

**EnCana Oil & Gas (USA) Inc.
LAND RECLAMATION**

**SUPPLEMENTAL IRRIGATION
&
OAK MATTED DRILL PADS**

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IRRIGATION OBJECTIVE

- Increase seedling establishment when precipitation is not adequate.
- Provide a longer season for seeding sites.
- Only irrigate 4-6 week period after seeding.

IRRIGATION PROCEDURE

- 2005. 24 DRILL PADS, 120 ACRES
 - 2006. 46 DRILL PADS, 180 ACRES
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1. Average 26 irrigation events/drill pad.
 - Either May – June or late August – September Periods.
2. Average 0.14 inches/irrigation event.
3. Average 3.4 inches water/drill pad.

IRRIGATION EQUIPMENT

7 DIFFERENT WELLS USED
TO IRRIGATE 46 PADS, 2006



TANK BATTERY

4-8 INCH DELIVERY LINE

PUMPS

GROUNDWATER WELL

- Sprinkler spacing 30 x 40 ft grid.
- 1.5-3.0 inch distribution pipe diameter.
- 2.4 gallons/minute/sprinkler head.

STRAW MULCH IN COMBINATION WITH IRRIGATION GREATLY ENHANCED GRASS DENSITY

IRRIGATED DRILL PADS

STRAW
MULCH
APPLIED

NO STRAW
MULCH

grass stems/m²

109

46

n = 4



GROUND WATER QUALITY FOR IRRIGATION

- pH 8.0-10.0
 - Bench and field test = No change in soil pH.
- Sodium Adsorption Ratio 14.4-46.5
 - Sodium concentration is low.
 - Bench and field tests = modest increase in soil SAR was measured, but this will not disperse the soil clay system or impair plant establishment.
- Electrical Conductivity 0.60-8.03 dS/m
 - Problem

GROUNDWATER QUALITY AND IRRIGATION THRESHOLDS

BASED ON IRRIGATION BENCH AND FIELD TESTS DURING 2005.....

- Avoid groundwater wells with salinity greater than 3 dS/m.
- Total irrigation water applied must not exceed 4 inches.

IRRIGATION EFFECT ON SOIL SALT CONTENT (0-2 INCHES)

(35 drill pads)

WELL WATER SALINITY (dS/m)	IRRIGATION WATER APPLIED / PAD (INCHES)	SOIL SALT CONTENT (dS/m)	
		BEFORE IRRIGATION	AFTER IRRIGATION
0.69	2.70	3.49	2.63
0.89	3.56	2.74	1.75
0.91	3.50	2.50	2.33
1.15	2.70	2.71	1.89
1.16	3.59	2.70	2.78
1.68	2.32	2.89	2.51
	MEAN	2.84 dS/m	2.31 dS/m

GRASS DENSITY, 2ND GROWING SEASON (IRRIGATED 4-6 WEEK PERIOD FIRST GROWING SEASON)

DRILL PAD	IRRIGATED Drill Pads stems/m ²	NOT-IRRIGATED Drill Pads stems/m ²
1	94	3
2	99	0
3	102	2
4	140	23
5	73	1
6	7	1
7	103	0
8	79	0
9	125	0
10	8	4
11	106	0
	MEAN = 85	MEAN = 3

IRRIGATION COST ANALYSIS

- 2006. 180 Acres Irrigated = 46 Drill Pads
Cost \approx \$3,333/Acre
- 2007 Estimated \$2,000-\$2,500/Acre
 - New wells developed = shorter water delivery distance to drill pad.

GAS WELL DEVELOPMENT WITH OAK MATS

- Pilot project started November 2005
- Objective is to minimize disturbance to soil, plant, wildlife and cultural resources.

- Track-hoe with grapple attachment is used to place and remove oak mats.
- Each mat is 8 x 12 feet; 2500 pounds.



OAK MATTED DRILL PAD AND ACCESS ROAD



- Approximately 950 mats required for each 2.1 acre pad.
- Matting used in landscapes with less than 5 % slope gradient.

- Access road to matted pad; 24 feet wide.
- Selected areas were mowed prior to mat construction.

OAK MAT FEATURES



- 'Tongue & groove' connects 8 x12 foot mat units which helps spread the load.

- Oak planks are 2 x10 inch.
- 3-layers of oak planks with 1 inch spacing between planks.
- Either nails or bolts used to connect planks.

