Effects of saline-sodic water on EC, SAR, and water retention
by Kimberly Marie Robinson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Land Resources and Environmental Science
Montana State University

Abstract:
There is significant concern regarding the potential impact of discharges of saline-sodic water from coal bed methane development sites within the Powder River Basin onto irrigated acreages of the area.

The specific objective of this study was to assess soil chemical and physical responses upon wetting with saline-sodic water. This was accomplished by exposing soil material collected from sites within the Powder River Basin to various combinations of two water qualities and three wetting/irrigation regimes. Water quality treatments consisted of either synthesized Powder River water or synthesized CBM product water. Wetting and irrigation regimes consisted of:1) a single wetting event, 2) a five-time wet/dry cycle and 3) a five-time wet/dry cycle followed by a single flood (flushing) event with distilled water.

Repeated irrigation with saline-sodic water or water with a chemical signature comparable to the CBM product water used in this study will result in a general increase in the soil salinity and sodicity. It is likely that elevated soil salinity levels will be substantially higher than published thresholds for some irrigated crops. The impact of rainfall on reducing EC and SAR is more predominant when salt concentrations are high, and in coarser-textured soils. Distilled water applications simulating rainfall resulted in a much greater lowering of EC than for SAR.

To assess the effects of saline-sodic water on the physical properties of the soil, water content was measured after the soils were exposed to the various water qualities and treatment scenarios at five different pressure potentials. It was found that water content associated with matric potential differed significantly due to predominant soil textures. Although statistically significant differences were detected among water quality treatments, differences were not considered large enough to have a significant ecological impact. It was determined that'CBM product water applied at these levels did not have a consistent significant impact on soil physical properties.

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MONTANA STATE UNIVERSITY-BOZEMAN
Bozeman, Montana

April 2003

APPROVAL

Of a thesis submitted by

Kimberly Marie Robinson

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGEMENTS

I would like to thank the members of my committee Dr. James Bauder, Dr. Douglas Dollhopf, and Dr. Jon Wraith for their efforts in support of my graduate research. My sincerest thanks go to Dr. James Bauder for his guidance every step of the way, without which I could not have completed this project. I would also like to thank Bernard Schaff, Susan Winking, and the team of students working for Dr. Bauder for their help in the many different aspects of this project. A very special thanks goes to my husband and family for their love, support, and encouragement.

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ABSTRACT

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The specific objective of this study was to assess soil chemical and physical responses upon wetting with saline-sodic water. This was accomplished by exposing soil material collected from sites within the Powder River Basin to various combinations of two water qualities and three wetting/irrigation regimes. Water quality treatments consisted of either synthesized Powder River water or synthesized CBM product water. Wetting and irrigation regimes consisted of: 1) a single wetting event, 2) a five-time wet/dry cycle and 3) a five-time wet/dry cycle followed by a single flood (flushing) event with distilled water.

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CHAPTER 1

Introduction

The growing need for new sources of energy has spurred development of the coal bed methane (CBM) industry in the western United States. CBM has a wide variety of energy-related uses and is generally considered a cleaner form of energy than traditional coal and oil. Conservative estimates suggest that there are approximately 141 trillion cubic feet (TCF) of economically recoverable CBM within the continental United States (Nelson, 1999). CBM is an attractive energy source, as exploration costs are low and wells used to extract CBM are cost effective to drill.

Environmental concerns have arisen with the increased emphasis on the extraction of the CBM resource. The extraction of CBM involves pumping large volumes of water from the saturated, coal-bearing aquifers in order to release water pressure that is trapping the gas in the coal. The quality of this pumped water coproduced with methane is a source of concern. This coproduced water (called CBM product water in this paper) has a modestly high salinity hazard and often a very high sodium hazard based on standards used for irrigation suitability. CBM product water also contains a significant bicarbonate (HCO_3) component, which enhances the precipitation of relatively insoluble carbonate minerals (Rice, 2000).

Much of the current CBM development is occurring in the Powder River Basin of Montana and Wyoming (Figure 1). The Powder River Basin encompasses both the

