4.0 Groundwater Modeling

P. D. Thorne

Computer models are used to forecast future groundwater conditions and predict the movement of contaminants in groundwater. Such predictions are important in planning waste management and cleanup activities for the Hanford Site. Groundwater modeling activities that address problems on a Hanford site-wide scale, such as contaminant movement from the operational areas on the Central Plateau to the Columbia River, have been consolidated under the Groundwater Performance Assessment Project. The consolidation of site-wide modeling eliminates redundancy and promotes consistency of groundwater models (DOE/RL-2000-11). Other groundwater models are used to address issues at a local scale (i.e., <~10 kilometers). Local-scale modeling is used to predict the migration of dense, non-aqueous liquid disposed at the 216-Z-9 crib through the vadose zone and aquifer. Local-scale modeling of the 300 Area is currently being performed to support evaluation of remediation alternatives for the 300-FF-5 Operable Unit. Local-scale modeling has also been used for the past several years to design and evaluate pump-and-treat systems for local-scale groundwater contaminant plumes.

This chapter summarizes Hanford Site groundwater modeling activities for fiscal year (FY) 2004. Section 4.1 reports on the continuing development of the consolidated site-wide groundwater model. Section 4.2 describes the groundwater modeling component of the System Assessment Capability, which was used to perform an updated composite analysis of the combined effects of all radiological waste that will be left on the Hanford Site at the time of site closure. Section 4.3 presents summaries of three applications of the site-wide groundwater model to specific waste-site assessments, which include:

- Modeling the movement of tritium disposed to the State-Approved Land Disposal Site north of 200 West Area.
- Site-wide groundwater flow and transport calculations supporting the performance assessment for the Integrated Disposal Facility and the preliminary performance assessment for closure of single-shell tank farms.
- Site-wide modeling of dissolved carbon tetrachloride migration from 200 West Area through the groundwater considering different source conditions and various degrees of sorption and natural degradation.

Local-scale modeling of dense, non-aqueous liquid migration in the vadose zone and aquifer at the 216-Z-9 crib is summarized in Section 4.4. Modeling to support evaluation of remedial alternatives of the 300-FF-5 Operable Unit is described in Section 4.5. Section 4.6 describes local-scale modeling activities performed to assess groundwater pump-and-treat activities.

Groundwater flow and transport models based on alternative conceptual models are being developed to improve predictions of contaminant transport and to evaluate uncertainty in model results.

4.1 Site-Wide Groundwater Flow and Transport Model

A site-wide numerical model of groundwater flow and contaminant transport has been developed and is being improved and refined. The "base case" site-wide model is a three-dimensional representation of the aquifer system that has been calibrated to water-table changes observed in well data collected from 1943 to 2001 (PNNL-13447). The transient, inverse calibration was performed using UCODE, a universal inverse modeling code developed jointly by the U.S. Geological Survey and the International Groundwater Modeling Center of the Colorado School of Mines. The site-wide model is implemented using the Coupled Fluid Energy and Solute Transport (CFEST) code, which is the forward model whose parameters are estimated by UCODE.

During FY 2004, the pattern of geologic facies-zones within the Hanford formation and Ringold Formation gravel units of the model has evolved in a continuing effort to improve the calibration of Alternative Conceptual Model (ACM)-2 (PNNL-14398). The calibration involves adjusting the facies-zonation configuration, the hydraulic conductivities associated with the facies-zones, and the amounts of recharge to the system in an effort to match historical changes in water-table elevation and the historical movement of tritium. Changes were also made to the configuration of hydrogeologic units in the model based on new well data and reinterpretation of geological contacts at some locations. Progress on calibration of ACM-2 during FY 2004 is described in the following section (4.1.1). Section 4.1.2 provides background information about the site-wide groundwater model.

4.1.1 Improved Calibration of ACM-2 Based on Hydraulic Heads and Tritium Movement

ACM-2 resulted in a better fit to measure water-level data and is more closely aligned with the geologic structure of the aquifer system.

The calibration of the "base case" model and ACM-1 (PNNL-13623) was linked to the distribution of unconfined aquifer transmissivity from an earlier two-dimensional steady-state model calibration (PNNL-11801). ACM-2 uses a facies-zonation approach in which zones of equal hydraulic conductivity are defined based on geological information. This approach is more closely aligned with the geologic structure of the aquifer system. It is also more suitable for the application of geostatistical methods to develop a range of probable conceptual models that will produce a range of results and thus help to quantify model uncertainty. The facies zones originally defined for ACM-2 Unit 1, the Hanford formation, are shown in Figure 4.1-1. Facies zones originally defined for Unit 5, which includes Ringold gravel units C and E and upper Ringold sand (BHI-00184), are shown in Figure 4.1-2. These zones were developed based on textural information in geologic descriptions from well drilling, knowledge of depositional environments, aquifer test information, and hydraulic head responses in wells (PNNL-14398).

During FY 2004, calibration of ACM-2 based on hydraulic heads was refined by adding additional facies zones. The model was then further calibrated by using data and information on the historical movement of tritium in the calibration process. Hydraulic parameters associated with the faces zones are adjusted to achieve a better match between simulated tritium transport and the concentration of tritium observed at monitoring wells. Tritium was used in the calibration because it is the most widespread groundwater contaminant on the Hanford Site.

Calibration of ACM-2 based on observed tritium movement is continuing at the present time. Current planning calls for the eventual development of a range of alternative conceptual models with equally possible zonation patterns based on the available data. Calibration of a selection of models within this range of alternatives will help to capture the uncertainty in the model results, which will strengthen the technical defensibility of groundwater transport predictions and lead to a better basis for waste-management and cleanup decisions.

4.1.2 Background Information on the Site-Wide Groundwater Model

The site-wide groundwater flow and transport model was developed from information that included the following:

- Three-dimensional location and extent of major hydrogeologic units within the aquifer.
- Distribution of textural and lithologic properties of aquifer sediments.
- Spatial distributions of hydraulic and transport properties.
- Aquifer boundary conditions including potential groundwater recharge and discharge.
- Distribution and movement of contaminants indicated by groundwater sampling.

