MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

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TO: Sybil Kolon, Project Manager, RRD, Jackson District

FROM: Rick Mandle, Groundwater Modeling Specialist, RRD, Lansing

SUBJECT: Review of Fate and Transport Model – Pall Life Sciences Feasibility Study

The Groundwater Modeling Program (GMP) has completed its review of the model used to evaluate the fate-and-transport of the Unit E 1,4-Dioxane plume at the Pall Life Sciences (PLS) site. The model was developed by Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) of Kalamazoo, Michigan. The purpose of this model was to evaluate the impact of Interim Response Activities (IRAs), proposed in the Unit E Feasibility Study (FS) report, on the expected concentrations of 1,4-Dioxane at the Groundwater/Surface-Water Interface (GSI) at the Huron River. On the basis of model simulations, FTC&H determined that, with or without the proposed IRAs, the simulated concentrations of 1,4-Dioxane will not exceed Part 201 GSI Criteria (2,800 ug/L).

The WinTrans© model files for this site and the model documentation test in Appendix C of the FS were used to complete this review.

FTC&H Model

FTC&H used WinTrans© to simulate the fate and transport of the Unit E 1,4-Dioxane plume. WinTrans© simulates two-dimensional steady-state groundwater flow in unconfined or confined aquifer using an analytic element flow model and transient (changes with time) two-dimensional solute transport using a finite element model. This is an appropriate model to use for screening proposed remedial actions provided the field conditions are accurately represented by the groundwater-flow and solute-transport equations that are solved in the model.

<u>Model Assumptions:</u>

The following assumptions were made by FTC&H in developing this model:

- Only groundwater-flow and contaminant migration within the Unit E aquifer is simulated,
- The Unit E aquifer is assumed to be laterally extensive and present over the entire area between Maple Village and the Huron River,
- The groundwater-flow and contaminant migration processes within this aquifer are two-dimensional – there is no vertical exchange of groundwater or contaminant mass between the Unit E aquifer and overlying aquifers,
- The Unit E aquifer has a uniform thickness of 75 feet,
- The aquifer is assumed to be homogeneous and isotropic with a hydraulic conductivity of 100 feet/day,
- The horizontal hydraulic-head gradient between Maple Village and the Huron River is uniformly 0.00946 feet/feet,

- The initial concentration and distribution of 1,4-Dioxane in the Unit E aquifer for the transport simulations are represented by the isoconcentration map from the July-August 2003 sampling event,
- The 1,4-Dioxane concentrations are assumed to represent vertically-averaged concentrations,
- The assumed retardation factor for 1,4-Dioxane is 1.3,
- Longitudinal dispersivity is assumed to be one-tenth the delineated plume length, or 900 feet,
- Transverse dispersivity is assumed to be one-tenth the longitudinal dispersivity, or 90 feet,
- There is no decay or degradation of 1,4-Dioxane,
- The assumed diffusion coefficient is 0.000905 feet^2/day,
- The pumping rate for the proposed extraction well, PW- , is 200 gpm, and
- The injection rate for each of the two injection wells, IW-n and IW-s, is 100 gpm.

<u>Model Simulation Results</u>

The results of two IRA model simulations were presented in Appendix C, one having a single extraction well with two injection wells, and the second, in which there are no pumping or injection wells.

The capture effectiveness of the single extraction well was not documented in Appendix C. Nor, was there an evaluation of the impact of re-injecting treated groundwater on the contaminant plume. In the report text in Appendix B it is stated that it the groundwater flow rate through the contaminant plume area in the vicinity of Maple Village is 433 gpm. A pumping rate of 200 gpm was used in the extraction well simulation. This scenario was re-run by the GMP using the files provided by FTC&H. The results of this simulation show that the extraction well contains part of the known extent of the contaminant plume, allowing much of the plume to migrate in a downgradient direction, presumably to the Huron River.

The second simulation, without any extraction or injection wells, also where not provided in Appendix C. Re-running this scenario simply showed the unimpeded downgradient migration of the 1,4-Dioxane plume.

Model simulations performed by FTC&H showed that with or without an extraction well system, the concentrations of 1,4-Dioxane that are expected to reach the Huron River (approximately 150 to 200 ug/L) will be well below the Part 201 generic GSI criterion of 2,800 ug/L. However, the results show that the simulated 1,4-Dioxane concentrations for both scenarios will exceed the Part 201 Generic Drinking Water cleanup criteria (85 ug/L) over the entire distance between Maple Village and the Huron River.

Evaluation of FTC&H Model

<u>Model Assumptions</u>

As previously stated, WinTrans© is an appropriate model to use for evaluating the relative merits of one remedial action compared to others provided the model equations and assumptions fit the subsurface conditions at the site. WinTrans© assumes highly idealized, uniform subsurface conditions. At this site, the subsurface geology and the contaminant migration path are very complex and not well characterized, especially east of Maple Village.

The model input parameters used for these simulations were, for the most part, assumed with very few values based on field data. Also, there was no attempt to show that the values of the model input parameters were appropriate for the site. As an example, it would have been useful, and appropriate, for FTC&H to have attempted to simulate the delineated length and width of the 1,4-Dioxane plume between the source area and the area east of Maple Village to "calibrate" the model parameters that control the migration rate and extent of the contaminant plume. If they had done so, they would have discovered that their choice of dispersivity coefficients were not appropriate (too high) and overstate the degree of contaminant spreading in the aquifer.

