

Appendix D

Methodology for Scaling RFDS for EIS Alternatives

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Introduction

In preparing this EIS, BLM has used the Reasonably Foreseeable Development Scenario (RFDS) developed for the White River National Forest (WRNF) as the basis for analyzing the potential future indirect effects of each of the alternatives. The WRNF RFDS (USFS 2010) was prepared by the **U.S. Forest Service (Forest Service or USFS)**, published in September, 2010, and was included as Appendix F in the WRNF Oil and Gas Leasing Draft EIS (USFS 2012). The RFDS is a long-term projection of the likely future oil and gas development and production within the WRNF over a defined period of time (20 years).

Based on the smaller and more specific area under consideration in this EIS than in the WRNF Oil and Gas Leasing Final EIS (USFS 2014), BLM has further refined the RFDS using reasonable assumptions based on patterns of observed development.

An RFDS is a long-term projection (scenario) of oil and gas exploration, development, production and reclamation activity for a defined area and defined period of time. An RFDS is not a prediction of activity; rather it is a possible reasonable scenario of activity under a specified set of assumptions in order to evaluate potential effects that might reasonably occur as a result of BLM leasing. The RFDS is based on geology; resource occurrence potential; past and current leasing, exploration, and development activity; and engineering technology. It also considers economics and physical limitations on access to resources. An RFDS is not a decision, and it does not establish or imply a cap on development.

General Concept for Approach to Scaling the RFDS

The approach to scale the RFDS builds on the previously-prepared RFDS for the **Forest Service (USFS 2010a)**. The intent is to:

- Use existing data to enhance efficiency in preparing the BLM EIS;
- Prevent conflicting estimates of future development and reduce the potential for confusion;
- Coordinate efforts and analysis; and
- Facilitate incorporation of the **Forest Service** analysis by reference.

While incorporating existing RFDS, this approach refines it to provide a more specific projection for the 65 leases in question, basing the refined projection on reasonable assumptions and patterns of observed development.

The basic assumptions used to scale the RFDS are listed below. These assumptions are used to analyze the impacts from future development in this EIS.

1. One well can be reasonably foreseen per undeveloped lease (including committed leases without on-lease development). This is assumed based on past bids to secure leases at auction and as a conservative starting point for effects analysis.
2. Additional foreseeable development will follow past development trends. Development trends can be grouped spatially based on the location of past development, production infrastructure, and access for exploration and production.
3. The total RFDS for the 65 existing (post-1993) leases is 444 wells. This assumption is based on:
 - a. The RFDS for Alternative B: No New Leasing in the WRNF Final EIS (USFS 2014) in which 423 wells are projected. This included the foreseeable development for all existing leases in the BLM Colorado River Valley Field Office (CRVFO), less the areas of No Surface

Occupancy (NSO) stipulations. It assumes 10 wells in the BLM White River Field Office (WRFO).

- b. The **Forest Service** approach was modified slightly to use the **Forest Service** assumption of 202 acres per well, but discards the **Forest Service** programmatic assumption of not allocating wells for NSO lands. The rationale for modifying this approach is that, at the lease-specific level, it is clear that some development could access NSO areas from non-NSO parts of leases or from adjacent fee or BLM land. Therefore, the future projection for an initial EIS assessment area estimate of 87,638 acres for 64 leases was 434 wells. The future projection for the single Meeker area lease was 10 wells per the RFDS.
4. Based on the **Forest Service** RFDS, approximately 3.9 percent of the wells on all leases will be horizontally drilled (28 out of 722 in the RFDS for all leased areas).

Piceance Basin Geology

As discussed in the Forest Service RFDS (USFS 2010a, p. 3), the formation of the sedimentary basins within the WRNF created a favorable geologic setting for the occurrence of hydrocarbons such as oil and gas and that the western portion of the WRNF lies within the Piceance Basin. The RFDS specifically states that high oil and gas occurrence potential lies in the portion of the WRNF overlapping with the Glenwood Springs (now the CRVFO) FO.