The model consists of nine separate hydrogeologic units, eight of which exist below the water table. The groundwater flow system is bounded by the Columbia River on the north and east and by the Yakima River and basalt ridges on the south and west, respectively. Additional information on the site-wide groundwater model is presented in PNNL-11801 and PNNL-13641.

The three-dimensional model was initially calibrated to historical changes in water-table elevation at the Hanford Site (PNNL-13447) in 2001. However, the hydraulic conductivity distribution of this initial calibration was linked to the transmissivity distribution from an earlier two-dimensional steady-state model calibration through scaling factors. ACM-1 (PNNL-13623) used the same calibration approach, but also incorporated interaction between the sedimentary, generally unconfined, aquifer system and the underlying basalt-confined aquifer system. Earlier models had assumed there was no movement of groundwater between these two aquifer systems.

Initial calibration of the facies-zone based ACM-2 to hydraulic head data was completed during FY 2003 (PNNL-14398). Six facies zones were defined for model Unit 1, the Hanford formation (Figure 4.1-1). Seven zones were defined for model Unit 5, which includes Lindsey's (BHI-00184; Figure 4.1-2) Ringold gravel units C and E and upper Ringold sand. Compared to the earlier ACM-1, the facies-based ACM-2 resulted in a better fit to measured water-level data. The sum of squared residual differences was 9% lower for ACM-2.

Uncertainty is inherent in all numerical models because of both incomplete information about the physical system and the impossibility of perfectly representing the system. An effort to incorporate uncertainty in the site-wide model began in 1999 with recommendations from an external peer review panel to establish a modeling framework that accepts the inherent uncertainty in model conceptual representations, inputs, and outputs (PNNL-13641). This framework will produce a range of predicted results for future groundwater conditions and contaminant transport based on differences in conceptual model assumptions. Uncertainty in model conceptualization has been found to be the most significant source of uncertainty in groundwater modeling (NUREG/CR-6805). As described in PNNL-13641, uncertainty in the site-wide groundwater model is being quantified through sensitivity analysis (e.g., alternative conceptual models and future scenarios) for those aspects of the analysis related to vagueness, and uncertainty analysis for those situations where the uncertainty (e.g., for parameters) can be represented by probability density functions.

4.2 System Assessment Capability

The System Assessment Capability is an integrated assessment tool. It includes several linked computer models designed to simulate the movement of contaminants from waste sites through the vadose zone, groundwater, and Columbia River to receptors. It also incorporates modules that calculate the risks to human health and the environment. The groundwater module of the System Assessment Capability receives contaminant flux from the vadose zone module. It simulates contaminant movement through the uppermost aquifer system to the Columbia River and other potential exposure locations such as wells or seeps. The concentrations of contaminants in groundwater are then used in the risk module calculations.

During FY 2004 and 2005, the System Assessment Capability is being used to perform a revised composite analysis.

During FY 2004 and continuing into 2005, the System Assessment Capability is being used to perform a revised composite analysis. This is an update of the composite analysis described in PNNL-11800. It is designed to calculate the combined impacts of all radiological waste that will be left on the Hanford Site at the time of site closure.

The groundwater module is based on the site-wide groundwater model described in PNNL-13447. This model was used in the initial assessment performed during 2002 (PNNL-14027). For the revised composite analysis, the model grid was refined around the contaminant plume areas in the Central Plateau and downgradient to the Columbia

River. The original model was based on a 750-meter grid spacing. The grid was refined to ~80-meter spacing in 200 West Area, where the Ringold Formation is present at the water table, and to ~250-meter grid spacing in areas downgradient of 200 West Area, where the Hanford formation is present in the water table. The revised grid spacing was designed to improve the simulation of contaminant movement from regions of the lower permeability in the vicinity of 200 West Area to regions of higher permeability in the vicinity of 200 East Area and downgradient to the Columbia River. The updated grid is shown in Figure 4.2-1. Some minor changes to the geological interpretation and recharge boundaries were also incorporated in the updated model.

The System Assessment Capability can be used for a stochastic analysis, which means that selected parameters are represented by probability distributions from which values are selected. This results in a range of calculated risks that are designed to encompass the uncertainty in the analysis. For the groundwater module of the revised composite analysis, only the sorption coefficients of contaminants are represented stochastically. Other sources of uncertainty in the groundwater model, including conceptual model uncertainty, will eventually be incorporated based on the strategy described in Section 4.1.

Background information on design of the initial System Assessment Capability tool is summarized in BHI-01365. Results of an initial assessment performed with the System Assessment Capability are provided in PNNL-14027 and a description of the software is provided in PNNL-14852, Volumes 1, 2, and 3.

4.3 Applications of the Site-Wide Groundwater Model

This section describes three groundwater modeling activities that were implemented during FY 2004 to support specific waste site assessments.

State-Approved Land Disposal Site modeling results using the updated groundwater model differed significantly from those predicted in the 1997 modeling.

4.3.1 Modeling of Tritium Migration at the State-Approved Land Disposal Site

Treated water from the Hanford Site 200 Area Effluent Treatment Facility is discharged to a drain field at the State-Approved Land Disposal Site (SALDS—also see Section 2.8.3.5). SALDS is located immediately north of 200 West Area in the Central Plateau of the Hanford Site (see Figure 2.8-2 in Section 2.8). Although water discharged at SALDS has been treated to remove other contaminants, it may contain tritium, which is very difficult to remove from water.

Impacts from water and tritium disposal at the SALDS facility were previously modeled in 1997 (PNNL-11665.1). During FY 2004, the site-wide groundwater model was used for an updated assessment of the impacts of SALDS as reported in PNNL-14898. The updated assessment included the following objectives:

- Incorporate up-to-date historical discharge and groundwater monitoring data into groundwater flow and transport model.
- Incorporate more recent and accurate projections of future tritium disposal and water discharge volume to the SALDS.
- Predict the extent of lateral and vertical movement of the tritium plume from the SALDS.
- Recommend strategies for future monitoring based on model results.

