USGS

# WATER RESOURCES RESEARCH GRANT PROPOSAL

**Title**: Mechanisms of Pesticide Transport to Surface Water at the Field Scale in a Dryland-Agriculture Region

**Focus Categories**: ST, HYDROL, WQL

**Keywords**: Agriculture, Contaminant Transport, Groundwater Hydrology, Groundwater Quality, Herbicides, Leaching, Organic Compounds, Pollutants, Rivers, Runoff, Solute Transport, Unsaturated Flow, Water Quality

**Project Duration**: The project duration shall be 3/1/99 to 2/28/2000.

**Fiscal year 1999 federal funds**: __$18,120__ (Total)

**Fiscal year 1999 Non-federal funds**: ___$36,501__ (Total)

**Principal investigator(s) name(s) and University**: Richelle Allen-King, C. Kent Keller, John Schaumloffel, Washington State University

**Congressional district of university where the research is to be conducted**: 5th

## STATEMENT OF CRITICAL REGIONAL OR STATE WATER PROBLEMS

Pesticides (insecticides, herbicides, and fungicides) are repeatedly applied to farm fields with the intent of increasing the productivity of agricultural crops. While the increased and more efficient food production derived from chemical use is beneficial to society, the accumulative effect of adding pesticides to crops within a regional area can have adverse effects on the quality of water resources, placing at risk both human and environmental health. The State of Washington Water Research Center has highlighted the identification of sources, amounts and types of pollutants entering streams and groundwater aquifers as Research Priority Areas II. B. and II. C. (Attachment D, Call for Research Proposals).

River basin-scale research conducted by U.S. Geological Survey and Washington Department of Ecology scientists has demonstrated that many pesticides are detectable in surface and groundwaters of Washington state - few are detected at concentrations which exceed a water quality standard. However, triallate (trade name, Far-go), has been detected in the Palouse River at Hooper at concentrations which exceed a freshwater chronic criteria for aquatic life. While these data demonstrate that triallate, an herbicide used extensively in the Palouse region of Washington state, is present in surface water, no studies in the region exist which provide information about the pathways by which triallate enters the surface water. Few studies on the fate of this chemical at the field-scale have been conducted in any region - none have been conducted in the Palouse region. Without information about transport pathways at the field-scale, solutions which will effectively reduce surface water concentrations cannot be determined. The proposed

study will determine the triallate mass discharge entering surface water from each of the overland and subsurface pathways at the field-scale. The triallate mass discharge data to be collected as part of the proposed project will be used to evaluate the primary pathway(s) for compound transport. It is expected that the process-based information collected will be useful in providing an improved understanding of the transport of other moderately hydrophobic organic pollutants in the hydrologic system in this region.

## STATEMENT OF RESULTS OR BENEFITS

The proposed research project will be the first field-scale study of the transport pathways for triallate in this region. Because the determination of subsurface transport is an important component of the work, the distribution of triallate within the subsurface will be better characterized than it has been previously. The project focuses on a mass balance or accounting of the chemical. Because the study begins to focus attention on the processes which control transport, the information gained will provide insights on the fate of other chemicals with similar physicochemical properties. We anticipate that the study will help to transform the conceptual model for chemical transport in the shallow subsurface in this region. The results of this quantitative and hypothesis-driven study will be publishable in an internationally recognized journal, such as the Journal of Contaminant Hydrology.

This project establishes a new avenue of research on a topic of regional and statewide water quality importance within the existing contaminant hydrology program at WSU. The project involves the development of research linkages between the Departments of Geology and Chemistry within the WSU campus. An active contaminant hydrology program will benefit WSU students by exposing them to high-quality and topical hydrologic research, and better prepare them to address Washington's environmental problems after graduation. The research will be of interest to both farmers in the region interested in minimizing herbicide expenditures and loss to surface water, and to the Washington Department of Ecology (WDOE) in strategic planning to clean-up Washington's surface water. PI Allen-King can make this information accessible to WDOE staff by continued participation in their Science Advisory Board.

## NATURE, SCOPE, AND OBJECTIVES OF RESEARCH

### Goal and Objectives

The occurrence of pesticides in surface waters is in part a consequence of increased chemical usage to improve agricultural productivity over the past approximately 50 years. Pesticides can be relatively mobile when suspended in stream or river flow, transport downstream and dispersion within the reservoirs of the hydrologic cycle occurs and gains the potential to affect both human and environmental health over a relatively wide area (Larson et al., 1997).

