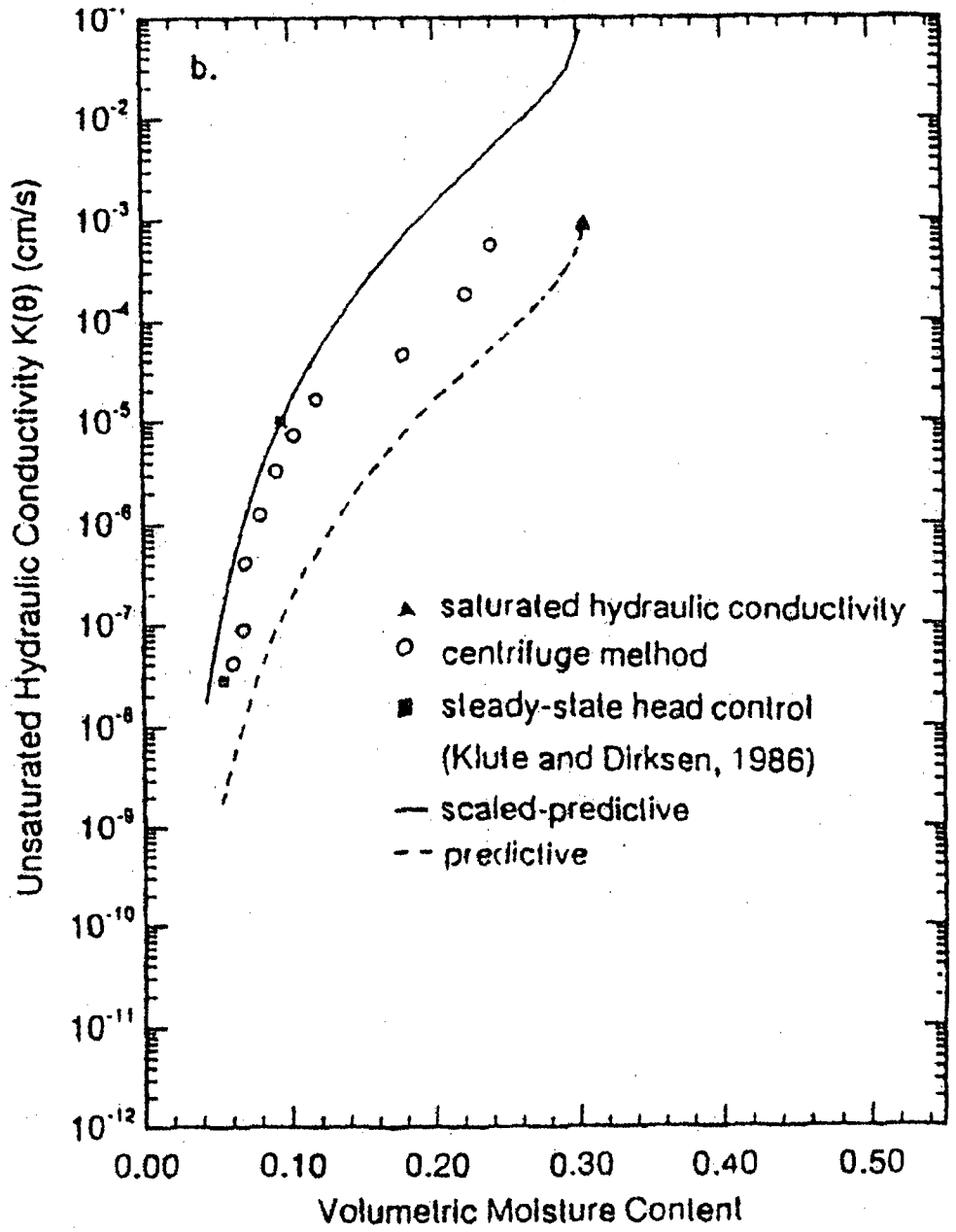


Unsaturated hydraulic conductivity, predicted (curves) and measured (points).

The difference is a factor of ten at 20%-30% moisture.

From Khaleel and Relyea, Water Resources Research 31, 2569-2668 (1995)

To provide an absolute (rather than comparative) prediction, the model must represent ***all*** of the relevant physics and conditions.