The updated assessment incorporated refinements in the Hanford site-wide groundwater model (PNNL-13447). Model simulations were performed for the period 1944 through 2100 using the revised site-wide groundwater model. Artificial recharge at all active Hanford discharge sites was included in the model. However, contaminant release was limited to the tritium source at the SALDS facility. Potential effects from other sources of groundwater contamination are not considered in this analysis.

Records of treated water volumes and inventories of tritium discharged to the SALDS from its startup in 1995 through 2004 were compared with projected values used in the 1997 modeling. The results showed that while actual discharge volumes through June 2004 exceeded projections, cumulative tritium inventories discharged to the SALDS were only about half of the projected inventories.

The updated model used the reported SALDS discharge data for inputs of water volumes and tritium inventories through June 2004 and updated projections of expected water volumes and tritium inventories through 2030. Projected tritium discharges increase for the period after 2008 because of expected effluents originating from the Waste Treatment Plant and associated facilities. It was assumed that there will be no discharge of tritium after 2030.

Results of the revised model showed tritium concentrations increasing to between 800,000 and 900,000 pCi/L by 2006, then declining to ~300,000 pCi/L in 2008. Concentrations are then predicted to increase after 2009 to a maximum of just over 3 million pCi/L at the end of waste treatment operations. This increase in concentration results from the increased discharge of tritium associated with the Waste Treatment Plant. The previous modeling had suggested that tritium concentration levels would drop below 500 pCi/L by the 2090. However, with the updated increase in future tritium inventories in the current projections, modeled results suggest that tritium concentration levels would not drop below the 500 pCi/L level until about the year 2140.

Modeling results suggest that the current monitoring well network, which consists of 3 proximal monitoring wells and 16 tritium tracking wells, will continue to provide adequate coverage for monitoring the movement of tritium from the SALDS. Current predictions suggest that concentration levels of over 500 pCi/L will arrive at well 699-51-75P (see Figure 2.8-1 in Section 2.8) within the next 5 to 10 years. After discharges cease in 2030, simulation results suggest that the plume will not grow much beyond this observation well because continuing plume dispersion and radioactive decay of tritium will reduce concentrations in the aquifer.

4.3.2 Groundwater Calculations Supporting Performance Assessments

During FY 2004, the site-wide groundwater flow and transport model was used to perform calculations that support groundwater flow and transport analyses associated with the performance assessment for the Integrated Disposal Facility and the preliminary performance assessment for closure of single-shell tank farms. This work is documented in PNNL-14891. The standard approach of sequentially simulating mass release from a waste site, transport through the vadose zone, and transport of the resulting plume through the groundwater was compared with two alternative methods. The examined alternatives are (1) the "well intercept factor" approach, and (2) the "convolution" approach. The sequential simulation approach has been used extensively and is preferred when transient vadose zone and groundwater conditions are important and the combinations of inventory distributions and parameter sets are less than the number of simulations required. However, for assessments that consider only the impact of future releases, after the effects of transient changes to the vadose zone and aquifer are considered less important, steady-state flow conditions can be assumed and the alternative approaches may provide reasonable estimates of groundwater concentrations. The advantage of the alternative methods is that groundwater impacts can be calculated for a large number of waste inventory and release scenarios in a much shorter time.

The convolution approach for estimating groundwater concentrations involves simulating a groundwater concentration response resulting from a "unit" inventory release of a particular contaminant. A unit release in each of the process models (e.g., source release, vadose zone transport, and groundwater transport) can be simulated independently. This is repeated for each contaminant. The principle of superposition is then applied to determine the combined groundwater impacts of different contaminant inventory distributions. By

assuming linearity, the unit release responses from each individual source area can be combined or superimposed. This approach can be used to estimate groundwater concentrations at specific locations and can be a preferred alternative when large combinations of inventory distributions, vadose zone, and groundwater flow and transport scenarios need to be simulated.

The well intercept factor approach for estimating groundwater concentrations involves simulating the groundwater system response to the influx of water from the overlying vadose zone over a specific water table surface area and with a given contaminant concentration. The ratio of the simulated concentration in the groundwater at a downgradient location to the contaminant concentration at the bottom of the vadose zone can then be used to estimate groundwater concentrations at those locations from other vadose zone contaminant concentrations that are calculated independently from waste release and vadose zone flow and transport models. The two performance assessment analyses intend to use well intercept factors as outlined in PNNL-13400. The flow and transport analysis applied to these calculations used both a site-wide regional-scale model and a local-scale model of the area near the Integrated Disposal Facility. The regional-scale model was used to evaluate flow conditions, groundwater transport, and impacts from the Integrated Disposal Facility and individual tank farm areas. Impacts were evaluated at the boundary of the "core zone," an area around the 200 East and 200 West Areas where groundwater use is expected to be restricted, and along the Columbia River. The local-scale model was used to evaluate effects from the transport of contaminants at a hypothetical well 100 meters downgradient of the Integrated Disposal Facility. Well intercept factors calculated for different Integrated Disposal Facility release areas and recharge rates using local-scale model and the regional-scale model are provided in PNNL-14891.

Additional simulations were also performed to evaluate the general performance of the well intercept factor approach in comparison to the standard sequential approach and the convolution approach. In these additional simulations, two release scenarios were evaluated to compare estimated groundwater concentrations using these different approaches. One case involved a hypothetical source release of technetium-99 near the Integrated Disposal Facility. The other case involved a hypothetical release of technetium-99 over a 600-year time frame from the S-SX Tank Farm area. These selected cases provide insight into the use of the well intercept factor approach for estimating groundwater concentrations from mass releases to the unconfined aquifer.

