with lands that were disposed of by virtue of various title transfers. This query process involved intensive comparison against the attribute tables in the spatial databases. The results of these processes allowed definition of all lands where subsurface oil and gas rights are owned by the United States.

   Figure A3-4 illustrates the distribution of subsurface mineral ownership within a four-township area. The parcels shaded gray represent patented lands where the United States has retained rights to the mineral or oil and gas estate.

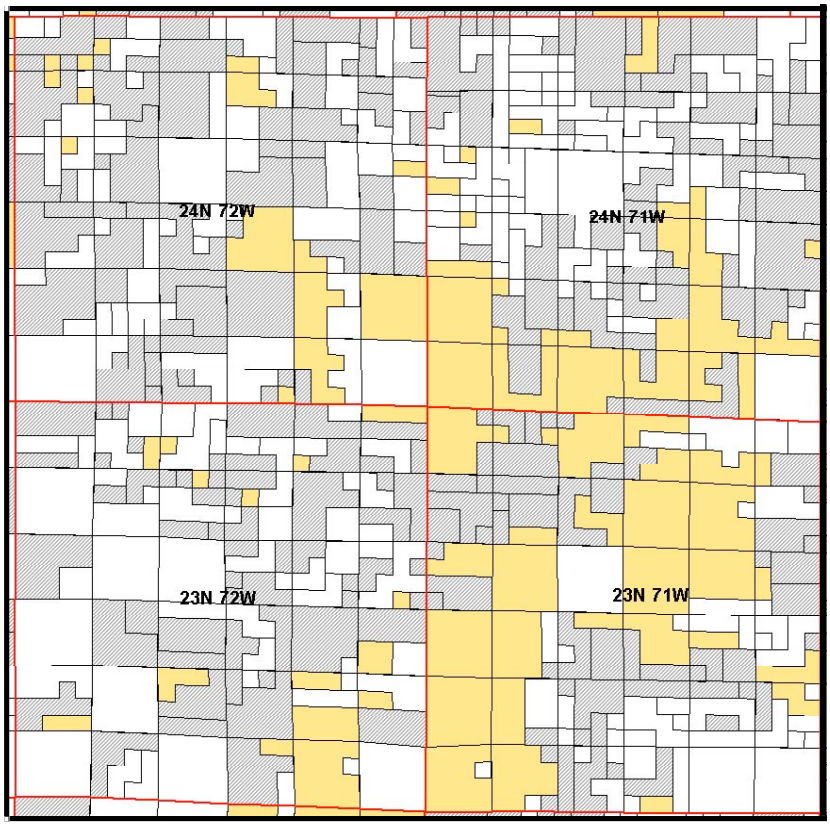

Figure A3-4 Retained U.S. Rights to Mineral or Oil and Gas Estate

5. Next, any surface management agencies or state ownership were defined. These determinations were made by completing a series of queries against the ownership fields in the shape files. An example of the results of this query is shown in Figure A3-5, where the parcels shaded blue represent lands that were granted to the State of Wyoming.

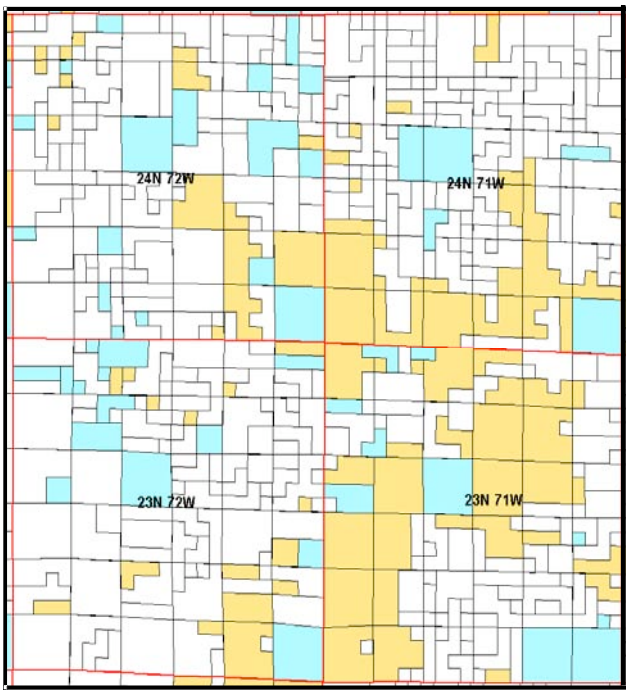

Figure A3-5 Defining Ownership

The final processing step was to dissolve the individual parcels into ownership categories that define the surface and mineral estates. Figure A3-6 shows the surface management agencies and how land ownership is distributed within an area of the Powder River Basin in Wyoming.

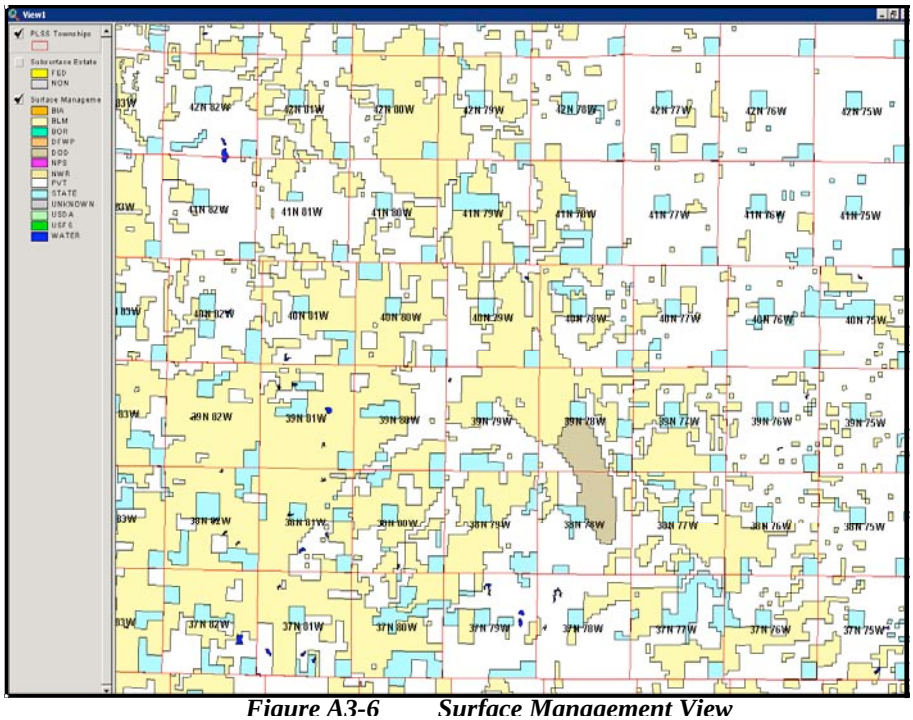

Figure A3-6 Surface Management View

In contrast to the surface management view, the mineral estate (shown in Figure A3-7) covers the same area and yields a much different picture. The yellow areas represent lands where the Federal government owns oil and gas rights.

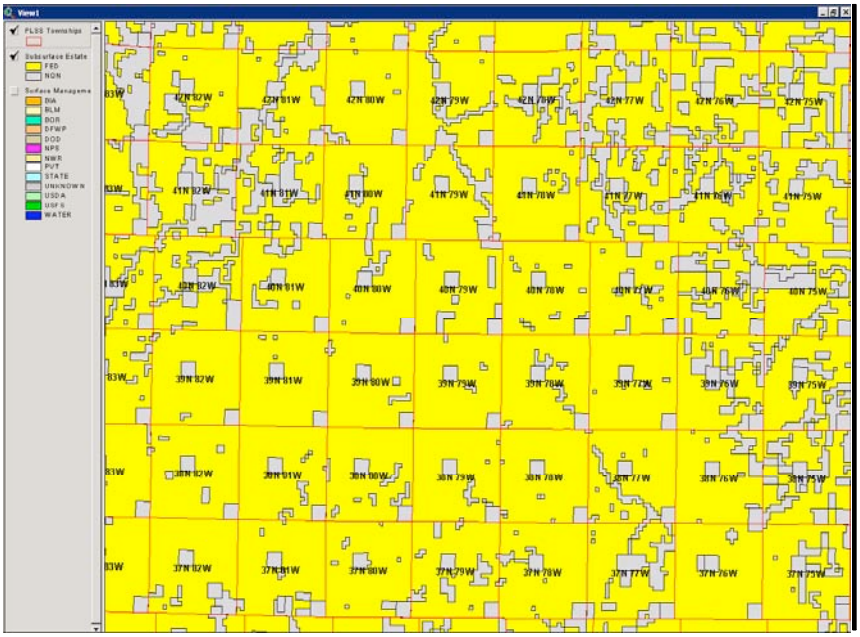

Figure A3-7 Subsurface Oil and Gas Ownership View

Through the above-described procedure, a detailed assessment of the land status was performed. To facilitate the analytical portion of the project, a simplified version of the status data was created, based on the allocation of the detailed land status to the fundamental Federal surface management agency (i.e., BLM, USDA-FS, etc.)[2]. Maps of the Federal land status for the study areas are presented in Section 2 in Figures 2a through Figure 2e.

The derivation of land status, while complex given the amount of recordation examined, was straightforward in process. However, the following limitations do exist:

- The data sets created from the processes described above reflect the legal land descriptions contained in the BLM databases. Case files were not consulted in the process. This procedure did generate error logs, especially if legal land descriptions had not been properly formatted according to BLM's published LR-2000 standards. The errors created in this process are believed to have minimal impact.

- If a legal description referenced a small survey lot or tract by number, a nominal location was mapped through a PROCESS that referenced the BLM's LLD file. This file is limited to a 40-acre description and carries a minor degree of generalization in complex areas.

- The BLM Case Recordation System is not consistently populated with U.S. rights data. To overcome this, the split estate ownership was established from Case Recordation Data by contacting BLM State and field offices. This process results in a minor degree of generalization.

- Some status information derived from GIS coverages was obtained from multiple sources, resulting in the creation of some sliver polygons during the spatial processing and merging of these data.

- These are an artifact of the differing sources of data and may be present in certain ownership themes; however, their impact on the analyses is minimal.

- The processing of the PLSS data, which are variably sourced, resulted in edge matching across State boundaries. This is believed to have a minimal impact on the analyses.

[2] The detailed and simplified land ownership databases are presented, by study area, on the CD accompanying this report.

APPENDIX 4

LEASE STIPULATION DATA PREPARATION

The bulk of the data preparation consisted of data gathering, data digitization, and compilation of the gathered data in a multi-layered GIS format (ESRI shapefiles). Federal Geographic Data Committee Standards (FGDC)-compliant metadata for the resulting GIS layers were also created. GIS coverages from surface management agency land status, stipulations, and the analyses, as well as the associated metadata, are presented on the CD-ROMs accompanying this report.

Where necessary, the shapefiles obtained from the Federal land management agencies were processed using ArcGIS software by matching specific leasing stipulations found in the guidance documents.

The EPCA inventory is limited to those Federal lands within the aggregate resource play boundaries of the five study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. The land status and stipulation shapefiles, which correspond to Federal land management agency jurisdiction boundaries, were "clipped" using the GIS to the appropriate study boundary. Some of the shapefiles fell into multiple study areas, so the clipping process was repeated for each area. The attribute tables of the compiled shapefiles were then queried for unique leasing stipulation values. The query results were then saved as separate polygon shapefiles. Each shapefile represents a unique stipulation value.

The following discussion of the specific data preparation steps uses the Paradox/San Juan Basin study area as an example.

1. The first step entails loading the study area (union of resource plays) boundary shapefile and the compiled stipulation shapefile into ArcGIS (Figure A4-1).

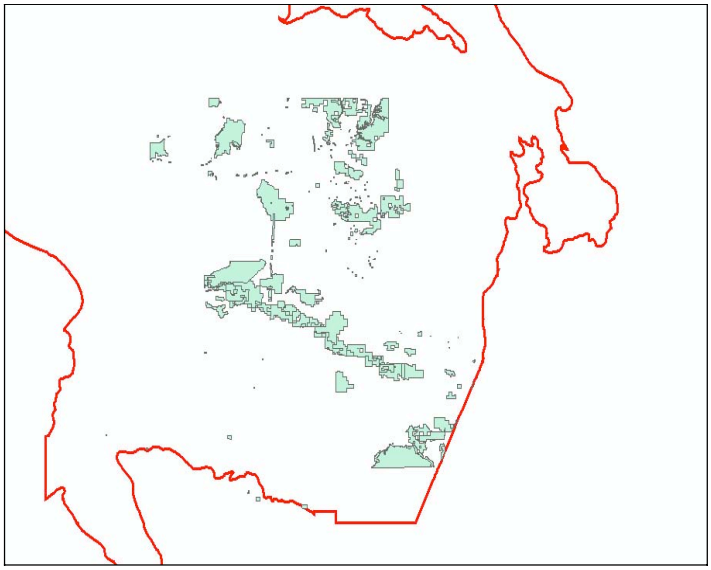

Figure A4-1 Multi-Stipulation Polygon and Study Area Boundary

2. The next step in this process is to "clip" or cut the compiled stipulation shapefile to the study boundary. Figure A4-2 shows how this GIS coverage partially falls outside

of the study boundary. Figure A4-3 shows the GIS coverage after it has been clipped.

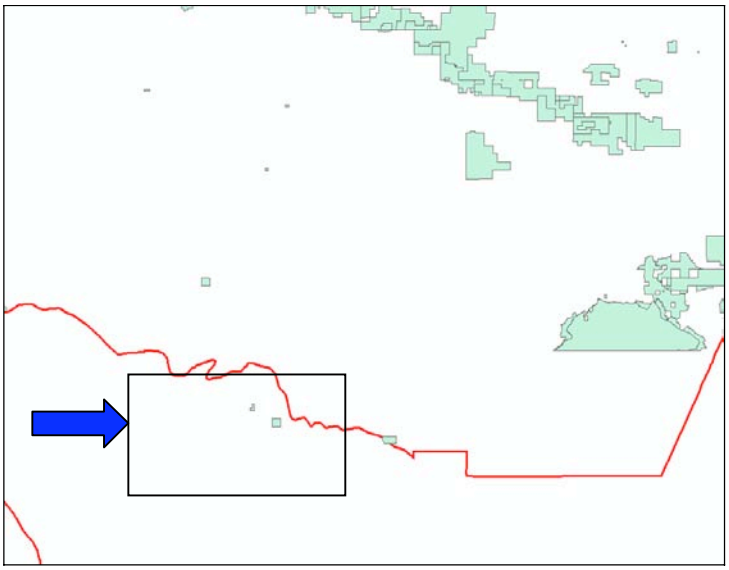

Figure A4-2 Example of Shapefile Extending Over Study Area Boundary

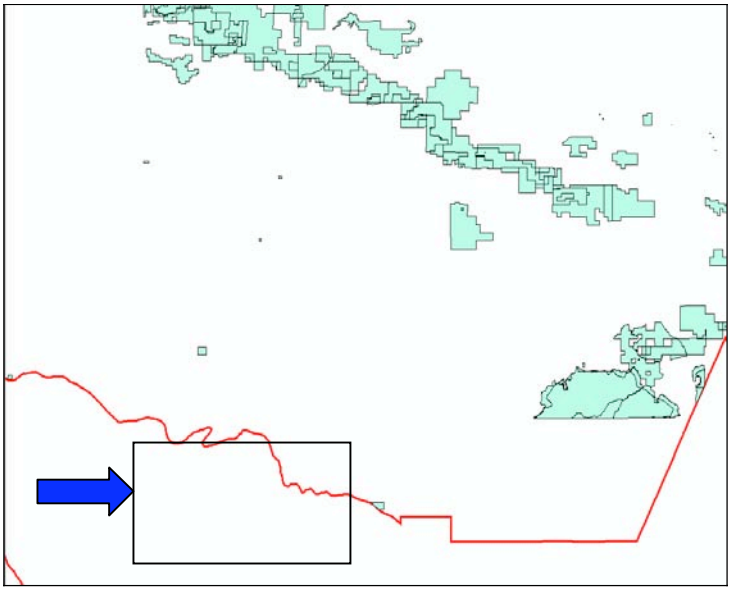

Figure A4-3 Example of Shapefile after Clipping to Study Area Boundary

3. The compiled stipulation shapefile is then queried for unique stipulation attributes values as shown in the ArcGIS Query Builder (Figure A4-4). For this example, all polygons covered by the leasing stipulation "Critical Big Game Habitat" were selected. The highlighted rows in the attribute table (Figure A4-5) show which records are selected. The polygons associated with the selected attributes are highlighted in Figure A4-6 (purple outline).