Section 3.1 of the Forest Service RFDS (USFS 2010a) contains a discussion of Piceance Basin geologic setting. As noted on pages 7 – 8, exposed bedrock in the Piceance Basin consists of sedimentary units ranging from Upper Cretaceous to Middle Eocene. Bedrock is exposed on dissected uplands, cliffs, and hogbacks. Outcrops include (in ascending order of age) the Mancos Shale, the Mesaverde Group, Wasatch Formation, Green River Formation, and Uinta Formation. The Mesaverde Group is divided into the Iles Formation and the overlying, massively stacked, lenticular non-marine Williams Fork Formation. Historically, most of the natural gas produced on the WRNF is from the Mesaverde Group. Other source rocks include the Mancos Shale, the source for gas migration into the reservoirs which occur in the lower part of the Mesaverde Group (Iles Formation).

Uinta-Piceance Oil and Gas Assessment Province

Section 3.2 of the Forest Service RDFS (USFS 2010a) contains an assessment of undiscovered oil and gas resources in the analysis area. As noted on page 9, assessments use a Total Petroleum System (TPS) approach. A TPS is a mappable entity that encompasses genetically related accumulations of petroleum. An assessment unit (AU) is a mappable volume of rock that contains hydrocarbon accumulations with shared geologic traits. Several AUs may be mapped within a single TPS. An AU can include one or more plays (sets of known or postulated oil and gas accumulations sharing similar properties). NFS lands in the southern Piceance Basin (including the CRVFO) fall principally in the Mesaverde TPS, which includes the Mesaverde Continuous Gas AU and the Mesaverde Transitional Gas AU, and the Mancos/Mowry TPS (Transitional and Migrated Gas AUs), all of which have tight gas plays. Specific gas plays include the Mesaverde (within the Mesaverde Continuous Gas and Transitional Gas AUs), the Niobrara (within the Mancos/Mowry Transitional and Migrated Gas AUs), and the Mesaverde Coalbed Natural Gas plays. Developed structures that produce from the Mesaverde TPS on the WRNF are the Divide Creek and Wolf Creek anticlines. The COGCC recognizes 3 fields on the WRNF: the Divide Creek, Wolf Creek, and Hells Gulch fields. No productive wells have been drilled in the WRNF outside of the southern Piceance Basin.

Zones Used to Allocate the RFDS

The four zones described in Chapter 1.0, Section 1.2.1 of this EIS, were identified to group the leases geographically and by similar development potential based on past development activity. Using zones as the unit of comparison of impacts across the alternatives analyzed in detail facilitates discussions of potential impacts in a larger area than each lease; specific future locations of well, road, and pipeline development are unknown at the leasing stage of permitting. **Figure D-1** displays the location of the zones.

Zone 1

The leases in this zone could be accessed from existing or newly constructed well pads from adjacent private or BLM property using directional and horizontal drilling methods. This area is trending toward development of the Niobrara Formation in addition to the Mesa Verde Formation so it is anticipated that horizontal methods will be a more common method of developing these leases than in other zones. Existing infrastructure in Zone 1 includes pipelines and roads accessing the existing pads and wells within the Orchard Unit and the Place Mesa Unit. The following leases considered in this EIS are in Zone 1.

- COC 058677
- COC 059630
- COC 066727
- COC 066728
- COC 066729
- COC 066730
- COC 066731
- COC 066732
- COC 066733
- COC 066926

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2 Zone 2

3 The leases in this zone could be accessed from existing and newly constructed well pads. This area has
4 primarily seen successful Mesa Verde Formation wells, but has had one successful horizontal Niobrara
5 Formation well. It is anticipated that future development could include both Mesa Verde Formation wells
6 and Niobrara Formation wells in those areas that can be accessed by both directional and horizontal
7 drilling methods. Existing infrastructure in the zone includes numerous pipelines and roads accessing the
8 existing wells. The following leases considered in this EIS are in Zone 2.

- COC 061121
- COC 066723
- COC 066724
- COC 066915
- COC 066916
- COC 066917
- COC 066918
- COC 066920
- COC 067147
- COC 067150
- COC 067542
- COC 067543
- COC 067544
- COC 070013
- COC 070014
- COC 070015
- COC 070016
- COC 070361
- COC 072157
- COC 075070
- COC 076123

1 **Zone 3**

2 The leases in this zone could be accessed primarily from newly constructed well pads. This area is
3 anticipated to initially have a minimal number of exploration wells until the potential of the area has been
4 proven. As a result, the number of wells that could be anticipated is lower than other zones. Existing
5 infrastructure in the zone includes existing Forest Service roads and existing pipeline rights-of-way. Road
6 improvements and pipeline installation would be required for the area to be developed. The following
7 leases considered in this EIS are in Zone 3.