The analysis showed that the well intercept factor approach provided reasonable and accurate estimates of groundwater concentrations in the vicinity of the source release. However, for locations at greater distances, the convolution method more closely matched groundwater concentration results calculated with the standard sequential simulation approach. Results were generally influenced by two factors: (1) the duration of the source term release to the water table and (2) the downgradient distance.

For the long-term contaminant release scenario at the Integrated Disposal Facility, the convolution approach produced estimated peak groundwater concentrations that were ~4% higher at the core zone boundary and 10% lower along the river when compared to the sequential simulation approach. Results from the well intercept factor method were 10% higher at the core zone boundary and 12% higher along the river when compared to the sequential simulation approach.

For the short-term contaminant release scenario from the S-SX Tank Farm area, the convolution approach produced estimated concentrations that were closest to those calculated using the sequential simulation method. The convolution approach produced estimated peak groundwater concentrations that were ~7% higher at a 250-meter distance from the source, 5% lower at the core zone boundary, and 5% lower along the river when compared to the sequential simulation approach. Peak groundwater concentrations from the well intercept factor method were 50% higher at a 250-meter distance from the source,

3.6 times higher at the core zone boundary, and 2.1 times higher along the Columbia River when compared to the sequential simulation results.

4.3.3 Modeling of Carbon Tetrachloride from the 200 West Area

Studies of carbon tetrachloride transport through the unconfined aquifer system were performed based on an initial evaluation of the nature and extent of carbon tetrachloride contamination in the unconfined aquifer beneath the 200 West Area (PNNL-13560). In FY 2004, the model was extended to the Columbia River based on the site-wide groundwater model, and groundwater transport was simulated assuming different source conditions and various degrees of sorption and natural degradation for carbon tetrachloride. Simulated groundwater concentrations were compared at an arbitrary boundary ~5 kilometers from the source and at the Columbia River. Results of the updated modeling are documented in PNNL-14855. These modeling analyses resulted in the following conclusions.

With the assumption of a continuing source of carbon tetrachloride entering the groundwater from the vadose zone and with no sorption or abiotic degradation (i.e., Case 1a), the following was observed:

- Development and migration of a substantial carbon tetrachloride plume from source areas in the 200 West Area to the Columbia River. Predicted concentrations reached ~200 µg/L at the arbitrary boundary chosen for this analysis and ~34 µg/L along the Columbia River during the 1,000-year period of analysis. Both of these values exceed the drinking water standard of 5 µg/L.
- The equilibrium carbon tetrachloride release estimate in the source area was ~73 kg/yr.
- Initial conditions yielded an initial mass of ~542 kilograms in the aquifer, which grew to 58,050 kilograms after 1,000 years (the year 3000).

Modeling showed the importance of sorption and abiotic degradation in determining whether carbon tetrachloride concentrations will exceed compliance limits (5 µg/L) outside the Central Plateau Core Zone.

With the assumption of a continuing source with median value estimates of sorption and abiotic degradation (i.e., Case 1b), the following was observed:

- Limited development and migration of a carbon tetrachloride plume from source areas within the general vicinity of the 200 West Area. Predicted concentrations reached ~4.5 µg/L at the arbitrary boundary chosen for this analysis. Concentrations at discharge areas along the Columbia River were essentially zero during the 1,000-year period of analysis.
- The combination of sorption and abiotic degradation rate significantly limits aquifer source loading and the aquifer area and volume affected by the carbon tetrachloride plume migration. It should be mentioned that the most important parameter of the two is the abiotic degradation rate because retardation alone will not reduce concentrations other than through dilution because of hydrodynamic dispersivity.

Without a continuing source of carbon tetrachloride and no sorption or abiotic degradation, we observed results that were very similar whether the source area with the highest concentrations in the plume (i.e., all concentrations above 3,000 µg/L) was assumed to be removed from the aquifer (Case 2) or the existing plume was considered as an initial condition of aquifer contamination (Case 3). In both of these cases, the following was observed:

- A more limited development and migration of a carbon tetrachloride plume outside the 200 West Area toward the Columbia River than with the continuing source assumption evaluated in Case 1a.
- A predicted concentration profile reaching ~6.5 µg/L at the arbitrary boundary chosen over a period of ~600 years between 2100 and 2700. This contrasts with the rapidly rising and plateau profile of carbon tetrachloride concentrations predicted under the continuing source assumption evaluated in Case 1a.

- A concentration profile at discharge areas along the Columbia River that is well below the drinking water standard of 5 µg/L during the 1,000-year period of analysis.

The results of these analyses illustrate the importance of developing field-scale estimates for sorption and abiotic degradation of carbon tetrachloride. With no sorption and abiotic degradation, carbon tetrachloride concentrations will exceed the compliance limit of 5 µg/L outside the Central Plateau waste management area, and the aquifer source loading and area of the aquifer affected will continue to grow until river arrival rates of carbon tetrachloride equal source release rates estimated at 33 kg/yr. Results of these analyses also show the significant change in predictions between continual source release from the vadose zone and complete source removal.

4.4 Local-Scale Multi-Phase Modeling of Carbon Tetrachloride Movement

Multi-phase modeling of carbon tetrachloride movement in the subsurface helps us evaluate remedial actions that will be most effective.

Simulations of the movement of carbon tetrachloride disposed at 216-Z-9 trench in the 200 West Area were performed using the multi-phase STOMP simulator (PNNL-14286). The carbon tetrachloride was modeled as a dense, non-aqueous liquid, a dissolved component of water in both the vadose zone and the aquifer, and as a gas mixed with air in the vadose zone. The purpose of this work was to enhance understanding of carbon tetrachloride in the subsurface beneath the 216-Z-9 trench. Discussion and results of the modeling effort are published in PNNL-14895.

The geological representation applied in the model was based on a local refinement of the site-wide groundwater model with additional detail added for units in the vadose zone. A total of 12 stratigraphic units were included. The lateral scale of the model was 440 by 540 meters.

