

MEMORANDUM - DRAFT

Groundwater Vulnerability Assessment Scientific Literature Recommended for Expert Panel

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The Expert Panel for the Long Term Irrigated Lands Regulatory Program has spent significant time and effort discussing various aspects of nitrogen leaching and potential groundwater contamination in areas of California agriculture in the context of the ILRP regulations. The following documents are recommended as excellent sources of information for the Expert Panel's charge, which is, in large part, to consider and recommend approaches to groundwater vulnerability assessment.

The following three documents contain critical information that is integral to any decision regarding groundwater vulnerability assessment approaches. They compile, review and explain the strengths, weaknesses, and applications of various groundwater assessment methods, as well as provide fundamental concepts of groundwater vulnerability assessment, its nature, and its ability/inability to be validated.

National Research Council Ground Water Vulnerability Assessment: Predicting Relative Contamination Potential Under Conditions of Uncertainty (1993)

This seminal document provides the fundamental concepts of groundwater vulnerability that should be considered before groundwater vulnerability assessment methods are selected and applied. It includes the following information:

- Groundwater vulnerability definition, and flaws in this definition according to laws of groundwater vulnerability
- The amorphous concept of vulnerability, as a probability rather than a measured property; relative rather than absolute
- Different types of vulnerability – intrinsic and extrinsic, or, respectively, vulnerability caused by hydrogeologic factors and vulnerability attributed to anthropogenic and/or management factors
- The effect of scale on the utility of vulnerability assessments
- Approaches to assessment – overlay and index, statistical methods, and process simulation models
- Strengths, weaknesses, and applications of various methods
- Assessment selection criteria – administrative and technical considerations
- Vulnerability assessment process, including intended uses and objectives

- Uncertainty in vulnerability assessment, and the applicability/non-applicability of validation
- Case studies in USA of applications of various types of assessment approaches

The main conclusions and recommendations of this document include:

- Ground water vulnerability is a relative rather than an absolute concept.
- Ground water vulnerability assessment is inherently uncertain, and is a dynamic, iterative, and interactive process.
- Structured, quantitative vulnerability assessments do not necessarily fill a direct decision-making role, but contribute to understanding of the scope of the problem and create a consensus for action.
- Overlay and index methods are the most widely used
- Statistical approaches have the potential for significant use, but require the contamination to already exist and may result in false negatives or positives
- Process-based simulation models are not good enough yet to predict where, when and at what concentration a constituent will appear
- None of the methods, including process-based models, can be validated in the usual scientific sense for vulnerability assessments because of spatial and temporal variability.
- The most sensible way to “validate” an assessment approach is to repeat and refine the assessment over time.
- Methods for incorporating process-based, statistical, and qualitative information into an integrated or hybrid assessment should be developed.
- Counterintuitive situations leading to a different true vulnerability than is perceived should be identified.

Environmental Protection Agency: A Review of Methods for Assessing Aquifer Sensitivity and Ground Water Vulnerability to Pesticide Contamination (1993)

This document references information found in the NRC document referenced above, but includes additional and more specific information about the types of parameters, both physical and management related, used in various assessment methods to assess groundwater vulnerability. Much of it is related pesticide contamination and is therefore not contaminant specific, nor is it specific to nitrate. It includes the following information:

- Overview of aquifer sensitivity and ground water vulnerability –reconciles the use of different terms and definitions by different entities
- Description and categorization of types of aquifer sensitivity assessment methods (scoring and hydrogeologic setting) and ground water vulnerability assessment methods (loading methods and process-based simulation models)
- Method selection, validation and calibration
- Method evaluation and uncertainty
- Specific descriptions of selected methods, including parameters used
- Case studies

The main conclusions and recommendations of this document include:

- Aquifer sensitivity considers only hydrogeologic factors, whereas ground water vulnerability also incorporates agronomic management practices and contaminant characteristics.
- Aquifer sensitivity may not necessarily be correlated with ground water vulnerability.
- Choosing an assessment method(s) includes administrative and technical considerations, such as staffing requirements, availability of support services, ease of applying a method, size of jurisdictional area, suitability for hydrogeologic setting, and availability and format of existing data.
- Choosing an assessment method requires knowledge of how the output will be used and what is the acceptable level of uncertainty.

United States Geological Survey: Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers (2001)

This more recent document builds on the information from the NRC 1993 document referenced above, and includes recent developments on one of the recommendations from the latter – *Methods for incorporating process-based, statistical, and qualitative information into an integrated or hybrid assessment should be developed*. This document focuses on scientific defensibility in the context of ground water vulnerability assessments, and demonstrates the advantages of combining hybrid methods that combine components of index, statistical, and/or process-based methods. It includes the following information:

- Definition and discussion of what is scientifically defensible
- Understanding the hydrologic system
- Overview of methodologies, including hybrid approaches
- Balancing objectivity, complexity, and accuracy under conditions of uncertainty
- Scientifically defensible ground water vulnerability assessments
- Interpreting water-quality data in context with other important controls on ground water vulnerability
- Scientifically defensible water resource management objectives and associated science objectives

The main conclusions and recommendations of this document include:

- To the extent that uncertainties in the assessment can be elucidated either quantitatively or qualitatively, the scientific defensibility and ultimate usefulness of the product will increase.
- Science objectives should be clearly distinguished from water-resource management objectives.
- Ultimately, successful ground-water-vulnerability assessments blend scientifically defensible analyses used to meet science objectives with additional interpretations by water-resource decision makers to meet management or policy objectives.