Standard Operating Procedure for Using PRZM-GW to Estimate Pesticide Concentrations in Groundwater for Drinking Water Exposure Assessments

United States Environmental Protection Agency
Office of Pesticide Programs, Environmental Fate and Effects Division

September 8, 2015

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Introduction

After the passage of the Food Quality Protection Act (FQPA) of 1996, the EPA developed SCI-GROW (Screening Concentration *in* Groundwater) as a screening-level tool to estimate drinking water exposure concentrations in groundwater resulting from pesticide use (Barrett, 1997).[1] As a screening tool, SCI-GROW provides conservative estimates of pesticides in groundwater, but it does not have the capability to consider variability in leaching potential of different soils, weather (including rainfall), cumulative yearly applications or depth to aquifer. If SCI-GROW based assessment results indicate that pesticide concentrations in drinking water may exceed levels of concern, the ability to refine the assessment is limited.

In 2004, the Environmental Protection Agency's (EPA) Office of Pesticide Programs (OPP) initiated an evaluation of advanced methods for estimating pesticide concentrations in groundwater as part of the cumulative risk assessment of carbamate pesticides. The OPP consulted with the FIFRA Scientific Advisory Panel (SAP) twice in 2005 on the development of the groundwater conceptual model (**Figure 1**) and the use of the Pesticide Root Zone Model (PRZM) to implement the conceptual model.[2,3] Concurrently OPP and Canada's Pesticide Management Regulatory Authority (PMRA) initiated a project under the auspices of the North America Free Trade Agreement (NAFTA)Technical Working Group on Pesticides to develop a harmonized approach to modeling pesticide concentrations in groundwater. After this project was completed, the two agencies issued a final report on the "Identification and Evaluation of Existing Models for Estimating Environmental Pesticide Transport to Groundwater"[4] recommending PRZM- ground water (GW) as the harmonized tool for assessing pesticide concentrations in groundwater.[4] The OPP implemented the use of PRZM-GW as an exposure model in 2012.[5] During a one year evaluation period (January 2013-December 2013), data were collected on the implementation of PRZM-GW. The analysis of these results demonstrated that PRZM-GW is an effective and versatile model that can be used as both a Tier 1 and Tier 2 risk assessment tool for estimating pesticide concentrations in groundwater. The results of this analysis are provided in the implementation report.[6]

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[1] SCI-GROW is an empirical model based on a linear best fit of 13 single-application groundwater studies. These studies were typically two- to three-year studies. SCI-GROW is a screening-level risk assessment tool that has been used by OPP to evaluate the effects of pesticide use on groundwater.

[2] U.S. Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel: N-Methyl Carbamate Pesticide Cumulative Risk Assessment: Pilot Cumulative Analysis, **February 15-18, 2005** (a), 2005-01, Docket Number: OPP-2004-0405.

[3] U.S. Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel: Preliminary N-Methyl Carbamate Cumulative Risk Assessment, **August 23-26, 2005** (b), 2005-04, Docket Number: OPP-2005-0172

[4] Baris, R.; Barrett, M.; Bohaty, R.; Echeverria, M.; Kennedy, I.; Malis, G.; Wolf, J.; Young, D. Final Report: Identification and Evaluation of Existing Models for Estimating Environmental Pesticide Transport to Groundwater; Health Canada, U.S. Environmental Protection Agency, October 15, 2012.

[5] Brady, D., Approval of PRZM-GW for Use in Drinking Water Exposure Assessments, U.S. Environmental Protection Agency, **December 11, 2012**.