A total of 23 simulations, 1 base case, and 22 sensitivity runs were performed. Figure 4.4-1 shows the saturation of available pore space by dense, non-aqueous liquid beneath the 216-Z-9 trench for the base case. The concentrations of carbon tetrachloride dissolved in water in the vadose zone and aquifer for the base case are illustrated in Figure 4.4-2. The sensitivity cases examined the effects of variation in fluid properties; disposal rate, area, and volume; fluid retention; permeability; anisotropy; sorption; porosity; and residual saturation. Additional simulations were performed to assess the effects of soil-vapor extraction on the distribution of carbon tetrachloride. The simulation results provided the following information:

- The Cold Creek unit has a large impact on the migration of dense, non-aqueous liquid through the vadose zone.
- The modeled dense, non-aqueous liquid did not move laterally outside the footprint of the disposal facility.
- The lateral extent of the vapor-phase plume in the subsurface is much greater than the lateral extent of the dense, non-aqueous liquid.
- The vapor phase plume partitioned into the underlying groundwater and onto the solid phase as it moved through the vadose zone resulting in contamination of the groundwater.

4.5 Local-Scale Modeling Associated with the 300-FF-5 Operable Unit

Local-scale modeling of groundwater flow and uranium transport at the 300 Area is currently being performed to support the evaluation of remediation alternatives for the 300-FF-5 Operable Unit. During FY 2004, this modeling effort involved the development

of a local-scale model of the 300-FF-5 Operable Unit area based on the STOMP code (PNNL-14286). Development of this local-scale model involved the construction of a model appropriate for the domain, spatial and temporal resolution, flow and transport processes, key sources, and boundary conditions. The development efforts make use of the following information:

- Estimates of hydraulic properties currently developed for the site-wide groundwater flow and transport model.
- A geological data set describing the configuration of major hydrogeologic units.
- Methods for directly translating the geological information to appropriate STOMP model input files.
- Current estimates of water sources and waste inventory information compiled under the System Assessment Capability for key waste facilities.
- Observed and predicted river stage and flow conditions for the Columbia River that are needed to establish model boundary conditions.
- Estimates of 300 Area uranium plume inventories based of interpretation of past and current field observations.

The primary accomplishments of this modeling effort completed in FY 2004 include completion of initial flow simulations with the newly developed STOMP model and compilation of data and information for the existing uranium plume that is currently being used to develop initial conditions for model simulations.

4.6 Local-Scale Modeling of Pump-and-Treat Systems

The Hanford environmental restoration contractor performs local-scale modeling to design and evaluate pump-and-treat systems for groundwater. The Micro-FEM code is used to model capture and injection zones of extraction and injection wells, respectively, and to estimate the area affected by the pump-and-treat systems over time. The local-scale model is used to evaluate the hydraulic effects of the remedial action sites in several different operational areas.

The operational areas and the contaminants of concern being treated at each are listed below:

- 100-KR-4 Operable Unit (100-K Area) – hexavalent chromium
- 100-NR-2 Operable Unit (100-N Area) – strontium-90
- 100-HR-3 Operable Unit (includes both 100-D and 100-H Areas) – hexavalent chromium
- 200-UP-1 Operable Unit (200 West Area) – technetium-99 and uranium
- 200-ZP-1 Operable Unit (200 West Area) – carbon tetrachloride

During FY 2004, these models were only updated to reflect the changing water-table elevation in the aquifer and changes in pumping rates. Additional information on the models is provided in DOE/RL-99-79, DOE/RL-2002-05, and DOE/RL-2002-67. Results of local-scale modeling of the pump-and-treat operations will be discussed in upcoming status reports for calendar year 2004.

