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February 13, 2007

Wyoming Environmental Quality Council
122 W. 25th Street, Herschler Bldg., Rm. 1714
Cheyenne, WY 82002
Attention: Terri A. Lorenzon, Director

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Terri A. Lorenzon, Director
Environmental Quality Council

Re: Wyoming Water Quality Rules Docket No. 06-3819, Surface Water Quality, Chapter 1, Appendix H

Thank you for the opportunity to provide comments to the Wyoming Environmental Quality Council regarding Wyoming Water Quality Rules, Chapter 1, Appendix H (the Agricultural Use Protection Rule) in accordance with the Notice of Intent to Adopt Rules and Regulations published by the DEQ in December, 2006. I am providing comments on behalf of Marathon Oil Company.

I have a Ph.D. in soil science from Montana State University and have worked in the field of environmental sciences and water quality protection for more than 30 years. At the beginning of my career, I worked with the Montana Cooperative Extension Service as a State Soil Scientist where one of my responsibilities was saline and sodic soil diagnosis and improvement and irrigation water quality. For the last 21 years I have worked as an environmental consultant. My resume is attached.



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**Appendix H, section (e)(i)**

Determination of EC and SAR limits is described in this section. A complex three-tiered methodology is outlined for identifying the site specific factors that together determine the permissible EC and SAR levels in produced water that will prevent impairment of crop yields. The introduction to Appendix H describes the complex interaction of site-specific factors that must be considered in assessing the suitability of produced water for direct discharge. Critical factors include the type of crops or forages grown, the irrigation management, other agronomic factors that can influence yield potential (e.g. fertilization, pest control), background water quality, soil texture, soil clay mineralogy, soil chemistry, and regional climate. Because of the site specific nature of these determinations, the Department procedures used to assess the suitability of produced water is likely to evolve rapidly through time. As a result, I believe the Agricultural Use Protection provisions are better administered as a policy, which naturally affords more flexibility, than as a rule, as proposed here.

**Appendix H, section (e)(i)(A & B)**

i. Tier 1 -Default EC and SAR limits. Default limits for EC and SAR may be used where the quality of the discharge water is relatively good or the irrigated crops are salt-tolerant. The default values shall be based upon the published soil EC tolerance values for the most sensitive crop and shall be calculated as follows:

A. Default EC limits will be based upon 100 percent yield threshold values for soil EC reported by the NRCS Bridger Plant Materials Center 1996 Technical Notes No. 26[1]. In the event that the species of interest is not included in the Bridger Plant Materials Center document, then the following alternative references can be consulted:

I. Hanson et al. 1999. Agricultural Salinity and Drainage. DANR Pub. 3375. Univ. of Calif. Davis;

II. Ayers and Westcot. 1985. Water Quality for Agriculture. UN FAO Irrigation and Drainage Paper 29 (revised); and

III. CPHA. 2002. Western Fertilizer Handbook. 9th Edition. Interstate Pub., Inc., Danville, IL.

B. The relationship between soil EC values and irrigation water EC values will be: EC (soil) = 1.5 EC (water), i.e., the published soil EC threshold obtained from the appropriate reference will be divided by the soil concentration factor of 1.5 to establish the discharge EC limit.

[1] The Water and Waste Advisory Board recommended using the Bridger Plant Materials Center document as the primary reference for soil salinity tolerance values based upon comments submitted by Kevin Harvey, an industry consultant. The DEQ/WQD disagrees with this recommendation and maintains that the Salt Tolerance Database published by the USDA Agricultural Research Service (ARS) National Salinity Laboratory is a more appropriate reference for this purpose.

The choice of which scientific reference or references to utilize for the determination of default EC is a critical issue that has the potential to determine whether most future discharges require Tier 1 analysis or the more detailed Tier 2 or 3 analysis. It is inappropriate for the Department to censure specific data sources by rule. This is especially egregious since no rationale was given for why the use of data from the USDA NRCS Bridger Plant Materials Center in south central Montana was less appropriate than data published by the ARS Salinity Lab located in Riverside, California.

If recommended references are provided by the Department, they should be contained in a footnote, or more appropriately in a guidance document rather than contained in the rule. Presumably, if relevant scientific data are collected in the future, the Department will also consider them. If so, this statement should be added to any citation of specific reference materials. Another alternative would be to replace this discussion of appropriate scientific references with an Agency guidance document that contains the default EC limits for common Wyoming crops and forages, which would be incorporated by reference.