[6] U.S. Environmental Protection Agency. Barrett, M., Bohaty, R., Corbin, M., Cowles, J., Fry, M., Shelby, A., Wolf, J., Young, D., Implementation of the Pesticide Root Zone Model Groundwater (PRZM-GW) for Use in EPA's Pesticide Exposure Assessments, September 8, 2015
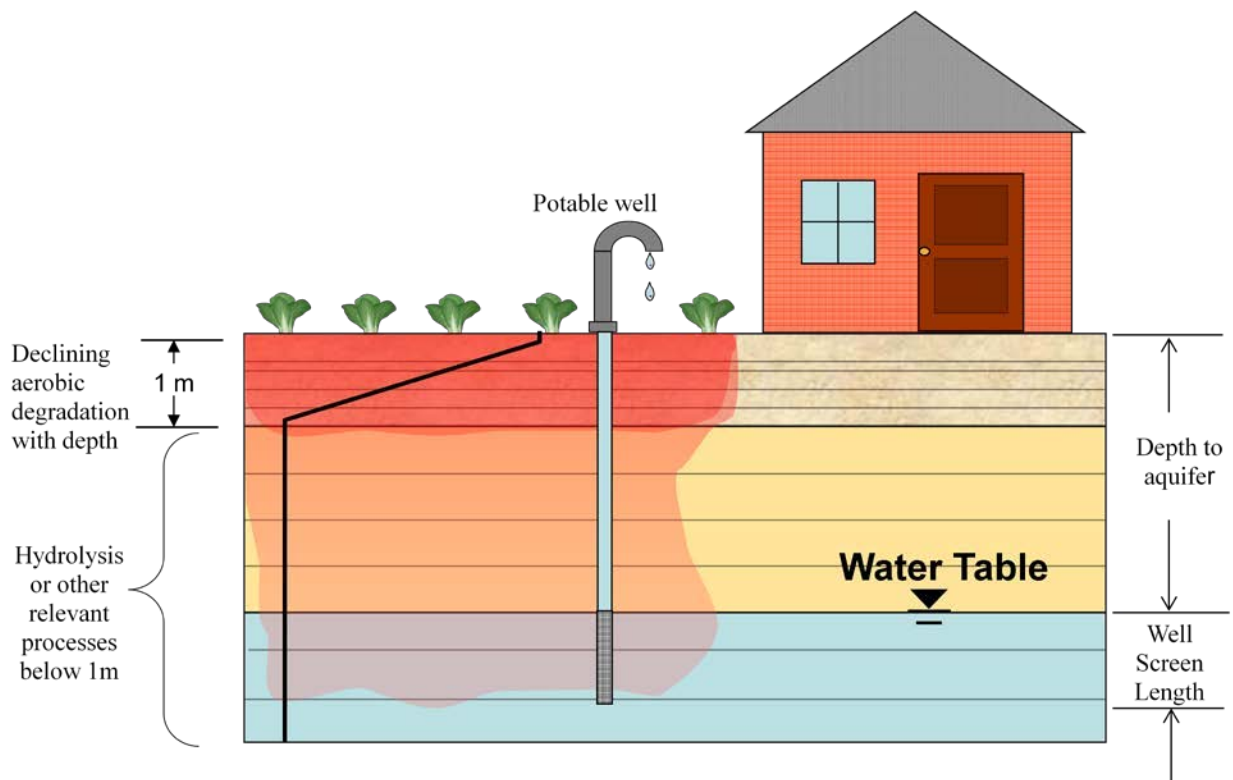
Figure 1. General Groundwater Scenario Concept for Estimating Pesticide Concentrations in Drinking Water as Implemented in PRZM-GW

Figure 1 depicts the general groundwater scenario concept for estimating pesticide concentrations in drinking water as implemented in PRZM-GW. This conceptual model is based on a rural drinking water well beneath an agricultural field (a high pesticide use area), which draws water from an unconfined, high water-table aquifer. The depth of the well is site-specific (*i.e.*, scenario specific). The well extends into a shallow unconfined aquifer and has a well-screen[7] that starts at the top and continues down into the aquifer. The length of the well-screen represents the region of the aquifer where drinking water is collected. The well-screen length is well-specific and can be adjusted. Processes included in the conceptual model that influence pesticide transport through the soil profile include water flow, chemical specific dissipation and transportation parameters (*i.e.*, degradation and sorption), and crop specific factors, including transpiration, pesticide interception and management practices. Runoff is not considered.

This document provides guidance on how to prepare Tier 1 and Tier 2 groundwater assessments using PRZM-GW. Guidance is also provided on how to characterize the resulting exposure estimates.

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[7] A well-screen is a filtering device that allows groundwater from unconsolidated and semi-consolidated aquifers to enter the well while at the same time keeping the majority of sand and gravel out of the well.

GROUNDWATER EXPOSURE ASSESSMENTS

Appendix A includes step-by-step instructions on how to install and run PRZM-GW. PRZM-GW is the only model approved for use by model users in OPP to estimate pesticide concentrations in groundwater that may be used as source drinking water. The sections below highlight how PRZM-GW should be used as a Tier 1 and Tier 2 tool for estimating pesticide concentrations in groundwater that are reported in drinking water assessments (DWAs). For specific cases, where deviation from the guidance documents is appropriate, the model user should document the rationale for each deviation. If additional guidance is desired, modelers may consult with the Environmental Fate & Effects Division's (EFED's) Water Quality Technology Team (WQTT).

Tier 1

As a Tier 1 assessment tool, PRZM-GW is used to develop an upper bound pesticide exposure concentration in groundwater for comparison with upper bound surface water estimated concentrations. PRZM-GW may be used to model a single analyte scenario (*i.e.*, parent, total toxic residue) or as part of a residue summation approach; however, PRZM-GW does not have the capability to account for formation/decline kinetics.[8]

Developing Modeling Scenarios

"Pesticide"Tab

For Tier 1 assessment, fill in the chemical specific parameters (*i.e.*, hydrolysis, aerobic soil metabolism and sorption) in the first tab of the graphical user interface (GUI) titled "pesticide" according to current model input parameter guidance based on the known or estimated environmental fate properties of the pesticide being modeled. **Table 1** should be completed and included in individual exposure assessments to document input parameter selections for PRZM-GW model runs. PRZM-GW can be used to automatically generate an input parameter table for use in DWAs. (See **Appendix A** *Step 5*).