RANGELAND

SAGE BRUSH

PLASTIC TARP

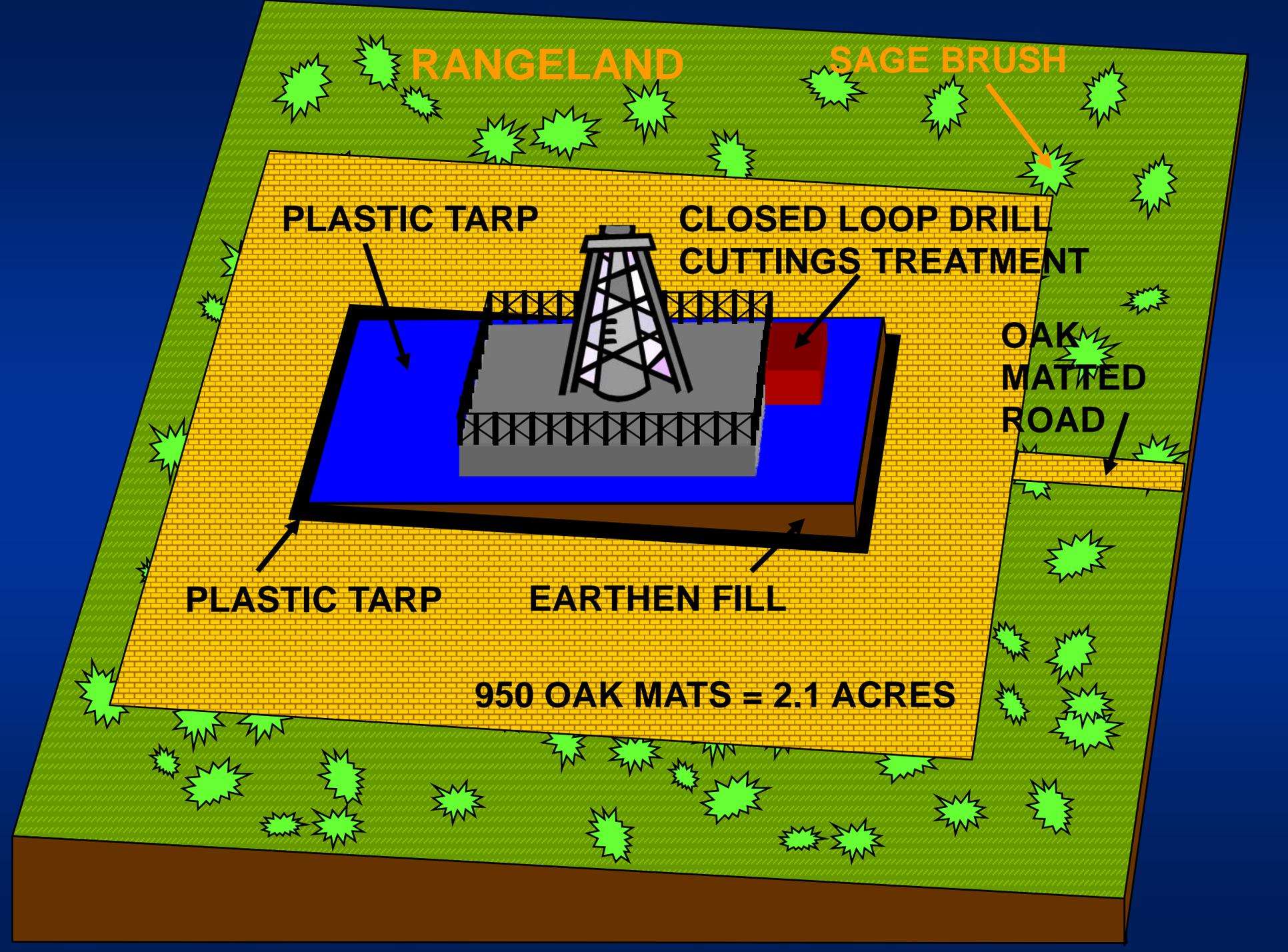
**CLOSED LOOP DRILL
CUTTINGS TREATMENT**