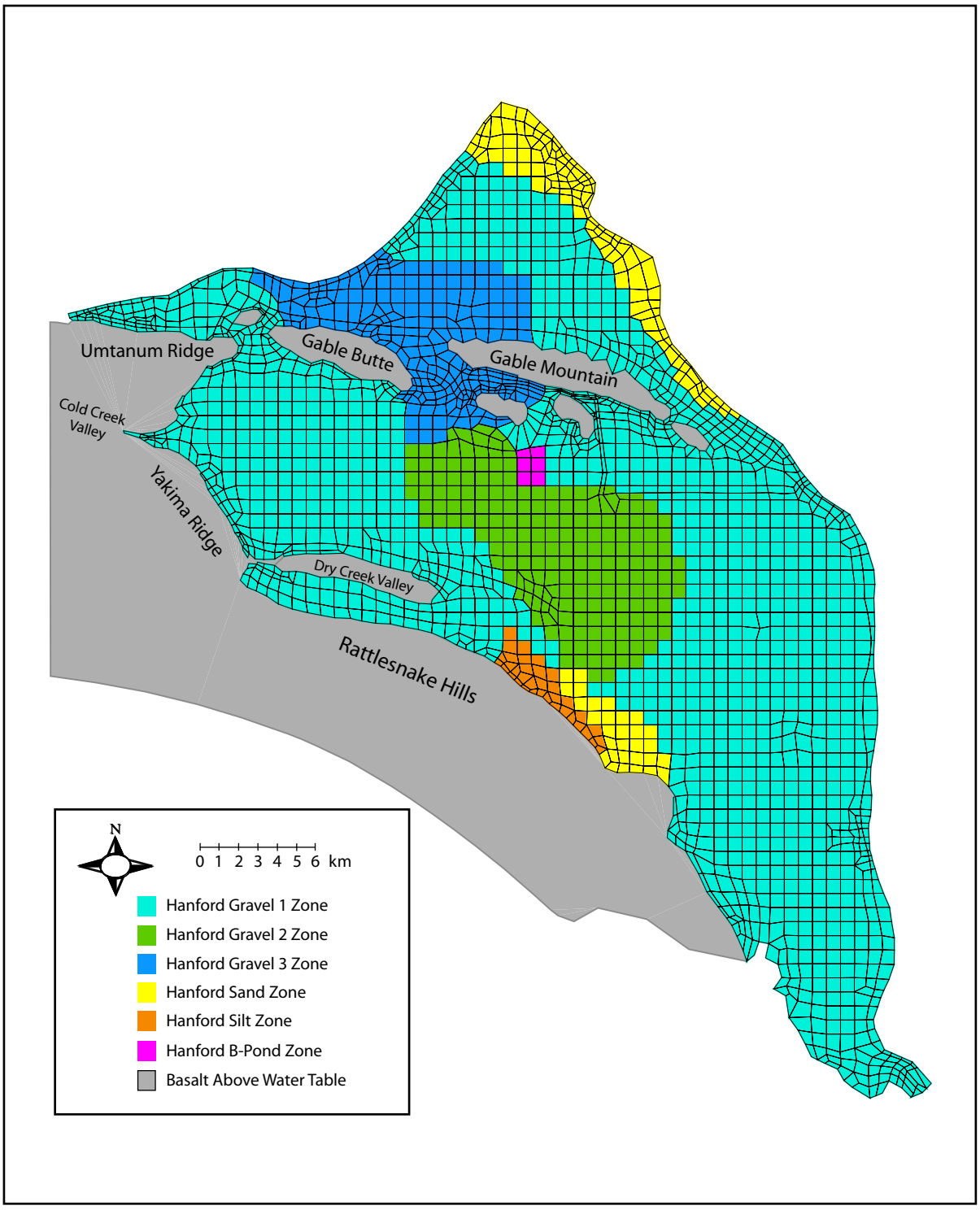

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Figure 4.1-1. Facies Zones Defined for Alternative Conceptual Model 2, Unit 1

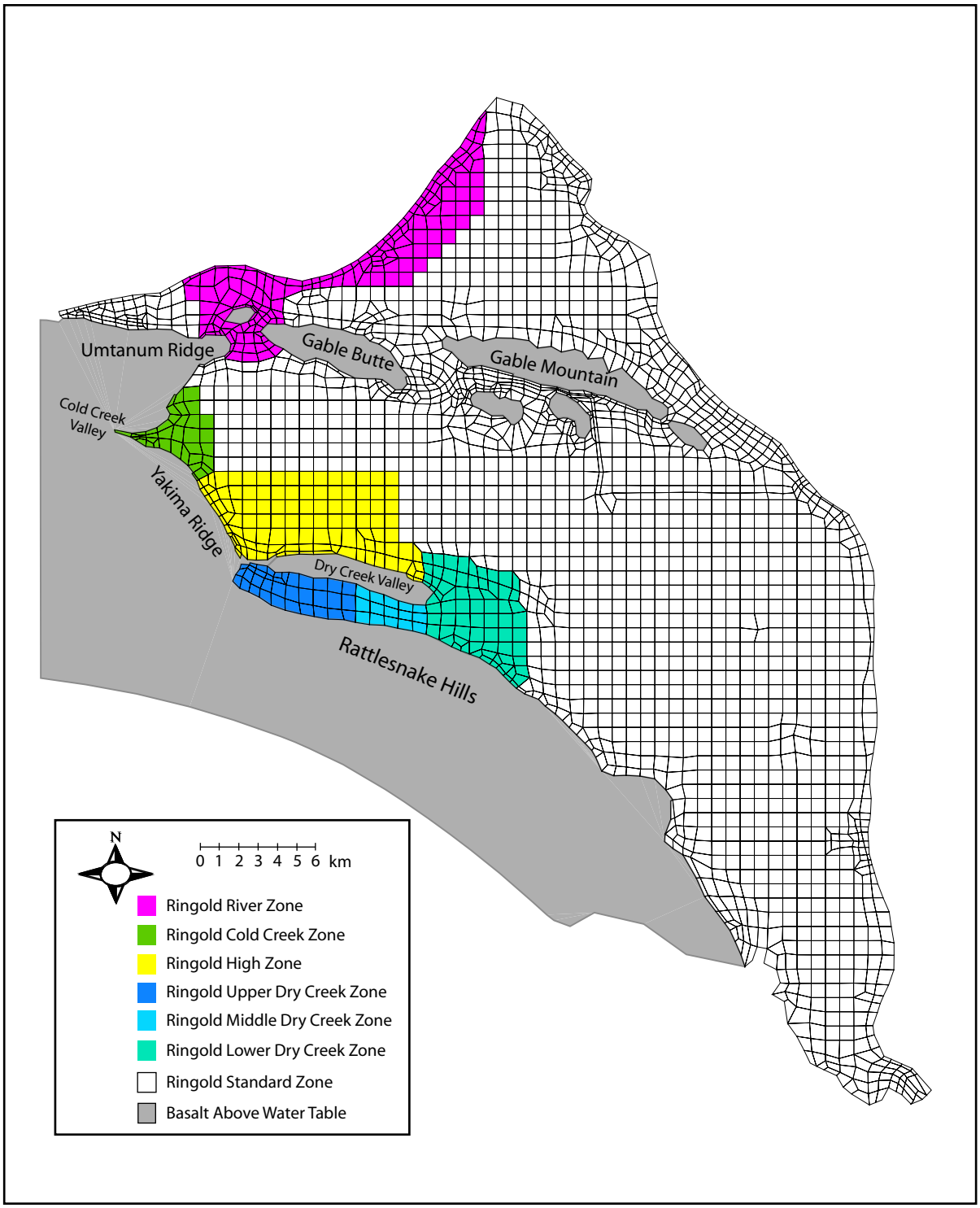

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Figure 4.1-2. Facies Zones Defined for Alternative Conceptual Model 2, Unit 5

