SALT MIGRATION

Bruce A. Buchanan, Ph.D

Buchanan Consultants, Ltd.

Oil Conservation Commission

May 2012

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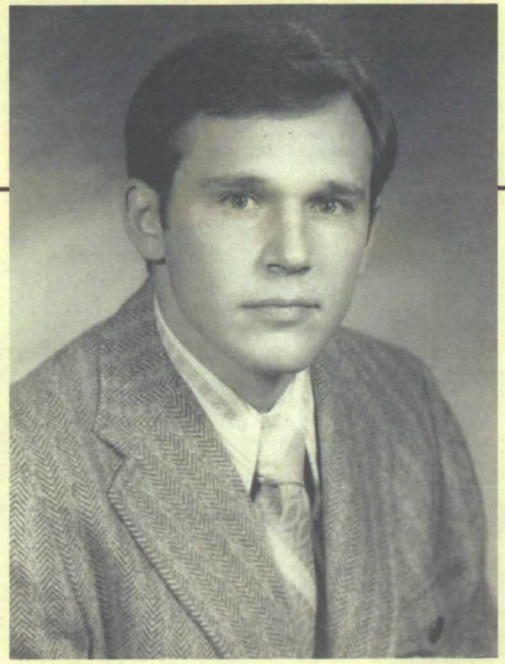
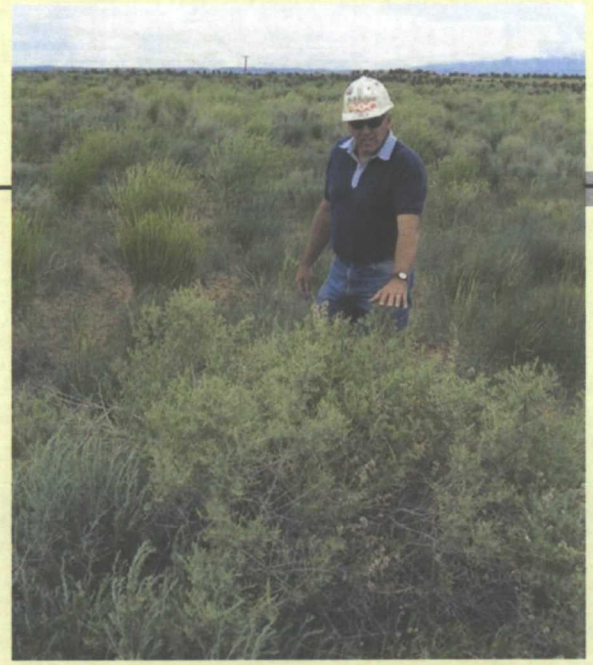
Consultants, Ltd.

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-1
HEARING DATE: MAY 14, 2012



1971



2011

Ph.D., Montana State University, 1971

Professor, NMSU, 1971 – 1991

President, Buchanan Consultants, 1991 – Present

President, American Society of Mining and Reclamation, 2012 – 2013

Certified Professional Soil Scientist

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-2
HEARING DATE: MAY 14, 2012

OBJECTIVE

To demonstrate that salts do not migrate to or accumulate at the soil surface when drilling pits are properly closed and reclaimed.

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BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-3
HEARING DATE: MAY 14, 2012

Statement

Research and practical experience from the fields of soil chemistry, soil physics and reclamation will be used to support the position that upward salt migration to the surface of closed drilling pits does not occur when the site is properly reclaimed.

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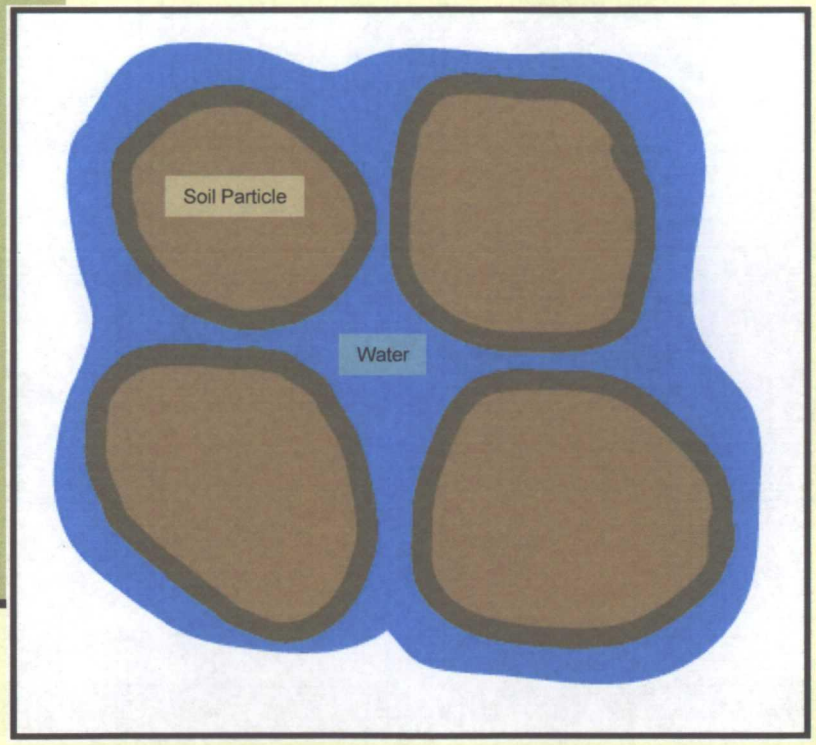
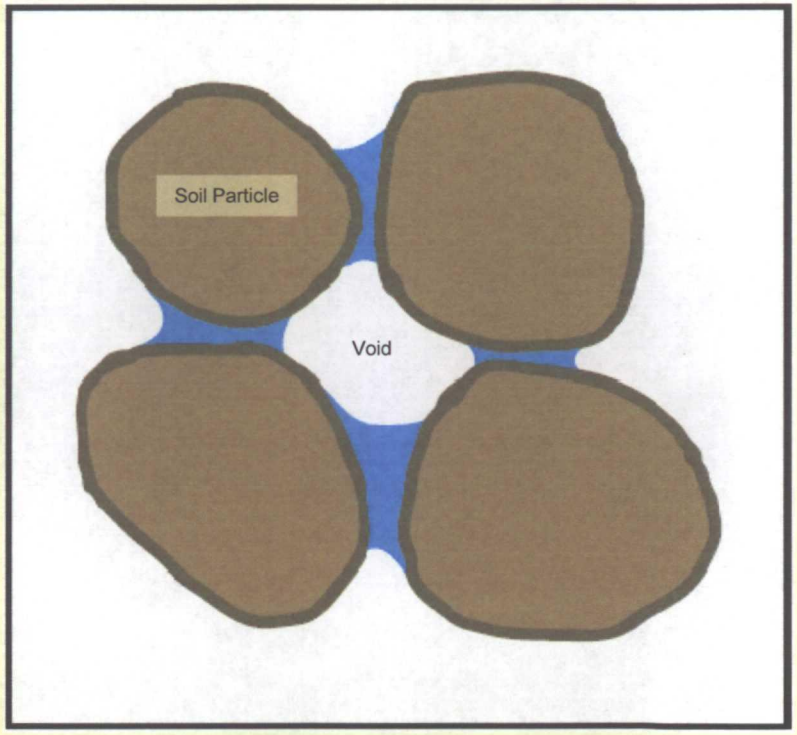
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-4
HEARING DATE: MAY 14, 2012

Soil Water



Saturated Flow



Unsaturated Flow

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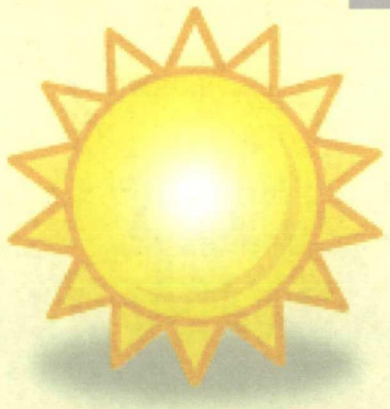
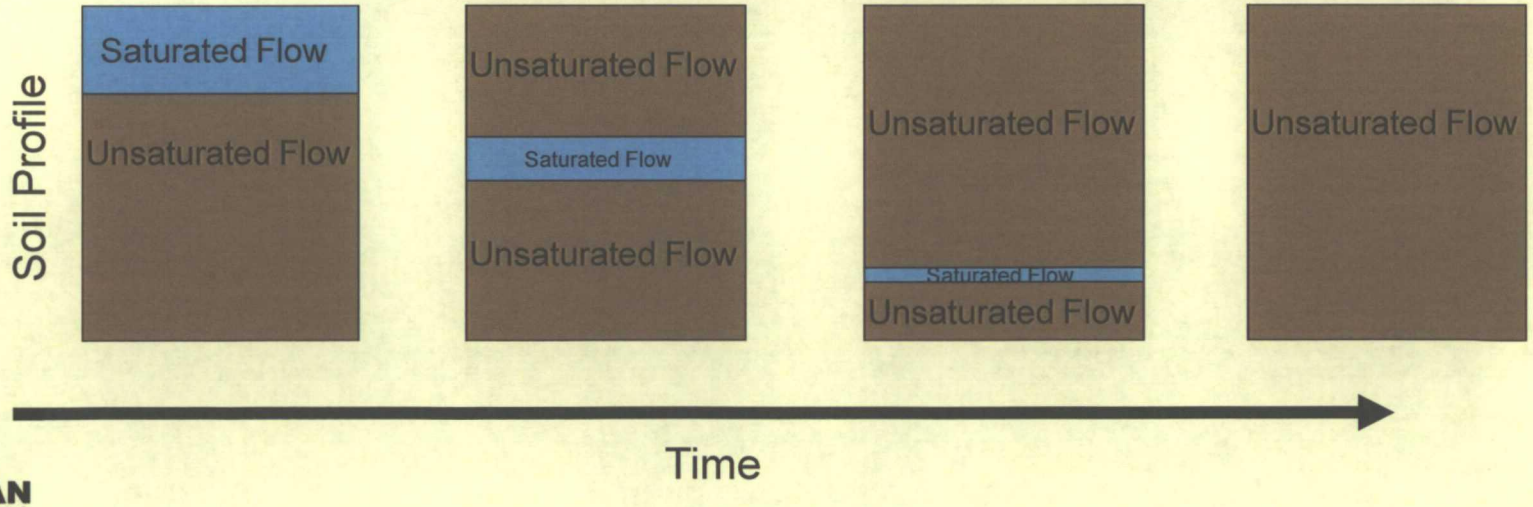
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-5
HEARING DATE: MAY 14, 2012