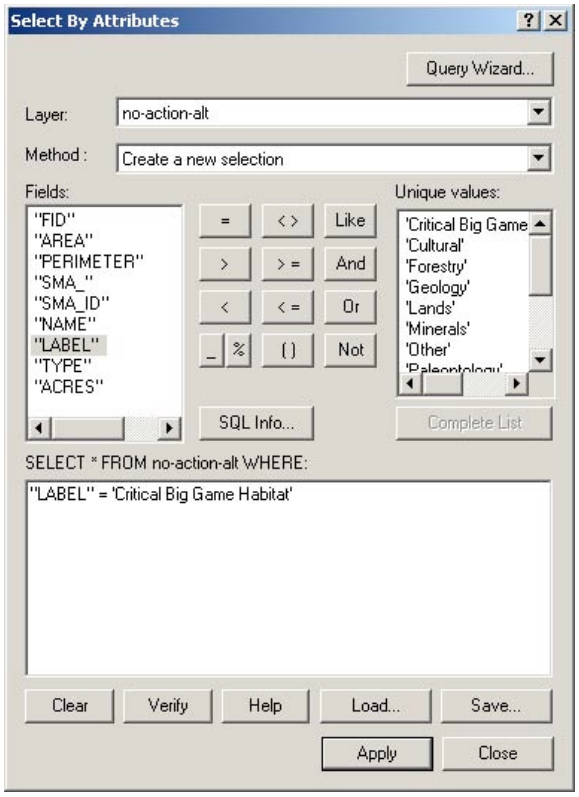

Figure A4-4 Query in ArcGIS for all "Critical Big Game Habitat"

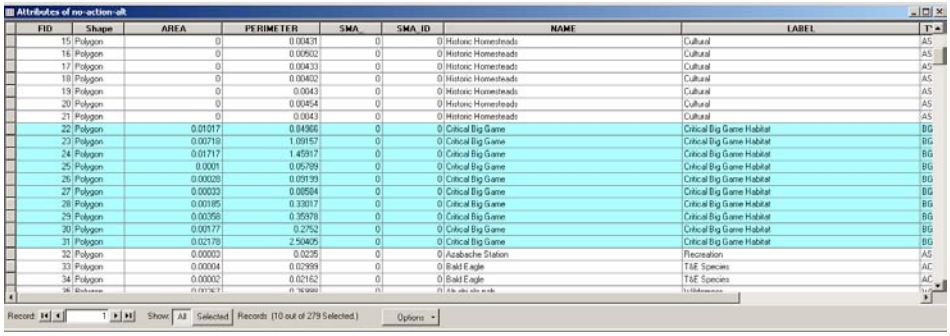

Figure A4-5 Attribute Table Showing all "Critical Big Game Habitat" Polygons

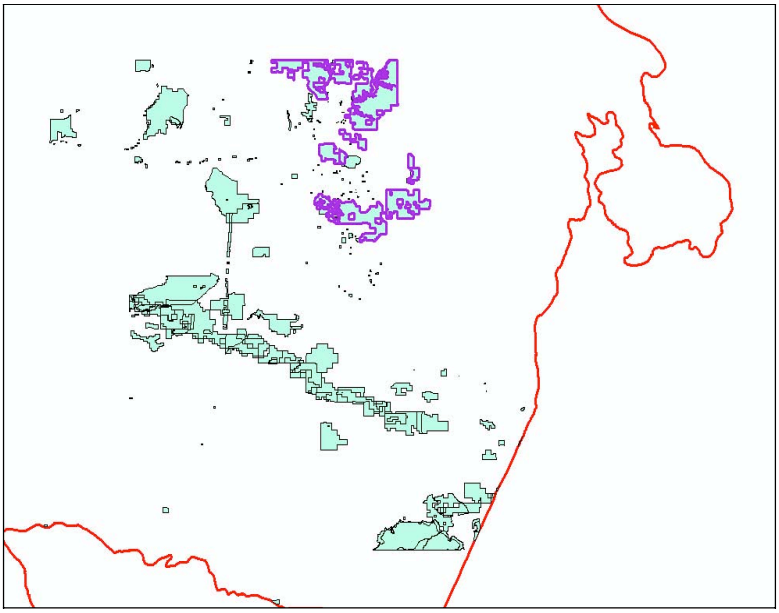

Figure A4-6 Polygons Selected by Query as "Critical Big Game Habitat"

4. Using the ArcGIS function "Create layer from Selected Features," a new shapefile is created that contains only polygons labeled with the attribute "Critical Big Game Habitat" (Figure A4-7). Figure A4-8 shows the new shapefile that is created.

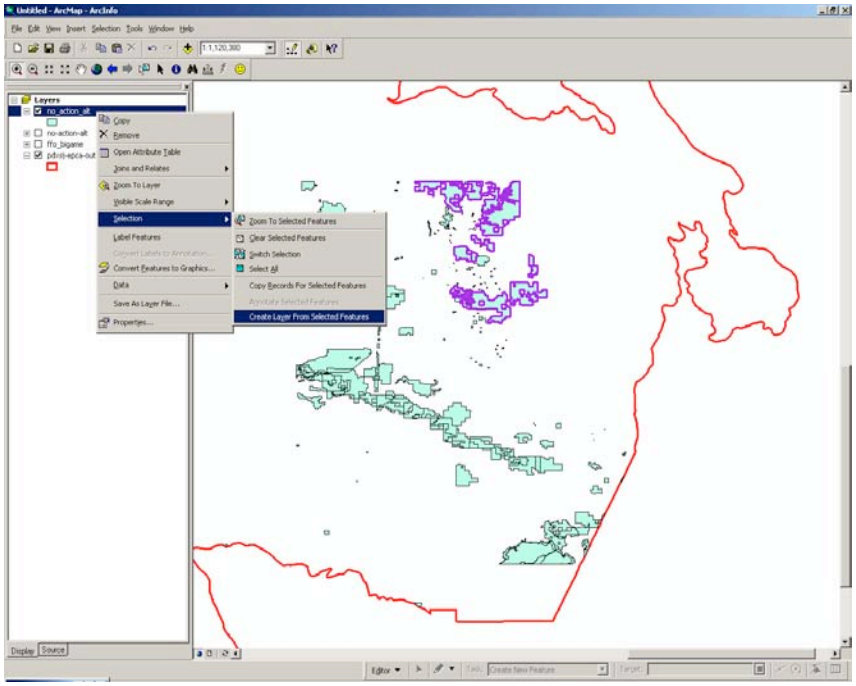

Figure A4-7 Creating New Shapefile from Selected Attributes

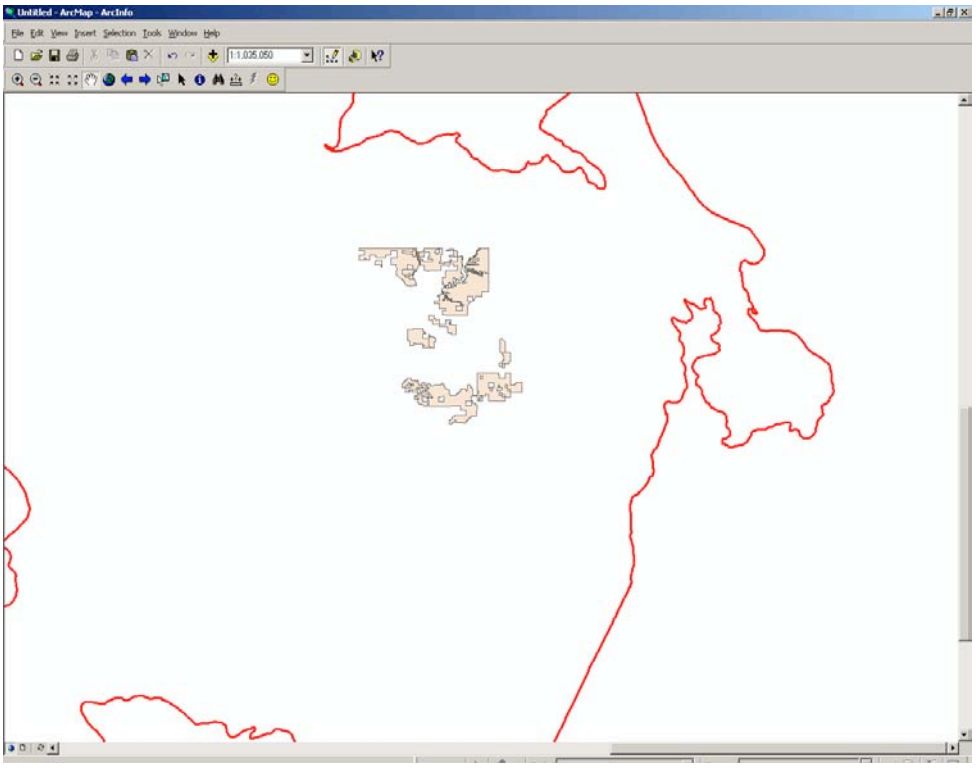

Figure A4-8 New Shape File Representing Land with Leasing Stipulation for "Critical Big Game Habitat"

For certain stipulations, such as steep slopes, for which GIS data were not available from the BLM or Forest Service offices, shapefiles were created from available data in conformance with stipulation requirements. For example, a typical steep slope stipulation impacts leasing in areas where slopes exceed 40 percent. Polygon themes were created from slope data derived from USGS 1:24,000 Digital Elevation Models (DEMs). These raster data sets contain elevation information on a 30-meter grid spacing.

The USGS DEMs were first clipped to the BLM or Forest Service jurisdictional area. In situations where more than one agency had the same stipulations, the digital elevation model (DEM) was clipped to the agencies' combined jurisdictional area. A raster coverage was then created containing slope percentage data as calculated by ArcGIS. This coverage was then queried to isolate the areas covered by the stipulation (i.e., all areas equal to or steeper than 40 percent). The selected raster data was then converted to a vector polygon coverage, and the coverage was coded and attributed as described above. Figure A4-9 shows the creation of steep slope coverages. The 30-meter USGS DEM for this portion of the Uinta Basin is shown in shades of beige. The red theme at the bottom center of the figure represents the polygon shapefile showing areas with a greater than 40 percent slope.

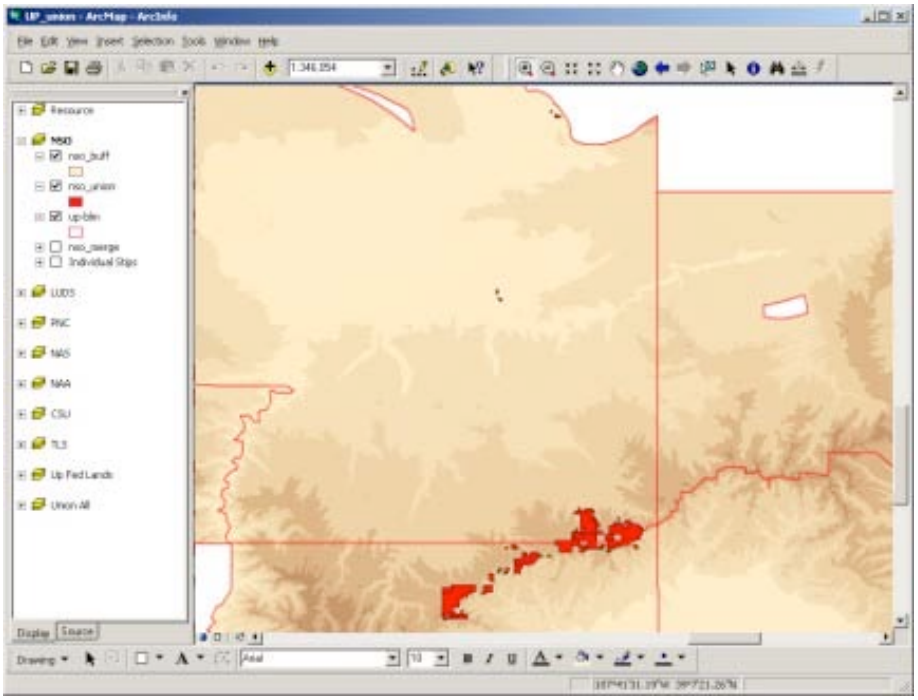

Figure A4-9 Creation of Steep Slope Restriction Coverages

Following the above procedures, the GIS shapefiles of the stipulations were coded with their respective descriptions from the various land use plans. These stipulations are listed in Appendix 9.

APPENDIX 5

U.S. GEOLOGICAL SURVEY METHODOLOGY FOR THE ASSESSMENT OF UNDISCOVERED OIL AND GAS RESOURCES

By U.S. Geological Survey National Assessment Review Team

Introduction

The USGS conducts assessments of technically recoverable undiscovered oil and gas resources of the onshore and State waters of the United States. The last comprehensive USGS oil and gas assessment was completed in 1995, and comprises the onshore and State waters portion of 71 geologic provinces (Gautier and others, 1996). In 1999, the USGS initiated a new, six-year plan to produce incremental assessments of the 25 most significant U.S. oil and gas provinces.

To meet the requirements of Section 604 of the EPCA, the USGS reorganized the priority list for the new re-assessments. For this EPCA report, new assessments were conducted for the Uinta-Piceance Basin, San Juan Basin, Montana Thrust Belt, Powder River Basin, and Greater Green River Basin. The 1995 assessment results were used for the Paradox Basin. The general assessment methodology has not changed from the 1995 assessments; however, some refinements have been made to accommodate increased geologic understanding of the occurrence of resources and more sophisticated means of capturing the range of uncertainty inherent in these variables. For example, the assessment model for continuous resources in the 1995 assessment assumed a homogenous distribution of oil and gas resources in a play. For the new assessments, that model has been replaced with an analysis of geologically controlled sweet spots of production, which demonstrate the geologic heterogeneity common to continuous oil or gas accumulations. The recognition of production sweet spots is a major advancement in the assessment of continuous resources.

This report includes the assessment of undiscovered conventional and continuous (unconventional) oil and gas resources of these resources to surface land ownership categories in the five priority EPCA provinces listed above: Uinta-Piceance Basin, Paradox-San Juan Basins, Montana Thrust Belt, Powder River Basin, and Southwest Wyoming (Greater Green River Basin).

Terminology

Terminology used in this report reflects standard definitions and usage of the oil and natural gas industry and the petroleum resource assessment community. Several terms have been developed by the USGS for oil and gas assessment purposes (see Glossary in Appendix 2). The 1995 USGS assessment focused on the definition and assessment of geologic *plays.* In the latest USGS assessment, the focus is on understanding total petroleum systems and defining *assessment units* within total petroleum systems. The total petroleum system approach is designed to focus the geologic studies on the hydrocarbon source rocks, processes that create hydrocarbons, migration pathways, reservoirs, and trapping mechanisms. For discussion purposes in this report, the term *play* will be used throughout to represent both *assessment units* and *plays.*

The USGS assesses two main categories of hydrocarbon occurrence: conventional and continuous (Figure A5). Conventional oil and gas accumulations are defined as discrete fields with well-defined hydrocarbon-water contacts, where the hydrocarbons are buoyant on a column of water. Conventional accumulations commonly have relatively high matrix permeabilities, have obvious seals and traps, and have high recovery factors. In contrast, continuous accumulations (also called unconventional accumulations) commonly are regional in extent, have diffuse boundaries, and are not buoyant on a column of water. Continuous accumulations have very low matrix permeabilities, do not have obvious seals and traps, are in close proximity to source rocks, are abnormally pressured, and have low recovery factors. The USGS assessment focused on understanding the geology and occurrence of continuous hydrocarbon accumulations, as the resource potential of these accumulations may be greater than that for conventional accumulations in the U.S. Included in the category of continuous accumulations are hydrocarbons that occur in tight reservoirs, shale reservoirs, unconventional reservoirs, basin-centered reservoirs, fractured reservoirs, coal beds, hydrates, and oil shales.