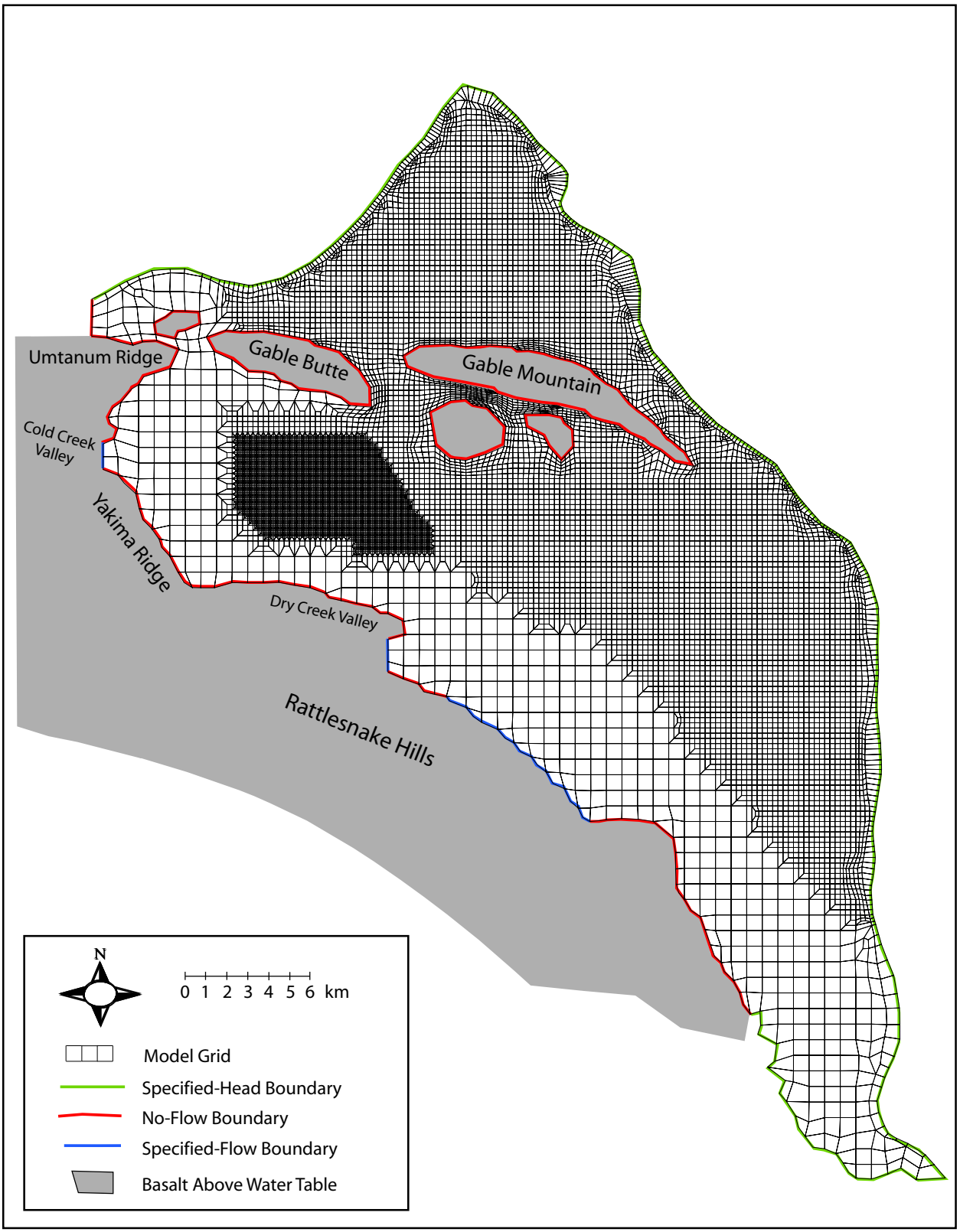

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Figure 4.2-1. Updated System Assessment Capability (SAC) Model Grid

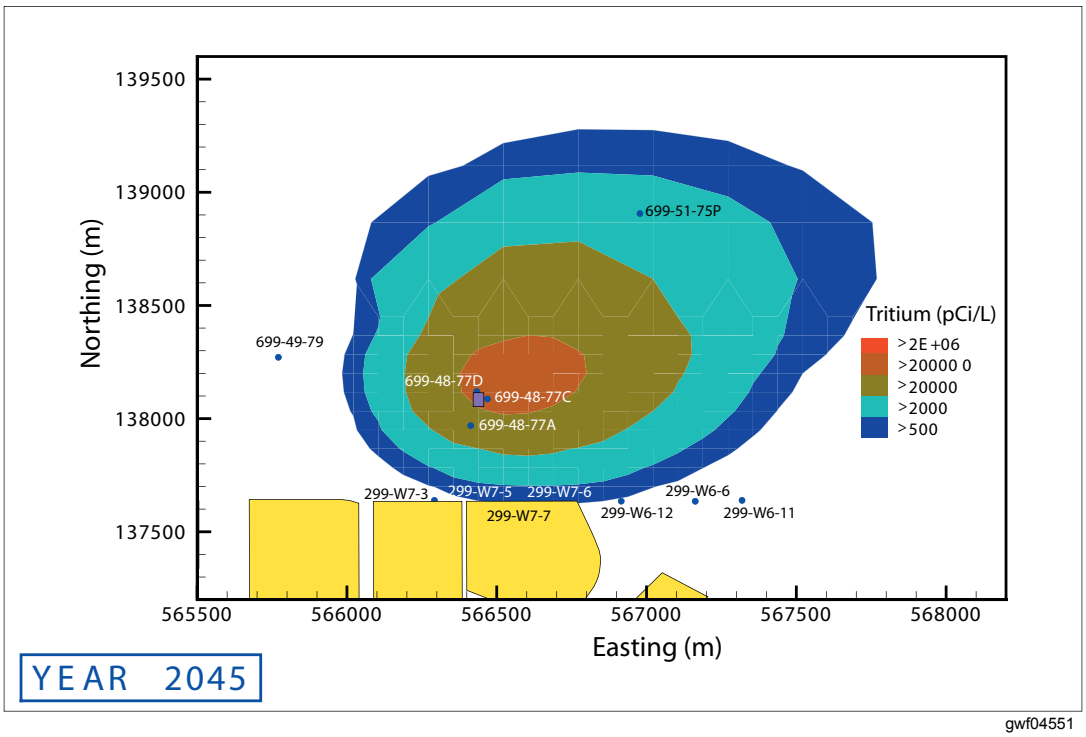

Figure 4.3-1. Simulated Tritium Plume at the State-Approved Land Disposal Site for 2045