- COC 058835
- COC 058836
- COC 058837
- COC 058838
- COC 058839
- COC 058840
- COC 058841
- COC 066687
- COC 066688
- COC 066689
- COC 066690
- COC 066691
- COC 066692
- COC 066693
- COC 066694
- COC 066695
- COC 066696
- COC 066697
- COC 066698
- COC 066699
- COC 066700
- COC 066701
- COC 066702
- COC 066706
- COC 066707
- COC 066708
- COC 066709
- COC 066710
- COC 066711
- COC 066712
- COC 066908
- COC 066909
- COC 066913

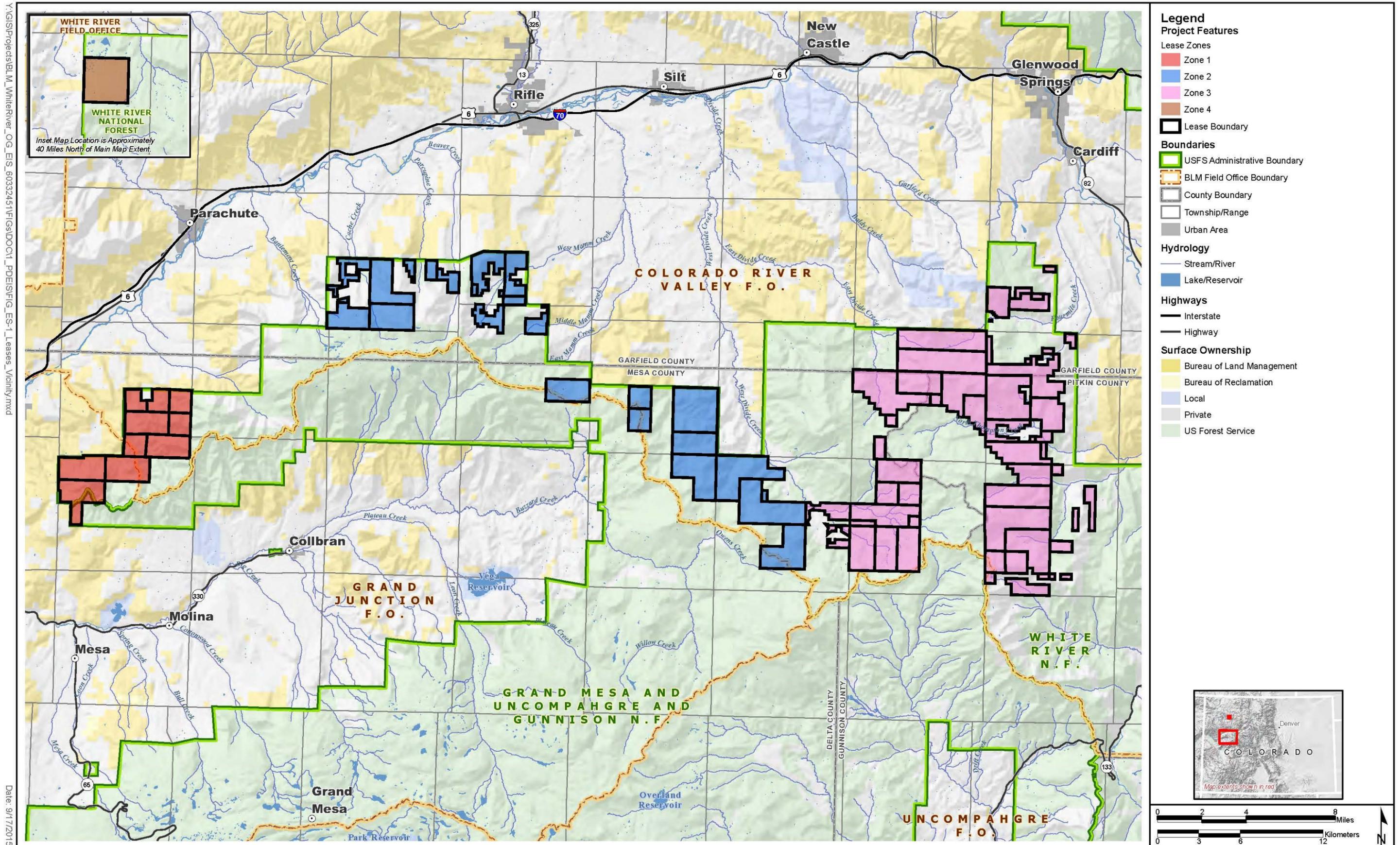
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2 **Zone 4**