Table 1. PRZM-GW Input Parameters

Parameter (units)	Input Value	Data Source	Comments
Koc (ml/g)			
Surface Soil Half Life (days)			
Hydrolysis Half Life (days)			
Diffusion Coefficient Air (cm^2/day)			
Henry's Constant			
Enthalpy (kcal/mol)			
Koc (ml/g)			

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[8] U.S. Environmental Protection Agency, Ruhman, M., Hetrick, J., Jones, R. Guidance for Modeling Pesticide Total Toxic Residues, draft document

Application Date (Month/Day)			
Application Method			
Application Rate (kg/ha)			

Since hydrolysis is generally the only transformation pathway considered at soil depths greater than one meter, it can have a large impact on the PRZM-GW estimated drinking water concentrations (EDWCs). A chemical may be assumed to be stable to hydrolysis based on minimal transformation in the guideline hydrolysis study (OCSPP 835.2120); however, reevaluation of the hydrolysis study may be completed for such chemicals. If reevaluation of the study shows that a small but statistically significant amount of hydrolysis was observed during the course of the study, a hydrolysis rate should be recalculated along with the corresponding half-life. In this case, including the hydrolysis rate, even if very slow (extrapolation well beyond the study duration), provides better pesticide estimation compared to monitoring data than assuming the chemical is stable. (This approach assumes that the rate observed during the course of the study would remain constant had the study been conducted longer). Characterization (*e.g.*, examination of the upper bound of the hydrolysis rate) of the influence of hydrolysis on the PRZM-GW simulation results should be reported.

If a compound is known to be volatile, this potential dissipation pathway can be explored using the volatility routine included in PRZM-GW. Input values needed to run the volatility routine include diffusion in air (cm^2/day), enthalpy (kcal/mol), and Henry's Law Constant. These parameters should be reported in the drinking water assessment.

"Pesticide Applications" Tab

For Tier 1 assessments, the maximum label rates and minimum retreatment intervals should be used in model simulations, and the annual application retreatment should be left at the default value of one (or once every year). This information should be included in **Table 1**.

To account for the well setback distances specified on a pesticide label, a plug flow model can be used to simulate the additional travel time for a pesticide to reach a drinking water well from the point of application. (See **Tier 2 Refinement Strategy 4** below for additional information on well setbacks and the corresponding equation). If assumptions are made because of the lack of information provided on a pesticide use label this information needs to be discussed in the drinking water assessment.

*Selection of Modeling Scenarios "Scenario: Part 1" tab "Scenario: Part 2" Tab*

All standard scenarios[9] should be run for a Tier 1 national scale pesticide assessment. To date, there are six standard scenarios representing regions known to have vulnerable groundwater supplies. The representative scenario locations are overlaid with a groundwater vulnerability map developed

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[9] Florida Citrus, Florida Potato, Wisconsin Corn, Georgia Peanuts, North Carolina Cotton, and Delmarva Sweet Corn

by the U.S. Geological Survey (USGS)[10] in **Figure 2**. The scenarios are intended to represent the Wisconsin Central Sands, New Jersey/Delaware Delmarva Coast, Florida Sands, Florida Central Ridge, and North Carolina Sands. These scenarios should not be adjusted for a Tier 1 assessment. All six scenarios can be modeled at once using the scenario batch run function (see **Appendix A** *Batch Function Tab*).
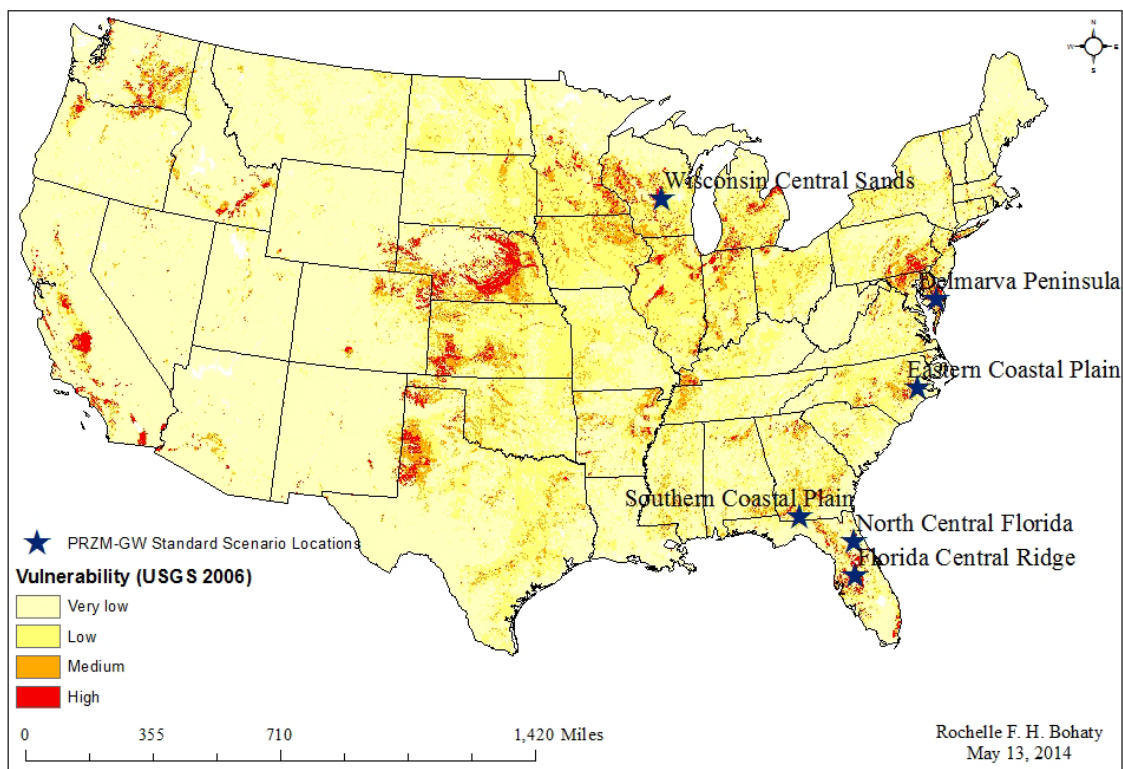
Figure 2. PRZM-GW Groundwater Scenario Locations Overlaid with a National Groundwater Vulnerability Map Developed by the USGS[10]