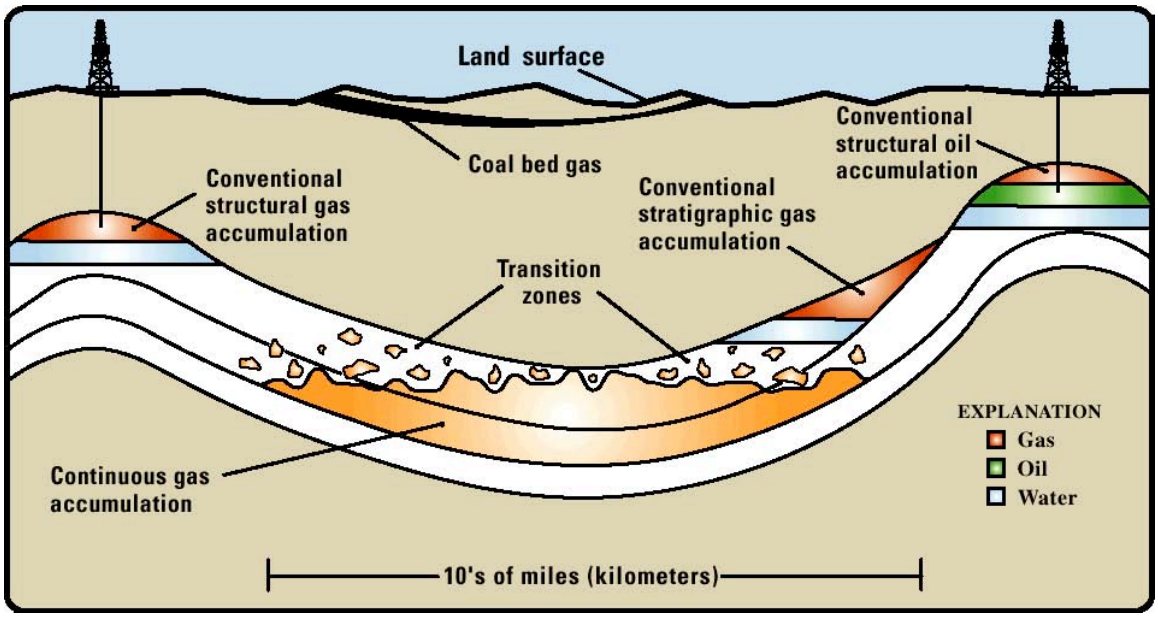

Figure A5 Conventional vs. Continuous Accumulations

Overview of the Oil and Gas Assessment Procedure

The assessment process is based on the characterization of the petroleum geology of each province. The geologists define the geologic elements of the total petroleum systems, and, in conjunction with an analysis of historic oil and gas production and exploration/discovery data, define the oil and gas plays within the provinces. The geologists then develop probability distributions for sizes and numbers of undiscovered conventional accumulations, or numbers of cells and EUR's for continuous accumulations, using all available geologic information and historic oil and gas data. These distributions are then used to generate probability distributions for undiscovered oil and gas resources.

Role of Geologic Information in the Assessment

The strength of the USGS oil and gas resource assessments is the province geologists' understanding of the petroleum geology of the provinces being assessed. These fundamental geologic studies allow new concepts and hypothetical plays to be incorporated into the assessment of undiscovered resources. A purely statistical approach to an assessment such as discovery process modeling that uses only historical data will overlook any new geologic concepts, models, or hypothetical plays.

The team of geologists develops an understanding of the province petroleum geology using published, proprietary, and original research and data. Studying the total petroleum systems within a province includes: (1) identification and mapping the extent of the major hydrocarbon source rocks; (2) understanding the thermal evolution of each source rock, the extent of mature source rock, and the timing of hydrocarbon generation, expulsion, and migration; (3) estimating migration pathways and all forms of hydrocarbon trapping; (4) modeling the timing of structural development and the timing of trap formation relative to hydrocarbon migration; (5) determining the sequence stratigraphic evolution of reservoirs, and the presence of conventional or continuous reservoirs, or both; and (6) modeling the burial history of the basin and the effect burial and uplift has had on the preservation of conventional and continuous hydrocarbons.

Once the total petroleum systems of the province are known in satisfactory detail, the team of geologists defines oil and gas plays, which represent a synthesis of all geologic information, including production and exploration data. The key component of this analysis is a geologic model for the assessment of each play. The geologic model encompasses all elements of the total petroleum system, and is commonly summarized by a total petroleum system events chart.

Sources of Oil and Gas Data

Data for domestic oil and gas fields, reservoirs, and wells are derived from commercial databases purchased annually by the USGS. With more than 2.5 million domestic oil and gas wells and 40,000 oil and gas fields, the USGS has opted to purchase the data from commercial vendors rather than attempt to generate a comprehensive database. The oil and gas wells and production databases are now purchased from the IHS Energy Group (2000 a, b). Previous assessments used the predecessors to IHS: PetroROM Production Data (Petroleum Information/Dwights LLC, 1999a) and the Well History Control System (Petroleum Information/Dwights LLC, 1999b). The USGS also relies on the NRG Associates, Inc. Significant Oil and Gas Fields of the United States (NRG Associates, 2001). Data from these commercial databases are subject to proprietary constraints, and the USGS cannot publish, share, or serve any data from these databases. However, derivative representations in the form of graphs and summary statistics can be prepared and presented for each play. The USGS, however, cannot verify the accuracy, completeness, or currency of data reported in commercial databases.

The IHS production database provides oil and gas production data for wells, leases, or producing units (collectively called "entities" in these databases). The IHS oil and gas wells database provides individual well data (including data for dry holes) that include well identification, locations, and information on penetrated and producing formations. Oil and gas field databases provide location, geologic characterization, and oil and gas production data for domestic oil and gas fields and reservoirs.

Additional oil and gas data are obtained, where available, from operators, state agencies, and other government sources, such as the U.S. Department of Energy's Energy Information Administration proprietary files, publications from the former Bureau of Mines, and other sources.

Assigning Accumulations and Wells to Plays

Digital maps of plays are created using a GIS. The oil and gas play boundaries are available at http://energy.cr.usgs.gov/oilgas/noga. Digital play maps are used to assign oil and gas wells and accumulations to their respective plays, and these assignments are entered into the databases. Oil and gas accumulations are assigned to only one play. Wells, however, can be assigned to more than one play if they penetrate vertically stacked plays. Oil and gas accumulations and well assignments are reviewed to ensure proper assignments, identify inconsistent data, and examine the need for minor revisions of play boundaries.

Historic production and exploration/discovery data are collected for each play using oil and gas accumulations or well assignments. Types of data retrieved include: (1) known volumes (sum of cumulative production and remaining reserves) of recoverable oil, gas, and natural gas liquids (NGL) of accumulations; (2) discovery dates of accumulations (the year the first reservoir in the accumulation was discovered); (3) monthly production and cumulative production of wells; (4) initial classification and final classification of wells (for example, new-field wildcat, development, producing, abandoned, and so on) of wells; and (5) completion dates of wells.

Oil and Gas Production Data

The historic oil and gas production data are compiled for each play so that the data from discovered accumulations can be used as a guide for potential undiscovered accumulations. For conventional plays, these data include (1) field name, (2) field discovery year or date of completion of the discovery well, (3) known volumes of oil, gas (non-associated and associated-dissolved), and NGL, and (4) depth to the top of each reservoir. All of the production data for conventional assessment units are arranged in terms of oil accumulations and gas accumulations and sorted by size and discovery date for statistical calculations and plotting. A list of new-field wildcat wells and their completion dates is compiled and organized into the number of wells drilled per year for conventional plays. (A new-field wildcat well is an exploratory well drilled at least two miles from a producing field to test a separate trap.) Once organized, the number of wells drilled in a given year is used as a measure of exploration effort. These data are then combined with the production data using the discovery dates of the accumulations and the completion dates of the wells.

Oil and gas production data compiled for each producing well in continuous-type plays include past monthly production of liquids (oil and NGL) and gas (non-associated and associated-dissolved), from which EUR's are estimated using well decline-curve analysis, the date of first production, and depth to the topmost perforation. A list of all wells and completion dates are compiled and organized. However, the number of wells drilled in a given year is not combined with production data, but analyzed separately.

Co-product ratios (GOR; NGL to gas ratio; and LGR) are calculated and major commodities (oil or gas) are identified for each conventional accumulation. Co-product ratios are based on accumulation-level oil, gas, and NGL volumes. Oil and gas accumulations are treated separately;

an oil accumulation is defined as one having a GOR less than 20,000 cubic feet/barrel whereas a gas accumulation has a GOR equal to or greater than 20,000 cubic feet/barrel.

Supplemental data from individual reservoirs within the accumulations include thickness (net and gross), average porosity, average permeability, temperature, pressure, fluid properties (for example, sulfur content of oil, API gravity of oil, non-hydrocarbon gas contents), trap type, drive type, and well spacing. These data are combined with the data from the commercial databases to help refine the geologic interpretations and assessment process.

Graphs and Statistics for Conventional Plays

Two sets of graphs and statistics are generated for conventional plays – one set using known accumulation sizes as of the effective date of the assessment and one set using accumulation sizes that are corrected for anticipated reserve growth (grown accumulation size) within the forecast span of the assessment.

The set of graphs and statistics generated for conventional plays includes sizes and number of accumulations with respect to discovery date and exploration effort, exploration effort through time, size distributions of accumulations, reservoir depth versus discovery date and exploration effort, co-product ratios versus reservoir depth, and a histogram of the API gravity. Accumulations containing less than a specified minimum volume of oil or gas (that is, the smallest accumulation size that is considered in the assessment process) are not included in these graphs or statistics. Counts of new-field wildcat wells are used as a measure of exploration effort for finding new accumulations.

Assessment Input for Conventional Plays

Critical input data for conventional plays are probability distributions for sizes and numbers of undiscovered oil and gas accumulations and co-product ratios. The geologists develop these distributions by synthesizing all petroleum systems information and historic oil and gas data. For hypothetical plays, the geologist may utilize an analog data set for sizes and numbers of discovered fields as a guide to the distributions of sizes and numbers of undiscovered fields in the play or assessment unit being assessed. Geologists provide information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

Graphs and Statistics for Continuous-Type Plays

A set of graphs and statistics comparable to that for conventional plays is generated for continuous-type plays, but the EUR per cell and numbers of tested cells are used rather than accumulation sizes and number of discovered accumulations. Tested cells of less than the specified minimum EUR per cell are not included in these graphs or statistics, and reserve-growth adjustments for cells are not incorporated.

The set of graphs and statistics generated for continuous-type plays includes number of wells drilled through time (all wells as opposed to new-field wildcat wells), probability distributions of EUR, EUR versus production-start year and number of all wells drilled, cumulative EUR versus production-start year and number of wells drilled, cumulative EUR versus depth of the topmost perforation, and GOR versus ranked EUR. All of this information is provided to the assessor as a guide to generating distributions for the assessment of undiscovered resources.

Assessment Input for Continuous Plays

Critical input data for the continuous play assessment model include numbers of cells that have potential to be added to reserves, the EUR distribution for these cells, and the co-product ratios. For hypothetical plays, the geologist may utilize an analog data set for distribution of cell size and for the EUR distribution as guides to the distributions of cell sizes and EUR's of undiscovered area in the play being assessed. The geologist provides information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

USGS Assessment Review

The province geologist must present the geology of the play and the input data to a team of USGS personnel for a formal review. The team consists of geologists, geophysicists, and assessment methodologists with broad expertise in petroleum geology, which together promotes a consistent geological and methodological approach to the assessment. Every aspect of the geology and input data are reviewed, and any changes are incorporated into the input data at this time. Once the input data have been finalized, the input data are ready for quantitative analysis.

Calculation of Undiscovered Conventional and Continuous Resources

The final reviewed assessment input forms are the basis of the quantitative calculations of undiscovered oil and gas resources. For conventional plays, the probability distributions for sizes and numbers of undiscovered accumulations and the co-product ratios provided by the assessor are entered into a Monte Carlo simulator and run for a specified number of iterations to provide distributions of undiscovered oil, gas, and NGL resources. In the 1995 assessment, a Truncated Shifted Pareto Distribution (Gautier and Dolton, 1996) was used for the shape of the curve for the distribution of sizes of oil and gas fields. For the present assessment, a Truncated Shifted Lognormal Distribution is used for this purpose (Charpentier and Klett, 2000).

For continuous plays, the distributions for assessment-unit area, untested percentage of assessment unit area, potential percentage of untested area, and area per cell of untested cells are combined analytically to determine the distribution for number of potential untested cells. The distribution for numbers of potential untested cells EUR per cell , and the co-product ratios are combined using an Analytic Probability Method (Crovelli, 2000) to directly calculate the probability distribution of undiscovered oil and gas resources.

Assessment Results

The results and maps of the resource assessment of more than 90 oil and gas plays for the Uinta-Piceance Basin, Paradox-San Juan Basins, Greater Green River Basin, Powder River Basin, and the Montana Thrust Belt provinces can be downloaded from http://energy.cr.usgs.gov/oilgas/noga.

Interim EPCA Report and Assessment Review Team:
Schenk, Christopher J., Charpentier, Ronald R., Klett, Timothy R., Pollastro, Richard M., Cook, Troy A., and Crovelli, Robert A.

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Greater Green River Assessment:
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Montana Thrust Belt Assessment:
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San Juan Basin Assessment:
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IHS Energy Group, 2000b [includes data current as of December, 1999], PI/Dwights Plus US Well Data: Englewood, Colo., IHS Energy Group; database available from IHS Energy Group, 15 Inverness Way East, D205, Englewood, Colorado 80112, U.S.A.

NRG Associates, Inc., 1993, 1994, 1999, 2000, and 2001 [includes data current as of December 31, 1992, December 31, 1993, December 31, 1998, December 31, 1999, and December 31, 2000, respectively], The Significant Oil and Gas Fields of the United States: Colorado Springs, Colo., NRG Associates, Inc.; database available from NRG Associates, Inc., P.O. Box 1655, Colorado Springs, Colorado 80901, U.S.A.

Petroleum Information/Dwights LLC, 1999a [includes data current as of December, 1998], PetroROM Production Data: Englewood, Colo., Petroleum Information/Dwights LLC; database now available from IHS Energy Group, 15 Inverness Way East, D205, Englewood, Colorado 80112, U.S.A.

Petroleum Information/Dwights LLC, 1999b [includes data current as of December, 1998], Well History Control System: Englewood, Colo., Petroleum Information/Dwights LLC; database now available from IHS Energy Group, 15 Inverness Way East, D205, Englewood, Colorado 80112, U.S.A.

APPENDIX 6

ENERGY INFORMATION ADMINISTRATION PROVED RESERVES ESTIMATION AND FIELD BOUNDARY CONSTRUCTION

Summary

The EPCA task of the Reserves and Production Division, Office of Oil and Gas, Energy Information Administration, was to ascertain the relationship of proved reserves of crude oil, natural gas and natural gas liquids to Federal lands located in selected geologic basins of the Rocky Mountain region. This involved attribution of reported and imputed proved reserves to individual fields, development of field boundaries, and relation of the field boundaries and the associated proved reserves estimates to Federal lands. The primary results are presented in multi-layered GIS format accompanied by metadata compliant with the Federal Geographic Data Committee Metadata Standard.