3 The leases in Zone 4 could be accessed primarily from newly constructed well pads. Existing
4 infrastructure in the zone is limited. However, there is an existing pipeline within approximately 1 mile of
5 the lease. The location would be accessed from an existing county road next to the lease. The only lease
6 considered in this EIS within Zone 4 is COC 066948.

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Figure D-1 General Location of Zones and Leases

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RFDS Allocation by Zones

The basic assumptions used to allocate the total unconstrained¹ RFDS by zone are summarized below.

1. Using the RFDS (USFS 2010) as a guide, unconstrained development is projected to be approximately one well for every 202 acres of a lease as a starting point.
2. There will be at least one well for each of the 65 leases without considering constraints from lease stipulations that may limit access to a lease.
3. Future development will follow past development trends and technology.
4. Almost 4 percent of all wells will be horizontally drilled but the distribution of horizontal wells is assumed to be based on past development techniques.

The process to estimate the number of wells per lease is summarized as follows.

1. Assign each lease within the BLM CRVFO an initial 1 well for a total of 64 wells.
2. Allocate the remaining reasonably foreseeable wells among each of the zones within the CRVFO (Zones 1, 2, and 3) according to past development trends. Past trends were assessed by identifying all wells drilled for oil and gas exploration and production within two adjacent sections of the zones, including dry holes, abandoned wells, plugged wells, and producing wells.
3. Per the WRNF EIS RFDS (USFS 2010), assume 10 wells for Zone 4 in the BLM WRFO.
4. Prorate zone totals to individual leases in proportion to lease acreage.

It is important to note that the application of these assumptions to each lease are only intended to be applied at the scale of the zone and do not reflect any knowledge or prediction of site-specific proposals for development at the scale of each lease. **Table D-1** summarizes the past trends and RFDS predictions by zone.

Table D-1 Existing Wells and Future Development by Zone

Current or Future	Well type	Zone 1	Zone 2	Zone 3	Zone 4	Total
Existing wells within 2 miles of lease boundaries	Horizontal	19	1	0	NA	20
	Directional	68	649	3	NA	720
	Vertical	44	83	47	NA	174
	Total	131	733	50	NA	914
Existing well distribution	Percentage of total wells	14.3%	80.2%	5.5%	NA	100%
	Percentage of horizontal wells	95.0%	5.0%	0.0%	NA	100%
Future Projection (Unconstrained)	All wells	63	318	53	10	444
	Horizontal wells	16	1	0 ¹	0	17

¹ For analysis purposes, it was assumed that 1 horizontal well would be drilled in Zone 3 although none have yet been drilled in this area to date.

¹ As stated in the Forest Service RFDS (USFS 2010a, p. 1), the term “unconstrained” in an RFDS means that there are no restrictions on surface use assumed in the baseline scenario.

Assumptions for Scaling the RFDS Projections by EIS Alternative

The basic assumptions used to develop the estimated future oil and gas development constrained by the stipulations under each EIS alternative within the 65 leases are summarized below.