If the use is restricted by geography, the model user may select to not run all six standard scenarios. The modeler may identify the best representative surrogate scenario(s) for the geographically specific use and run only this scenario. In choosing an appropriate surrogate scenario, users should consider the location of each scenario as it relates to the pesticide use area and climatic conditions, including rainfall and soil hydrology as the primary selection criteria, followed by crop type (*e.g.*, corn, cotton, cucurbits, etc.). When a surrogate scenario is used, the model user should document the rationale for using the surrogate scenario, including a description and justification. If guidance is needed for selecting an appropriate surrogate scenario, OPP model users should consult with EFED's WQTT. For specific cases, when a suitable standard scenario is not available, a new scenario can be developed. (See the **Tier 2** section *Refinement Strategy 1* included in this document).

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[10] Nolan, B. T., Hitt, K. J. Vulnerability of Shallow Groundwater and Drinking-Water Wells to Nitrate in the United States, Environ. Sci. Technol. 2006, *40*, 7834-7840

It should be noted that regions such as Nebraska, California, and Washington, known to have vulnerable groundwater sources, may not be represented by one of the current scenarios because of differences in weather, agronomic practices, soil properties, etc. Nevertheless, the EDWCs derived from the six standard scenarios is expected to be protective of these sites based on the model evaluation completed to date.[4,6]

Results

For all DWAs, a description of PRZM-GW should be included in the Drinking Water Exposure Modeling section, or a source (*e.g.*, models website) describing the model should be cited. This information should include a description of the model, including version and version dates. The following example can be used:

Tier 1 groundwater estimated drinking water concentrations (EDWCs) for [insert chemical being assessed], resulting from its use on [insert crop uses being assessed] were derived with PRZM-GW (Pesticide Root Zone Model for Groundwater, version 1.07, January 23, 2014), using the GUI (Graphical User Interface, version 1.07, January 23, 2014). PRZM-GW is a one dimensional, finite-difference model that estimates the concentrations of pesticides in groundwater. It accounts for pesticide fate in the crop root zone by simulating pesticide transport and degradation through the soil profile after a pesticide is applied to an agricultural field. PRZM-GW permits the assessment of multiple years of pesticide application (up to 100 years) on a single site. Six standard scenarios, each representing a different region of the United States known to be vulnerable to groundwater contaminations, are available for use with PRZM-GW for risk assessment purposes. In PRZM-GW simulations, each of these standard scenarios was used. PRZM-GW output values represent pesticide concentrations in a vulnerable groundwater supply that is located directly beneath a rural agricultural field.

PRZM-GW simulation results [(*i.e.*, estimated drinking water concentrations (EDWCs)] should be included in drinking water exposure assessments by use. A simulation that does not result in a throughput value equal to or greater than one should be rerun with the corresponding extended weather file. The results for the simulation with the extended weather file should be reported for that specific scenario. For each model simulation, the highest (peak) concentration should be reported for short-term exposure, while the post breakthrough average should be reported for longer term exposures. In addition, the average simulation breakthrough time should be reported. If the PRZM-GW estimated concentration is less than the limit of detection (LOD) for the chemical being assessed, the LOD should be reported as the EDWC. If the PRZM-GW estimated concentration is between the LOD and the limit of quantification (LOQ), the LOQ should be reported as the EDWC. An example table, which can be used to summarize the EDWCs for drinking water exposure assessment, is presented below (**Table 2**). If the LOD or LOQ are reported as the EDWC, it should be mentioned in the DWA.

Table 2. **PRZM-GW Estimated Drinking Water Concentrations in Groundwater Resulting from the Use of [insert chemical being assessed]**

Crop/Scenario	Highest Daily Value µg/L	Post Breakthrough Average µg/L	Average Simulation Breakthrough Time days
[Crop]/Tier I [Standard Scenario]	[#]	[#]	[#]
[Crop]/Tier I Standard Scenario	[#]	[#]	[#]

A percent cropped area (PCA) adjustment factor should **not** be applied to PRZM-GW model output data to generate EDWCs. The conceptual model for groundwater exposure, as implemented using PRZM-GW, represents pesticide concentrations in a vulnerable groundwater source that is located directly beneath a single, rural agricultural field and assumes the entire field (zone of influence) is treated. The zone of influence does not represent an entire watershed.