The dilemma faced by the Department is that many of the references concerning salt tolerance are internally inconsistent. For example, the threshold soil ECe at which yield reduction occurs is listed as 2,000 uS/cm by ARS Salinity Lab references and as 4,000 uS/cm by the Bridger Plant Materials Center. Rather than rejecting one source of information as "wrong", a more credible and scientific approach is to embrace both data sets and try to determine why they provide different results. A few plausible reasons for the discrepancies were provided by Kevin Harvey in his written comments. Namely, when sulfate salts are predominant, the higher EC threshold applies, whereas 2,000 uS/cm is appropriate where chloride salts prevail. So which limits should be used if bicarbonate salts are dominant as in produced water from CBNG operations? Bicarbonate is more similar to sulfate in that it tends to be removed from solution as the soil dries (or may actually be removed from solution through off-gassing). Therefore, the 4,000 uS/cm limit is more appropriate for protection of alfalfa in the Powder River basin.

**Appendix H, section (e)(i)(C)**

C. Default SAR values will be extrapolated from the Hanson et al. (1999) Chart *(see Figure 1 attached)* based upon the default EC value in each circumstance up to a maximum default value of 16[2]. The effluent limit for SAR will be determined in conjunction with EC so that the relationship of SAR to EC remains within the "no reduction in rate of infiltration" zone of Figure 1. The maximum SAR limit is, therefore, set below the line separating the "no reduction in rate of infiltration" zone from the "slight to moderate reduction in infiltration" zone in the Hanson et al. diagram, which is represented by the following equation: SAR ≤ (7.10 x EC) – 2.48. It must be noted that SAR values are tied to the EC concentration and might need to be adjusted to correlate to the actual EC concentration rather than the theoretical maximum.

Use of the Hanson diagram to extrapolate default effluent limits for SAR is capped at a maximum SAR of 16[2] to minimize the potential for sodium build-up in poorly drained soils. This 16 SAR cap is only intended to apply when utilizing the default procedure and may be modified according to the provisions of section C.2 "Refining EC and SAR Limits", described below.

[2] The DEQ/WQD originally proposed setting a default SAR cap at 10. The Water and Waste Advisory Board raised the default SAR cap to 16 based upon industry comments. The DEQ disagrees with the Board's recommendation and believes that an SAR cap of 10 is more defensible as a statewide default.

H-6

A sliding scale is proposed for the SAR limit, which would have a maximum cap at 16 (or 10 if you use the DEQ's recommendation contained in footnote 2). The use of SAR measurements to assess the suitability of irrigation water evolved as a means of predicting the exchangeable sodium percentage (ESP) that would develop in soil after several seasons of irrigation. Therefore, the soil ESP level is the factor that is most strongly correlated with soil permeability. The critical threshold ESP is usually understood to occur at 15 %. In soils with lower ESP levels, soil aggregates tend to be preserved and permeability remains high. Dispersion in soils with higher ESP levels may reduce permeability. Dispersion is favored in low EC waters and in expanding type clay soils. The correlation between SAR and ESP varies regionally, but generally the ESP can be approximated as SAR x 1.16 (at an SAR of 13) based on research published by the ARS Salinity Laboratory. Therefore, the critical ESP of 15 would correspond to an SAR of 13. Kevin Harvey developed a basin-specific correlation of SAR and ESP that suggests a SAR of 26 corresponds to an ESP of 15 % for the Powder River basin. The higher SAR level found in Powder River basin soils at a given ESP level may occur because of the more pervasive presence of calcium and magnesium salts found in Powder River basin soils. Dr. George Vance and Girisha Ganjegunte recently published results of a

Wyoming study showing that the traditional ESP-SAR equation tends to over-predict the ESP[1] in the Powder River basin.

For the above reasons, I feel the Hanson equation should apply up to a SAR cap of 16 or higher. The maximum SAR limit of 10 is inappropriately conservative for areas with naturally high EC surface waters such as the Powder River basin.

Additionally, the Hanson chart should not be used to extrapolate to very low SAR values if the ambient EC of surface water is below 800 to 1,000 uS/cm. The lowest applicable default SAR should be 3. At lower levels of salinity (e.g. below about 300 to 500 uS/cm), soils may disperse even at a SAR of 0. The low salt content rather than the excess sodium causes dispersion in these cases. There is no evidence in the literature of adverse effects of excess sodium when the SAR is at or below 3 to 5. As a final point of clarification, I agree with DEQ's caution that the actual EC rather than the default EC value (determined from crop tolerance data to protect crop yields) should be used to determine SAR using the Hanson chart. However, owing to the chronic nature of sodium effects, the long-term average ambient EC rather than an instantaneous ambient EC should be used to determine the default SAR.