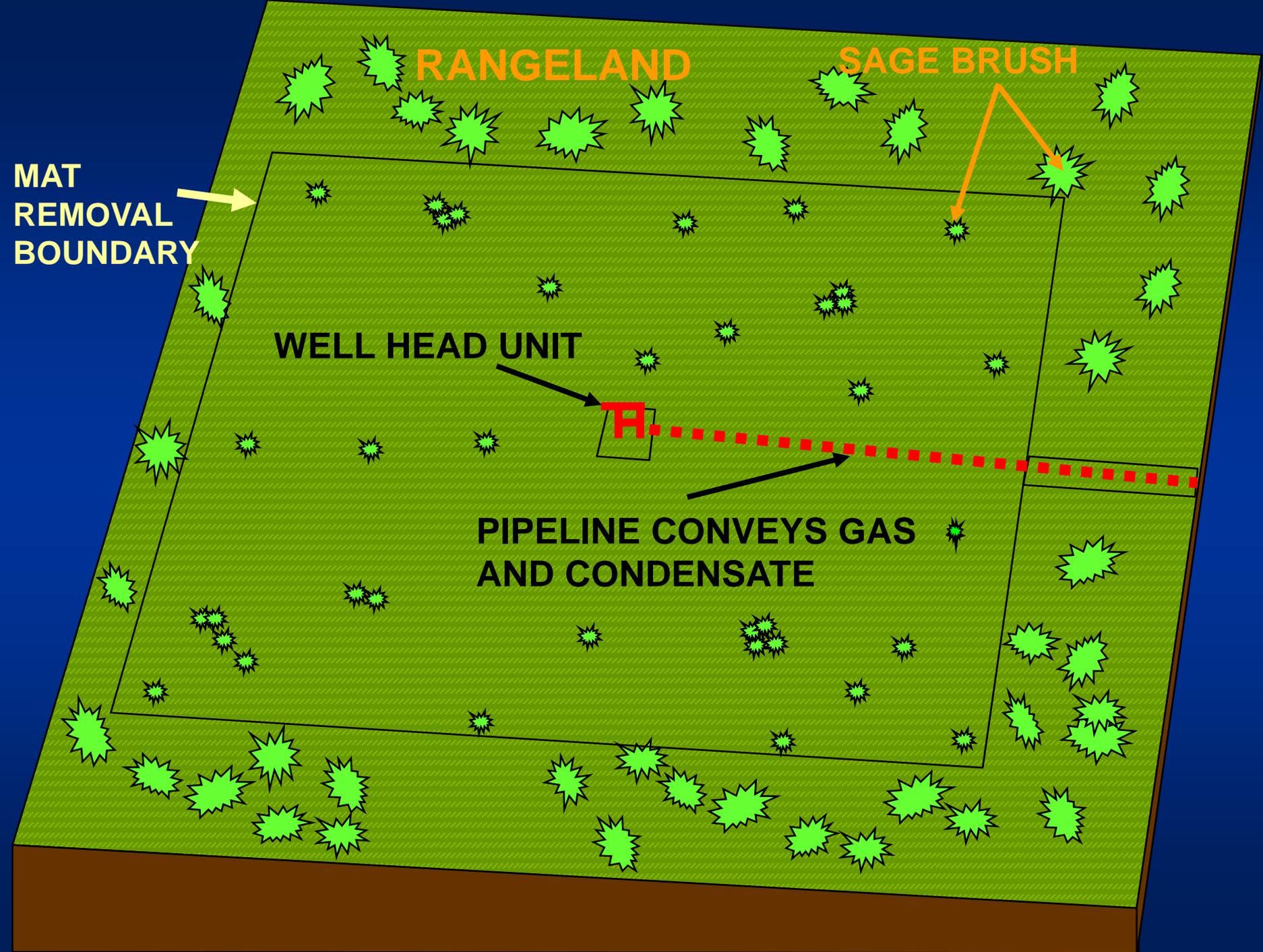
**OAK
MATTED
ROAD**

PLASTIC TARP

EARTHEN FILL

950 OAK MATS = 2.1 ACRES





RANGELAND

SAGE BRUSH

**MAT
REMOVAL
BOUNDARY**

WELL HEAD UNIT

H

**PIPELINE CONVEYS GAS
AND CONDENSATE**

MAT REMOVAL AREA



EFFECT OF OAK MATS ON SOIL AND PLANT RESOURCES



- SOIL COMPACTION

- PLANT GROWTH TRAITS AFTER MAT REMOVAL



- JIO ROLLOVER ACREAGE CREDIT TIME TABLE

SOIL COMPACTION WITH **CUT/FILL**, TOPSOIL REPLACEMENT, AND RIPPING PROCEDURES

DEPTH (inches)	MEAN* DRY SOIL BULK DENSITY, g/cm ³		
	UNDISTURBED RANGELAND	DRILL PAD AFTER TILLAGE	CHANGE
0-2	1.30	1.40	+8.4 %
2-6	1.29	1.45	+12.3 %
6-18	1.33	1.50	+12.9 %
UNWEIGHTED MEAN	1.31	1.45	+11.2 %

* Mean of 6 drill pad locations.