Five sources of data were assembled and conditioned for the project:

1) The 2001 Form EIA-23 Reserves Survey, which was the source for the bulk of proved reserves
2) The commercially vended IHS Energy Group (IHS) Production Data set, which provided field and reservoir names and 2001 production
3) The IHS Well History Data set, which provided the bulk of the individual well locations
4) Relevant State web sites that were consulted to augment the IHS data as respects field and reservoir names, locations, and status
5) Federal lands boundary data, provided by the Department of the Interior

Several steps were involved in the data assembly and conditioning phase:

1) Identifying study area wells, reservoirs, and fields
2) Editing and renaming of reservoir and field names to make them consistent from source to source
3) Identification and standardization of well types
4) Exploration of alternative methods for determining appropriate well buffer sizes
5) Testing of alternative methods for the rendering of field boundary polygons
6) Merging of the IHS Production data, the IHS Well History data and the Form EIA-23 survey data

To compare the fields and their reserves to Federal lands it was necessary to construct a boundary for each field. Placement of appropriate buffers around individual wells, followed by their union, was relied on to create reasonable field boundaries. Buffer size was based on well spacing as determined from measurements of the latitude and longitude of an individual well's spud point relative to those of neighboring wells within the same reservoir. Rules were developed to determine on the basis of these measurements which standard well spacing should be used for each reservoir, as well as to handle exceptional cases. Field boundary polygons were generated using ESRI's ArcGIS Version 8.2 software using the standard well spacing-based buffers assigned to each reservoir. A Visual Basic application was written to automate this process. The software performed these main steps:

1) Selection of all wells and buffer distances with a specific field
2) Creation of a buffer around each well in the field using the assigned "buffer distance"
3) Unioning of the buffers in each field to dissolve inner boundaries of overlapping buffers
4) Outputting of a boundary polygon, sometimes more than one polygon, for each individual field
5) Areal comparison the field boundary polygons to the Federal lands polygons resulting in output of the Federal lands fraction of the total field area

Proved reserves estimates submitted on the 2001 Form EIA-23 survey were used in the proved reserves estimation process as-reported. For those fields in which only some of the operators reported on Form EIA-23, the weighted average reserves-to-production ratio of those which reported was multiplied by the production of non-reporting operators to impute the latter's proved reserves. To impute proved reserves for those fields in which no operator had reported on Form EIA-23, regression equations were developed from the reported observations that were used to estimate proved reserves for these typically small fields. The portion of proved reserves associated with Federal lands within the field was then computed using the Federal lands fraction and each field was assigned to a proved reserves size class sufficiently narrow to be useful for EPCA purposes while at the same time broad enough to ensure confidentiality of each Form EIA-23 respondent's proprietary proved reserves estimates.

For the entire study area, proved Federal lands liquid reserves (crude oil plus condensate) were estimated to be 53.6 percent of total proved reserves; individual basins ranged from 0.0 to 68.9 percent. Similarly, for the entire study area, proved Federal lands gas reserves were estimated to be 60.1 percent of total proved reserves; individual basins ranged from 0.0 to 79.4 percent. Also for the entire study area, Federal lands proved BOE reserves were estimated to be 59.5 percent of total proved reserves; individual basins ranged from 0.0 to 78.6 percent.

The Study Areas

The basins targeted in this initial EPCA study and the States and counties pertinent to them are listed in Table A6-1. Final Federal lands boundaries for the study areas were received from the USGS on July 17, 2002. All wells in the listed States and counties for which location information (in the form of latitude and longitude coordinates) was available were plotted along with the study area boundaries. Wells not located within the study area boundaries were then discarded.

Table A6-1: Targeted Basins and Their State and County Affiliations

Montana Overthrust Belt

State	Counties
Montana	Beaverhead, Broadwater, Cascade, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis & Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Park, Pondera, Powell, Ravalli, Sanders, Silver Bow, Teton

Paradox-San Juan Basin

State	Counties
Colorado	Archuleta, Dolores, La Plata, Mesa (part), Montezuma, Montrose (part), San Miguel, San Juan
New Mexico	Cibola, McKinley, Rio Arriba, San Juan, Sandoval
Utah	Emery (part), Garfield, Grand (part), Iron, Kane, Piute, San Juan, Sevier (part), Washington, Wayne

Powder River Basin

State	Counties
Montana	Bighorn, Carter, Custer, Powder River, Rosebud, Treasure
Nebraska	Sioux
South Dakota	Custer, Fall River
Wyoming	Campbell, Converse, Crook, Johnson, Natrona, Niobrara, Sheridan, Weston

Greater Green River (SW Wyoming) Basin

State	Counties
Colorado	Eagle, Garfield (part), Moffat (part), Rio Blanco (part), Routt
Utah	Daggett, Summit
Wyoming	Carbon, Fremont, Lincoln, Sublette, Sweetwater, Teton, Uinta

Uinta-Piceance Basin

State	Counties
Colorado	Delta, Garfield (part), Gunnison, Mesa (part), Moffat (part), Montrose (part), Ouray, Pitkin, Rio Blanco (part)
Utah	Carbon, Duchesne, Emery (part), Grand (part), Juab, Sanpete, Sevier (part), Uintah, Utah, Wasatch

Note: "(part)" indicates that more than one basin applies to a county

The Data Sources

Five principal sources of data were used for this study:

a. The **2001 Form EIA-23 Survey** files which contain field production and proved reserves estimates as reported by the largest operators.

b. **IHS Production CD's** which contain crude oil, AD gas, NA and condensate production at the well (for gas) or lease (for oil) level.

c. **IHS Well History CD's** which contain well history records. The well data include well spud point location (latitude and longitude thereof generated by Tobin International, Ltd.), field names, producing formation(s), and well type at the time of completion.

d. Many of the Rocky Mountain States have **official websites** that provided supporting data on locations and field names. Links to the websites used in this study are listed below.

Colorado web mapper	http://cogccweb.state.co.us/maps/
Colorado data	http://oil-gas.state.co.us/
Montana web mapper	http://www.bogc.dnrc.state.mt.us/website/mtcbm/webmapper_intro.htm
Montana data	http://bogc.dnrc.state.mt.us/jdpIntro.htm
New Mexico web mapper	http://geoinfo.nmt.edu/resources/petroleum/poolmaps.html
New Mexico data	http://octane.nmt.edu/data/,http://www.emnrd.state.nm.us/ocd/data.htm
South Dakota maps (not interactive)	http://www.sdgs.usd.edu/digitalpubmaps/testholewells testholewellsmapne.html
South Dakota data	http://www.state.sd.us/denr/DES/Mining/Oil&Gas/producti.htm
Utah web mapper	http://dogm.nr.state.ut.us/oilgas/MAP%20SEARCH/map_search.htm
Utah data	http://dogm.nr.state.ut.us/oilgas/qref_Find_data.htm

e. **Federal lands** boundary data provided by the Department of the Interior.

Limitations Imposed by the Available Data Sources

A variety of shortcomings and flaws in the presently available data sources impose unavoidable limitations either on what can be done or on the achievable level of accuracy. Chief among these are:

1) Aside from the Form EIA-23 survey data base, which contains standardized field name spellings and corresponding standardized field codes, field and reservoir names are all too frequently non-standard as respects content and/or spelling. This makes accurate automated -- often even manual -- matching of field and well records across data sources difficult at best and sometimes impossible. While the standardized field codes are assigned and supported by EIA, most field names and their spellings are assigned by State agencies. Much of the problem is rooted in the fact that, over the past two-plus decades, many of the producing States have trimmed the resources devoted to this task, with the result that the extant staffs are overburdened and large backlogs exist. When reporting well or production information for a field on which the State has not yet acted, a field's operator is free to use any name it fancies, spelled however it wishes.

   An additional causative factor was the demise of the American Association of Petroleum Geologists' Committee on Statistics of Drilling, which for many years performed an essential initial and subsequently recursive quality control function relative to the Nation's well statistics and field and reservoir identities. Staffed by experienced industry personnel whose services were "voluntarily" contributed by the firm they worked for, the Committee was disbanded in the wake of the 1986 oil price collapse. Its files were turned over to the American Petroleum Institute (API) which for many years attempted to maintain and update them absent the "in-the-field" quality control that the Committee had provided. When API's budget also diminished, and the last of the API staff familiar with the well files retired, they were transferred to two competing commercial data vendors for continued maintenance and updating. Both recipient firms are now subsumed in IHS.

2) Well misclassification is a perennial problem. For the most part, it is caused by insufficient recursive quality control. For example, a new well may initially be classified as a wildcat well, which by definition has discovered a new field. Subsequent drilling of extension wells in this or an adjacent field may, over time (sometimes over decades) connect the two adjacent fields, at which point both fields will shift to the field name of the earliest discovered of the two. This and similar sorts of things happen frequently, but that fact often never filters backward in time,

i.e., in this case to re-classification of the wildcat well type to extension or even development status.

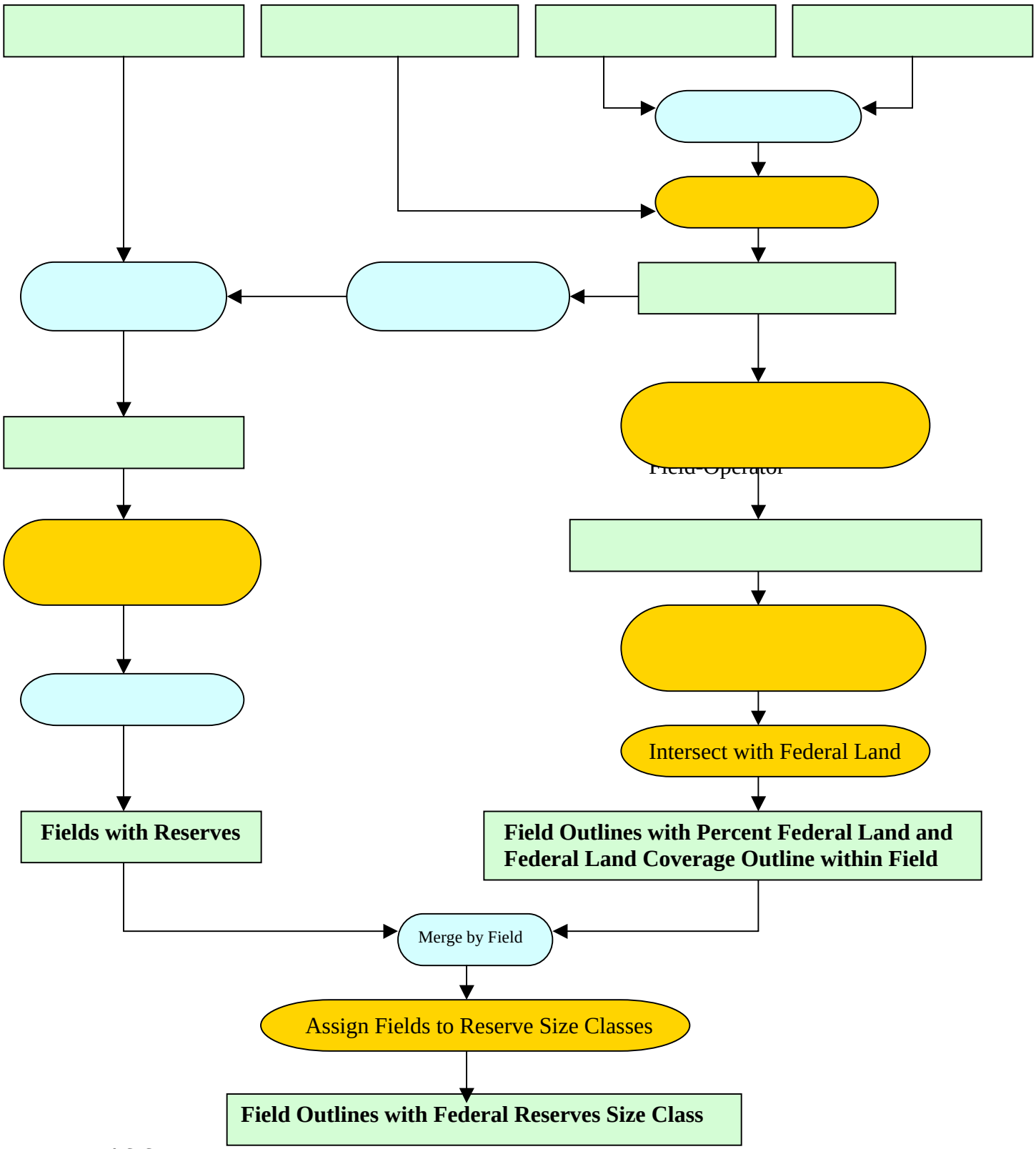
3) With the notable exception of fields located on the Federal Outer Continental Shelf, the Federal government does not as a rule have access to subsurface data other than the usually incomplete well-specific data resident in the IHS Well History file. We do not have access to field operators' seismic data and interpretations, nor to their surface and subsurface geologic maps, nor to their well logs. Such information has historically been treated as proprietary and private in the United States. In the context of the EPCA study, lack of this information limits what can be done as respects the construction of field boundaries to a purely geometric approach based on the buffering of well locations around their surface spud points.

   The resultant field boundaries are therefore approximations, the accuracy of which in the absence of adequate subsurface information depends to a greater or lesser extent, from case-to-case, on the professional judgment of RPDs experienced petroleum geologists and engineers as to what appears to be a reasonable boundary. ***Collectively the field boundaries provided here are likely to be of sufficient accuracy for policy formulation as respects access to Federal onshore lands. But in specific instances, they may not be good enough for the application of policy and regulation***.

General Process Overview

Figure A6-1 is a flow chart of the major steps followed in estimation of field-level proved reserves (on the left-hand side) and the construction of field boundaries (on the right-hand side), as well as their merger into the final principal reserves product. The following discussion provides details for each of the indicated steps.

Figure A6-1 *Proved Reserves Estimation and Field Outline Development*
Process Flows

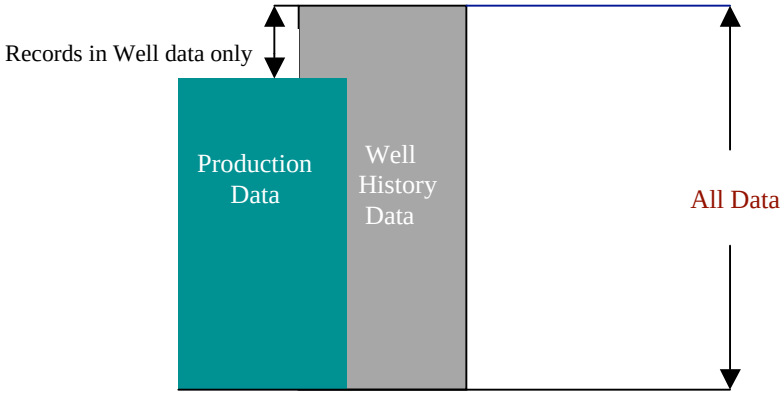


Data Conditioning

Merging of the IHS Production and Well History files

This step combined the annual production data with well location and well type. The API well number, present in both files, was the key to this merging process. Figure A6-2 shows the percentage of wells that were matched by API number and the percentage that was unique to the Well History file.

Figure A6-2 Matching of Wells by API Number and Source



Well Data Production Well Data

In the IHS Well History file and the IHS Production file	82.25%
In the IHS Well History file only	17.75%
Total	100.00%

IHS Well History records that did not match with IHS Production records were most often dry holes, injection, or storage wells. These were discarded. To create valid field boundaries, only oil and gas wells were retained, whether or not they had recorded 2001 production data. The following rules and procedures were developed and used to merge the files:

a. Preparation of spud point location information (well latitude and longitude at the surface)

The location information in the IHS Well History file is Tobin's most accurate coordinates. They were therefore used when available. If location information was not present in the Well History file, the location information in the Production file was used. If location information was not available in either dataset, the well record was deleted from the data used for field boundary construction. These well records were, however, retained for merger with the Form EIA-23 data base because, even absent a location, these wells could at the field level be rolled up with other wells in the same field for which location information was available.

b. Editing/Renaming of Fields and Reservoirs

As previously noted, variations in field and reservoir names and spellings are common in the commercially-vended data files and some State sources. Names were altered when necessary to make them as consistent as possible. The problem of missing names also had to be addressed, often through contact with State personnel. To achieve better field boundaries it was assumed that the buffers created for wells should be calculated on a reservoir level and that the field boundary would then be constructed by unioning of the reservoirs in the field.