1. Most wells will be directional or S-curve wells, rather than vertical wells. If a target formation cannot be reached using an S-curve wellbore, it is not likely to be developed.
2. The projections considered only apply to federal minerals. Unit boundaries and limitations were not considered.
3. The reach of directional wellbores depends on the type and depth of the target formation. While the maximum reach for directional wellbores is approximately 6,000 feet in this area, the historic data for the leases under consideration shows a range of directional reach between 500 and 6,000 feet, with a median of 2,000 feet.
4. Horizontal wells can reach target formations up to 10,500 feet away from the surface location of a well. **However, the actual distance for a successful horizontal well depends on many factors, such as the topographic and stratigraphic constraints and the location and depth of the target formation. Some minerals that are assumed not to be accessible through directional (s-curve) drilling due to a lack of a suitable surface location may be accessible given the longer reaches and alternative methods possible through horizontal drilling. If horizontal drilling proves to be productive and economical in the area in the future, the RFDS may underestimate the future level of horizontal (or total) drilling.**
5. Due to the relatively low projected future well numbers (as compared to full field development), well spacing and density were not considered limiting factors.
6. All NSO stipulations were considered when evaluating whether surface occupancy would be allowed on a lease. NSO stipulations were evaluated programmatically, so no consideration was given to the resource being protected by a specific NSO stipulation or whether that resource actually exists on the ground.
7. The number of well pads was calculated based on an assumed average of 7 wells per pad.
8. It is possible, or even likely, that off-lease development and associated surface disturbance could occur to access federal minerals in a lease if NSO stipulations make the lease surface unavailable.
9. In Zone 3 under Alternatives 1, 2, and 3, there are existing leases that are not closed to leasing surrounded by areas that are closed to leasing by the Forest Service. It was assumed that no off-lease surface locations would be allowed in areas that are identified as closed to leasing.
10. In all areas outside the existing 65 leases under consideration, future NSO stipulations and closed to leasing designations are based on the WRNF Oil and Gas Leasing **Final** Record of Decision (USFS 2015).
11. Where off-lease locations within the maximum directional reach extend beyond the Forest Service lands, NSO stipulations assigned by the BLM were considered on public lands. There are no NSO stipulations on fee lands without federal minerals.

Process of Scaling the RFDS Projections by EIS Alternative

GIS Analysis

A spatial analysis was performed using the geographic information system (GIS) for each alternative to assess the assumed reachable areas within each lease. Assumed areas of potential future development were identified using a combination of the assumed lateral wellbore reaches for each lease and exclusionary zones made up of NSO stipulations and lands closed to leasing, where applicable under

each of the **six** alternatives. The specific reach of directional wellbores (see assumption 3 above) represents the distance around and within the lease that could be used to locate future wells. No potential future development was assumed within areas of NSO or within lands closed to leasing.

Scripting using the ArcPy Python libraries in Python 2.7.5 in ArcGIS was employed to identify and map the areas within and surrounding the existing 65 leases where there could be future development. The following general process steps for generating the areas of potential future development were completed for Alternatives 1, 2, 3, and 4 using the stipulations applicable to each alternative.

