

Nitrate Hazard Index (NHI) Description

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INTRODUCTION

The California Regional Water Quality Control Board – Central Valley Region (CVRWQCB) has issued Order R5-2013-XXXX titled, Waste Discharge Requirements General Order for members of a third-party group within the Tulare Lake Basin, excluding the area of the Westlands Stormwater Coalition. This white paper/technical memorandum has been developed in support of the comments submitted by the Kern River Watershed Coalition Authority (KRWCA).

BACKGROUND

In 1994, the California State Water Resources Control Board (State Water Board) appointed a Nutrient Technical Advisory Committee (TAC) to assess water quality problems associated with agriculture and make suggestions for addressing such issues. A hazard indexing methodology was conceptualized in which growers could identify field nitrate leaching vulnerabilities based on the soil characteristics, the crop grown, and irrigation method used. An index or ranking method allows for a way to quickly and easily determine risk severity and identify the major factors contributing to this risk, without requiring a large, variable and expensive data set.

The UC Center for Water Resources proceeded with this work, developing the matrix-based (overlay and index method) Nitrate Groundwater Pollution Hazard Index (NHI) for irrigated agriculture (Wu et al. 2005). It was made available online to the public. This online tool borrowed and built upon the conceptual framework of the TAC, assigning soil series, crop types, and irrigation methods individual leaching risk values through consideration of multiple factors by expert collaboration. Index values proposed for soils, crops, and irrigation systems were then subjected to external review by experts.

The NHI was then used by Dzurella et al. (2012) to identify the nitrate leaching risk of individual fields in the Tulare Basin as well as other areas of the Central and Salinas valleys. During this effort, values assigned to irrigation methods were modified to allow for conditions specific to the regions that were not considered during the original, more general iteration of the NHI. These modifications were made because of knowledge of practices that were known to be common in the

region, but did not neatly fall within the categories of nitrate-influencing factors identified during the development of the NHI. The NHI can and should be modified to allow for region-specific conditions and should leverage as much information as possible about pertinent agricultural practices, soil conditions and cropping patterns within specific regions. Without this “customized” approach to the NHI, the results of the NHI analysis do not truly reflect the nitrate risk of agricultural fields with specific attributes.

OVERVIEW

The concept that underpins the NHI approach recognizes three important points:

1. No individual factor on its own (soils, crop types, irrigation method, or other variable) can fully account for the potential magnitude of nitrate leaching
2. Nitrate contamination is exceedingly difficult and costly to quantify through field sampling and analysis and correlate with agricultural fields spatially
3. Nitrate leaching risk from agriculture occurs over a wide range of conditions and is best represented by a spectrum from low to high risk

The NHI is a tool for evaluating the potential for nitrate leaching to groundwater under agricultural fields. As such, it does not provide an absolute value of how much N will be leached under various conditions of soil, cropping and irrigation; rather, it is an index that provides a rank for each field situation within an overall range or spectrum.

The NHI is simply a ranking system for factors that influence N leaching. Each soil series, crop type and irrigation method in use is assigned a value that ranks its risk or potential contribution to N leaching. The rankings assigned to these factors are multiplied together and the result is the NHI composite value. Therefore, each combination of soil, crop type and irrigation method risk values results in a composite NHI value that has no value or meaning in itself, but is a relative value that indicates the potential for a field to leach N.

It should be noted that to date, soil type, crop type and irrigation method have been used as variables to establish a relative NHI. The NHI approach could be modified further to include other variables that may be especially important to a certain areas or cropping system. For example, other parameters that impact nitrate leaching include: effective rainfall, nitrogen use efficiency, depth to groundwater, etc.

WHY THE NHI IS A PREFERRED METHOD FOR EVALUATING RISK OF N LEACHING

The NHI is the preferred method for evaluating risk or vulnerability of groundwater contamination by nitrate for several reasons.

First, it was developed specifically for nitrate and does not use a proxy (such as pesticides) to represent its fate in the environment. The vulnerability assessment used in the Draft General Order, for example, uses Department of Pesticide Regulation data to identify potentially contaminated groundwater. It also considers depth to groundwater and soil type. This approach assumes that nitrate behaves similarly to pesticides as they encounter soil, soil water, microbes, and plant roots. Unlike pesticides, nitrate is part of the nitrogen cycle and may be transformed into forms of

nitrogen other than nitrate that are not available for leaching, or used by plant roots and microbes depending on soil conditions. In addition, agricultural practices, such as irrigation methods, highly influence the amount of nitrate that is available for leaching. This approach, importantly, lacks two of the main factors that affect nitrate leaching risk – crop type and irrigation method. While these two factors may not have as significant effects on pesticide movement in soils, they most certainly impact nitrate leaching potential.

The NHI, on the other hand, captures the important factors that influence nitrate leaching – soils, crops, and irrigation methods. Other factors of importance that are not included in the original NHI format, such as depth to groundwater, nitrogen use efficiency and effective precipitation, could easily be appended to the NHI index. This flexibility of the NHI approach is advantageous and can be leveraged to produce even more accurate results than the original NHI would have produced.