Water Flow





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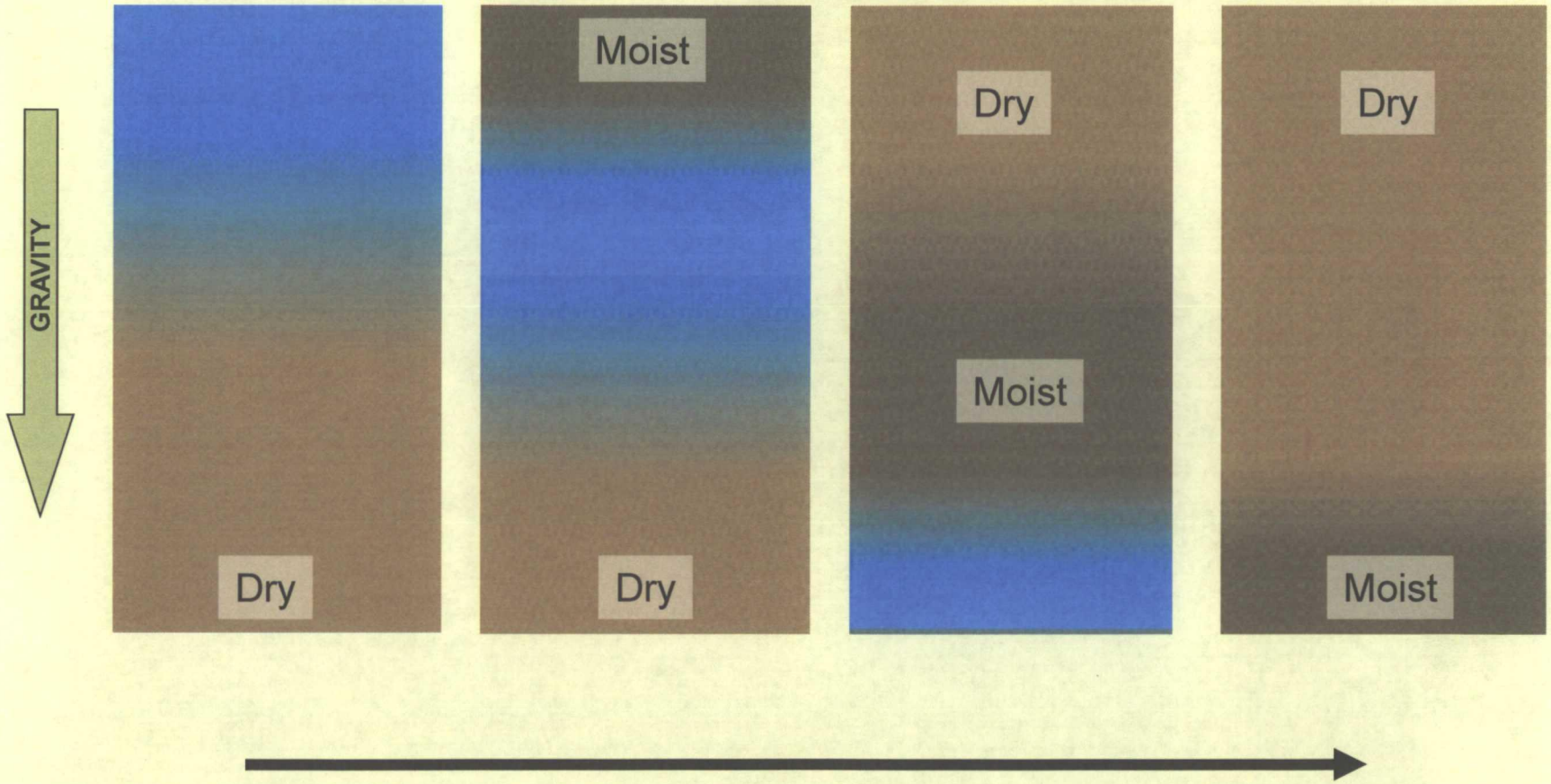
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-6
HEARING DATE: MAY 14, 2012

Soil Water Movement



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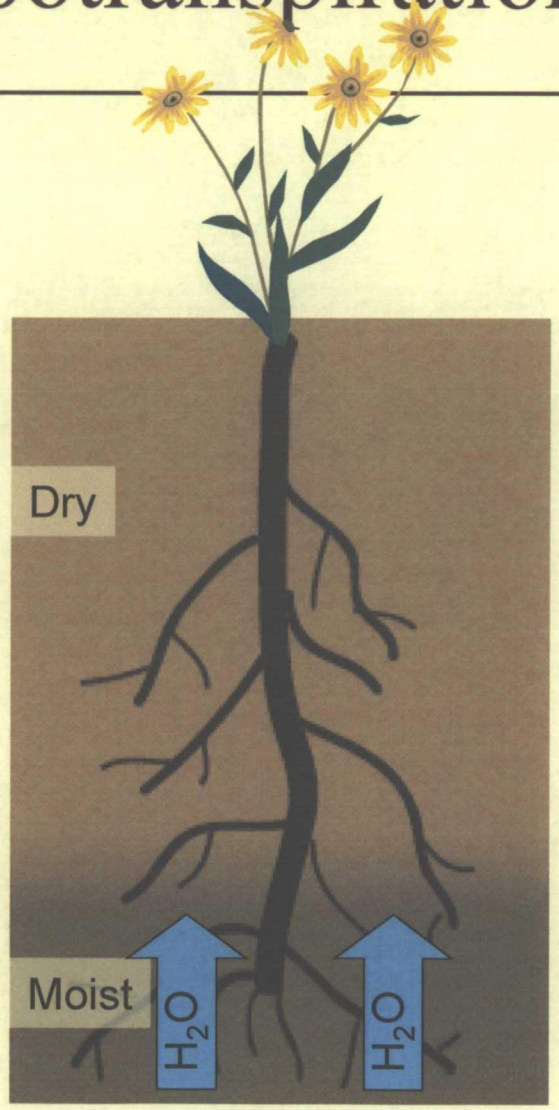
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-7
HEARING DATE: MAY 14, 2012

Plant Evapotranspiration



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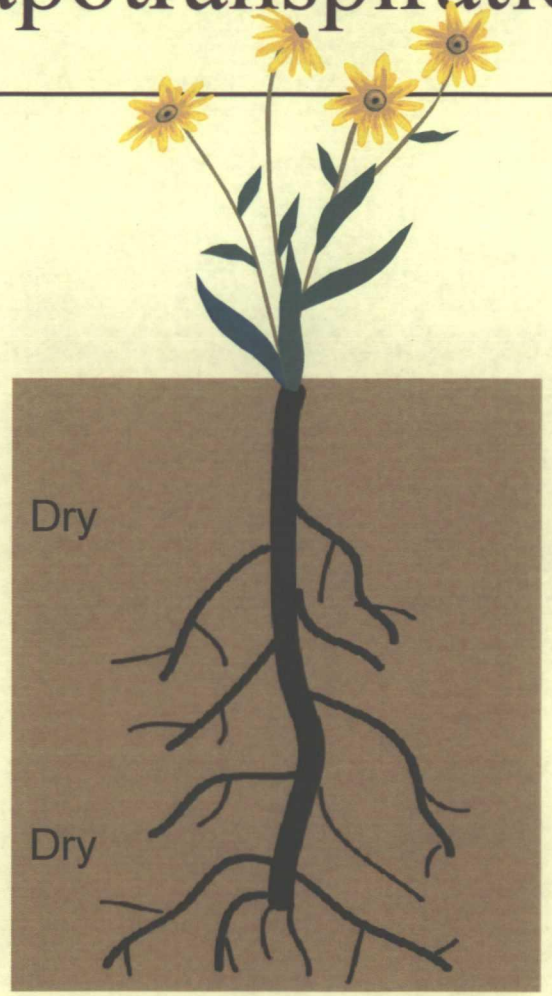
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-8
HEARING DATE: MAY 14, 2012