The Unit E aquifer is assumed to be consistent and uniform between Maple Village and the Huron River. The presence, extent, thickness and hydraulic conductivity of the Unit E aquifer east of Maple Road is not well known, as there are very few borings completed in this area. The subsurface geology in the vicinity of Maple Village is very complex. The geology of the Unit E, and other aquifers, is likely just as complex east of Maple Road.

The hydraulic conductivity used in the model was 100 feet/day. The hydraulic conductivity used in the groundwater-flux calculations in Appendix B (307 feet/day) was based on the analysis of data from an aquifer test conducted in TW-16 at Maple Village. It's not clear why the latter value was not used in the model. Using the higher value of hydraulic conductivity would have resulted in less capture by the single extraction well and higher downgradient concentrations.

The direction of groundwater flow and the flow rate are based on a potentiometric surface map prepared by Fleis and Vandenbrink for a wellhead protection area delineation of the Montgomery well field for the City of Ann Arbor. This surface is only reasonably accurate for the Unit E aquifer, or equivalent, for the area upgradient of the Montgomery well field, the direction in which the wellhead protection area is located. There are no measured static-water-level elevations between the PLS monitoring wells and the Huron River to support the potentiometric surface contours or hydraulic gradients in this area. As a result, the assumed direction and rate of contaminant migration is not known. We assume that the plume migrates toward the Huron River; we just don't know where it may discharge to the river.

FTC&H used the distribution of 1,4-Dioxane determined during the July-August 2003 sampling event to represent the initial distribution of this chemical for the model. Assuming this delineation of the contaminant plume to be accurate, the isoconcentration map shows that the plume is relatively narrow with relatively-sharp concentration gradients along its north and south boundaries. This should indicate that the degree of transverse dispersion is relatively small. The same statement may be made, to some extent, with respect to longitudinal dispersion. We believe that the values of dispersivity used in this model (900 feet for longitudinal dispersivity and 90 feet for transverse dispersivity) are not reasonable for this aquifer. These values are based on "rules-of-thumb" approximations that assume that longitudinal dispersivity is approximately equal to one-tenth the plume length and the transverse dispersivity is approximately one-tenth the longitudinal dispersivity. Running the model with a contaminant released in the source area results in a plume width that is far too wide and not supported by the data presented to date. Using relatively-high values of dispersivity in the model also results in relatively-low predicted concentrations downgradient of Maple Village. Lower values of dispersivity will result in higher predicted 1,4-Dioxane concentrations downgradient of Maple Village.

In the vicinity of Maple Village, the highest detected 1,4-Dioxane concentration is slightly greater than 3,200 ug/L (MW-72d). The model does not assume a continuous source of 1,4-Dioxane to the Unit E aquifer, whether from the source area or from overlying aquifers. Once the main part of the contaminant plume has migrated through the aquifer, concentrations decline. This is the reason that the simulated concentration of 1,4-Dioxane at the Huron River shows a decrease after ten years from present conditions (see concentration versus time plot, found Appendix C). Concentrations higher than 3,200 ug/L will results in higher simulated concentrations downgradient of Maple Village and at the Huron River. A continuous source of 1,4-Dioxane to the Unit E aquifer will result in a "leveling-off" of concentrations rather than a continuous decline in concentrations.

Finally, the 1,4-Dioxane concentrations used in the model are assumed to represent the vertically-averaged concentrations over a 75-foot thick aquifer. FTC&H states that this assumption results in a conservative estimate of concentrations at the GSI. This only has impact on the simulation results at the GSI if there is vertical dispersion of the contaminant plume. That is, if we assume that there is not vertical dispersion, the same concentrations are calculated whether the plume is relatively-thick or relatively-thin. This is a two-dimensional model that is calculating concentrations at downgradient locations, not contaminant mass passing through these locations.

<u>Model Simulations</u>

The model simulations presented in Appendix C show that, with or without extraction wells, the simulated concentration of 1,4-Dioxane will not exceed the Part 201 generic GSI criterion for 1,4-Dioxane (2,800 ug/L) at the Huron River.

The model predictions are heavily dependent on the horizontal distribution and concentrations of 1,4-Dioxane used in the model, and the relatively high values of dispersivity used in the model. With these assumptions, both simulations presented in the FS report show that the Part 201 Generic Residential Drinking Water criterion for 1,4-Dioxane (85 ug/L) over the entire area between Maple Village to the Huron River. Using lower values for dispersivity and no contaminant retardation or decay, the simulated 1,4-Dioxane values will be even greater. It is not possible for the simulated 1,4-Dioxane concentrations to be lower than the Part 201 Generic Residential Drinking Water criterion for 1,4-Dioxane unless the contaminant plume is captured at Maple Village or if there is significant degradation of 1,4-Dioxane.

An analysis showing the impact of model assumptions or uncertainty in parameter values on the predictive simulations should have been performed. The result of this type of analysis would be a range of possible concentrations that would hopefully contain the correct concentration. This assumes that the model parameter values are varied over their entire range of uncertainty.

Conclusions

As a result of the many simplifying assumptions made in developing this model, the lack of model calibration or uncertainty analysis, the model simulations presented in the FS should be viewed as gross approximations and not necessarily accurate predictions of the fate of the 1,4-Dioxane plume. Also, since this model represents the groundwater flow system as a highly idealized single aquifer it is not likely that it can be used to accurately simulate the extraction well capture effectiveness or evaluate the impact of re-injecting treated groundwater on the contaminant plume.

You may contact me to discuss the model simulations at mandler@michigan.gov or (517) 241-9001.