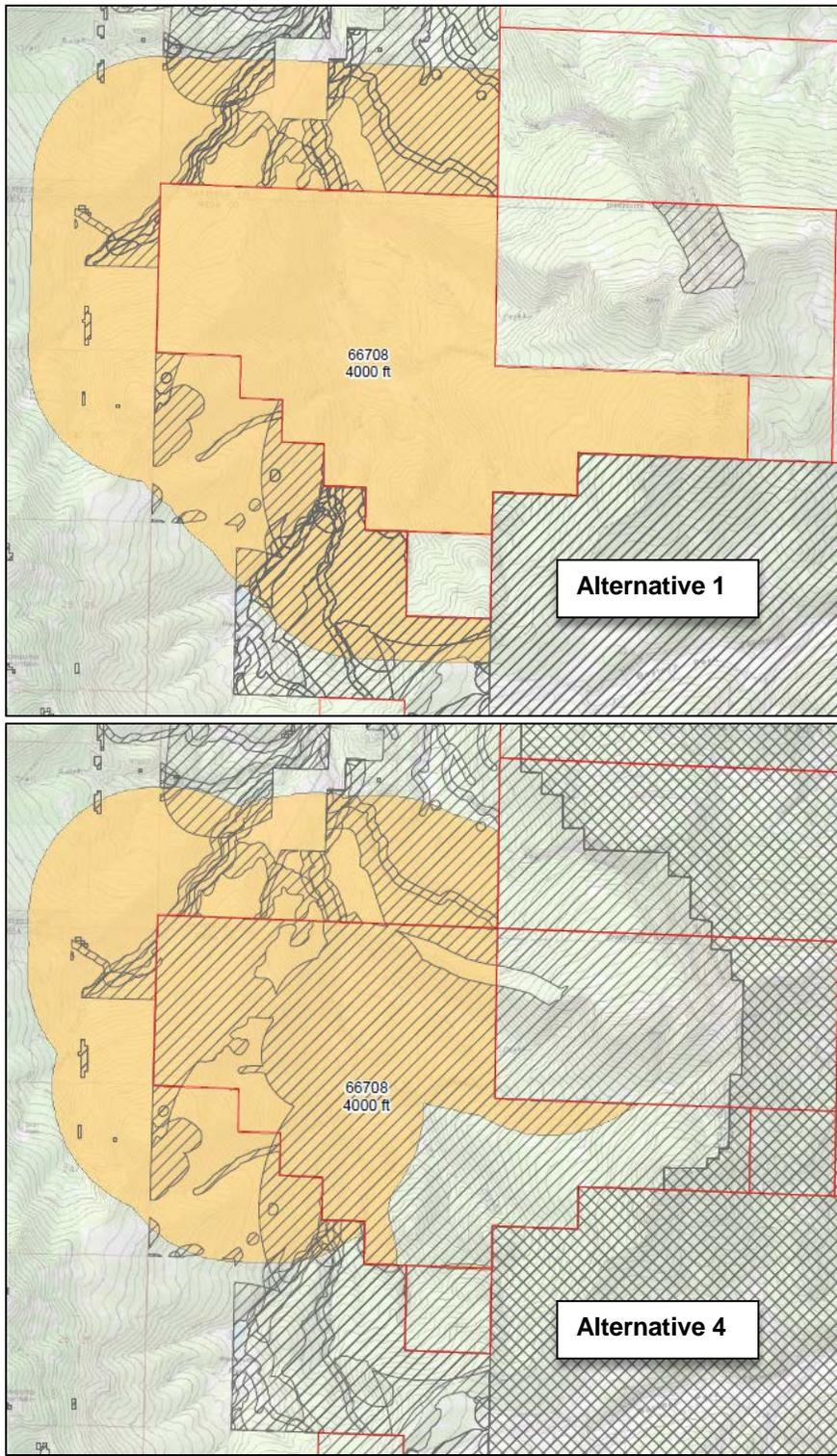
1. Compile exclusionary zones based on lands closed to leasing and the areas of NSO for lands within and adjacent to the leases.
2. For each lease, identify areas within the assumed directional reach for that lease.
3. Remove exclusionary zones (NSO and closed to leasing) from each lease's directional reach area.
4. Merge all of the directional reach areas within a lease to produce the area of potential future development for the alternative.
5. Create maps of each lease under each alternative to show the areas where surface occupation was assumed to be allowed for the purposes of analysis.

Figure D-2 displays a comparison of the resulting maps under Alternative 1 and Alternative 4 for Lease Number COC 066708 in Zone 3. This figure is provided as an example of how the GIS analysis was applied but is only intended to be applied at the scale of the zone for analysis of impacts in the EIS. It does not reflect any knowledge or prediction of site-specific proposals for development at the scale of each lease.

The maximum reach for the target formations that can be accessed in Lease Number COC 066708 was assumed to be 4,000 feet. The tan area displayed on the maps indicates the extent of the maximum directional reach either within the lease or off-lease. Note that where the hatched areas overlap, there are NSO stipulations delineated to protect more than one resource.

In **Figure D-2** under Alternative 1, no NSO stipulations have been designated in Lease COC 066708 so it is assumed for analysis that wells could be developed anywhere within the lease boundaries as well as off-lease. The only locations where it is assumed well pads could not be constructed are those areas off-lease within the tan shaded area with the hatching that indicates NSO stipulations.

In **Figure D-2** under Alternative 4, much of the lease has NSO stipulations and to the east, there are lands closed to leasing. The closed to leasing designation covers a small portion of Lease Number COC 066708, so this lease would be contracted (or cancelled) should Alternative 4 be selected for implementation. There remains some areas on-lease and off-lease within the tan area denoting the assumed maximum directional reach where it is assumed for analysis that well pads could be constructed to the access leased minerals.



- Legend**
- Lease Boundary
 - Lands Closed to Leasing
 - NSO for Alt 4 and Adjacent Lands (Alt 4)

Figure D-2 Comparison of Potential Development Areas in Lease COC 066708 under Alternatives 1 and 4

Per Alternative Estimation of Well and Well Pad Numbers by Zone

Once the GIS analyses were completed and maps were generated, it was necessary to determine whether each individual lease could be developed under each alternative and to assign the projected number of wells that could be developed after the constraints resulting from NSO stipulations were applied. The BLM minerals staff estimated the number of wells that may be developed without consideration of lease stipulations or other constraints within each lease by distributing the number of wells shown for each zone in **Table D-1** across the leases in that zone, utilizing the RFDS assumptions stated in the previous section titled “General Concept for Approach to Scaling the RFDS.”