Plant Evapotranspiration



Time

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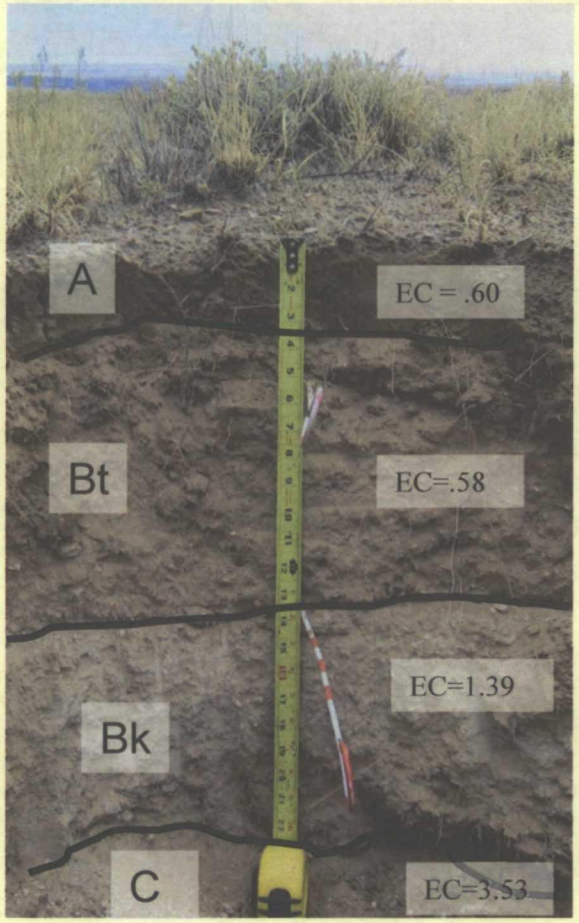
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-9
HEARING DATE: MAY 14, 2012

Semi-Arid Native Soil



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BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-10
HEARING DATE: MAY 14, 2012

Reclaimed Mine Spoils
Stutz & Buchanan 1987

- New Mexico
- 12 years post-reclamation
- Spoil study
- No cover soil
- Salts migrated downward 10 to 30 inches

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BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-11
HEARING DATE: MAY 14, 2012

Reclaimed Mine Spoils
Buchanan 1998

- New Mexico
- 4 years post-reclamation
- 24 inches of cover soil over spoil
- No surface salts
- Salts migrated ≤ 4 inches upward from spoil

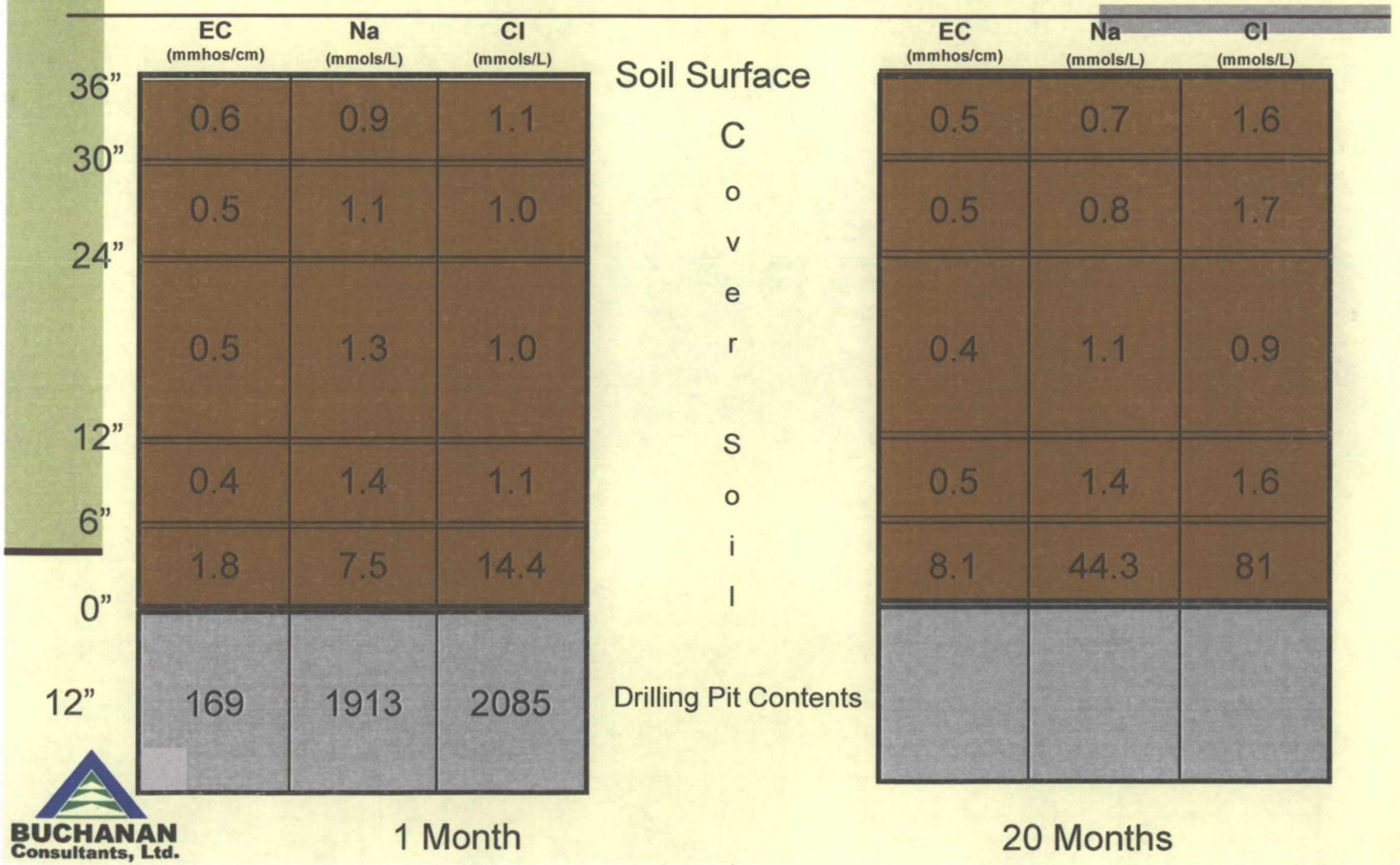
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-12
HEARING DATE: MAY 14, 2012

Reclaimed Drilling Pits McFarland et al. 1992

- Texas
- 20 months post-reclamation
- 36 inches of cover soil
- No surface salts
- 6 and 12 inches of upward salt migration from pit contents

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-13
HEARING DATE: MAY 14, 2012

Mertz Drilling Pit Study Site



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1 Month

20 Months

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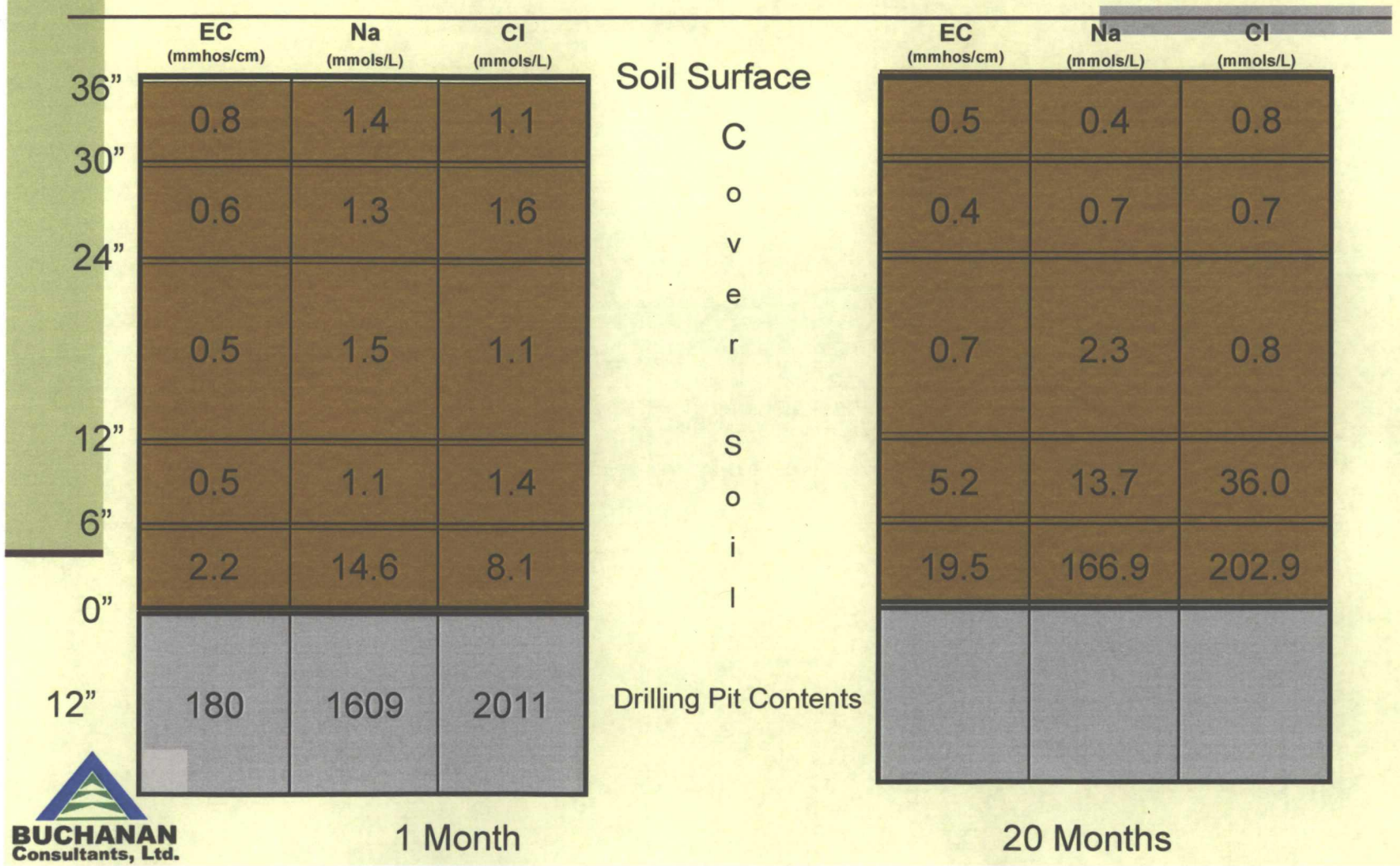
HEARING DATE: MAY 14, 2012