Pesticide concentrations exceeding published water quality standards have been detected in the Palouse River at a point which provides integrated, basin-scale information about

this dryland agriculture region (Roberts and Wagner, 1996). For example, triallate (trade name Far-Go), the pesticide with the largest active ingredient application rate in the region (Roberts and Wagner, 1996), was detected in the Palouse River by U.S. Geological survey scientists at concentrations that seasonally exceeded the freshwater-chronic criteria for the protection of aquatic life of 0.24 µg/L (Wagner et al., 1996a). The Palouse River drains a semi-arid portion of the Columbia Plateau which is characterized by dryland wheat and pea agriculture and soil formed in loess parent material. The Palouse River is the main outflow pathway for surficial water in the Palouse Drainage Basin, which measures approximately 2,500 square miles (Greene et al., 1994) and empties into the Snake River, which is widely used for recreational purposes and drains into the Pacific Ocean.

There are two distinct trends observable in the basin-scale triallate hydrograph presented in Figure 1: 1) the highest concentrations and mass discharges (triallate concentration x streamflow or stream discharge) are associated with some high streamflow events, and 2) concentrations during the March-June 1993 and January-May 1994 time periods, aside from the peak concentrations (occurring in May 1993 and Jan. 1994), appear to be relatively unaffected by the magnitude of stream discharge. The first observation may be explained by direct runoff. High turbidity during periods of high runoff, resulting in part from the fine textured and easily erodible soil of this region, may play a role in facilitating the transport of this moderately hydrophobic compound. However, because the period of direct runoff in this region is relatively short and sporadic, the second observation suggests that an alternate mechanism must contribute to pesticide transport in the hydrologic system. It should also be noted that the total mass represented by the "off-peak concentration" or background portion of the hydrograph for spring 1993 is substantive in comparison to the mass associated with the peak concentration occurring in May, 1993.

The basin-scale integrated data (Figure 1) provide insufficient evidence upon which to draw conclusions about pesticide transport pathways into surface water. In short, there is a need for a field-scale understanding of the transport mechanisms in order to develop effective solutions which will reduce aquatic concentrations. In addition, management practices cannot be determined to solve the problem until the route(s) of transfer are identified.

The alternate mechanisms which could explain the second observation from the hydrograph include: subsurface transport and/or atmospheric transport. Loess soils are characteristically fine-textured with a high moisture retention, a quality which traditionally has been assumed to prohibit subsurface pesticide migration due to relatively low permeability. However, the soils in this region are also highly structured, containing numerous root, worm and other macropores (Mallawatantri et al., 1996). The soils become extremely wet, near saturation, from late fall until early summer (e.g. Bacon, 1997), potentially allowing these macropores to become active preferential flow paths. Field observations of conservative compounds transport suggests preferential transport in both the vadose (Mallawatantri, 1990) and saturated zones (O'Brien et al., 1996; Kafka, 1995) occurs. Soils in toe-slope positions are frequently tile-drained, which can facilitate

rapid transport of chemicals in the shallow subsurface environment. The culmination of these facts suggests the hypothesis that triallate is transported to surface water via shallow subsurface transport (including colloid-facilitated transport) to tile-drain systems. Transport by this route may be particularly important during periods of low surface runoff.

The goal of the proposed research is to determine the importance of local-scale (field-scale) subsurface transport as a pathway for pesticide migration to surface water in the Palouse region, a dryland agriculture area. The approach will be to quantify total pesticide discharge by direct surface run off and by subsurface transport for a target pesticide, triallate, at the field scale. A field to which triallate will be applied at spring planting will be used for the study. By determining the change in triallate mass discharge in the stream adjacent to and receiving water from the field, we will be able achieve the goal. Triallate has been selected as the target analyte: because it is a moderately volatile and hydrophobic organic compound, properties common to other pesticides used for agricultural purposes; because it has a high application rate in the area; and, because it has been identified at relatively high concentrations in the basin-scale discharge.

The specific objectives of the study are:

1. to determine the triallate mass discharge attributable to surface versus subsurface transport pathways at the field scale;
2. to determine the effect of these two mass discharges on the mass discharge in surface water over time;
3. and to determine the effect of turbidity on transport by surface runoff.

If additional mechanisms are key in controlling triallate transport (e.g. atmospheric transport), they will be identified in the project as a consequence of the study design.