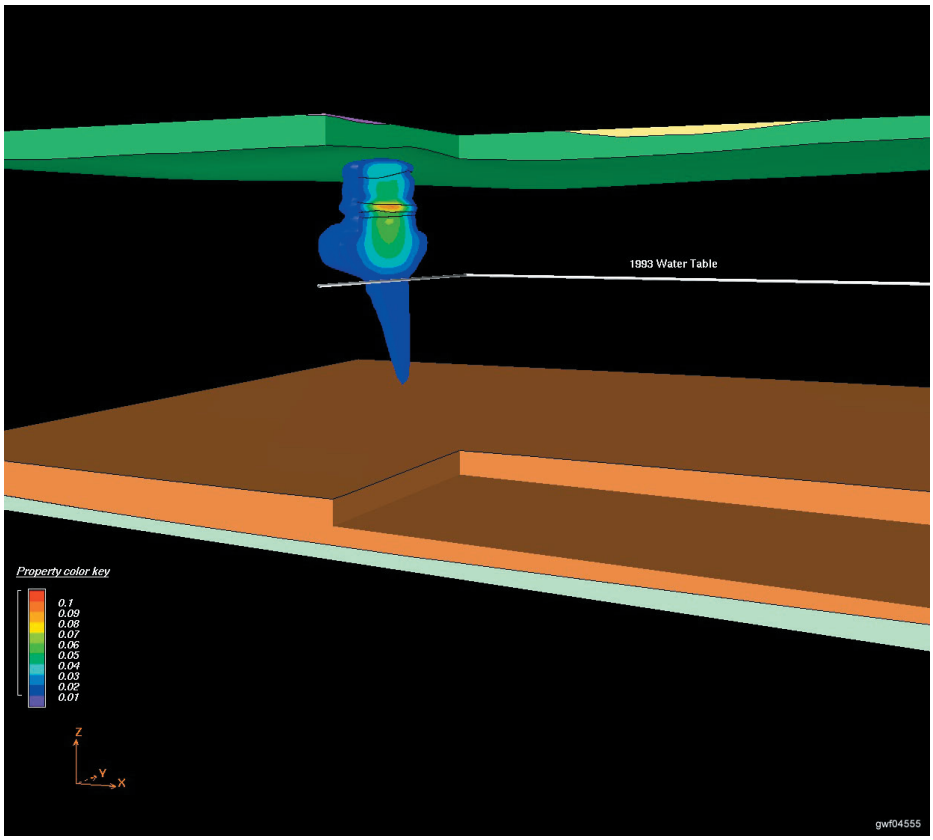

Figure 4.4-1. Simulated Saturation of Dense, Non-Aqueous Liquid at the 216-Z-9 Trench (after PNNL-14895)

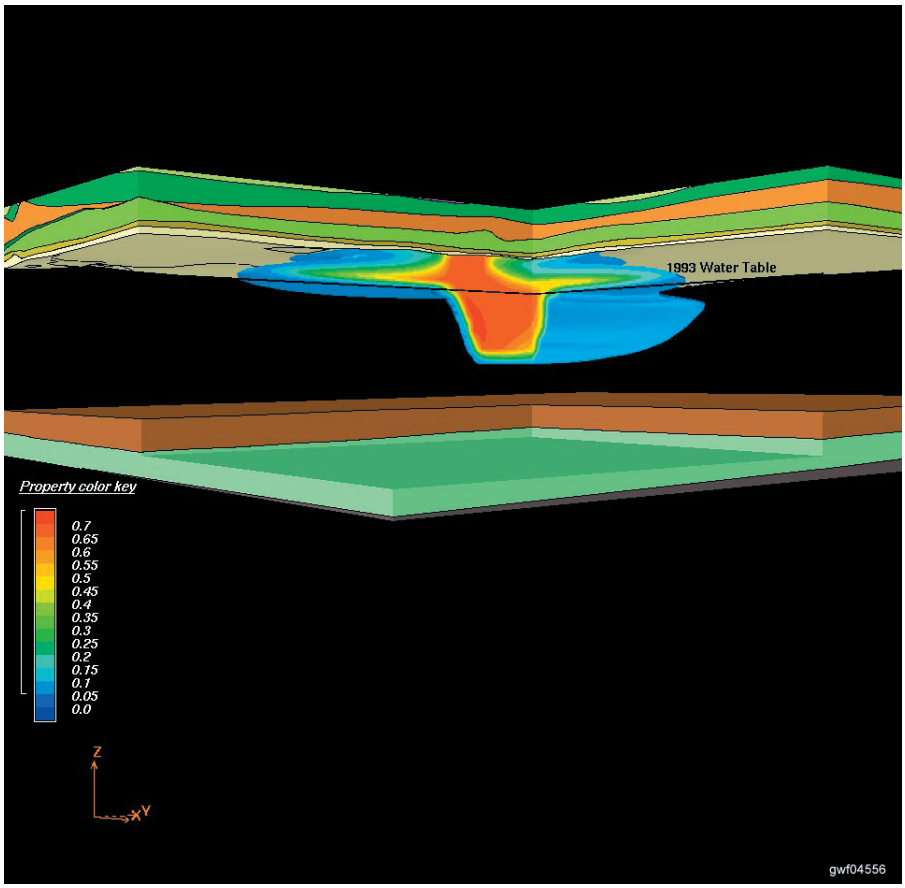

Figure 4.4-2. Simulated Carbon Tetrachloride Concentration in Water Within the Ringold Gravel for 1993 (after PNNL-14895)