Using the maximum projected well numbers as a starting point, each lease map (such as the example shown in **Figure D-2**) was reviewed under each alternative to determine whether the unconstrained number of wells could be developed or whether the number would be reduced due to on-lease and off-lease NSO stipulations making portions of the lease inaccessible. Essentially, the maps were used to answer the following two questions:

- Is there land available within the lease to construct a well pad and develop a well?
- If NSO stipulations cover the entire lease, is there land available off-lease that could be reached using directional drilling up to the maximum reach assumed?

In some situations, where an entire lease would be covered by NSO stipulations under an alternative, it was assumed that a well could be developed off-lease where there is land without NSO constraints within the maximum directional reach assumed for that lease. No consideration was given to land ownership so it is possible that off-lease development could occur on fee land or land managed by the Forest Service or the BLM.

Horizontal wells were allocated per zone, were not assumed to change per alternative based on the reach analysis, and could occur anywhere in the zone. Well numbers and well pad numbers were aggregated for each zone, providing the information in **Table D-2** that was used for analysis of impacts.

Table D-2 Number of Projected Wells by Alternative

Zone/Well Type	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Preferred Alternative
Zone 1					
Vertical/Directional Wells	19.7	19.7	19.7	19.7	19.7
Horizontal wells	16	16	16	16	16
Pads	5.1	5.1	5.1	5.1	5.1
Zone 2					
Vertical/Directional Wells	318.1	318.1	318.1	318.1	318.1
Horizontal wells	1	1	1	1	1
Pads	45.6	45.6	45.6	45.6	45.6
Zone 3					
Vertical/Directional Wells	50.7	50.7	47.6	17.9	10.6
Horizontal wells	1	1	1	0.4	0.2
Pads	7.4	7.4	6.9	2.6	1.5

Table D-2 Number of Projected Wells by Alternative

Zone/Well Type	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Preferred Alternative
Zone 4					
Vertical/Directional Wells	10	10	10	10	10
Horizontal wells	0	0	0	0	0
Pads	1.4	1.4	1.4	1.4	1.4
Totals					
Vertical/Directional Wells	398.4	398.4	395.4	365.7	358.4
Horizontal wells	18	18	18	17.4	17.2
Pads	59.5	59.5	59.1	54.7	53.7

Note: Under Alternative 5 all leases would be cancelled so no well numbers have been included for this alternative.

One final evaluation was performed to identify whether there are any leases that would not be accessible for development using horizontal drilling. To do this, a map was prepared to show the locations of NSO stipulations and areas closed to leasing within the maximum reach of a horizontal wellbore (10,500 feet), which is approximately 2 miles. **Figure D-3** displays NSO stipulations within 2 miles outside of the boundaries of the 65 previously issued leases and areas closed to leasing that are reflected in the decision presented in the WRNF **Final** ROD (USFS 2015f). Based on this map, it was determined that all leases could be developed horizontally so all leases could be developed should more extensive use of horizontal drilling be employed by operators, except where leases would be cancelled under Alternative 4 (shown in pink and identified as Closed to Leasing in the legend of **Figure D-3**).

Once the numbers of wells and well pads were estimated for each zone, the acres of surface disturbance per pad, miles of roads and pipelines, water usage for drilling and completion, and production of gas and produced water was estimated (see Table 2-10 in Section 2.7.5) using average information derived from the RFDS (USFS 2010) and assumptions presented in the WRNF Oil and Gas Leasing Final EIS (USFS 2014).

This information formed the basis of the analysis of impacts from predicted future oil and gas development under Alternatives 1, 2, 3, and 4 in this EIS.

Reference

- U.S. Forest Service (USFS). 2014. White River National Forest Oil and Gas Leasing Final Environmental Impact Statement. Eagle, Garfield, Gunnison, Mesa, Moffat, Pitkin, Rio Blanco, Routt, and Summit Counties, Colorado. U.S. Department of Agriculture, White River National Forest, December.
- U.S. Forest Service (USFS). 2015f. **Final** Record of Decision. Oil and Gas Leasing on Lands Administered by the White River National Forest. Eagle, Garfield, Gunnison, Mesa, Moffat, Pitkin, Rio Blanco, Routt, and Summit Counties, Colorado December 3.
- U.S. Forest Service (USFS). 2010. Reasonably Foreseeable Development Scenario for Oil and Gas Activities on the White River National Forest. White River National Forest. September.