Weatherby Drilling Pit Study Site



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BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-15
HEARING DATE: MAY 14, 2012

Conoco/Phillips Study
Buchanan et al. 2007

- New Mexico
- 40 years post-reclamation
- No pit liner
- 20 inches of cover soil over pit contents

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-16
HEARING DATE: MAY 14, 2012

Conoco/Phillips Study
Buchanan et al. 2007

DC Federal #3 Reclaimed circa 1967

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CASE NO. 14784 NMOGA EXHIBIT 17-17
HEARING DATE: MAY 14, 2012

Conoco/Phillips Study
Buchanan et al. 2007

DC Federal #3

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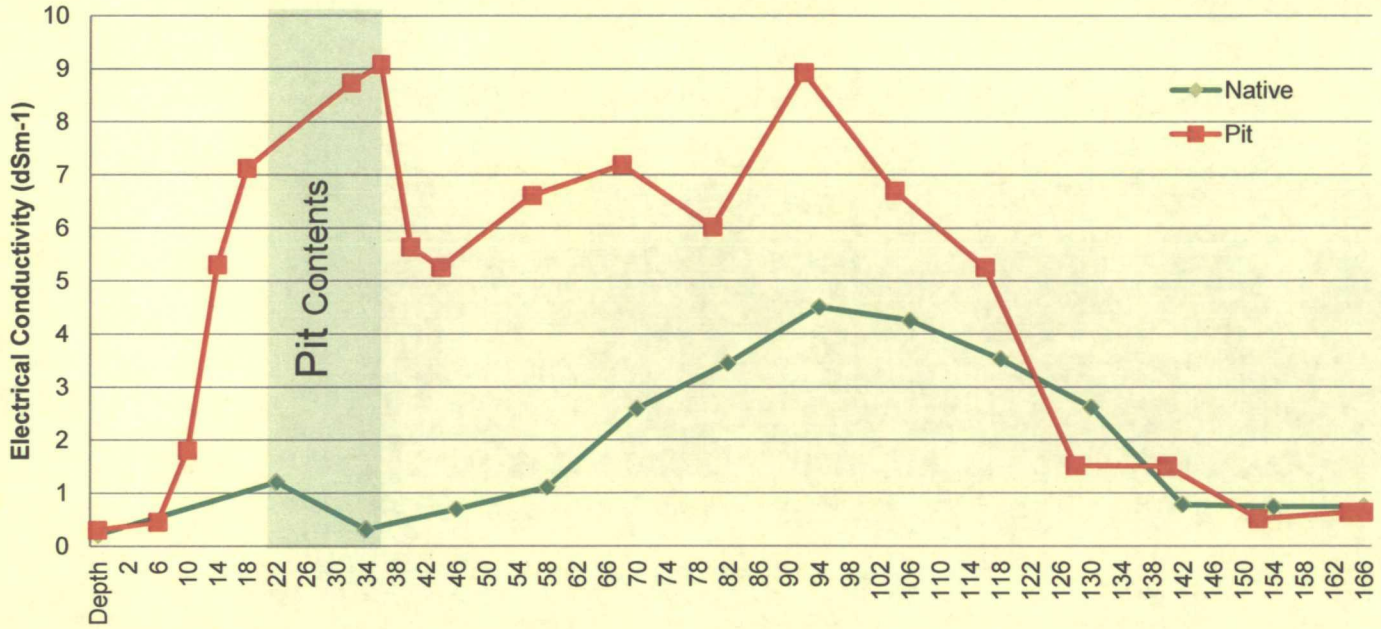
CASE NO. 14784 NMOGA EXHIBIT 17-18
HEARING DATE: MAY 14, 2012

Conoco/Phillips Study
Buchanan et al. 2007



BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-19
HEARING DATE: MAY 14, 2012

Conoco/Phillips Study
Buchanan et al. 2007

- New Mexico
- 25 years post-reclamation
- No pit liner
- 20 inches of cover soil over pit contents
- No surface salts
- Salts migrated upward ≈ 12 inches from pit contents
- Salts migrated downward ≈7 feet from pit contents

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-20
HEARING DATE: MAY 14, 2012

Summary: Salt Migration

- Salts migrate upward into cover soils.
- Salts do not migrate to the soil surface.
- Salts migrate downward below pit contents.

- Current Rule 17 requires 48 inches of cover soil.
- Cover depth of 48 inches is sufficient for successful reclamation and salt management.

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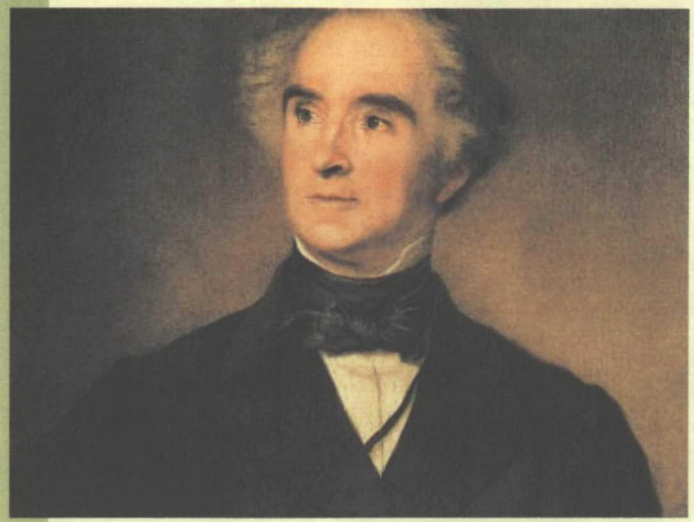
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-21
HEARING DATE: MAY 14, 2012

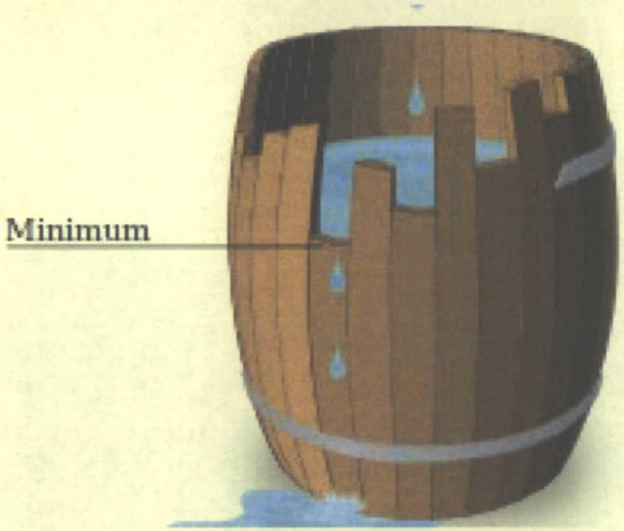
Reclamation

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-22
HEARING DATE: MAY 14, 2012

