

## APPENDIX 9

### GIS METHODOLOGY

Following are further descriptions of how Federal lands were assigned into the nine categories referred to in Table 2-8 and a detailed description of the GIS methodology used.

Based upon guidance from BLM and FS offices, Table A9-1 shows the NLA/LUP jurisdictions within the Inventory area.

#### **Table A9-1. Jurisdictions Classified as NLA/LUP**

Table A9-2 shows how agency jurisdictions were used to categorize lands for this Inventory.

#### **Table A9-2. Federal Land Categorization**

While GIS files were available to define most of the access categories, for the NLA/LUP category, they had to be created. To accomplish this, an administrative boundary (such as a National Forest) was extracted from the surface ownership data and the resultant polygon was then attributed as NLA/LUP as appropriate. For example in Figure A9-1, the Wasatch-Cache National Forest boundary in the Wyoming Thrust Belt is shown in green. The grey represents the area within the forest that is undergoing land use planning, which is categorized as NLA/LUP in the Inventory.

#### **Figure A9-1. Creation of NLA/LUP Polygons**

### **A9.1 STIPULATION EXCEPTIONS**

Exceptions (also including waivers and modifications) to stipulations are sometimes granted. For example, a crucial elk winter range timing limitation 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 proper records of exceptions to lease stipulations are not available to address this issue specifically, BLM and FS field personnel were asked to determine, based on their experience, which lease stipulations were granted exceptions for drilling and how often. The field personnel were asked to surmise the long-term (measured in decades that energy development would take place) relative to the hypothetical situation where virtually all drilling permit requests in the affected habitat asked for exceptions. The personnel then provided an estimate of the portion of request for which exceptions would be granted. The exception factors thus determined are shown by jurisdiction in Table A9-3.

#### **Table A9-3. Stipulation Exception Factors by FS and BLM Office**

Lease stipulations, particularly timing limitations, can overlap. Where exception factors overlap, the cumulative effect is calculated by multiplying the overlapping factors (from Table A9-3). 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 Wyoming Thrust Belt study area are determined as shown in Table A9-4. The application of these exception factors is described below in Section A9.3.

**Table A9-4. Exception Factors Example for Overlapping Stipulations (WTB Study Area)**

## **A9.2 TREATMENT OF NSO AREAS**

Directional drilling (or "extended reach drilling") is technology that can be employed to reach subsurface targets not located directly underneath the drilling rig. In this Inventory resources beyond a certain EDZ are assumed to not be technically recoverable (Figure A9-2). 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 not the general case in the lower 48 and is impracticable for exploration.

**Figure A9-2. Extended Drilling Zone Conceptual Diagram**

Directional drilling for exploratory purposes occurs in some areas but is much more limited in scope. As in the case of stipulation exceptions, BLM and 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 this Inventory are shown in Table A9-5.

**Table A9-5. Extended Drilling Zones by Jurisdiction**

The effect of the inclusion of the EDZs in the analysis is 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 A9-5) as determined by each field office. The area removed then defaults to the resource 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.

Figure A9-3 shows an actual example from the Wyoming Thrust Belt. Areas shown in light blue represent a 1/2-mile extended drilling zone removed from the NSO areas for the resource categorization. Areas shown in blue represent the resource Net NSO. The black area depicts an area of no leasing; as such the EDZ was not applied to these lands as a rig cannot be sited in no-lease areas.

**Figure A9-3. Removal of the Extended Drilling Zone from NSO Areas**

## **A9.3 Analytical Modeling of Federal Lands and Resources**

The analytical goal of the 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 objectives for the development of the categorization is 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 the Kemmerer, WY, BLM FO in the Wyoming Thrust Belt, where sage grouse leks and nesting habitat and big game winter range define an access category. These types of stipulations are among the most common found in the study areas.

Figure A9-4 shows a selected point where the stipulations overlap and the resultant categorization is "Timing Limitation Stipulations >6 to ≤9". A query at that point brings up a dialog box which lists the stipulations in effect. Table A9-6 contains the corresponding stipulation data extracted from a corresponding master stipulations list.

**Figure A9-4. Display of Overlapping Timing Limitations (WTB Study Area)**

**Table A9-6. Sample Master Stipulations List for a Selected Area**

Figure A9-5 shows the land categorization as determined by the stipulations listed in the relevant land use plan. Note that the core nesting habitat of the sage grouse (shown in blue), is designated a "no surface occupancy" area. The remaining area is under various timing limitations (colored in shades of red), controlled surface use (gold) or standard lease terms (green).

**Figure A9-5. Display of Federal Land Access Categorization (WTB Study Area)**

Note that in the Inventory, with regard to NSO areas, lands and resources are treated differently due to the application of EDZs. Figure A9-6 shows the effect where the EDZ is applied to NSO areas to determine the resource categorization. Note that the application of the EDZ in this example renders the resources under the sage grouse nest area accessible. While the acreage figures for each access category faithfully reflect the management prescriptions contained in the land use plans, the oil and gas volumes are calculated using this adjustment. The net result is that more oil and gas resources are accessible than would be assumed if NSO stipulations were taken at face value.

**Figure A9-6. Display of Resource Access Categorization with Extended Drilling Zone Applied (WTB Study Area)**

In addition, to account for stipulation exceptions, the GIS 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 A9-7, which shows an example for the Wyoming Thrust Belt where the sage grouse nesting habitat stipulation has been removed. Note that in the case of an excepted stipulation, the analysis defaults to the underlying stipulation or standard lease terms, as appropriate.