**Appendix H – Section (e)(ii)(A)**

The Tier II determination allows the applicant to use background levels of EC and SAR instead of the default limits described in the Tier 1 analysis. Background water quality can either be measured, if data are available, or predicted using site-specific studies (Appendix H – Section (e)(ii)(A)(II)). The Tier II rule appears to suggest that detailed characterization of irrigated soils provides the only suitable means of estimating background water quality. The data requirements for soil studies are described in detail. I have two concerns with this rule. First, the rule appears to foreclose other means of establishing background water quality (like for example using synoptic surface water sampling on a mainstem to assess flow and load contributions from a watershed). Therefore, the Tier II rule should provide added procedural flexibility (another reason why this protocol would be better adopted and administered as a policy rather than a rule). Additionally, the methods used to interpret the soils data are not provided. Calculating background irrigation water quality from soil extract salinity is not straightforward, and requires multiple assumptions. As such, a single soils data set will not necessarily yield a unique determination of background water quality. Consequently, the Department's attempt to standardize the determination of the suitability of produced water has failed because a wide variety of techniques will likely be employed to derive background water quality. Again, owing to the complexity of Tier II and Tier III determinations, I believe that the Agricultural Use Policy is better managed as a policy than a rule.

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[1] Ganjegunte, G.K.; and G.F. Vance. 2006. Deviations From The Empirical Sodium Adsorption Ratio (Sar) And Exchangeable Sodium Percentage (Esp) Relationship. Soil Science. 171(5):364-373, May 2006.

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# Resume

## Dr. William M. Schafer


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## POSITION DESCRIPTION

CURRENT POSITION: 2001 TO PRESENT

Dr. Schafer formed Schafer Limited LLC in 2001 to work as an independent consultant in environmental consulting, expert testimony and forensic evaluations, and mediation of environmental disputes.

SHEPHERD MILLER INC: 1999 AND 2000

Schafer & Associates merged their professional staff in Bozeman, Montana and Golden, Colorado with Shepherd Miller Inc in July 1999. Dr. Schafer served as Vice President of the Earth Sciences business unit for Shepherd Miller from August 1999 until December, 2000.

SCHAFER & ASSOCIATES: 1985 TO 1999

Founded by Dr. Schafer in 1985, Schafer & Associates provided environmental, engineering, and ecological services to a variety of Federal, State and private clients in mining and other industries. With a staff of 40 professionals, Schafer & Associates maintained offices in Montana, Colorado, and Arizona.

MONTANA STATE UNIVERSITY: 1976 TO 1985

Dr. Schafer was a research soil scientist specializing in land reclamation research on coal-mined lands in the Northern Great Plains from 1976 to 1980. From 1980 to 1985, he was a state soil scientist with the Montana Agricultural Experiment Station and the Extension Service. He provided expertise to Montana agriculture in the areas of irrigation water quality, improvement of saline and sodic soils, and soil fertility.

## PROFESSIONAL EXPERIENCE

**Mining Services:** Dr. Schafer served as project manager or technical director for over 200 projects involving the environmental aspects of mining. His projects have included prediction, prevention, and control of acid rock drainage (ARD); mine closure including reclamation of waste rock, tailings, and spent ore piles; decommissioning of leach pads; prediction of pit lake chemistry; baseline studies in support of permit applications; and groundwater and vadose zone monitoring programs. He has extensive regulatory experience in the western US including Nevada, Montana, South Dakota, Colorado, New Mexico, Idaho, Utah, Washington and Arizona.

**Petroleum Development – Coalbed Natural Gas (CBNG):** Dr. Schafer worked closely with the Montana Coalbed Natural Gas Alliance during development of numeric water quality standards for electrical conductivity (EC) and sodium adsorption ratio (SAR) by the Montana Department of Environmental Quality. He has helped develop permits for discharge of CBNG production water, and helped evaluate other water management alternatives. Additionally, Dr. Schafer has served as an expert witness in litigation regarding alleged soil and water impacts associated with CBNG water.