Names carried on the IHS Production file were used when they were available. Otherwise, names from the IHS Well History file were used.

If a record appeared not to have a legitimate *field* name, (e.g., 'UNDESIGNATED', 'UNKNOWN', 'WILDCAT'), a concatenation of Basin and State was used to replace it (e.g. new field names like "PRB_WY", "UPB_CO", "UPB_UT", etc, were created). When records appeared not to have a legitimate *reservoir* name, (e.g., 'UNKNOWN', 'UNKNWN', 'WILDCAT'), "UNNAMED" was used as reservoir name.

If a reservoir name was abbreviated, the full reservoir name was assigned. If a reservoir name was augmented by a layer/zone/horizon modifier (e.g. "Dakota A," "Dakota B") the modifier was removed (e.g. all were changed to "Dakota"). Most records did not have horizon information available so the zone name was used instead as the best available data for reservoir naming.

Some field names were changed based on information obtained from State websites and conversations with State agency personnel. The CBM reservoir and field names were especially affected by the State agencies. For example, as development progressed in Wyoming's Powder River Basin (PRB) the State initially classified wells into fields using a system originally designed for application to conventional reservoirs and fields. The result was usually related to pre-existing field names for deeper conventional oil and gas reservoirs. In apparent belated recognition that the CBM in the PRB is really resident in a whole coal field, they now assign all CBM wells in the basin to the field "PRB," i.e., the wells are assigned to a field comprising the entirety of a producing coal seam (see http://wogcc.state.wy.us/coalres.cfm for a list). After conversations with geologist Gary Strong of the Wyoming Oil & Gas Conservation Commission, it was decided that for this study all wells in the PRB with a producing coal reservoir name or which had the IHS attribute "CBM" = yes would be reclassified into the field "PRB_CBM_WY". An exception to this procedure was the Fort Union formation where, per Strong, most of the current wells are CBM completions but a few are conventional oil or gas. Thus Fort Union wells were not put into "PRB_CBM_WY" unless "CBM" = yes or the word "coal" was in present in the reservoir name.

c. Identification of Well Types for Later Buffering

Deciding which wells to include in the buffering process was critically important to the construction of field boundaries. All wells with type = oil or gas in the IHS Production file were kept. If wells were identified as a dry hole, a CO_2 producer, or an injection well in the IHS Production file, but were identified as an oil or gas well in IHS Well History file, the well type was reclassified to oil or gas. If well records came from IHS Well History file only, the many well types were grouped into four classes: Oil, Gas, Dry hole,

and Injection. Following final assignment of the well type, only the oil and gas wells were retained for input to the buffering process.

The Construction of Well Buffers

The procedure used to generate well buffers consisted of several development and application steps:

a. Testing of Alternative Procedures

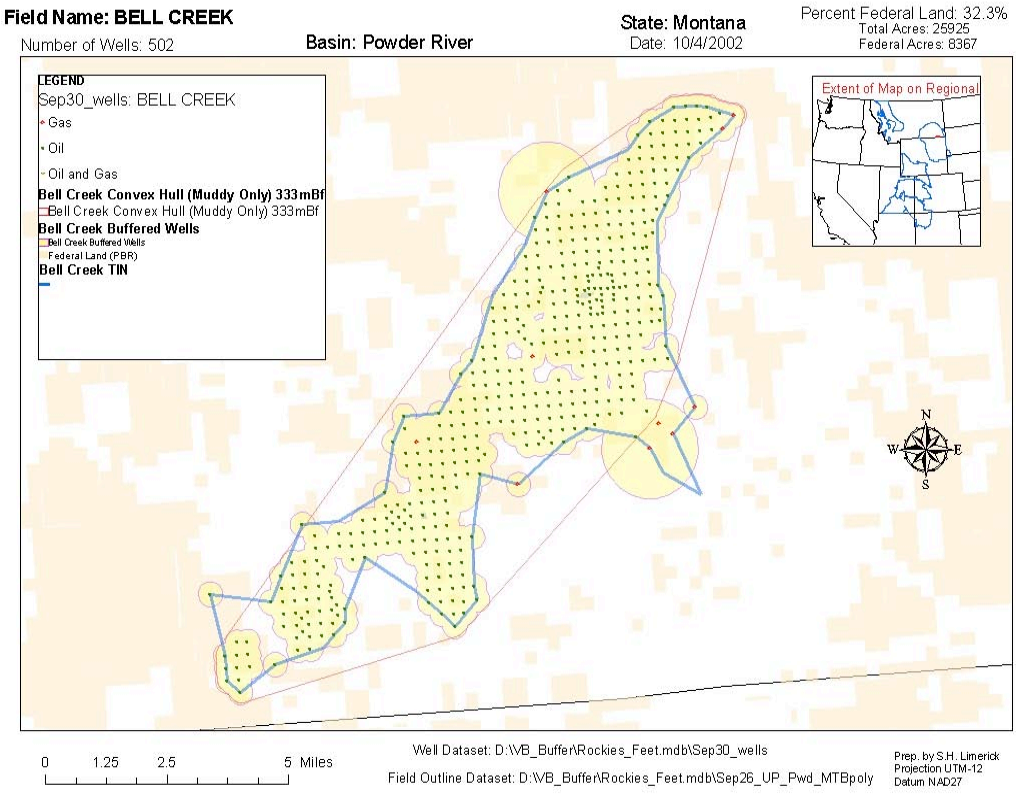
Creation of oil and gas field boundaries was accomplished using ArcGIS. The first method tested was the convex polygon method, which draws a minimum-bounding polygon around a group of wells such that all of the outer angles are convex. While this technique is fine for a structurally simple field, such an oval-shaped anticline with a uniform hydrocarbon-water contact, many fields have an irregular boundary owing to stratigraphic and/or structural complexity. For these fields a convex hull overestimates productive acreage.

The second method tested was the triangular irregular network (TIN). A TIN represents a set of points (wells) as a set of contiguous, non-overlapping triangles. The triangles are then unioned into one polygon for the entire field. This method has the advantage of being able to include a z-value such as thickness or perforated interval. Its disadvantage is that the maximum edge length for triangle construction must be specified field-by-field, which made it too laborious for a project with almost 2000 fields boundaries to build.

The method ultimately used for construction of the field boundaries was to buffer each well in a field with a circle. The radius of the circle was determined by analysis of the spacing pattern for each reservoir in the field. The buffer polygons were then unioned into a single field boundary polygon record for each field. Given the time constraints on the EPCA project, this method was selected because it most effectively utilizes the different reservoir spacing patterns within a field and is relatively easy to perform on a large data set.

Figure A6-3 shows Bell Creek Field with the field boundaries created using each of the three methods described above. The convex hull boundary shown does not include all of the field's wells, only those in the Muddy reservoir.

Figure A6-3 Bell Creek Field, Powder River Basin, Wyoming, Showing Alternative Field Boundaries



b. Determination of Nominal Well Spacing and the Assignment of Buffer Radii

An analysis of the distances between wells in a reservoir, calculated from their spud point locations, was used to assign a standard well spacing unit to each reservoir. Nearest neighbor inter-well separation distances were calculated separately for oil wells and gas wells. The upper and lower bounds of observed spacing ranges are shown in the two left-hand columns of Table A6-2. The corresponding nominal standard well spacings (a geometric distribution) and buffer radii are shown in the two right-hand columns. The 75th percentile (P75) of the observed inter-well distance distribution was taken to be the observed inter-well distance. This statistic was selected because, as judged by the Reserves and Production Division of the EIA (RPD) project team, it yielded the best match to nominal spacings in an extensive set of map trials. If the P75 distance fell within the corresponding interval shown in the two left-hand columns of the table then corresponding nominal spacing was selected and its buffer size was initially assigned to every well in the reservoir.

Inter-Well Distance		Nominal Spacing Unit (acres)	Corresponding Buffer Radius (feet)
Lower Bound (feet)	**Upper Bound (feet)**		
0	277	1.25	233
277	392	2.5	330
392	555	5	467
555	785	10	660
785	1110	20	933
1110	1570	40	1320
1570	2220	80	1867
2220	3140	160	2640
3140	4440	320	3734
> 4440		640	5280

Table A6-2. Interwell Distance Ranges, Nominal Standard Well Spacings, and Buffer Radii

c. Well Buffer Construction Rules

Rules for the assignment of buffers were created to handle reservoirs that did not, for whatever reason, readily yield a nominal spacing. They are based on well types and well counts.

1. For oil reservoirs, the maximum spacing allowed was 160 acres, i.e. a buffer radius of 2,640 feet (exceptions are listed below).

2. If the reservoir had between 1 and 10 oil wells or the reservoir name was 'UNNAMED', a spacing of 160 acres was assigned.

3. For gas reservoirs the maximum spacing allowed was 640 acres, i.e. a buffer radius of 5,280 feet (for exceptions, see below).

4. If the reservoir had only 1 gas well or the reservoir was named 'UNNAMED', a spacing of 640 acres was assigned.

5. For coal bed methane wells a spacing of 160 acres was assigned, i.e. a buffer radius of 2,640 feet (exceptions are listed below).

6. If the oil well count /(oil well count + gas well count) ratio was less than or equal to 5% and if the oil well spacing was greater than the gas well spacing, the oil well spacing was set to the gas well spacing; otherwise, the original oil well spacing was retained.

7. If the ratio of gas well count/(oil well count + gas well count) was less than or equal to 5%, the gas well spacing was set to the oil well spacing for the field or reservoir; otherwise, the original gas well spacing was retained.

d. Exceptions to These Rules

Altamont-Bluebell-Cedar Rim Field (three names for different parts of same physical field), Uinta Basin, Utah:

The P75 calculated buffer radius for the main Green River and Wasatch reservoirs ranges from 320-640 acres. Because production is oil, the default maximum 160-acre buffer was used initially, resulting in numerous isolated polygon rings. According to Montgomery and Morgan (1998, *American Association of Petroleum Geologists (AAPG) Bulletin* 82:6:1113-1132), the major portion of this field was developed on 320-ac spacing for the fractured Green River and Wasatch reservoirs. Thus, an exception was made in this field and 320-acre spacing was assumed for the buffers (3,734 feet buffer radius).

Puerto Chiquito West Field, San Juan Basin, New Mexico:

The P75 calculated buffer radius for the main Mancos reservoir is 640 acres. Because the production is oil, the default maximum 160-acre buffer was used initially, resulting in numerous isolated polygon rings. Spacing rules for the field specify 320-acre units due to the excellent reservoir communication in the fractured Mancos, according to Gorham et al (1979, *AAPG Bulletin* 63:4:598-607. Thus, 320-acre spacing was assumed for buffer construction (3,734 feet buffer radius).

Blanco Field, San Juan Basin, New Mexico:

This field ranks third within the study area as respects total number of wells. It has 8,669 wells, of which 8,498 are Mesa Verde Formation gas completions. The P75 calculated buffer distance of 2130 feet for the Mesa Verde falls in the uppermost range of 1570'-2220' for 80-acre units. At that default spacing, the resultant product shows numerous small gaps between the buffers. The largest fields (in numbers of wells and reserves) such as Blanco are so much larger than the average field that they warrant making of an exception if the default buffer size does not appear to be appropriate. Therefore, 160-acre spacing was assumed (2,640 feet buffer radius).

Fruitland Coal Reservoir, Basin Field, San Juan Basin, New Mexico:

The default radius of 160 acres was overridden on the basis of results of consultations with individuals familiar with the field. 320 acre spacing was assigned, i.e., the buffer radius is 3,734 feet.

The Construction of Field Boundaries

A SAS file containing the oil and gas well data labeled with field name attribute "Field" and reservoir name attribute "Reservoir" was imported into ArcGIS as a dBase (.dbf) file. The wells were then plotted and converted to a geodatabase feature class. The coordinate system used was geographic, decimal degrees, NAD27.

Visual Basic for Applications (VBA) code was written within ArcGIS to provide an automated procedure for creation of polygonal field boundaries from buffered wells. The principal steps performed were:

- Select the "field name" attribute and “buffer distance” attribute from the well file
- Select all wells with the first "field name" encountered
- Create a buffer around each selected well using "buffer distance"
- Union the buffers
- Dissolve the barriers between overlapping buffers
- Iteratively perform the above steps for each unique "field name”
- Output a polygon feature class with one polygon (often consisting of multiple polygon rings) for each field
- Convert to a shapefile

Calculation of the Federal Lands Fraction within a Field's Boundary

The Federal land ownership coverages provided by the Department of the Interior (one coverage per basin) were utilized. A definition query of "Minerals" = 'Fed' was used to exclude private and state land within the coverages. An automated procedure was developed to calculate the fraction of federal land and acres of federal land within each oil and gas field polygon. It:

- Intersected the federal land coverages with the field polygons
- Populated two columns in the field boundary polygon table: “FractionFedLand” and “Fed_Acres.”

In the process of calculating the fraction of federal land in the PRB, a “non-simple geometry” error was encountered. The only way to work around this was to eliminate some of the very small slivers of non-federal land in the PRB coverage. While such slivers are present in all five federal land coverages, they only caused problems in the PRB. These are likely not real gaps in federal ownership. Rather, they are most probably the result of merging land parcels from different sources and/or with different projections. The ELIMINATE command was used to merge narrow slivers of non-federal land smaller that 0.5 acres into adjacent federal land polygons. The resultant coverage was visually checked against the original to insure that no non-sliver land parcels were eliminated. After this was done, the calculation proceeded without error.

Review and Quality Control of the Resulting Maps

An additional part of the VBA routine not included in the above list of steps automated the construction of field boundary maps for quality checking purposes. The maps displayed the wells in the field and the field boundary polygon. They also showed selected field attributes such as State, basin, and percent Federal land.

To quality control the resultant buffers at a more detailed level, boundaries were also constructed at the reservoir level to determine whether the buffer sizes appeared to be appropriate in fields that had multiple reservoirs. Numerous fields were checked in this fashion to verify that the buffering rules produced a reasonable field boundary.

The final field-level buffers and fraction of federal land calculations were checked by inspection of approximately 150 field maps which covered all fields that had more than 300 wells or more than 500,000 barrels-of-oil equivalent proved reserves per the 2001 Form EIA-23 survey.

Figure A6-4 provides an example of the quality control maps.