The results from the simulation that provides the highest EDWC should be incorporated with surface water EDWCs and highlighted in the executive summary of the drinking water exposure assessment. The PRZM-GW derived EDWCs should be characterized as representing vulnerable groundwater sources that may be used to supply drinking water. The following example can be used:

The reported EDWCs are upper bound estimates that were derived using conservative model input assumptions related to the environmental fate of [chemical name] as well as the proposed use patterns. The EDWCs represent the potential exposure to [chemical x] in a rural drinking water well beneath an agricultural field (a high pesticide use area), which draws water from an unconfined, high water-table aquifer that is used as source drinking water. Vulnerable groundwater supplies are highly localized; therefore, the EDWCs are not expected to represent actual drinking water concentrations resulting from the proposed use across the entire country but rather provide an upper bound exposure estimate for use in the new chemical dietary risk assessment that represent the potential exposure to a subset of the U.S. population. The USGS indicates that 14% (42,900,000) of the US population derives their drinking water from self-supplied sources with groundwater being the dominant source.[11] Moreover, the EDWCs are not intended to represent the exposure to individuals drinking from publicly supplied water that is sourced from confined aquifers. However, confined aquifers may be vulnerable to [chemical x] contamination if natural or man-made preferential flow pathways exist. In addition, high-volume pumping (e.g., irrigation) in confined aquifers can create a significant downward hydraulic gradient between an overlaying unconfined aquifer and a confined aquifer. [12]

[11] Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.
http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf

[12] Chen, X., Y. Yin, J.W. Goeke, and R.F. Diffendal, Jr., 2005. Vertical Movement of Water in a High Plains Aquifer Induced by a Pumping Well. Environmental Geology 47(7): 931-941.

There is no national dataset on the percentage of private drinking water wells that are in shallow unconfined aquifers. However, available data for the Virginia Coastal Plain indicate that approximately 25% of all wells in the area have depths to the bottom of the well screen that are 50 feet or less from the surface.[13] The USGS developed a groundwater vulnerability map (**Figure 2**) highlighting vulnerable groundwater supplies that may be used as source drinking water based on empirical data and linked these vulnerable supplies to populations served using census data.[10] This map may be referenced in order to determine areas where vulnerable groundwater supplies are located as well as to identify populations that may use vulnerable groundwater as source drinking water.

When monitoring data are available, the data should be integrated into the DWA; however, caution should be used when comparing PRZM-GW EDWCs with monitoring data. Monitoring data provide snapshots of pesticide concentrations in time at specific locations under the conditions which the data are collected. Concentration of various contaminates in groundwater, specifically in wells that are represented by the conceptual model implemented in PRZM-GW, may fluctuate similar to fluctuations observed in surface water. Data are available that show pesticide concentrations in groundwater can rise following an application and/or rain/irrigation event and then rapidly return to background levels.[14] In addition, the monitoring sites may not represent the conceptual model well implemented in PRZM-GW as well as the Tier 1 use scenario modeled. For example, the monitored well may not have been located in the treated field or directly down gradient of the treated field. In addition, the field directly upgradient or above the monitoring well was most likely not treated at the maximum application rate for 30 or 100 years as simulated using PRZM-GW Tier 1 screen.

Tier 2

As a Tier 2 assessment tool, PRZM-GW Tier 1 provides EDWCs that may be refined when additional data are available to better characterize the potential exposure. Tier 2 PRZM-GW simulations are expected to provide reasonable upper bound EDWCs and should be compared with upper bound surface water EDWCs.

<div align="center">Modeling Scenarios Refinements Strategies</div>

Refinement Strategy 1: Development of Representative Scenario

It may be necessary to develop a scenario that specifically represents a use site for which one of the standard scenarios is not a suitable surrogate. For example, a new scenario may be needed when mitigation measures prohibit the use of a given pesticide in areas known to be prone to groundwater contamination. Soil type and characteristics, weather data, and depth to aquifer are all refinements that can be included in a site-specific scenario. To ensure consistency in the development and use of crop scenarios, scenarios developed for use with PRZM-GW should follow the PRZM-GW Scenario Development Guidance[15] and should be shared with EFED's WQTT before

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[13] Pope, J. P., McFarland, E. R., Banks, R. B., Private Domestic-Well Characteristics and the Distribution of Domestic Withdrawals Among Aquifers in the Virginia Coastal Plain U.S. Geological Survey 2007

[14] Wade, H. F., York, A. C., Morey, E., Padmore, J. M., Rudo, K. M., J. title of article? Enviro Quality, 1998, 27 1018-1026

[15] Baris, R.; Barrett, M.; Bohaty, R.; Echeverria, M.; Wolf, J.; Young, D. PRZM-GW Scenario Development Guidance U.S. Environmental Protection Agency, October 15, 2012.

being used in an exposure assessment. All WQTT approved scenarios will be distributed to members of the WQTT for use in exposure assessments to ensure consistency within OPP.

Refinement Strategy 2: Identify Pesticide Fate Parameters not Considered in the Tier 1 Simulations

There are several different chemical specific parameters that can be considered for refinement as well as additional subsurface transformation or adsorption processes. Consideration of additional subsurface transformation or sorption processes not considered in Tier 1 simulations should be considered if data are available.

Guideline hydrolysis studies are only designed to capture abiotic hydrolysis and may not capture other mechanisms of subsurface hydrolysis such as soil surface catalyzed hydrolysis. This is supported in the literature. For example, atrazine has been shown to undergo hydrolytic degradation in groundwater.[16]

While subsurface degradation studies are not routinely submitted to the EPA as part of the pesticide registration process, if transformation data are available for a given pesticide in subsurface materials these data may be used to refine PRZM-GW modeling. While pesticide degradation may be slow and is generally expected to slow with increasing depth degradation, it is still possible to use the data. In conjunction with observed field data and hydrolysis data, it is justifiable to use other data sources such as aerobic soil and aquatic metabolism data as lines of evidence to estimate a dissipation half-life value in subsurface materials. Shallow, unconfined aquifers have the potential to exhibit conditions conducive to aerobic metabolism though the extent and prevalence of this type of degradation is uncertain.