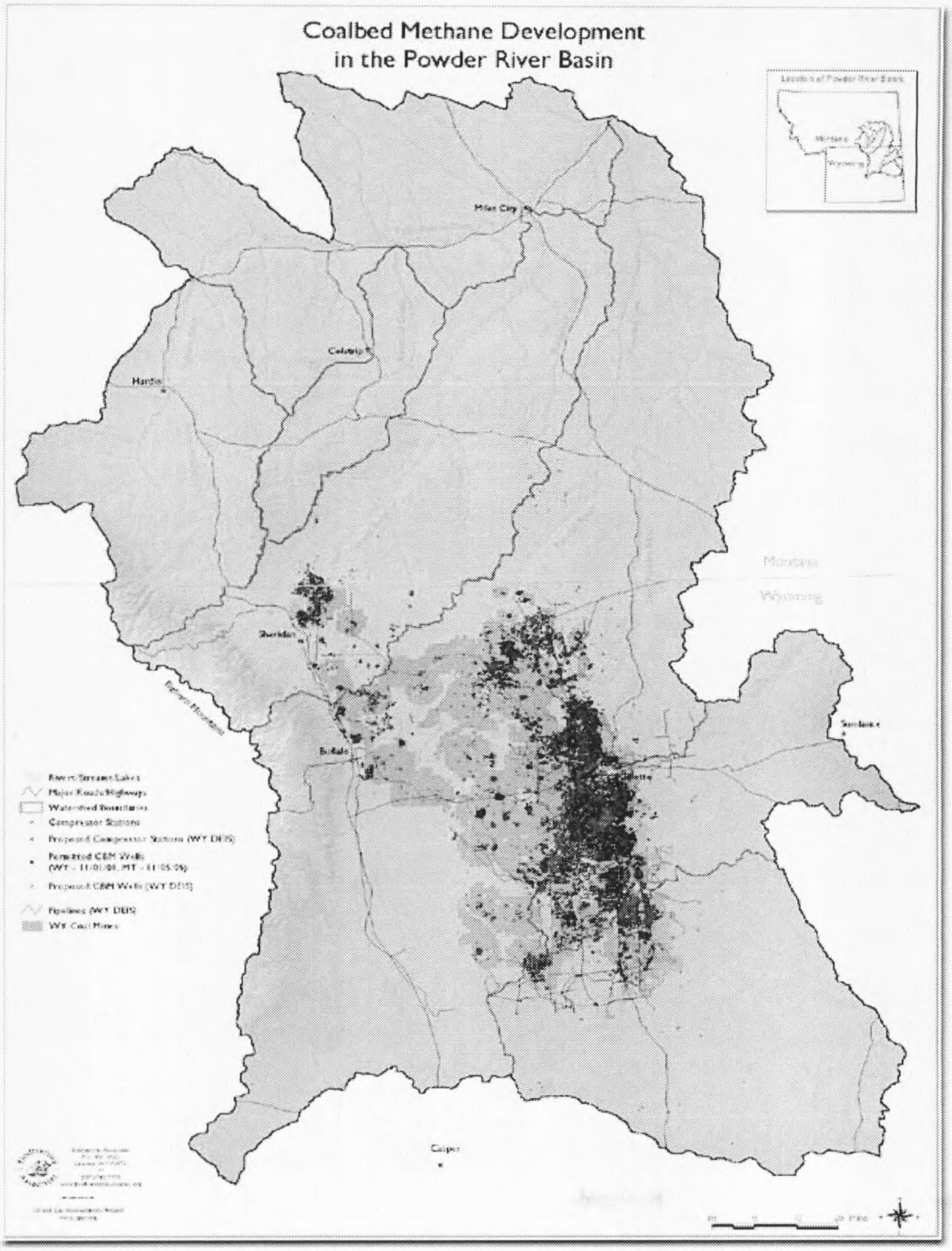

Figure 1. The Powder River Basin. Black dots represent permitted CBM wells. (Source: www.biodiversityassociates.org)

Powder River and the Tongue River watersheds. The Powder River originates in north-central Wyoming, flowing northward, where it joins the Yellowstone River near Terry, Montana. The soil survey for Powder River County, Montana (USDA, 1971) indicates that soils along the river within the basin consist primarily of silt loams, silty clay loams, and silty clays. These soils have historically been irrigated with Powder River water, roughly 4500 hectares in Montana (Brock, 1991). The Powder River Basin receives minimal precipitation, less than 35 cm annually. The basin's structural geology consists mostly of tertiary sandstones and shales (Thompson, 1991). The combination of these factors creates a flow within the Powder River that has an inherently high salt content, especially during periods of low flows. Suitability of Powder River water for irrigation varies seasonably. Figures 2-5 represent thirty years of water quality data collected by the United States Geological Society (USGS) on the Powder River at Moorhead, Montana. These figures show that water within the river is of marginal quality with respect to salinity and sodicity standards generally considered acceptable for irrigation.

Objectives

The present study assessed the effects of waters having a range of EC x SAR on chemical and physical properties of selected soil materials. A laboratory experiment was conducted that subjected soils of varying clay content to diverse wetting/drying regimes using two water qualities. It was hypothesized that saline-sodic water at the treatment levels used would have deleterious effects on chemical and physical