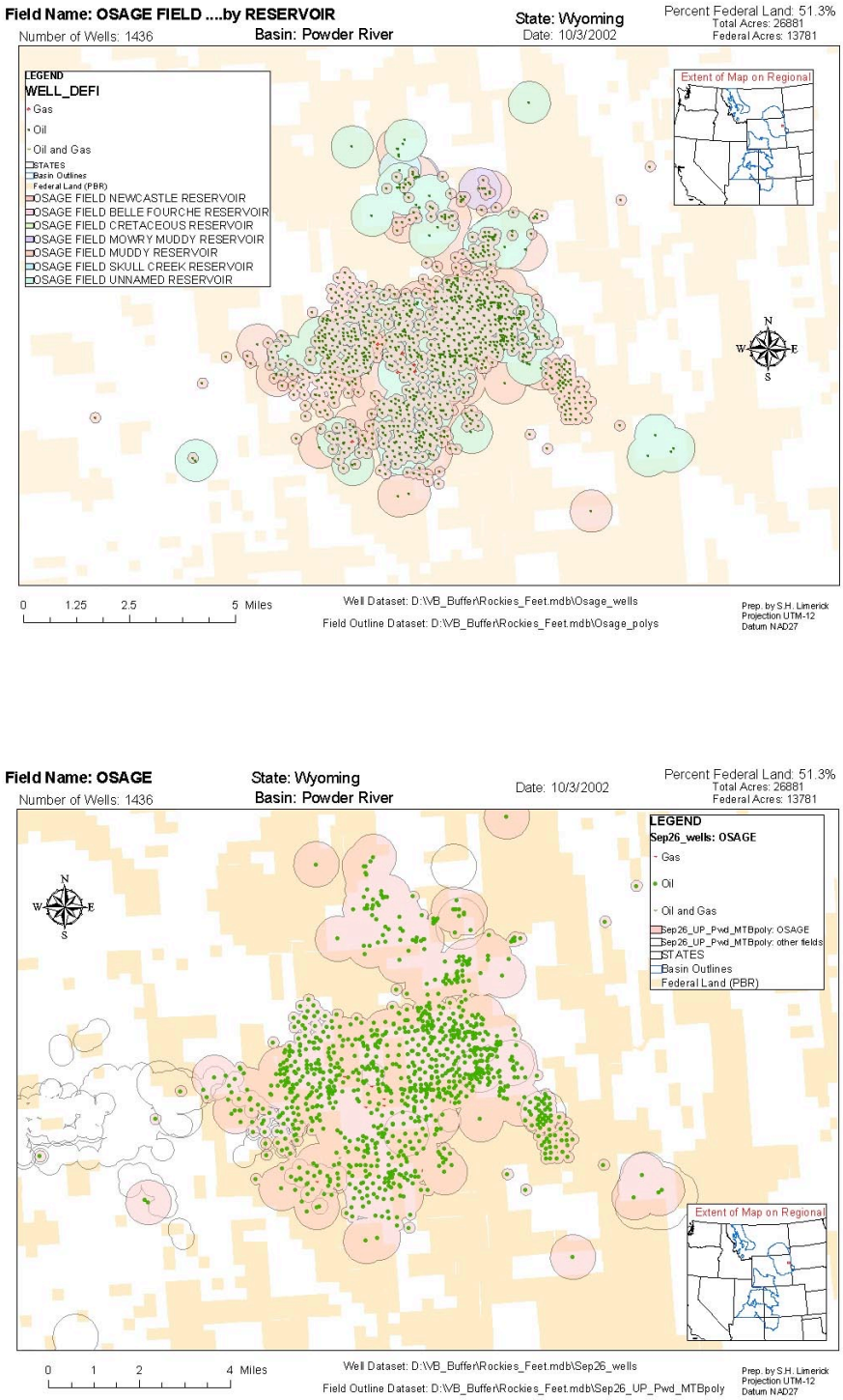


Figure A6-4 Osage Field, Powder River Basin, Wyoming, Showing Buffers by Reservoir (top) and the Field Boundary Resulting from their Union (bottom)

Field-Level Proved Reserves Estimation

The conditioned IHS well history and production data were summed to the field/operator level and then merged with the by-field proved reserves estimates reported on Form EIA-23 by the largest operators.

Of the 753 field/operator combinations, only 40 (about 5%) could not be matched to the IHS data. Since they could not be matched, they were not mappable owing to lack of location information; their relationship to federal lands is unknown. The portion of total proved reserves contributed by these unmatched fields was very small -- about 1 percent.

Of the 713 field/operator combinations that matched with the IHS data, 398 (about 56%) had all operators in the field reporting. The proved reserves estimates submitted for these fields were used as-reported.

Of the 713 field/operator combinations that matched with the IHS data, 315 (about 44%) had part of their proved reserves reported by the surveyed operators. The remainder of these fields' proved reserves was estimated by RPD. Imputation of proved reserves was accomplished by assigning the weighted average reserves-to-production ratio of the reporting operators to the non-reporting operators. The non-reporting operators' production volumes, taken from the IHS data, were multiplied by this ratio to impute proved reserves for the non-reported portion of these fields.

Proved reserves imputation was also necessary for the remaining 542 fields that had recorded 2001 production, but whose operators were not required to submit Form EIA-23. Although these fields constitute a sizeable fraction of the total fields in the study areas, their proved reserves are only a small portion of total proved reserves, less than 4%. Predictive regression equations were developed to estimate the proved reserves of these fields, as follows:

a. Development of Regression Equations

   The proved reserves estimates and corresponding production data reported on the 2001 Form EIA-23 were used to develop least squares regression equations quantitatively descriptive of the relationship between two. The equations were then used to impute proved reserves for the 542 fields whose operators were not required to complete a Form EIA-23, based on their IHS production data.

Four equations were developed using SAS statistical software, one each for oil, associated-dissolved gas, nonassociated gas, and condensate. The form of the equations is:

$$\log_e (\text{Proved Reserves}) = a + b \log_e (\text{Production})$$

The resulting parameters, the number of proved reserves and production pairs each is based on (n), and the goodness of fit statistics (r^2) are provided in Table A6-3.

Product	n	a	b	r^2
Crude Oil	460	1.4725	1.0924	0.90
Associated-Dissolved Gas	208	1.6646	1.0237	0.93
Nonassociated Gas	672	1.6559	1.0687	0.84
Condensate	294	1.9140	1.0030	0.73

Table A6-3 Regression Equations for the Estimation of Non-Reported Reserves

b. Assignment and Imputation of Proved Reserves

When operators reported both production and proved reserves on Form EIA-23, the reported volumes were used. When one or more operators reported for a field but one or more other operators did not report, a weighted average reserves to production ratio was calculated for the reporting operators and multiplied by the missing operators' IHS production to estimate their proved reserves. When a field had no reporting operators, the regression equations shown above were used to impute reserves based on the IHS production data for the field. The final step was to sum the reported and imputed proved reserves to obtain the total proved reserves estimate for the field.

Crude oil proved reserves were then summed with proved condensate reserves to yield proved liquid reserves. Similarly, proved associated-dissolved gas reserves and proved nonassociated gas reserves were summed to yield total proved gas reserves. Last, a gas-to-oil ratio of 6000 cubic feet per barrel was used to convert proved gas reserves to their oil equivalent, which was then summed with proved liquid reserves to yield proved barrel-of-oil-equivalent reserves.

c. Reserves Classification

In order to sufficiently protect the proprietary proved reserves data submitted to EIA, each field was placed into a reserves class, by product, per the following classification scheme:

Class Number	Proved Liquid Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 Mbbl liquid
2	Greater than 10 but less than 100 Mbbl liquid
3	Greater than 100 but less than 1000 Mbbl liquid
4	Greater than 1000 but less than 10000 Mbbl liquid
5	Greater than 10000 Mbbl liquid

Class Number	Proved Gas Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MMcf gas

4	Greater than 10 but less than 100 MMcf gas
5	Greater than 100 but less than 1000 MMcf gas
4	Greater than 1000 but less than 10000 MMcf gas
5	Greater than 10000 but less than 100000 MMcf gas
6	Greater than 100000 MMcf gas.

Class Number	Proved BOE Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MBOE
2	Greater than 10 but less than 100 MBOE
3	Greater than 100 but less than 1000 MBOE
4	Greater than 1000 but less than 10000 MBOE
5	Greater than 10000 but less than 100000 MBOE
6	Greater than 100000 MBOE

Note: M=1,000; MM=1,000,000; bbl=barrel; cf=cubic feet

Merging of Proved Reserves Classes with Field Boundaries and Fraction of Federal Land

A GIS file was then produced that contains the intersection of the Federal land coverages with the field boundaries. Owing to the existence of multiple federal land parcels within each field boundary, the resultant boundary polygons were then dissolved on the attribute "field" to union the data into one polygon record per field. A table with the reserve classes by field (range 0 to 6) and the field name was then joined to the dBase file associated with the field boundary shapefile. The latter was then converted to coverage format and thence to interchange file format (.e00).

Summary of Results

GIS is clearly the information conveyance method of choice where both analysis of Federal lands policy and regulations and their application are concerned. The primary proved reserves result is therefore a GIS layer containing field boundary polygons attributed with field name and a proved reserves size class for each field product. Unfortunately, none of that detailed information can be usefully conveyed on a piece of paper this size. You have to use a GIS workstation to view it and a wide-format printer to print it at a size where detail can be distinguished. Therefore, in lieu of such a close look at the reserves results, basin-by-basin summary statistics are provided in Table A6-4.

Basin	Number of Fields	Total Liquid Reserves (Mbbl)	Federal Land Liquid Reserves	Percent	Total Gas Reserves (MMcf)	Federal Land Gas Reserves	Percent	Total BOE Reserves (Mbbl)	Federal Land BOE Reserves	Percent
Paradox-San Juan	250	174,193	53,103	*30.5*	20,653,622	11,033,357	*53.4*	3,616,464	1,891,996	*52.3*
Uinta-Piceance	180	254,329	142,495	*56.0*	7,181,669	3,779,755	*52.6*	1,451,274	772,454	*53.2*
Greater Green River	281	177,362	122,234	*68.9*	12,703,038	10,081,667	*79.4*	2,294,535	1,802,512	*78.6*
Powder River	543	193,456	110,783	*57.3*	2,398,604	927,738	*38.7*	593,223	265,406	*44.7*
Montana Thrust Belt	1	1	0	*0.0*	0	0	*0.0*	1	0	*0.0*
Total	1,255	799,341	428,616	*53.6*	42,936,933	25,822,517	*60.1*	7,955,497	4,732,368	*59.5*

Table A6-4 Summary of 2001 Federal Lands Proved Reserves by Study Area

Another notable result involves the hypothesis that:

1) on-average, and

2) owing to the existence of stipulations and other impediments to drilling on Federal lands beyond those customarily associated with private leases,

Even within the boundaries of the study area's producing fields, the well density would be lower on the Federal lands than on the non-Federal lands.

The well density on Federal lands within study area's fields was found to be 103.5 acres per well, or 6.19 wells per square mile (640 acres). The well density on the non-Federal lands within the study area's fields was found to be 96.5 acres per well, or 6.63 wells per square mile. This result supports the hypothesis.

APPENDIX 7

GIS METHODOLOGY

Following are further descriptions of how Federal lands were categorized into the ten categories referred to in table 2c in Section 2.4.1 and a detailed description of the GIS methodology used.

Table A7-1 shows the "No Leasing Pending Land Use Planning or NEPA Compliance (NLA/LUP)" jurisdictions within the EPCA inventory area.

FS or BLM jurisdiction	Comments
Ashley NF	Northern unit only
Big Horn NF	
Bitterroot NF	
Bridger-Teton NF	Areas east of of Highway 191
Custer NF	
Dillon, MT BLM Field Office	
Dixie NF	
Fish Lake NF	
Flathead NF	
Gallatin NF	
Gunnison, CO BLM Field Office	
Kootenai NF	
Lewis and Clark NF	Western portion only
Lolo NF	
Rio Grande NF	
Routt-Medicine Bow	Medicine Bow portion only
Wasatch-Cache NF	
Uinta NF	Unmapped western portions only

Table A7-1 Jurisdictions Classified as NLA/LUP

Table A7-2 shows how agency jurisdictions were used to categorize lands for this inventory.

Federal Land Management		Categorization	Level
Bureau of Land Management	BLM	Subject to stipulations	
Bureau of Reclamation	BREC	Subject to stipulations	
Department of Agriculture*	USDA	No Leasing (Administrative), general category (NLA)*	3.
Department of Defense**	DOD	No Leasing (Administrative), general category (NLA)**	3.
Federal Split Estate	SPLIT	Subject to stipulations	
Fish and Wildlife Service	FWS	No Leasing (Administrative), general category (NLA)	3.
Forest Service	FS	Subject to stipulations	
National Park Service	NPS	No Leasing (Statutory/Executive Order), (NLS)	1.
Federal Land Use Designations			
Inventoried Roadless Areas	IRA	Subject to stipulations	
National Conservation Areas	NCA	No Leasing (Statutory/Executive Order), (NLS)	1.
National Monuments	NM	No Leasing (Statutory/Executive Order), (NLS)	1.
National Recreation Areas	NRA	No Leasing (Statutory/Executive Order), (NLS)	1.
National Wildlife Refuges	NWR	No Leasing (Statutory/Executive Order), (NLS)	1.
Special Designated Areas	SDA	No Leasing (Statutory/Executive Order), (NLS)	1.
Wilderness Areas	WILD	No Leasing (Statutory/Executive Order), (NLS)	1.
Wilderness Reinventory Areas	WRA	No Leasing (Administrative), general category (NLA) for offices listed in next table; otherwise subject to stipulations	3.
Wilderness Study Areas	WSA	No Leasing (Statutory/Executive Order), (NLS)	1.

* Ft. Keo Agricultural Experimental Station, MT, only
** Except for the Naval Petroleum Reserve, Casper Field Office, which is subject to stipulations

Table A7-2 Federal Land Categorization

Jurisdiction	Comments
Ashley NF	
Farmington NM BLM Field Office	
Glenwood Springs CO BLM Field Office	
Grand Junction CO BLM Field Office	Uinta/Piceance Study Area
Grand Mesa /Uncompahgre /Gunnison NF	
Gunnison CO BLM Field Office	
Kemmerer WY BLM Field Office	
Lander WY BLM Field Office	
Little Snake CO BLM Field Office	GGR Study Area
Manti La Sal NF	
Moab CO BLM Field Office	
Monticello CO BLM Field Office	
Pinedale WY BLM Field Office	
Price UT BLM Field Office	
Rawlins WY BLM Field Office	
Rock Springs WY BLM Field Office	
Routt-Medicine Bow NF	
Uinta NF	
Uncompahgre CO BLM Field Office	Uinta/Piceance Study Area
Vernal UT BLM Field Office	
White River CO BLM Field Office	
White River NF	

Table A7-3 Jurisdictions with Wilderness Reinventory Areas (WRAs) Classified as NLA

Jurisdiction	Comments
Cedar City UT BLM Field Office	Spring Creek Canyon only
Durango CO BLM Field Office	
Glenwood Springs CO BLM Field Office	
Grand Junction CO BLM Field Office	
Grand Mesa /Uncompahgre /Gunnison NF	
Little Snake CO BLM Field Office	
Price UT BLM Field Office	
Uncompahgre CO BLM Field Office	
Vernal UT BLM Field Office	

Table A7-4 Jurisdictions with Citizen's Proposal Areas (CPAs) Classified as NLA

National Forests affected by the Roadless Areas Conservation Rule (36 CFR 294) were considered available for leasing in this inventory. The rationale for this decision is that as of the date of this report, implementation of the Roadless Rule has been enjoined by the Federal District Court of Idaho.[12] However, if current litigation upholds this rule, it could highly restrict or make inaccessible approximately 6.1 million acres within the study areas. For this reason, leases offered and/or issued in areas covered by the Roadless Rule have attached to them a Notice to Lessees informing them that all or part of the lease is within an area covered by this rule.

Citizens' Proposal Areas (CPAs) located on Federal land, primarily managed by the BLM in Utah and Colorado, are places which have been proposed as wilderness by environmental groups. The treatment of CPAs differs by state and by office (Table A7-4). In Utah, offices that have CPAs individually determine their treatment with respect to oil and gas leasing. In Colorado, the CPAs are generally considered NLA unless the area under consideration has been explicitly examined as part of a particular BLM Field Office's planning process.[13]

GIS files were available to define most of the access categories; however, for the NLA/LUP category, they had to be created. In these situations, the administrative boundary (such as a National Forest) was extracted from the surface ownership data and the resultant polygon was then attributed as NLA/LUP. For example in Figure A7-1, the national forests in the western Uinta Basin are shown in green. The beige area represents the Ashley National Forest (northern unit), which is categorized as NLA/LUP.

[12] Idaho vs. Dombeck CV01-11-N-EJL (D.C.Id. 2001 Kootenai Tribe of Idaho et al. vs. Dombeck). Colorado and Alaska have joined Idaho; Utah has also filed.
[13] BLM, Colorado State Office, Instruction Memorandum No. CO-97-044.