When model users are considering the incorporation of subsurface transformation, it should be noted that the field "Hydrolysis Half-Life" only considers transformation occurring in the aqueous phase, while the "Surface Soil Half-Life" considers both sorbed and aqueous phase transformation. OPP model users should consult EFED's WQTT before modifying these parameters to ensure the adequacy of the relevant data and the appropriate modification of the transformation rates. All changes should be described and characterized in the refined drinking water assessment. In addition, the impact of the modified PRZM-GW simulation results should be reported in the assessment.

Guideline sorption studies are not of sufficient quality to derive the necessary parameters for non-equilibrium modeling; therefore, non-equilibrium sorption should not be considered as a refinement. On the other hand, consideration of nonlinear isotherms may be possible with currently available studies, and EFED is considering including Freundlich isotherms in future PRZM-GW releases. Nevertheless, nonlinear sorption is not a recommended refinement at this time.

Refinement Strategy 3: Consideration of Annual Application Retreatment

If data are available [such as from the Biological and Economic Analysis Division (BEAD) or provided on the label] on the yearly reoccurrence of the pesticide applications, this information can be

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[16] Navarro, S., Vela, N., Giménez, M. J., Navarro, G. Persistence of Four s-triazine Herbicides in River, Sea and Groundwater Samples Exposed to Sunlight and Darkness Under Laboratory Conditions, Science of the Total Environment, 2004, *329*, 87-97

considered in model runs. To change the application reoccurrence, click on the "Pesticide" tab and change the field "Applications occur every "x" year(s)" to the appropriate value. The model user should document the rationale for changing the application reoccurrence in the refined drinking water assessment and discuss the impact on the PRZM-GW simulation results. The annual applications retreatment interval should be recommended as additional label language.

Refinement Strategy 4: Consideration of Well Setbacks

To account for the well setback distances specified on a pesticide label, a plug flow model can be used to simulate the additional travel time for a pesticide to reach a drinking water well from the point of application. A well setback increases the amount of time for a chemical to reach the wellhead, thereby increasing the amount of time for dissipation and ultimately reducing the pesticide concentration at the well. Reductions in the expected concentration can be calculated in drinking water assessments using the plug flow approximation:[5]

$$\frac{C}{C_0} = \exp\left(-\frac{L}{v}k\right)$$	C = concentration at well C_0 = concentration at point of application L = well setback distance [feet] v = lateral groundwater velocity [feet/day] k = dissipation rate in aquifer [day^{-1}]

The well setback equation is highly sensitive to small changes in the lateral groundwater velocity (v) and the aquifer dissipation rate (k) or sorption. Groundwater flow velocities can vary greatly as the U.S. Geological Survey indicates that a lateral groundwater velocity of one foot per day or greater is high, while groundwater velocities can be as low as one foot per year or one foot per decade.[17] This suggests that groundwater flow varies widely across the country, and when coupled with dissipation, which is also known to vary across the landscape, results in a large amount of uncertainty in the EDWCs when using this approach. Thus, groundwater flow should be noted in the DWA. For guidance on selecting an appropriate degradation rate, model users should consult EFED's WQTT.

Additional information on well setbacks is provided in the preliminary N-methyl carbamate cumulative assessment.[4,5]

Refinement Strategy 5: Exploring Exposure Durations That Are Representative of the
Exposure Duration of Concern

The model output file should be saved in the same directory as the input file. The output file contains the daily distribution of pesticide concentrations, which can be provided for use in the Human Health Assessment.[18] Additional post processing can be completed to develop exposure values that reflect the exposure duration of concern. Programs such as Excel, SigmaPlot, or R can be used for post-processing of the data.

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[17] http://pubs.usgs.gov/circ/circ1186/html/gen_facts.html
[18] *Guidance on Generating Drinking Water Distribution Files for HED's Dietary Risk Assessments*, Environmental Protection Agency, Office of Pesticide Programs. January 21, 2005.

Appendix A

PRZM-GW Instruction Manual

Pesticide Root Zone Model-Groundwater (PRZM-GW) is a standard environmental fate and exposure model used by the Office of Pesticide Programs to estimate pesticide concentrations in groundwater. This instruction manual was developed for use with PRZM-GW version 1.07.

Installation

If PRZM-GW is not currently on your computer, it can be downloaded from the model repository (G:\Models_Repository). PRZM-GW associated files should be saved to the model folder on the C:\ drive (C:\models\przmgw) of EPA issued computers.

Running the Model

Step 1: Starting PRZM-GW

To open the PRZM-GW (version 1.07) graphical user interface (GUI), click on the "PRZM-GW.exe" icon. On EPA issued computers the executable file is normally located in the model folder on the C:\ drive (C:\models\przmgw).

Step 2: Prepare Pesticide Specific Parameters for Model Runs

Under the first tab labeled "pesticide," complete (**Figure 4**) the appropriate fields, including chemical name and descriptive information, followed by the hydrolysis half-life, aerobic soil metabolism half-life and sorption coefficient. (See the PRZM-GW Input Parameter Guidance for additional information).[19] Note, descriptions of each of the parameters are provided in the GUI help file under User Guidance for easy reference.