**Figure A9-7. Display of Federal Land Access Categorization with Extended Drilling Zone Removed and with Sage Grouse Nesting Habitat Stipulation Excepted (WTB Study Area)**

For example, if sage grouse nesting stipulations are excepted 10 percent of the time (as shown on Table A9-6), then, for an area represented by the sage grouse polygon (where sage grouse stipulations do not overlap other excepted stipulations), 90 percent of the resources is categorized according to the stipulation and 10 percent is categorized according to the underlying stipulation category next in the hierarchy. This calculation is performed accordingly for all of the exception factors within a given office jurisdiction (see Table A9-3) or where combinations of these exceptions exist (see Table A9-4).

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

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

Where

- FlorRs = Federal Lands or Resources
- EF = Exception Factor (e.g., see Table A9-4)
- FLorRs<sub>(EDZ)</sub> = FLorRs determined using the Extended Drilling Zone
- FLorRs<sub>(EDZ w/ Excepted)</sub> = FLorRs determined using the EDZ plus removal of stipulations for which exceptions are granted

This equation accounts for the occurrence of the extended drilling zone and stipulation exceptions. For excepted stipulations the model defaults to the underlying stipulation category in the hierarchy.

This process results in the generation of numerous individual GIS polygons for each study area. 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 (presented on spreadsheets on the accompanying DVD).

## **A9.4 Quality Control of Modeling Results**

A rigorous quality control (QC) check was instituted for the Phase III model. During processing a typical study area will generate more than one million discrete GIS polygons, each with unique characteristics in terms of land status, oil and gas resources, stipulations and exception factors. Complex study areas generate two to three million polygons each. As such, imprecision in GIS mapping data that are insignificant for individual polygons can be amplified in the aggregate. Such imprecision is a direct function of the quality of the data received from the various sources contributing to the Inventory.

For all study areas, the quality of the model output is high. For QC purposes, input oil and gas resource volumes and land areas were compared to outputs. A comparison of the study areas inputs and outputs revealed percentage differences ranging from zero to a maximum of 0.62 percent, with the vast majority well below 0.1 percent.

The model's land output data differs by 0.1 percent from the input data on an aggregate basis. For oil and gas resources, model output data differs by 0.1 percent from the input data on an aggregate basis.

## A9.5 Extrapolated Areas

The EPCA study areas, which were examined comprehensively, comprise 18 oil and natural gas resource basins. Where additional oil and natural gas resources occur outside the comprehensively studied areas extrapolations were made and were split into three regions, Alaska, Western U.S. and Eastern U.S., using the Mississippi River and the border of Louisiana as the boundary for the continental U.S., for the purpose of reporting the results. Figure A9-8 depicts the extrapolated resource areas relative to the EPCA study areas.

### Figure A9-8. Map of EPCA Study Areas and Extrapolated Resource Areas

The USGS National Oil and Gas Assessment (NOGA)<sup>1</sup> was used as the base for the undiscovered resources for the extrapolation effort, and excludes areas where the resource was not quantitatively assessed. The oil and natural gas resources in USGS provinces not comprehensively studied during the Inventory were then unioned with the Federal land status layer created by the National Atlas.<sup>2</sup> A list of all the provinces and resources that were included in the extrapolation analysis can be found in Table A9-7.<sup>3</sup> The undiscovered resources with an extrapolation area were distributed to access categories based on the distribution of access categorizations within the comprehensively studied basins for a given land status type.

### Table A9-7. Resources Associated with Extrapolated USGS 1995 NOGA and EPCA-Updated Basins

An approach to determine reserves growth associated with extrapolated areas, presented below, was developed with Steering Committee guidance. First, proved reserves associated with extrapolated areas needed to be determined. To do so, total proved reserves by state based upon EIA data were obtained<sup>4</sup> and aggregated by extrapolation region. By region, the proved reserve totals for the comprehensively studied EPCA basins (see Appendix 8) were then subtracted from the proved reserves totals for each region to determine the remaining reserves to be associated with the extrapolation areas.

Subsequently, to determine reserves growth associated with each of the extrapolation areas, a weighted ratio of reserves growth to proved reserves<sup>5</sup> based on individual EPCA study area was established. These ratios were then applied to the proved

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<sup>1</sup> The USGS National Oil and Gas Assessment. <http://energy.cr.usgs.gov/oilgas/noga/>

<sup>2</sup> The National Atlas of the United States. <http://www.nationalatlas.gov/>

<sup>3</sup> Differences in this table compared to Table 2-8 are the result of resources associated with state waters and overlap with comprehensively studied basins.

<sup>4</sup> The Energy Information Administration. <http://www.eia.doe.gov/>

<sup>5</sup> Performed on a technical basis and thus includes state waters, a feature important in the Alaska extrapolation area.

reserves associated with the extrapolation areas outside the EPCA study areas to determine the reserves growth associated with respective extrapolation areas.

To determine reserves growth associated Federal lands within an extrapolation area, the total reserves growth was multiplied by the portion of Federal resources in the extrapolation area. Subsequently, reserves growth were distributed to access categories relative to the portion of Federal resources within a respective category.

While the above approach is simplistic, given the absence of comprehensive data outside of the EPCA study areas, it does provide an estimate of reserves growth that can be associated with the extrapolation areas. To the extent that reserves growth cannot be associated with proved reserves and resource distribution, it will be in error.

In a similar process, extrapolation of land and oil and gas resources associated with each access categorization was made within each extrapolated area based upon the results for individual Federal land types within correlative EPCA study areas.

Within the EPCA study areas, based on Steering Committee guidance, Federal lands that had less than 5 BCFE of undiscovered resource were also extrapolated using the land and resource access categorization by Federal land type within the study area. A list of the areas and the basins where this occurred can be found in Table A9-8.

**Table A9-8. Extrapolated BLM and FS Areas**