**Expert Testimony:** Dr. Schafer served as an expert witness for several cases involving the Clean Water Act (especially Citizen's Suits) and environmental effects of mining; coalbed natural gas development, confined animal feeding operations, and alleged contamination of surface water or groundwater with acid rock drainage, metals, salinity, nutrients and organic compounds. He also provided expert reports, sworn testimony, and depositions in various administrative hearings in addition to litigation support.

**Services to State and Federal Clients:** Dr. Schafer has worked for numerous State and Federal agencies including the US Forest Service, Bureau of Land Management, Fish and Wildlife Service and Bureau of Mines. He has also contracted with State natural resource agencies in Montana, South Dakota, Arizona, Washington, Idaho, and other States.

**Solid and Hazardous Waste:** Managed or directed numerous CERCLA (Superfund) investigations including RI/FS (remedial investigation and feasibility study) activities at several mining sites. He developed and implemented numerous work plans and planning documents to support site characterization, treatability studies, and risk assessments and was responsible for development and evaluation of the performance of in-situ remediation techniques for inorganic mine waste at CERCLA sites. Dr. Schafer conducted fate and transport analyses of contaminant migration from a variety of sources. These analyses required numerous field investigations that employed a variety of field screening techniques including soil gas surveys and X-ray fluorescence determination of soil lead, arsenic, copper, zinc, and chromium levels.

**Soil Investigations:** Conducted a number of soil survey investigations in support of mine permitting and planning, major facility siting, irrigation development, basin-wide erosion prediction and control, and salinity control. Numerous small-scale soil investigations have been performed for on-site waste treatment system siting and design; for land application/ treatment of liquid and solid wastes; litigation support for industrial damage claims; and in support of archaeological investigations.

**Project Management:** Successfully managed over 300 projects in the environmental sciences concerning hazardous waste (under CERCLA, SARA, and RCRA); solid waste landfills; disturbed land reclamation; baseline studies for mine and facility permitting (NEPA); reclamation of abandoned mines (SMCRA); surface water, groundwater and vadose zone monitoring; soil investigations; contract R&D; delivery of educational short-courses; and services in support of litigation.

**Professional Education and Instruction:** While on faculty at Montana State University, Dr. Schafer's responsibilities included instruction of students and adults through on-campus teaching, and extension. Additionally, he has developed and delivered a number of professional short courses on mine closure, acid rock drainage prediction and control, vadose zone monitoring, cyanide heap leaching, underground storage system installer certification, groundwater impacts of petroleum exploration, control of dryland salinity, fertilization of small grains and forages, and salinity and sodium control under irrigation.

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## EDUCATION

**Montana State University** *1976 to 1979*
Bozeman, Montana
PH.D. IN SOIL SCIENCE

Dissertation Topic: Completed an evaluation of the land capability of soils on reclaimed surface coal-mined areas throughout the Northern Great Plains.

**University of California at Davis** *1974 to 1975*
Davis, California
M.S. IN SOIL SCIENCE

Thesis Topic: Developed a technique to measure the shrink-swell potential of soils in the Central Valley of California, and to predict the hazard for construction.

**Colorado State University** *1971 to 1974*
Fort Collins, Colorado
B.S. IN WATERSHED SCIENCE

### CONTINUING EDUCATION

- Mediation of Pubic Policy Disputes: 24-hour short course taught by CDR Associates in Boulder, Colorado.
- Introduction to Mediation 40-hour short course taught by CDR Associates.
- Clean Water Act and NPDES Permits 24 hour short course involving all aspects of water permits
- Groundwater Modeling 40 hour course in groundwater modeling taught by Dr. Robert Cleary and faculty from Princeton University

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## ORGANIZATIONS

Professional improvement maintained through active involvement in professional societies (ASTM, Society of Mining Engineers, and Soil Science Society of America). More than 100 articles, papers, short courses and book chapters have been authored in professional publications, and in symposia proceedings

## PUBLICATIONS

### *SYMPOSIA PUBLICATIONS*

Schafer, W.M. 2001. Factors Controlling Transient Change in Water Quality in Heap Leach Pads. Presented at the University of Nevada Reno – Heap Leach Closure Workshop. Winnemucca, NV, February 16,2001.

Schafer, W. M. 2000. Use of the Net Acid Generation pH Test for Assessing Risk of Acid Generation. In Fifth International Conf. on the Abatement of Acidic Drainage, Denver, CO.

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