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[19] Baris, R.; Barrett, M.; Bohaty, R.; Echeverria, M.; Kennedy, I.; Malis, G.; Wolf, J.; Young, D. *PRZM-GW Input Parameter Guidance*; Health Canada, U.S. Environmental Protection Agency, October 12, 2012.

Figure 1. Screen Shot of PRZM-GW Pesticide Tab

Step 3: Prepare Pesticide Use Specific Parameters for Model Runs

Under the second tab labeled "Pesticide Applications" (**Figure 5**), select the number of applications, corresponding application dates (absolute and relative), rates, methods, and annual application retreatment based on the pesticide use label.
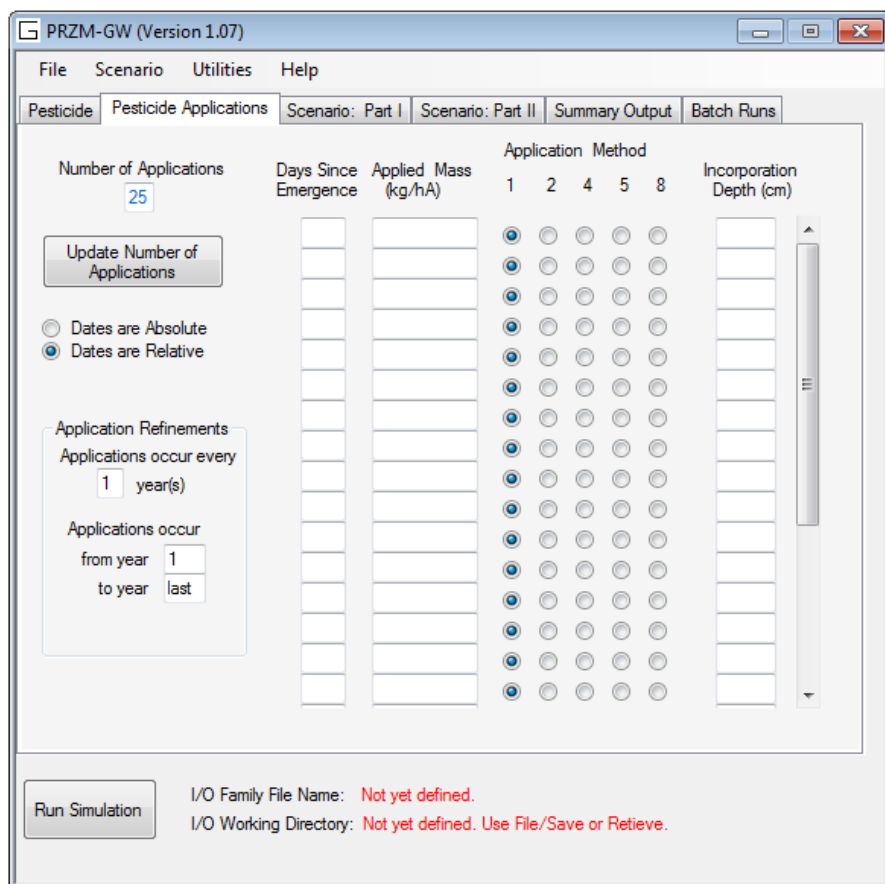
Figure 2. Screen Shot of PRZM-GW Pesticide Applications Tab

Step 4: Save Pesticide Specific Parameters for Model Runs

Click on "File" and select "Save." Create a file name and save the file to the desired directory.

Previously saved chemical files can be loaded by clicking "File" and selecting "Retrieve" (pointing the browser to the desired chemical file). The file will need to be resaved following any changes.

Step 5: Select Scenario Parameters for Model Runs

To select a scenario, click "scenario" from the menu bar and then "load scenario" from the dropdown window. On EPA issued computers, the scenario files are normally located in the model folder on the C:\ drive in the subdirectory scenarios (C:\models\przmgw\Scenarios). Once a scenario is loaded, the details of the individual scenario can be viewed under the third and fourth tabs, "Scenario: Part 1" and "Scenario: Part II," respectively.

Step 5: Running Groundwater Simulations and Viewing Results

Click on the fourth tab "Summary Output," and then click the "Run Simulation" button located in the bottom left corner of the GUI to run the simulation. ("Run Simulation" is visible in the screen shot shown in **Figure 5**). The summary output contains a graph of the daily concentration values