Chloride transport may not occur according to the uniform infiltration assumed in the models. Fluids in soils often flow along preferential pathways.

Proposed chloride limits are based on modeling of infiltration to groundwater.

The assumption that chloride transport occurs as a uniform infiltration may or may not represent reality.

A quantitative prediction would require on-site measurements and investigation with various models including dual-porosity models (transport by bursts of water that follow preferential pathways).

There have been many scientific investigations of preferential flow. For example, the technical library of the **American Society of Agricultural and Biological Engineers** lists 72 papers under the following heading:

Preferential Flow: Water Movement and Chemical Transport in the Environment

Conclusion regarding modeling:

The proposed requirement for a 50-ft depth to groundwater beneath a waste facility is not necessarily protective.

We suggest a 100-ft depth for surface waste facilities **except for small landfarms**, which are temporary in nature and small in extent.

OUTLINE

SCIENCE

Modeling: absolute *vs* relative answers

Salt, sodium, and chloride in soil

Petroleum hydrocarbons in soil

Sampling and statistics

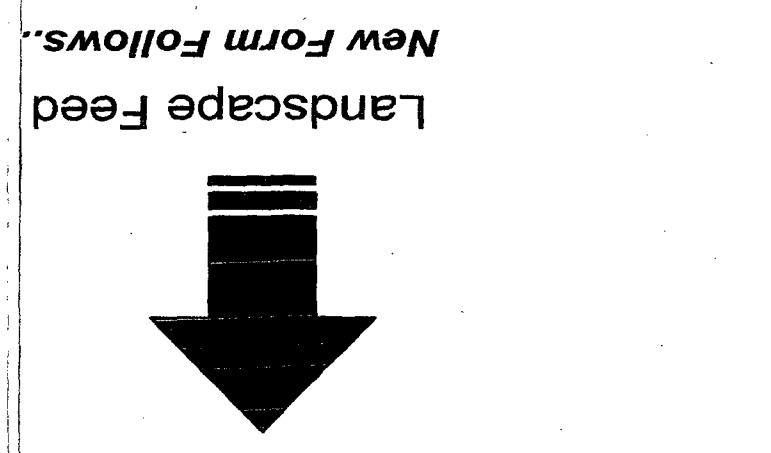
PROPOSED RULES AND CLOSURE

Bonding

Design of facilities

Monitoring and sampling

Bioremediation endpoint



Sodium

Replaces calcium on clay particles,

Causes loss of plant nutrients from the soil.

Makes the soil "sodic", without sponginess, unable to hold water, and often powdery.

Is toxic to some plants in various quantities.

Chloride

Increases the osmotic pressure, reducing the availability of soil water for plants.

Is toxic to some plants in various quantities.

Chloride *is* toxic, depending on the species of plant.

Salt sensitivities in barley, soybean, citrus, and grape are related to chloride transport from root to shoot.

Chloride is the primary damaging ion in stone fruits.

Chloride toxicity in woody species is generally more severe and observed in a wider range of species than is sodium toxicity.

Notes from M. C. Shannon, Adaptation of Plants to Salinity, U.S. Salinity Laboratory report (undated, late 1990's).

Chloride also increases the osmotic pressure, making it more difficult for the plant to suck moisture from the soil.

In the scientific literature, the effects of salt on soil, plants, and subsurface species are usually expressed in terms of EC and SAR.

EC Electrical Conductivity

Usually of the liquid drawn from a saturated paste of the soil.

SAR Sodium Absorption Ratio

A particular ratio of the sodium to calcium and magnesium in the saturated paste or in sometimes in the soil itself, or in irrigation water.

EC tolerance levels of crops .

Test values in mmhos/cm	Interpretation
0-2	Satisfactory for Crops
2-4	Affects sensitive Crops
4-8	High for many Crops
above 8	Very high for most Crops

Adapted from: P. N. Soltanpour and R. H. Follett, "Soil Test Explanation," Colorado State University, http://www.ext.colostate.edu/pubs/crops/00502.html

NMCCA&W Exhibit 3 (lower)

EC

"The traditionally accepted objective criteria ... for all plants ...has been to decrease the salinity ... **to less than 4** mmhos/cm ..."

American Petroleum Institute, Publication 4663, "Remediation of Salt-Affected Soils at Oil and Gas Production Facilities."