Another reason why the NHI is a preferred method for evaluating nitrate leaching risk is because its results are accurate as validated in the Central Valley (Wu et al., 2005). When results of the NHI were compared to USGS groundwater data, they were found to be representative of the condition of groundwater and reflective of the nitrate leaching that had occurred under specific conditions. This shows that it is useful in practice as well as theory.

WHY THE NHI IS A PREFERRED REGULATORY TOOL

The NHI is the preferred tool to regulate agricultural practices that may contribute to nitrate contamination in groundwater for the following reasons:

The NHI is a modifiable tool that can be customized to specific regions and refined by other regulatory activities such as monitoring. Though the NHI was developed as a stand-alone tool, its use in conjunction with other approaches and methods would only make the regulatory process more accurate and more efficient. In fact, monitoring could not only be used to supplement NHI results, but could be used to validate them as well.

The NHI has low data needs, is quick and low-cost. Kern County, in particular, maintains an excellent, up-to-date spatial database of crops. The inputs to the NHI are not only available, therefore, but are assured to be current and accurate. No other approach in the scientific literature can produce results that are as representative with the amount of effort it takes to do an NHI.

The NHI can be used to analyze agricultural landscapes at different scales. While the proposed approach in the Draft General Order uses somewhat of a “fish net” approach, where one vulnerable area may cause a very large area to be deemed vulnerable because the resolution of the vulnerability assessment is relatively coarse, the NHI can be used on a field by field basis especially in Kern County where field-specific information is readily available.

The results of the NHI are applicable, useful and require little interpretation. In contrast with monitoring or even detailed planning, the NHI results clearly indicate where priority attention should be given to agricultural practices that influence nitrate leaching risk. Because the NHI must necessarily be done on an area that includes many units of analysis (because the resulting composite values are relative to some other value), no interpretation is required. Nitrate leaching risk is either lower than somewhere else or higher than somewhere else in the area of analysis. Regardless of the absolute amount of contamination that has occurred or could potentially occur,

regulation should be focused on areas with higher risk while areas of lower risk should be lower priority. The simplicity of this approach affords efficiency and greater potential compliance.

The NHI is representative of current conditions, and those are the only conditions that can be changed. In contrast, evaluating nitrate risk using monitoring only reveals the practices and conditions of the past, and those are no longer under growers' control. Modeling, on the other hand, requires a large data set and is subject to the "garbage in garbage out" concept, meaning that the model results are only as good as the data that produce them.

IMPLEMENTATION OF AN NHI FOR KRWCA

The authors of the work in the Central Valley who used NHI to estimate nitrate leaching risk on individual fields conceded that their results suffered from inaccuracy caused by out-of-date crop data (Dzurella et al., 2012). They recognized that cropping patterns and irrigation methods change rapidly and are often not accurately represented by the DWR crop data they used in their analysis. Kern County has a unique advantage in that most of the work that needs to be done to produce an accurate NHI analysis has already been completed in the crop database. Furthermore, this allows for the NHI to be updated annually as long as the crop database is updated annually. This approach would refine the process of prioritizing regulation even more, so that low vulnerability areas are not unduly regulated.

An NHI with current crop data and a customized approach that leverages knowledge of local agricultural practices and conditions specific to Kern is a powerful tool for estimating potential nitrate leaching and prioritizing its regulation. For that matter, it is the simplest method for discriminating between like regions and sub-regions of the state as whole; especially unique areas similar to the Kern Sub-Basin.

A proposed development and implementation of an NHI in the Kern Sub-Basin would likely be to:

- Achieve consensus with CVRWQCB Staff and Board to implement an NHI for the Kern Sub-Basin
- Work together and in consultation with CVRWQCB staff and their designees/experts to agree upon the most impactful NHI variables (e.g. soil type, irrigation method, crop type, nitrogen use efficiencies, effective rainfall, depth to groundwater, etc) unique to the Kern Sub-Basin
- Work together and in consultation with CVRWQCB staff and their designees/experts to use all available and applicable science in defining the relative importance within each variable (e.g. accurately ranking irrigation methods such as: flood, furrow, sprinkler, drip/micro).
- Integrate the agreed-upon variables and rankings into the already existing spatial database of the Kern Sub-Basin.
- Work with the varied data-rich resources within the Kern Sub-Basin (e.g. Kern County, irrigation districts, local agricultural extension resources, climatic resources, university research resources, water storage districts, agribusinesses, individual growers) to additionally populate the spatial database.
- Identify data gaps and develop an on-going program for acquisition, creation, integration and improvement of remaining data resources.
- Utilize current technology (e.g. remote sensing) and additional local knowledge to expand and improve the NHI predictability.

- Use the NHI to strategically and economically locate and manage necessary monitoring and overall regulatory reporting and other requirements.
- Annually update the spatial database with existing resources and work with providers to enhance those data.

REFERENCES

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