Liebig Law of Minimum



1803-1873



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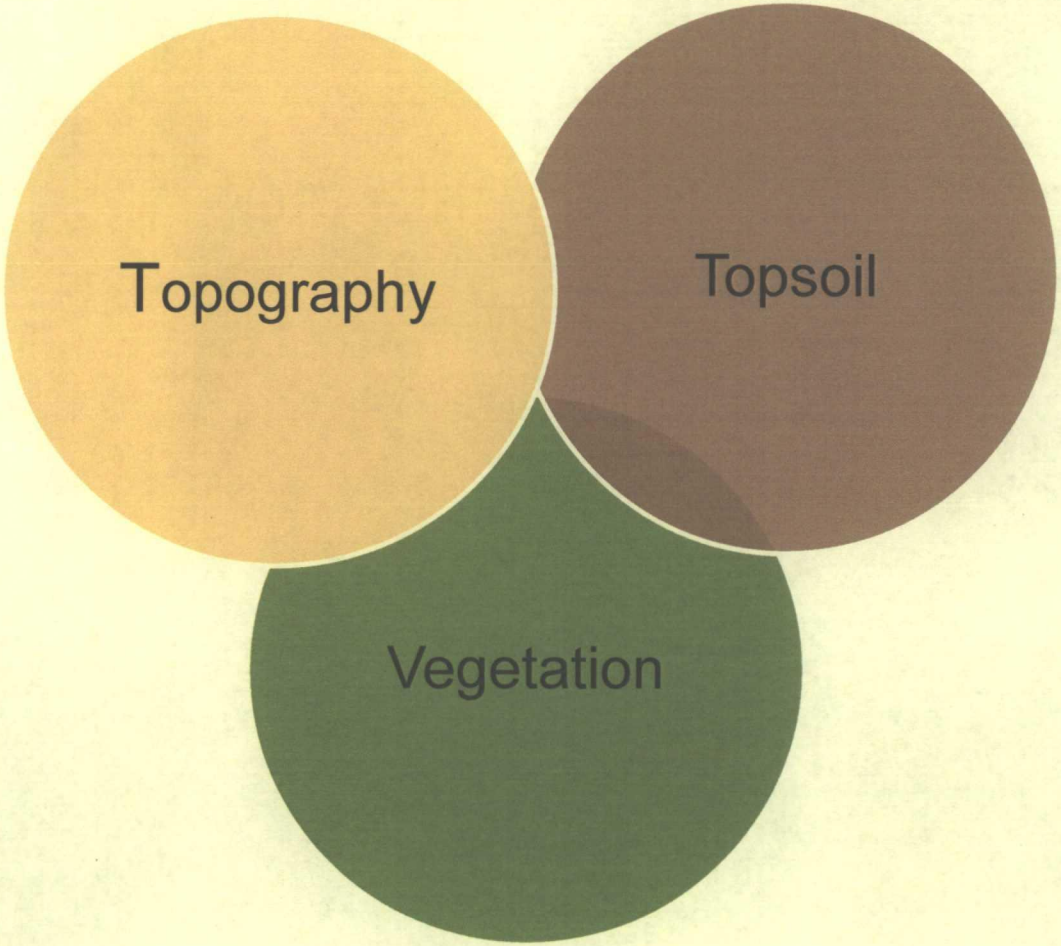
HEARING DATE: MAY 14, 2012



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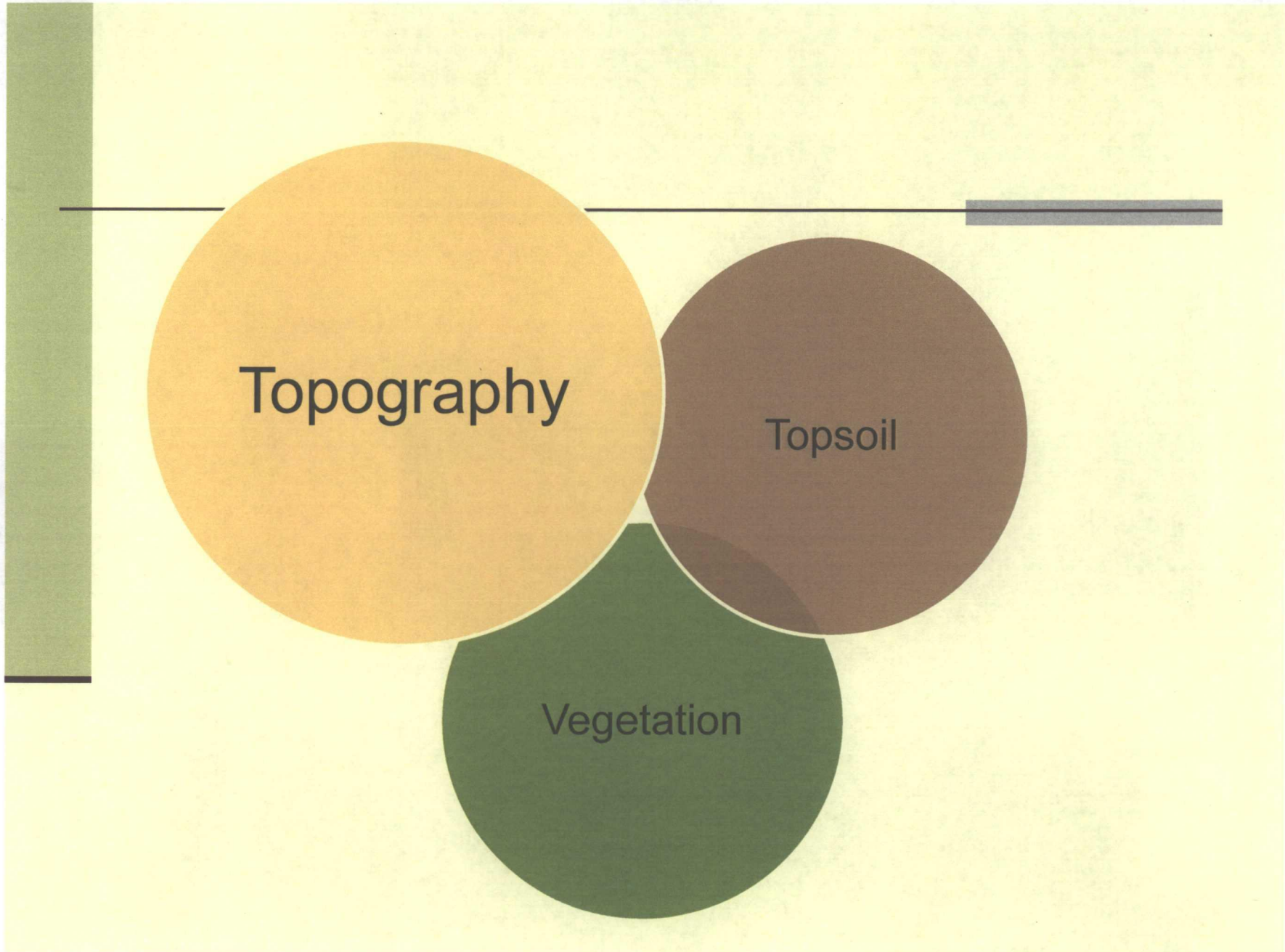
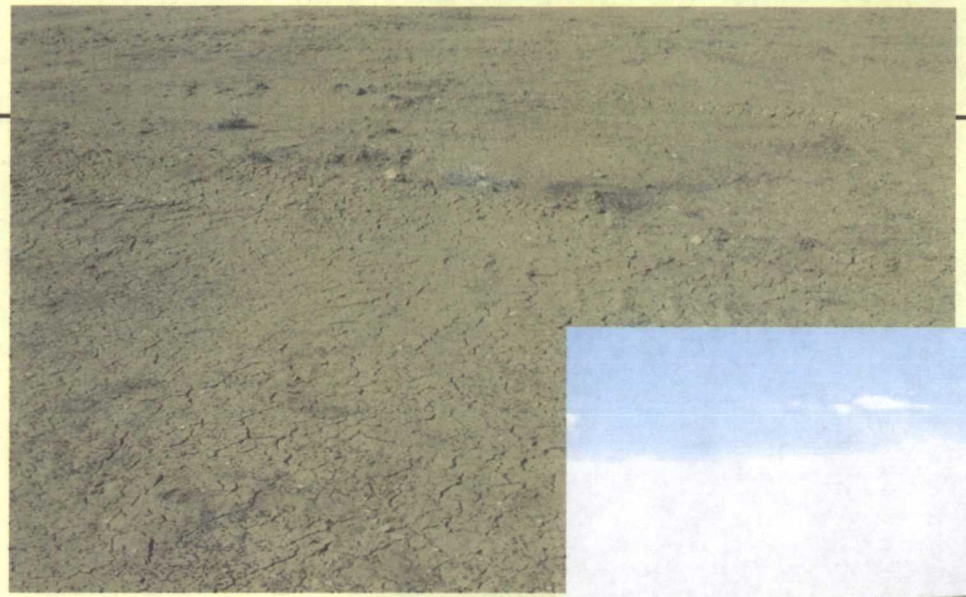
HEARING DATE: MAY 14, 2012



BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-25
HEARING DATE: MAY 14, 2012



Stable Topography

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CASE NO. 14784 NMOGA EXHIBIT 17-26
HEARING DATE: MAY 14, 2012