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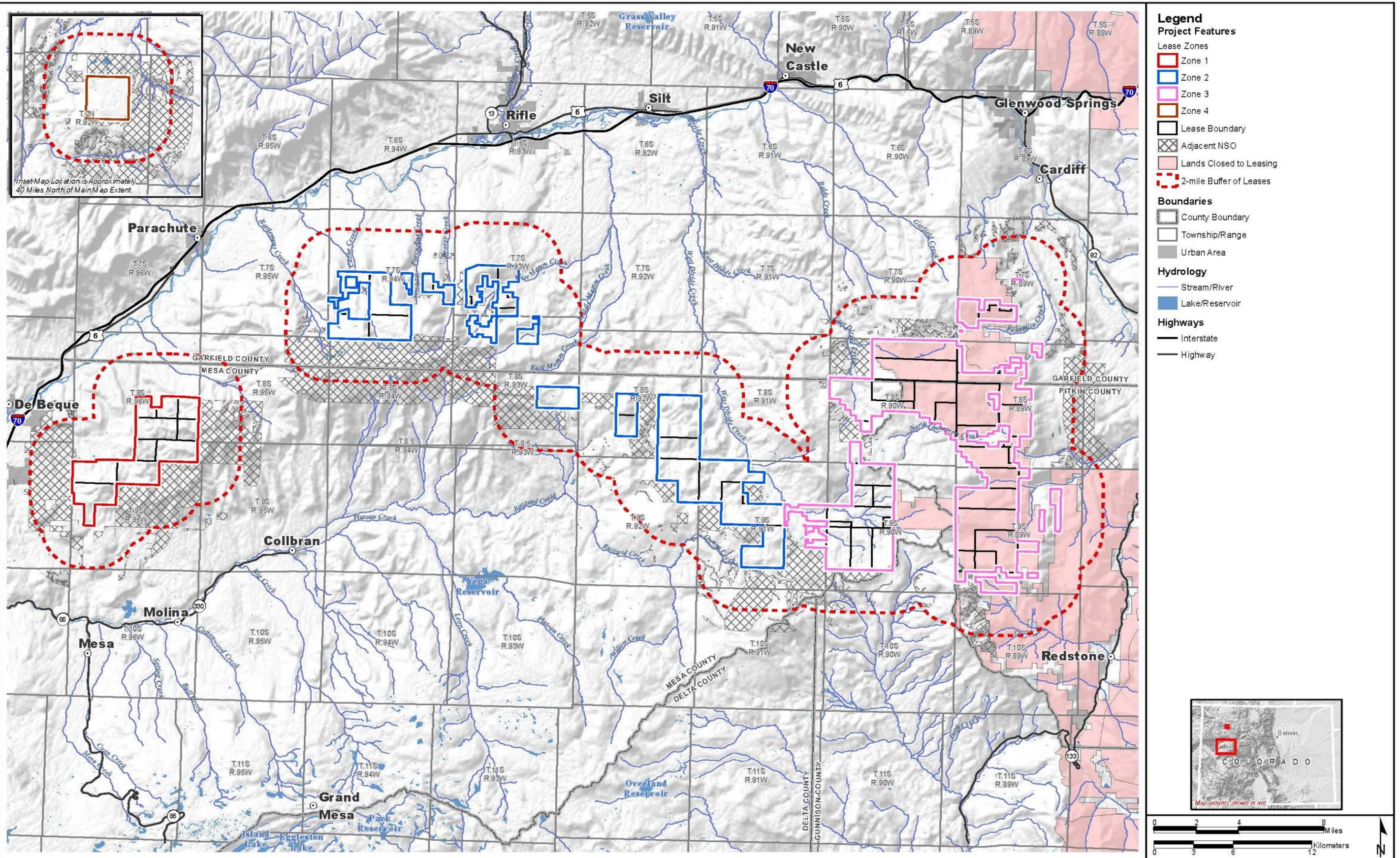


Figure D-3 Stipulations within 2 Miles of Lease Boundaries

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