Density Threshold = 1.65 g/cm³

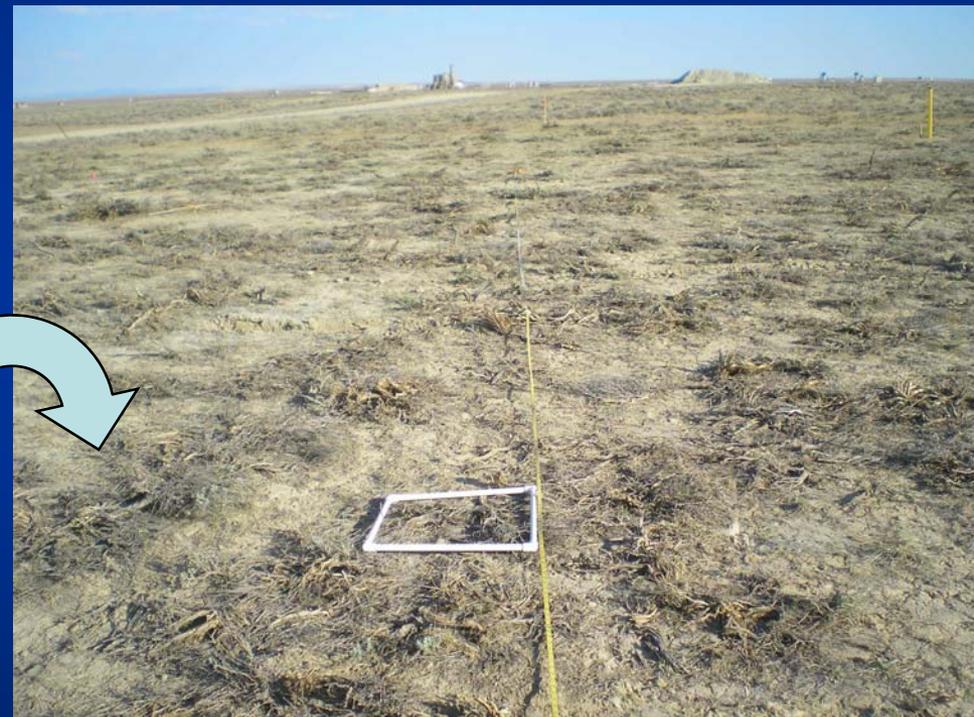
SOIL COMPACTION WITH OAK MATS

DEPTH (inches)	MEAN* DRY SOIL BULK DENSITY, g/cm ³		
	BEFORE MAT CONSTRUCTION	AFTER MAT REMOVAL	CHANGE
0-2	1.29	1.26	-2.3 %
0-6	1.32	1.35	+2.3 %
0-12	1.32	1.41	+6.8 %
UNWEIGHTED MEAN	1.31	1.34	+2.3 %

* Mean of 17 drill pad locations.

Density Threshold = 1.65 g/cm³

Most mat removal areas may pass J10 rollover acreage criteria after first growing season.



Reference Area - Undisturbed Rangeland

Oak Mat Removal Area

JIO ROLLOVER ACREAGE CRITERIA

SOIL EROSION ANALYSIS

1. Matted area must be in stable condition.
2. Matted area % bare ground \leq reference area.

VEGETATION TRAITS

3. Matted area forb & shrub diversity \geq reference area.
4. Matted area has minimum 3 perennial grass species including at least 2 bunchgrasses.
5. In the matted area, ≥ 15 % of the shrub density must be the dominant species found in the reference area.
6. Matted area shrub density ≥ 50 % reference area.
7. Matted area forb density ≥ 75 % reference area.
8. Matted area free of noxious and invasive weed species.
9. Matted area plants appear resilient (e.g. seed heads, flowers).

RECLAMATION TIME TABLE

- Rollover acreage credit request on 12 of 17 oak mat removal areas, 2006.
- Shrub mortality on several matted sites precluded rollover acreage request.

COST ANALYSIS



- MAT ACQUISITION
- MOBILIZATION
- CONSTRUCTION LAYOUT
- DISASSEMBLY
- SUPPORT EQUIPMENT
- DEPRECIATION
- LAND RECLAMATION

**OAK MATTED DRILL PAD COST IS LESS
THAN A DRILL PAD CUT/FILL/RESERVE PIT
CONSTRUCTION PROCEDURE**

COST ANALYSIS



- DRILLING COST IS HIGHER ON A MATTED PAD DUE TO 'CLOSED LOOP' TREATMENT OF DRILL CUTTINGS COMPARED TO USING A CONVENTIONAL RESERVE PIT.

- LOWER COST ALTERNATIVES TO THE PRESENT 'CLOSED LOOP' TREATMENT PROCEDURE ARE EMINENT.

Fill used to level drill pad atop oak matted site.

SYNOPSIS

MERIT OF OAK MATTING METHOD

- No effect on soil structure.
- No loss of soil A-horizon.
- No weeds introduced.
- Seed bank remains in place and viable.
- Subsurface saline and carbonaceous soil does not get mixed with better quality surface soil.
- No ripping needed for compaction relief.
- Potential rollover acreage credit after 1 growing season.
- Oak mat procedure cost less than cut/fill drill pads.