Erosion

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CASE NO. 14784 NMOGA EXHIBIT 17-27
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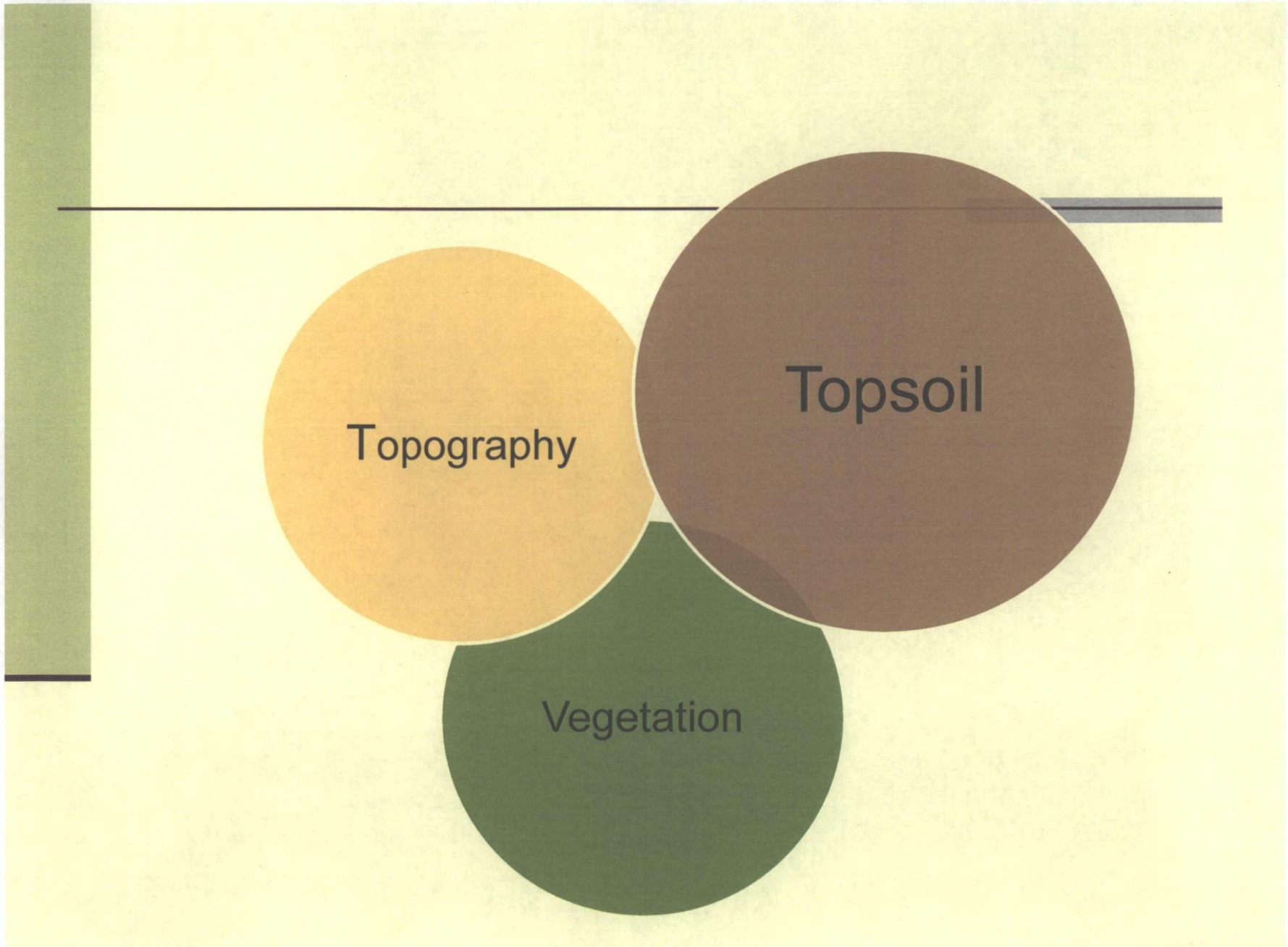
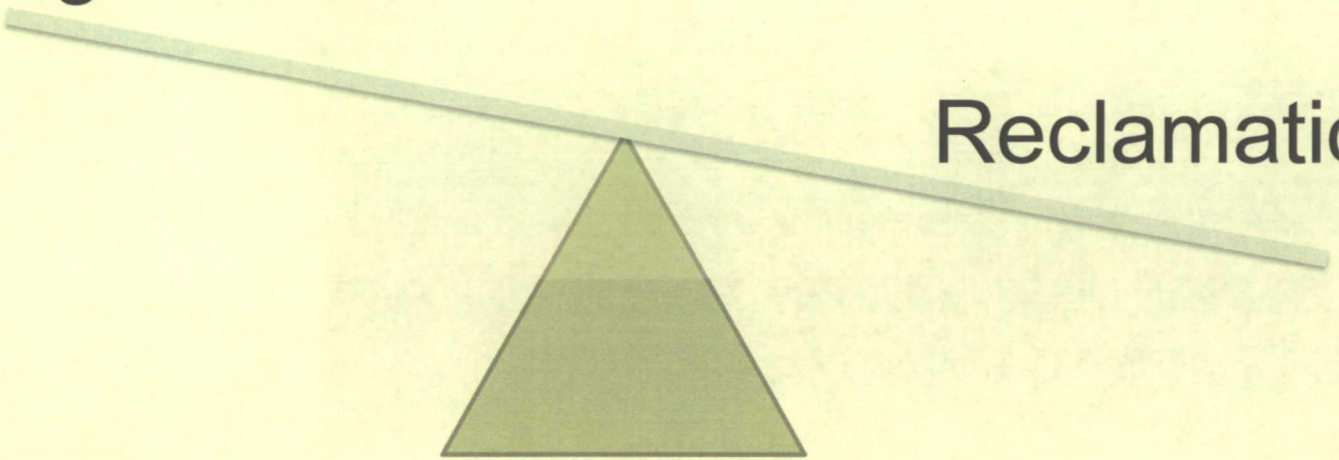


BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-28
HEARING DATE: MAY 14, 2012

Topsoil Standards

Agriculture



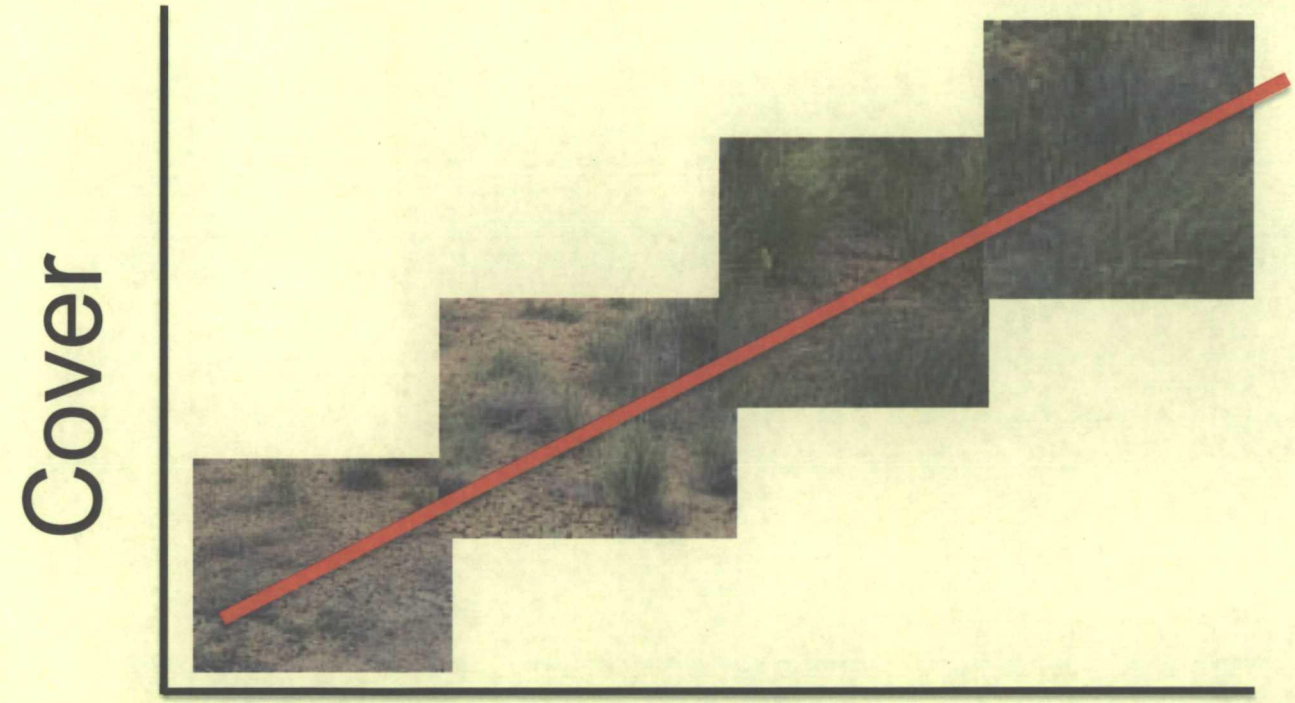
Reclamation

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-29
HEARING DATE: MAY 14, 2012

Topsoil Standards

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-30
HEARING DATE: MAY 14, 2012