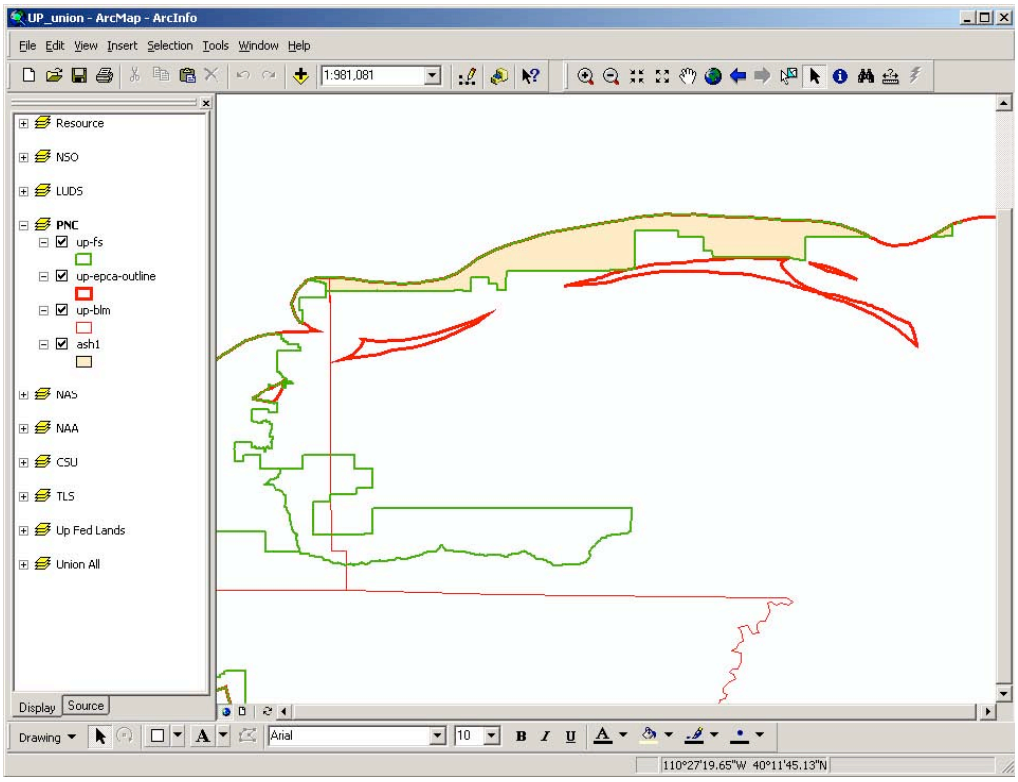


Figure A7-1 Creation of NLA/LUP Shapefiles

Stipulation Exceptions

Sometimes exceptions to stipulations are granted for valid reasons. For example, for a crucial elk winter range timing limitation, an exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general areas during a particular year. Because records of exceptions to lease stipulations were not available, BLM and USDA-FS field personnel were asked to determine, based on their experience, which lease stipulations were granted exceptions for drilling and how often. The exception factors thus determined are shown by jurisdiction in Table A7-6.

Lease stipulations, particularly timing limitations, can overlap. Where exception factors overlap, the cumulative effect is calculated by multiplying the overlapping factors (from Table A7-6). This calculation implicitly assumes that exceptions for multiple stipulations would likely not be obtained for a given area. For example, cumulative effects of excepted stipulations for the Greater Green River study area are computed as shown in Table A7-7. The application of these exception factors is described below in the section titled "Analytical Modeling of Federal Lands and Resources."

Jurisdiction	Exceptions to stipulations											Comments
	Big Game Winter Range	Raptors	Sage Grouse	Steep slopes	Bald Eagle Winter Roost	Calving and Fawning	Antelope Fawning	City of Rifle Water-shed	Sensitive Resources	Soils, Watershed	Sedimentation (roads)	
Buffalo WY BLM Field Office		25%	25%									
Carson NF	10%										10%	
Casper UT BLM Field Office	25%	25%										
Durango CO BLM Field Office	50%	50%			50%							
Glenwood Springs CO BLM Field Office								100%				Uinta/Piceance Study Area
Glenwood Springs CO BLM Field Office	20%	30%	20%									GGR Study Area
Grand Junction CO BLM Field Office	70%			15%					30%			
Kemmerer WY BLM Field Office	30%	50%	50%									
Lander WY BLM Field Office	20%	30%	20%									
Little Snake CO BLM Field Office	20%	30%	20%									
Manti La Sal NF				50%		80%						
Miles City MT BLM Field Office	50%	50%	10%									
Missoula MT BLM Field Office	20%	20%		15%								
Moab UT BLM Field Office	70%						70%			70%		
Pinedale WY BLM Field Office	50%	40%	40%									
Rawlins WY BLM Field Office	20%	30%	20%									
Rock Springs WY BLM Field Office	30%	25%	20%									
Routt-Medicine Bow NF	20%	30%	20%									GGR Study Area
Uncompahgre CO BLM Field Office	50%	50%			50%							Paradox/San Juan Study Area
Uncompahgre CO BLM Field Office	10%	10%										Uinta/Piceance Study Area
White River CO BLM Field Office	80%	25%										Uinta/Piceance Study Area
White River CO BLM Field Office	20%	30%	20%									GGR Study Area
White River NF						50%						

Table A7-6 Stipulation Exception Factors List by USDA-FS and BLM Office

Stipulation	Exception Factor (EF)
Big Game	20%
Sage Grouse	20%
Raptors	30%
Big Game and Sage Grouse	4%
Big Game/Raptors	6%
Sage Grouse/Raptors	6%
Big Game, Sage Grouse and Raptors	1.2%

Table A7-7 Exception Factors (GGR Study Area)

Treatment of NSO Areas

Directional drilling (or "extended drilling") is a technology that can be employed to reach subsurface targets not located directly underneath the drill site. Resources beyond a certain "extended drilling zone" (EDZ) are assumed not to be technically recoverable (Figure A7-2). While it is true that directional drilling horizontally out to distances of 5 or 6 miles is possible in production settings such as Alaska, this type of drilling is impractical for exploration in the Western basins.

Directional drilling for exploratory purposes occurs in Western basins, but it is much more limited in scope. As in the case of stipulation exceptions, BLM and USDA-FS field personnel were interviewed to determine the practicable width of the EDZ. The width of the EDZ is partially a function of the depth to the drilling objective—generally the deeper the objective, the larger the EDZ. The EDZ distances supplied by the offices and used in the EPCA inventory are shown in Table A7-8.

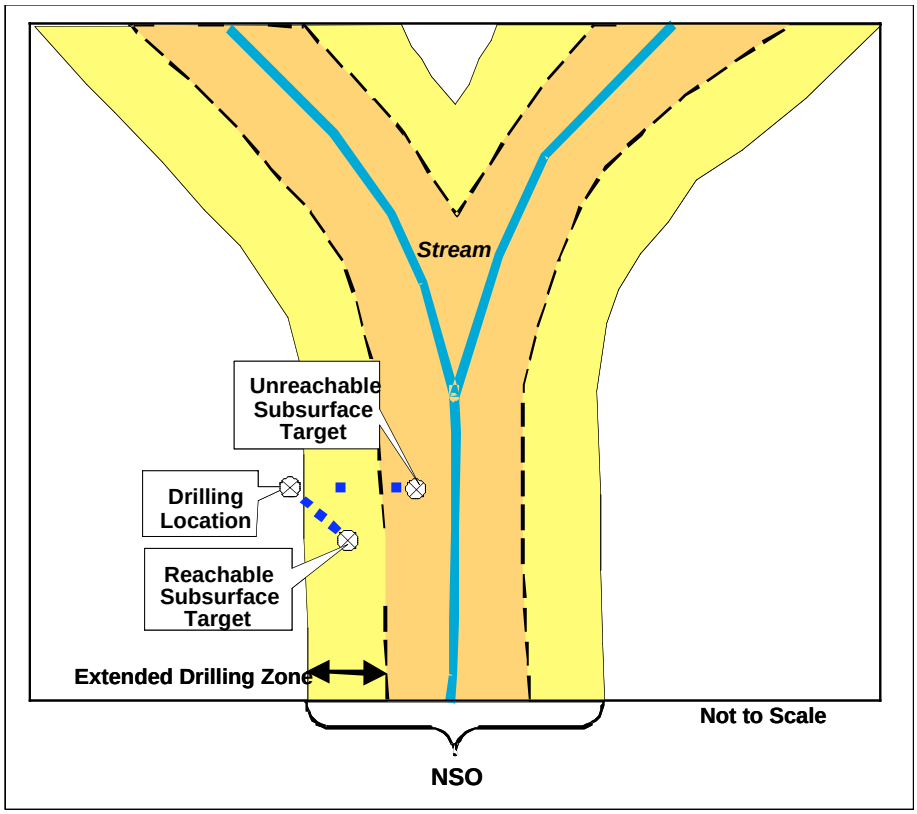


Figure A7-2. Extended Drilling Zone

The effect of the inclusion of the EDZs in the analysis was to remove an area of land from the perimeters of NSO polygons. The width of this area removed via GIS processing is determined by Federal jurisdiction (Table A7-8). The area removed then defaults to the access category that would otherwise apply in the absence of the NSO stipulation. The net effect is that the underlying resource is no longer considered inaccessible even though the surface above it cannot be occupied by drilling equipment.

Jurisdiction	EDZ (miles)	Comments
Albuquerque NM BLM Field Office	0.25	
Ashley NF	0.25	
Beavehead-Deerlodge NF	0.50	
Black Hills NF	0.25	
Buffalo WY BLM Field Office	0.25	
Buffalo Gap NG	0.13	
Butte MT BLM Field Office	0.25	
Carson NF	0.25	
Casper WY BLM Field Office	0.25	
Cedar City UT BLM Field Office	0.00	
Cibola NF	0.25	
Durango CO BLM Field Office	0.00	San Juan Basin portion
Durango CO BLM Field Office	0.50	Paradox Basin portion
Farmington NM BLM Field Office	0.25	
Glenwood Springs CO BLM Field Office	0.25	
Grand Junction CO BLM Field Office	0.25	
Grand Mesa /Uncompahgre /Gunnison NF	0.00	Paradox/San Juan Study Area
Grand Mesa /Uncompahgre /Gunnison NF	0.25	Uinta/Piceance Study Area
Gunnison CO BLM Field Office	0.25	
Helena NF	0.25	
Kanab UT BLM Field Office	0.00	
Kemmerer WY BLM Field Office	0.25	
Lander WY BLM Field Office	0.25	
Lewis and Clark NF	0.25	Eastern portions only
Lewistown MT BLM Field Office	0.25	
Little Snake CO BLM Field Office	0.25	
Manti La Sal NF	0.25	Paradox/San Juan Study Area
Manti La Sal NF	0.50	Uinta/Piceance Study Area
Miles City MT BLM Field Office	0.25	
Missoula MT BLM Field Office	0.50	
Moab UT BLM Field Office	0.25	
Monticello UT BLM Field Office	0.25	
New Castle WY BLM Field Office	0.00	
Oglala NG	0.13	
Pinedale WY BLM Field Office	0.25	
Price UT BLM Field Office	0.00	Paradox/San Juan Study Area
Price UT BLM Field Office	0.25	Uinta/Piceance Study Area
Rawlins WY BLM Field Office	0.25	
Richfield UT BLM Field Office	0.00	Paradox/San Juan Study Area
Richfield UT BLM Field Office	0.25	Uinta/Piceance Study Area
Rock Springs WY BLM Field Office	0.25	
Routt-Medicine Bow NF	0.25	
Salt Lake UT BLM Field Office	0.25	
Santa Fe NF	0.25	
South Dakota BLM Field Office	0.25	
St. George UT BLM Field Office	0.00	
Thunder Basin NG	0.25	
Uinta NF	0.25	
Uncompahgre CO BLM Field Office	0.50	Paradox/San Juan Study Area
Uncompahgre CO BLM Field Office	0.25	Uinta/Piceance Study Area
Vernal UT BLM Field Office	0.00	
White River CO BLM Field Office	0.25	
White River NF	0.25	

Table A7-8 Extended Drilling Zones by Jurisdiction

Figure A7-3 shows an example from the Uinta/Piceance Basin. Areas shown in red represent a 1/4-mile extended drilling zone removed from the NSO areas. Areas shown in beige represent the remaining NSO stipulations. Note that many small features are completely removed from the NSO theme by use of the EDZ. Similarly, linear NSO features less than 1/2 mile wide, such as trails, are removed as well.

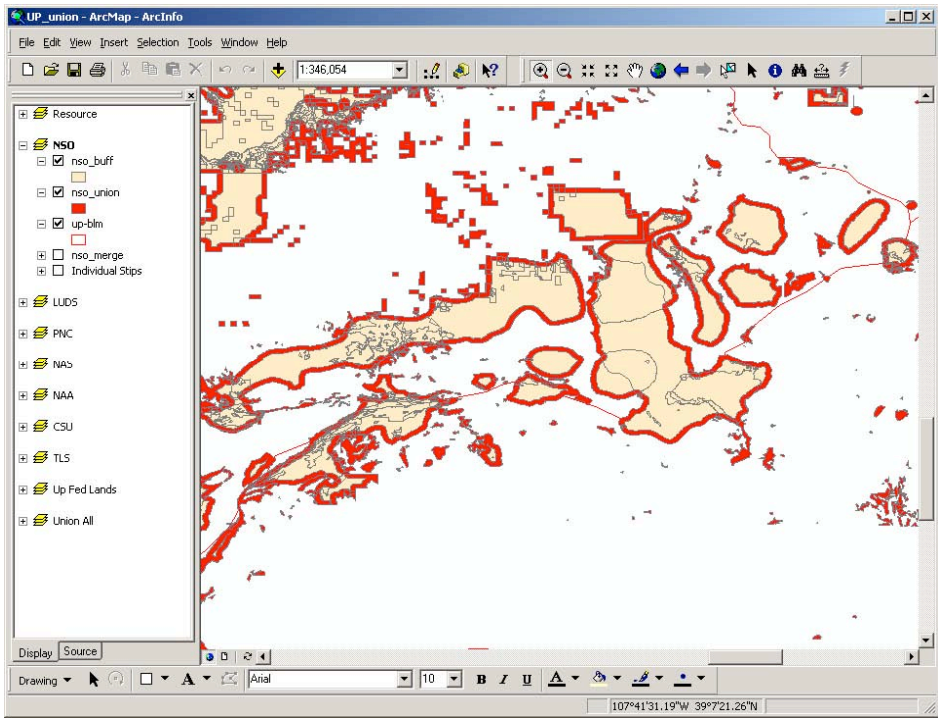


Figure A7-3 Removal of the Extended Drilling Zone from NSO Areas

Analytical Modeling of Federal Lands and Resources

The analytical goal of the EPCA inventory is to calculate the area of Federal lands (including non-Federal lands overlying federally owned oil and gas estate [split estate]) in each access category in the hierarchy and the volume of oil and gas resources underlying the Federal lands in each access category, while at the same time accounting for stipulation exceptions and the accessibility of the EDZ.

One of the primary goals for the development of the categorization was to achieve geographic independence for a given parcel of land subject to overlapping stipulations (hence, the use of the categorization hierarchy where that parcel of land would be subject to only one category). The following discussion illustrates the application of the land access categorization for an area of multiple stipulations from southern Wyoming near the Colorado state border (Greater Green River Study Area), where a raptor nest, sage grouse nest, and mule deer winter range define an access category. These types of stipulations are among the most common found in the study areas.

Figure A7-4 shows a selected point where the stipulations overlap and the resultant categorization is "Timing Limitation Stipulation (TLS) 6-9" according to the access categorization hierarchy. Figure A7-5 shows the land categorization before processing, but with the application of all stipulations in the area. Note that the core nest of the sage grouse stipulation (shown is blue), which cannot be occupied, is

considered "no surface occupancy" area (NSO). The remaining area is under various timing limitations (colored in shades of red) or under standard lease terms (in green).