over the course of the simulation as shown in **Figure 5**. This graph can be saved or copied to the computer clipboard, using the buttons below the figure GUI. In addition, the "Word Doc" button can be used to automatically generate an output file that includes a text summary of the results, tables of the results, chemical properties, and application scheme used in the model simulation as well as a figure of the breakthrough curve. These graphs can be easily copied and pasted into other documents are needed.
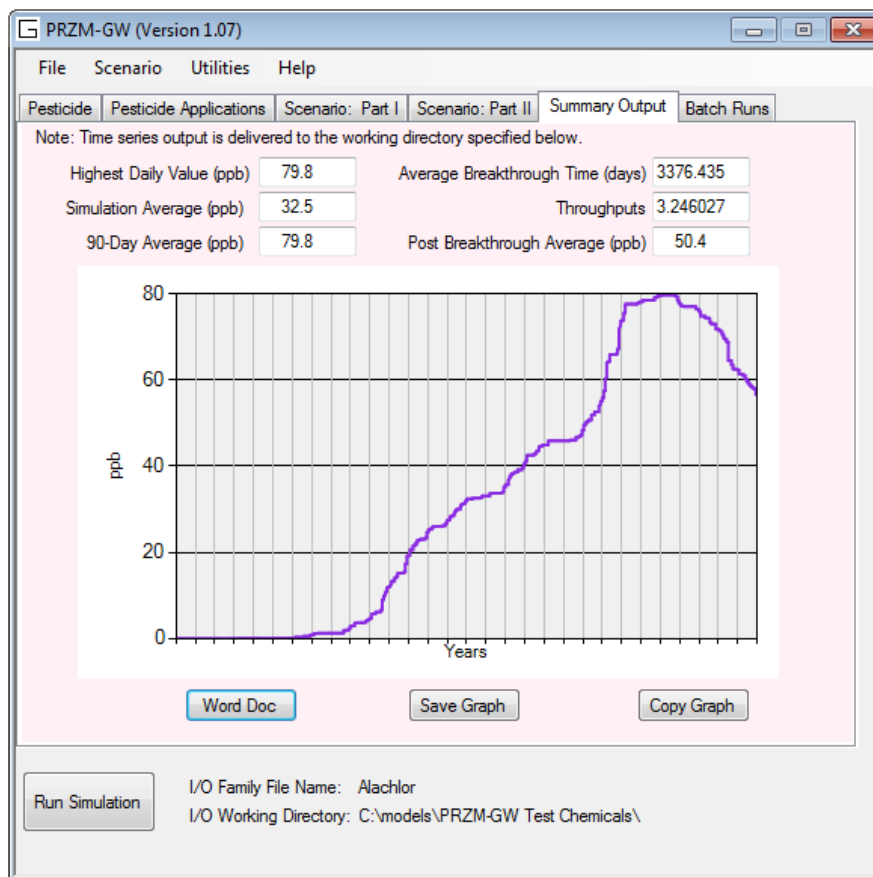
Figure 3. Screen Shot of PRZM-GW Summary Output Tab

Batch Run Function Tab

A batch run capability is available under the "Batch Runs" tab (**Figure 6**). By selecting the box next to the "Scenario Batch Run," a modeler can run all scenarios listed in a single directory. When the box next to the "Scenario Batch Run" is checked, a window will appear allowing the user to point the browser to the desired folder that contains the scenarios to be used in the model simulations.

In addition, multiple chemical batch runs may be run by selecting the box next to the chemical batch run. The multiple chemicals batch run function allows model users to run several application scenarios for the same pesticide or multiple pesticide simulations or combination thereof. To save all the zts (output) files, the modeler must select the box next to "Save ALL zts Files".
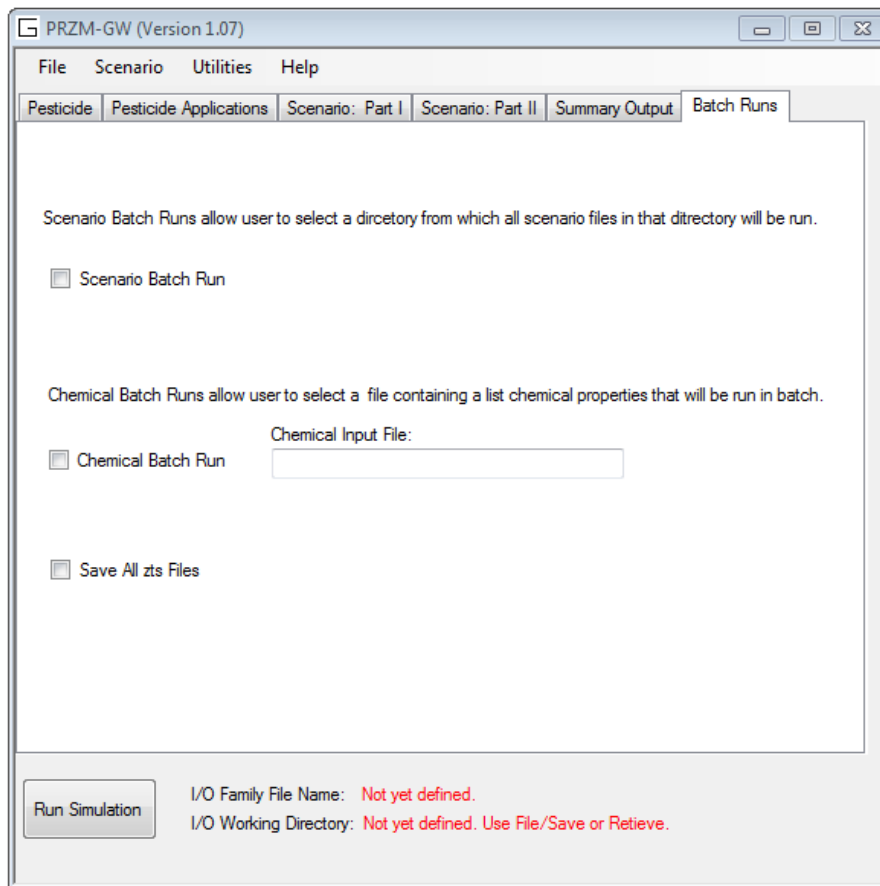
Figure 6. Screen Shot of PRZM-GW Batch Run Tab