Topsoil Depth



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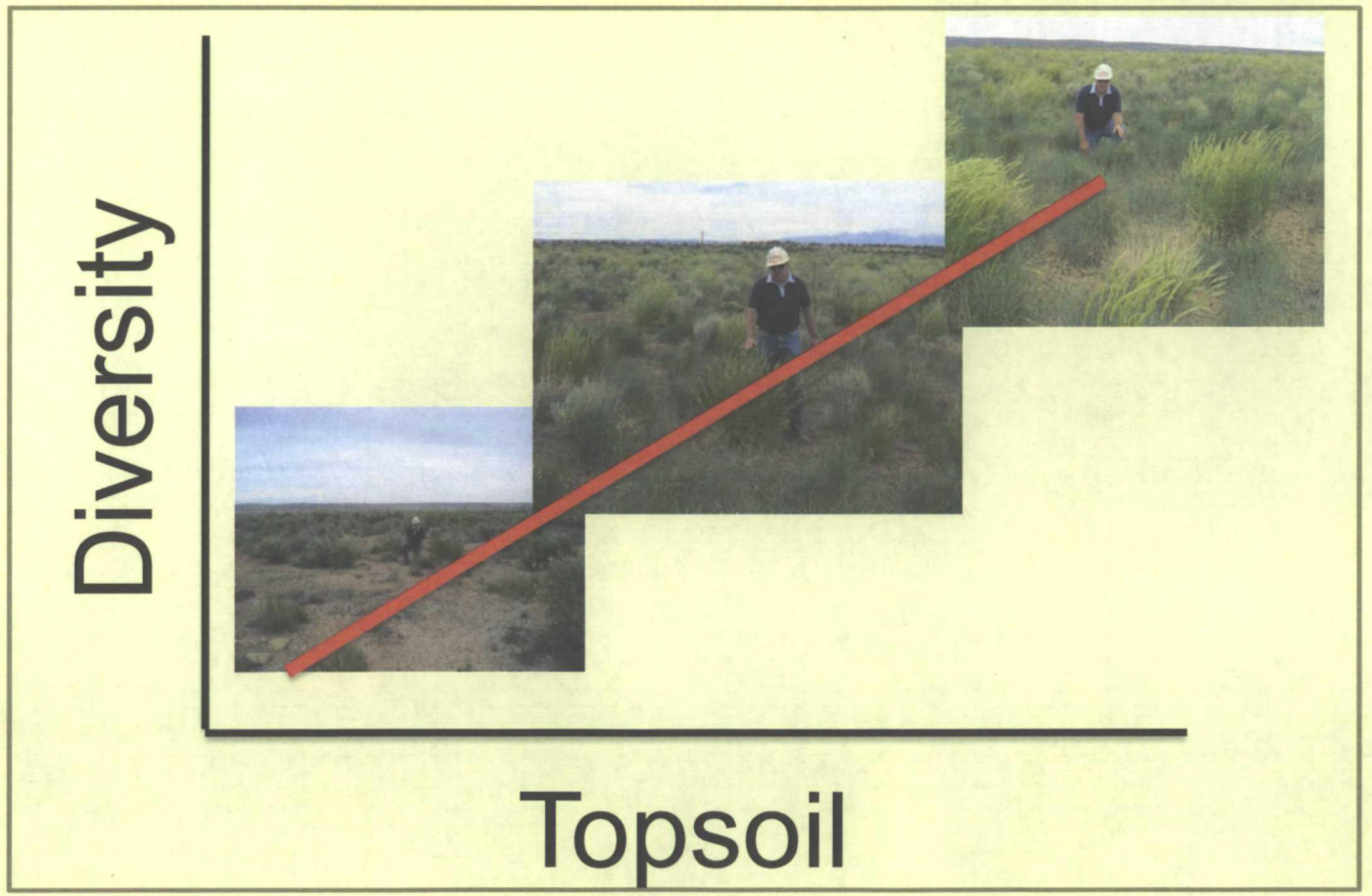
CASE NO. 14784 NMOGA EXHIBIT 17-31
HEARING DATE: MAY 14, 2012

Topsoil Depth



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CASE NO. 14784 NMOGA EXHIBIT 17-32
HEARING DATE: MAY 14, 2012

Compaction

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CASE NO. 14784 NMOGA EXHIBIT 17-33
HEARING DATE: MAY 14, 2012

Chisel

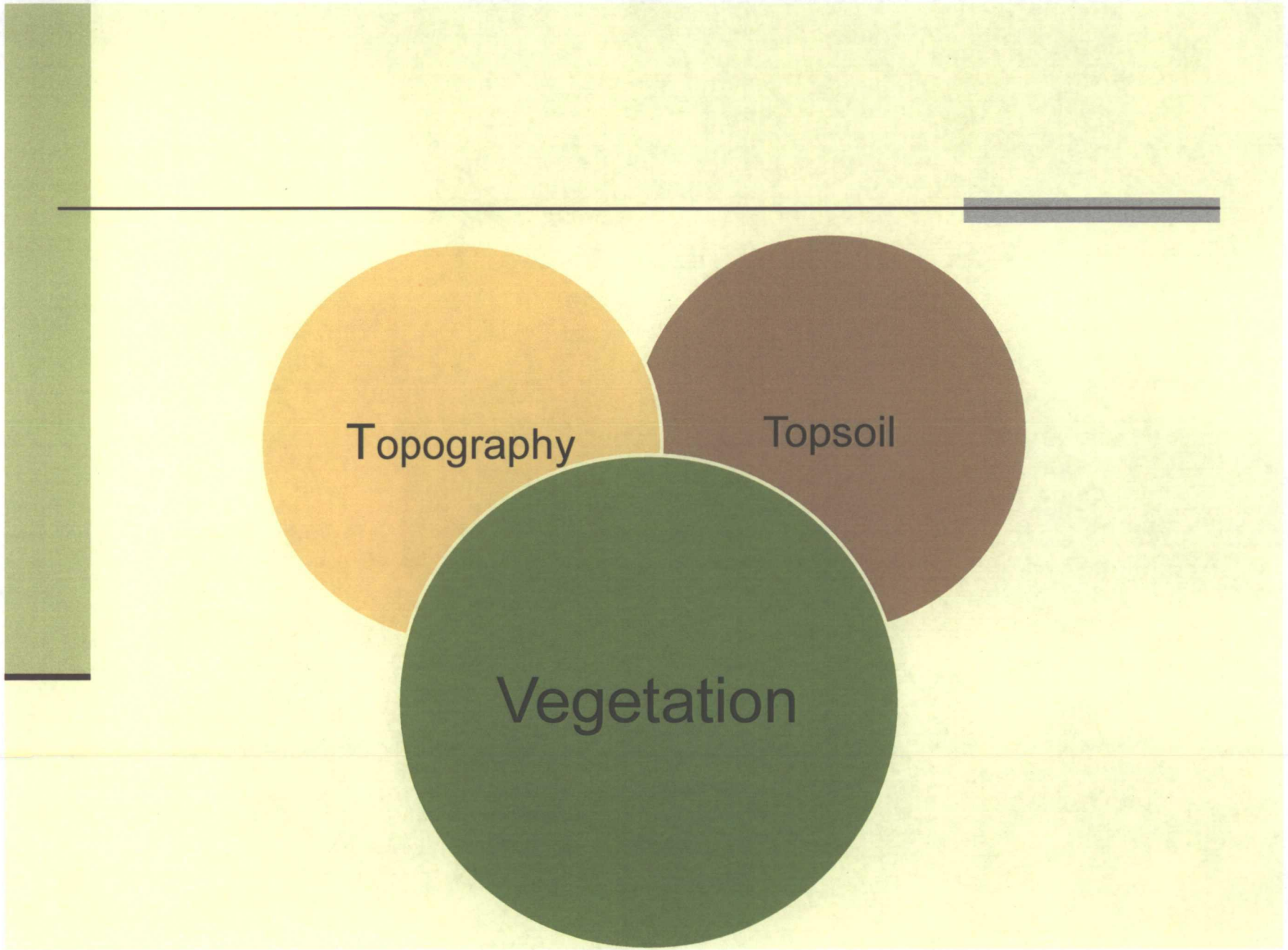
BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-34
HEARING DATE: MAY 14, 2012

Seed Bed Preparation

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-35
HEARING DATE: MAY 14, 2012

Fertilizer

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-36
HEARING DATE: MAY 14, 2012



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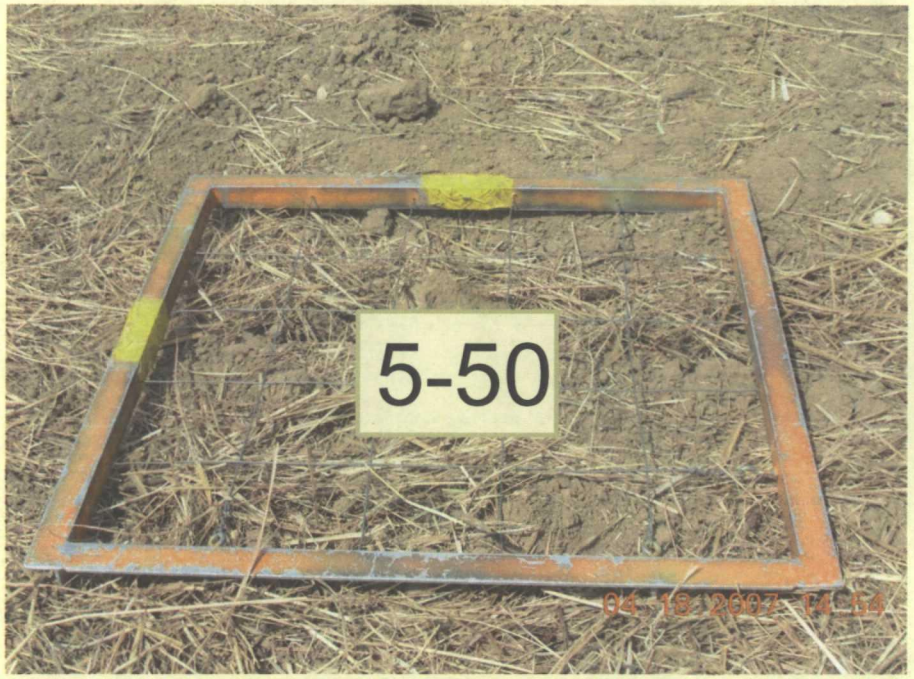
CASE NO. 14784 NMOGA EXHIBIT 17-37
HEARING DATE: MAY 14, 2012