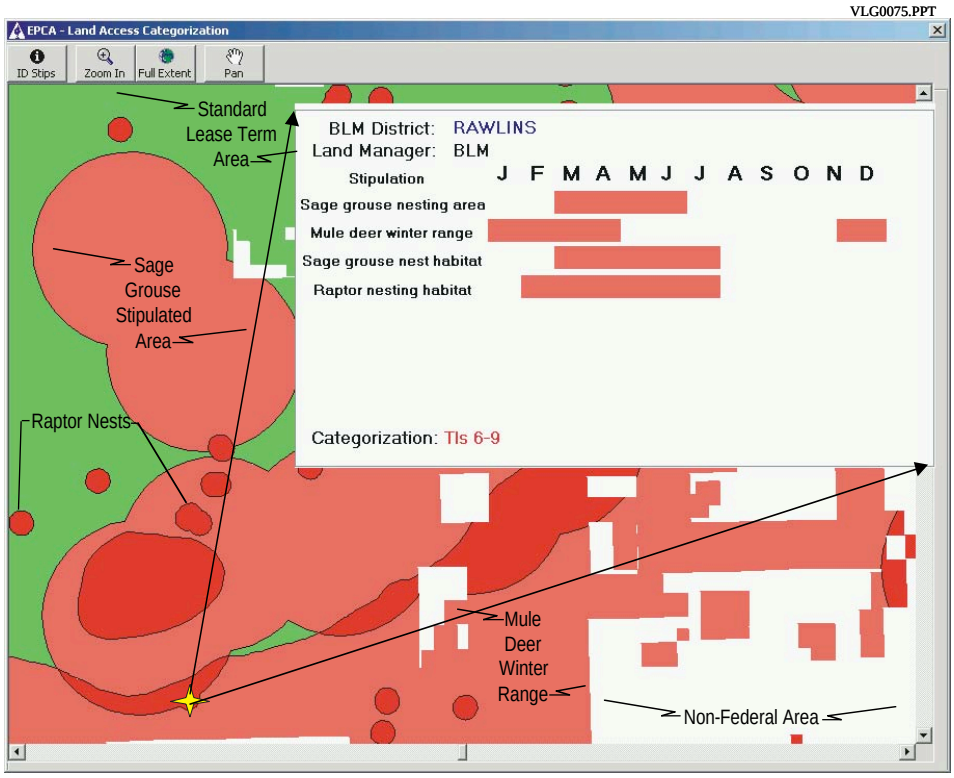


Figure A7-4 Display of Overlapping Timing Limitations (GGR Study Area)

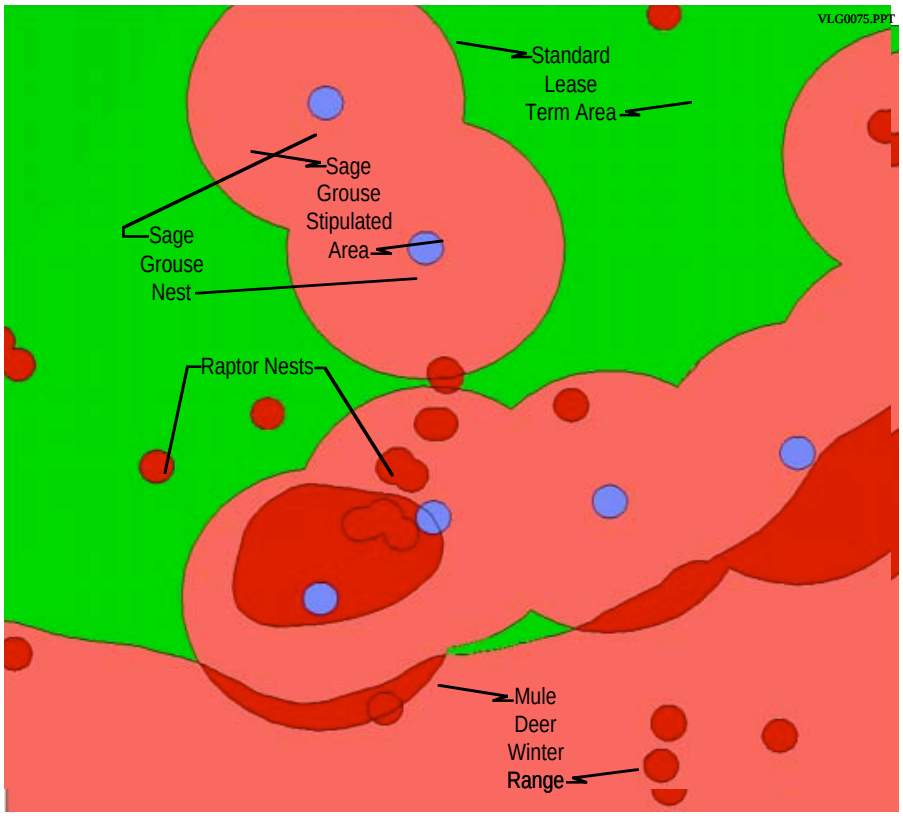


Figure A7-5 Display of Land Access Categorization (GGR Study Area)

Next, Figure A7-6 shows the effect where the EDZ is applied to NSO areas. Note that use of the EDZ makes the sage grouse nest transparent to the categorization. Using a GIS-driven model developed for the project, all stipulations were similarly subjected to the categorization hierarchy and are presented in an interactive map, termed LACE (land access categorization, executable), accompanying this report.

Additionally, to account for stipulation exceptions in the analysis, the GIS-driven model determined the effects due to the presence or absence of the stipulations by selectively removing excepted stipulations in the computer. This is illustrated by Figure A7-7, which shows this for the example for the Greater Green River Study Area, where the raptor stipulation has been removed. Note that, in the absence of an excepted stipulation, the analysis defaults to the underlying stipulation or standard lease terms, as appropriate.

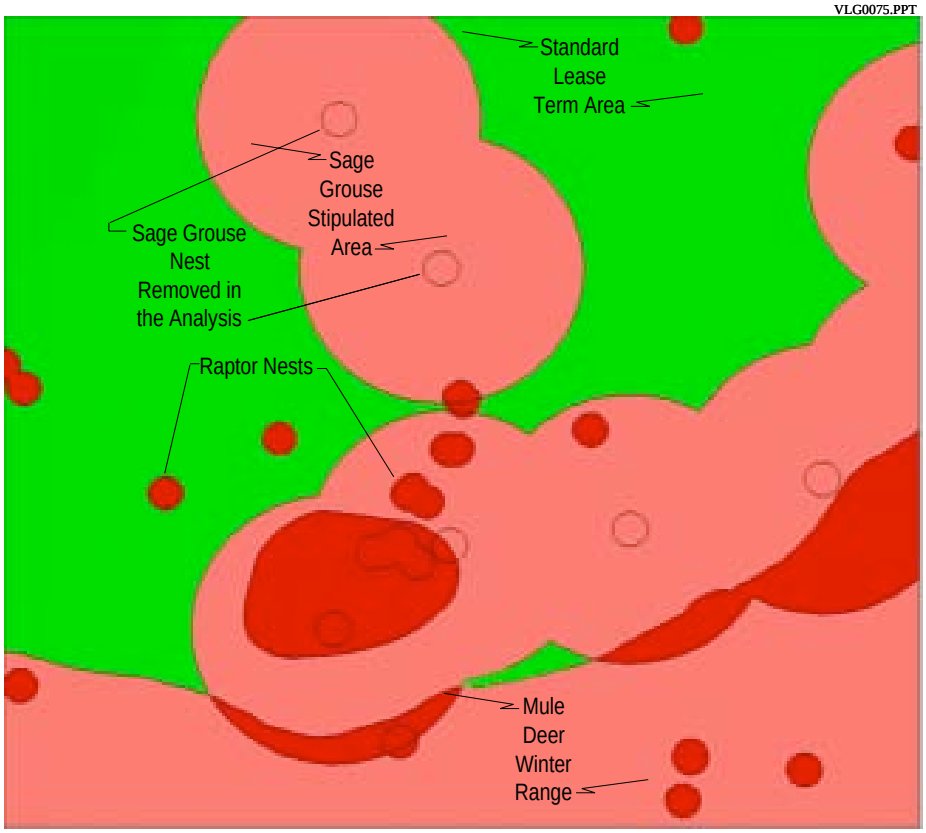


Figure A7-6 Display of Land Access Categorization with Extended Drilling Zone Applied (GGR Study Area)

If, for example, raptor stipulations are excepted 30 percent of the time, then, for an area represented by the raptor polygon (where raptor stipulations do not overlap other excepted stipulations), 30 percent from the contribution are represented by conditions where the raptor stipulation is not present and 70 percent (=1 minus 30 percent) of the contribution comes from the conditions represented where the raptor stipulation is present. The total is calculated accordingly for all combinations of the exception factors within a given office jurisdiction (see Table A7-8) or where combinations of these exceptions exist (see Table:A7-9).

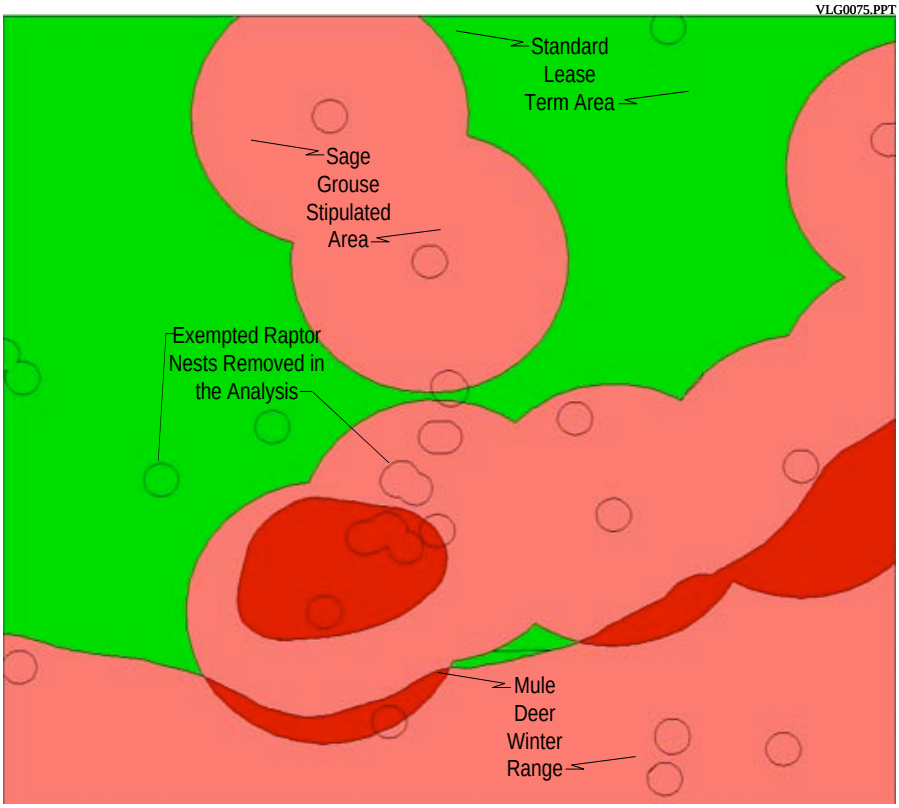


Figure A7-7 Display of Land Access Categorization with Extended Drilling Zone Applied and with Raptor Stipulation Removed (GGR Study Area)

Access categorization of the Federal lands and resources was determined in aggregate in the studies based upon discrete examination of individual GIS polygons using the following equation:

$$FLorRs = 3((1-EF) * FLorRs_{(EDZ)} + (EF * FLorRs_{(EDZ\ w/\ Excepted)}))$$

Where FlorRs = Federal Lands or Resources
EF = Exception Factor (e.g., see Table 7.4.1.3b)
$FLorRs_{(EDZ)}$ = FLorRs determined using the Extended Drilling Zone
$FLorRs_{(EDZ\ w/\ Excepted)}$ = FLorRs determined using the EDZ plus removal of stipulations for which exceptions are granted

This equation allocates Federal lands and resources to access categories in the analysis based on use of the extended drilling zone and depending upon the presence or absence of excepted stipulations. As the excepted stipulations are removed to estimate Federal lands and resources, the model is set so as to default to the underlying stipulation category in the hierarchy.

This process results in the generation of hundreds of thousands of individual GIS polygons for the study areas, each with unique Federal lands and resources access characteristics. These data are then summed and reported by access category and Federal management agency. For oil and gas resources,

categorization is provided by specific resource type (Section 7.2.1) .[14] By definition of their producibility, proved reserves are categorized as standard lease terms in the EPCA inventory.

[14] An Excel spreadsheet showing the results for Federal lands and resources by BLM office jurisdiction for each study area in the EPCA inventory is provided on the CD-ROMs accompanying this report.

APPENDIX 8

LAND MANAGEMENT AND RESOURCE DOCUMENTS USED IN THE EPCA INVENTORY

Approved RMP for Public Lands Administered by the BLM Buffalo Field Office, 2000

Beaverhead National Forest EIS, 1996

Black Hills National Forest Land and RMP, 1991

Book Cliffs Proposed RMP/ Final Environmental Impact Statement (FEIS), 1984

Book Cliffs Record of Decision (ROD) & RPS, 1985

Bridger-Teton National Forest Plan

Bureau of Reclamation Special Stipulations, Billings Montana Office

Carson Nation Forest Plan, 1982

Cedar Beaver Garfield antimony Approved Resource Management Plan (ARMP)/ROD and RPS, 1986

Cibola National Forest Plan

Colorado State BLM Statewide Stipulations

Department of Energy Federal Lands Analysis Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, 1999

Diamond Mtn Recreation Area (RA) ARMP/ROD, 1994

Diamond Mtn RA PRMP/FEIS, 1993

Farmington Oil and Gas Leasing Amendment, 1991

Final EIS for the Newcastle Resource Management Plan, 1999

Garnet RMP, 1986

Glenwood Springs Resource Area Plan Amendment, 1999

Grand Mesa/Uncompahgre/Gunnison National Forest Forest Plan, 1993

Grand Resource RMP, 1985

Grand Staircase Escalante National Monument Management Plan, 1999

Headwaters RMP, 1983

Helena National Forest Forest Plan, 1986

Henry Mt Management Framework Plan (MFP), 1982

Kemmerer RMP/ROD, 1986

Lewis & Clark National Forest Oil and Gas Leasing Final EIS, 1997

Lopez Project Utah State BLM Statewide Stipulations

Manti-La Sal Final EIS for Oil and Gas Leasing on Lands Administered by the Manti-La Sal National Forest, 1986

Manti-La Sal Final EIS for Oil and Gas Leasing on Lands Administered by the Manti-La Sal National Forest, 1986

Master Index of Utah BLM Land Use Plans & Amendments on CD, 2001

Miles City Oil and Gas Amendment, 1994

Miles City RMP, 1991

Montana State BLM Standard Stipulations

Northern Great Plains Final EIS

Paria Management Framework Plan, 1981

Parker Mountain MFP, 1982

Platte River RMP Revised & Updated Decisions, 2001

Rio Puerco RMP, 1992

ROD & Approved RMP for Public Lands Administered by the Newcastle Field Office, 2000

Routt National Forest Oil and Gas Leasing Analysis/FEIS, 1993

San Juan National Forest Forest Plan, 1983

San Juan RA ARMP/ROD, 1991
San Juan/San Miguel RMP 1991 Oil and Gas Amendment

San Rafel RA ARMP/ROD, 1991

Santa Fe National Forest Plan 1987, 1996 Amendment

Shoshone National Forest Final Oil and Gas Leasing EIS/ROD, 1992

St. George Office RMP, 1999

Vermillion Management Framework Plan, 1981

White River National Forest ROD

White River Resource Area RMP

Wyodak Coal Bed Methane Project final EIS, 2000

Wyodak drainage Coal Bed Methane EA, 2000

Wyoming St BLM Statewide Stipulations

Zion Management Framework Plan, 1981