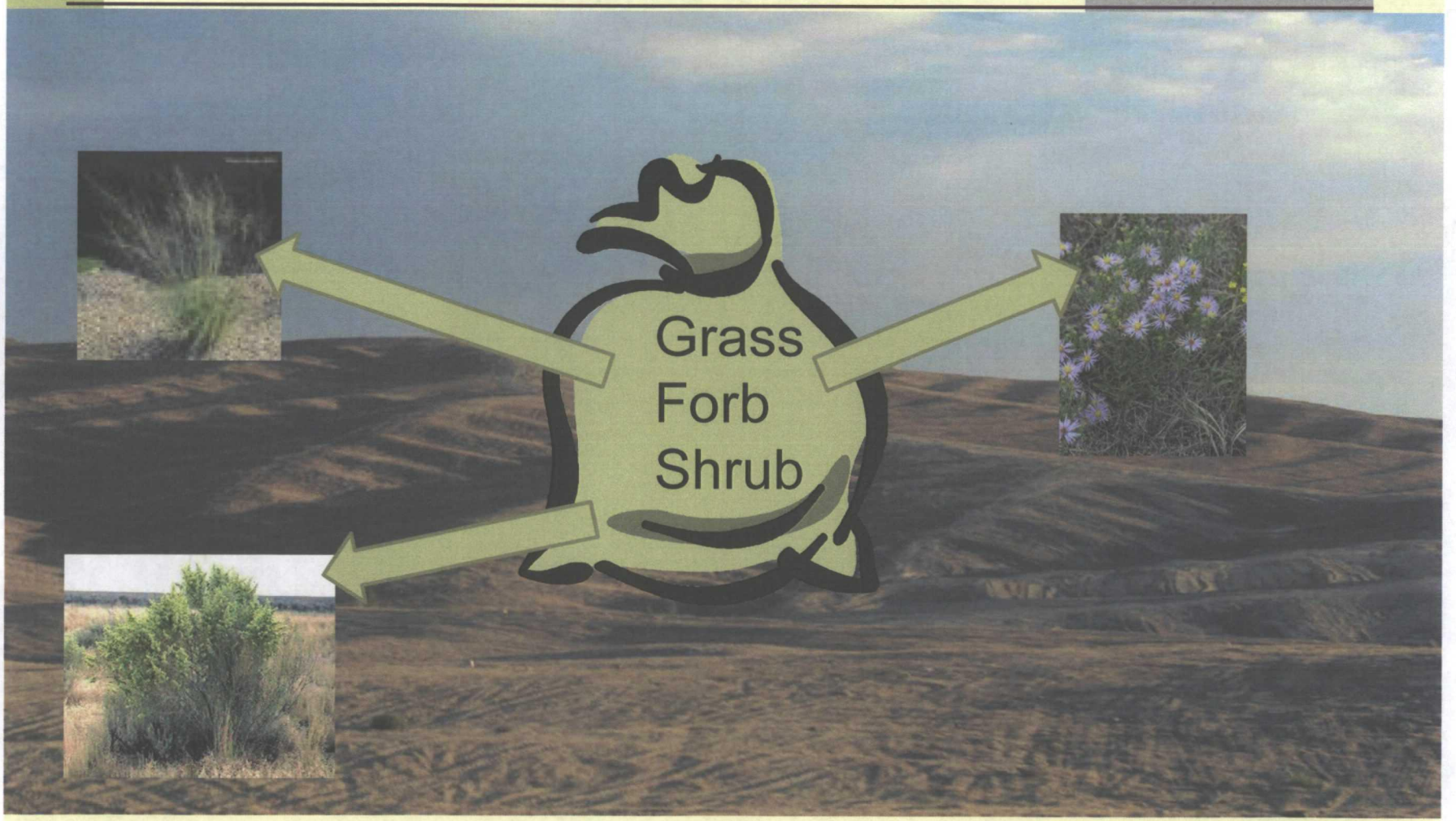
Seed Rate



PLS/sq ft

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-38
HEARING DATE: MAY 14, 2012

Seed Mix



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CASE NO. 14784 NMOGA EXHIBIT 17-39
HEARING DATE: MAY 14, 2012

Seed Mix / Topography

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CASE NO. 14784 NMOGA EXHIBIT 17-40
HEARING DATE: MAY 14, 2012

Seed Timing

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CASE NO. 14784 NMOGA EXHIBIT 17-41
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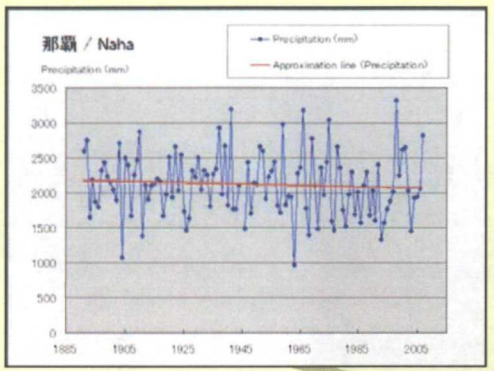
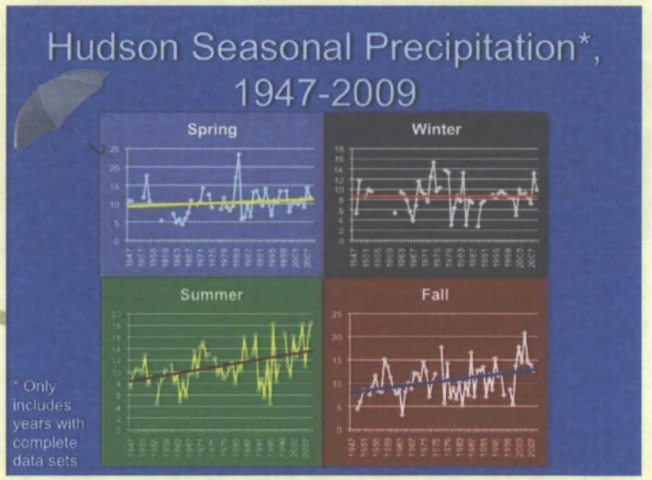


Annual



Seasonal

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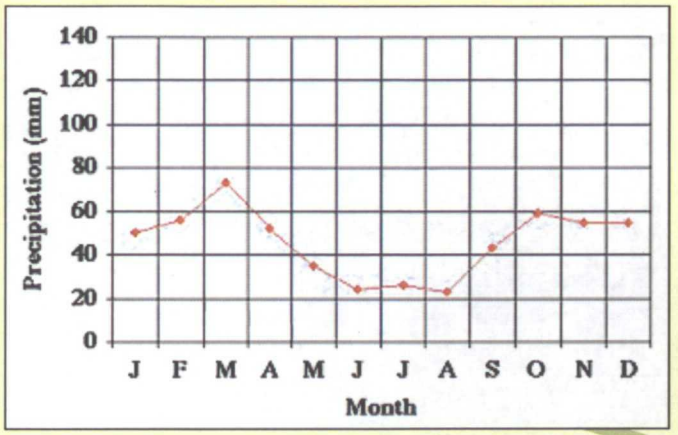
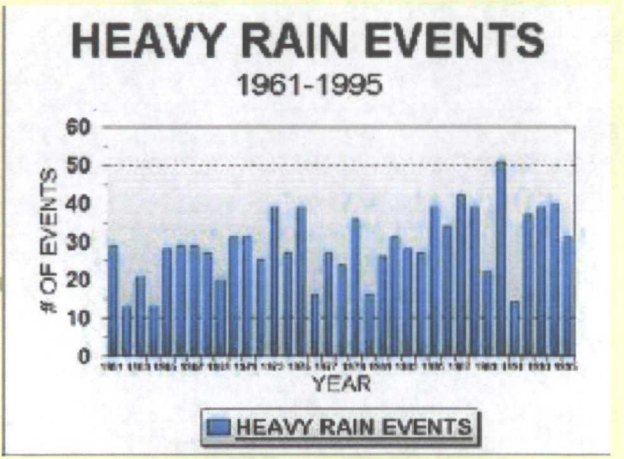
HEARING DATE: MAY 14, 2012



Amount



Event

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CASE NO. 14784 NMOGA EXHIBIT 17-43
HEARING DATE: MAY 14, 2012

Lifeform diversity

Sand dropseed

Alkali sacaton

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-44
HEARING DATE: MAY 14, 2012

Reclamation Summary

- Critical elements for success:
  - Stable topography (control erosion)
  - Cover depth ≈ 3 feet and Topsoil depth ≈ 1 foot
  - Compaction management (final reclamation)
  - Seed Mix (diversity)
  - Favorable growing season

BEFORE THE OIL CONSERVATION COMMISSION
CASE NO. 14784 NMOGA EXHIBIT 17-45
HEARING DATE: MAY 14, 2012