Summary of Addendums and Respective GIA Changes to the IEPA February 2008 Application

January 2009 Addendum to the IEPA, Response to Draft Denial Points

- Revised horizontal gradients for the Lower Radnor Till Sand and Organic Soil groundwater models.
- Increased flow length for the Lower Radnor Till Sand groundwater model.
- Revised effective porosities.
- Upgraded liner design incorporated in the IEPA February 2008 Application is no longer considered in the Lower Radnor Till Sand and Organic Soil groundwater models. The groundwater models assume that a composite liner with 3 feet of compacted soil and a 60-mil HDPE liner is present, ignoring the double composite liner system and making the model extremely conservative.

The revised models with the changes discussed above demonstrate no impact to groundwater quality.

June 2009 Addendum to the IEPA, Response to Draft Denial Points

- Increased integration parameters in the Lower Radnor Till Sand and Organic Soil groundwater models.
- Upper Radnor Till Sand may extend below the northern half of the CWU, therefore the Upper Radnor Till Sand groundwater model is revisited to address IEPA concerns.

The revised models with the changes discussed above demonstrate no impact to groundwater quality.

August 2009 Addendum to the IEPA, Response to Draft Denial Points

- Integration parameters in the Lower Radnor Till Sand and Organic Soil groundwater models are increased again.
- As discussed above, the Upper Radnor Till Sand may extend below the northern half of the CWU, therefore an Upper Radnor Till Sand groundwater model is conservatively redeveloped for the CWU. It should be noted that in all of the groundwater models, the adsorption of PCBs is ignored in the liner and in-situ clays.

The revised models with the changes discussed above demonstrate no impact to groundwater quality.

September 2009 Addendum to the IEPA, Response to Draft Denial Points

- Upper Radnor Till Sand groundwater model is revised with a new Darcy velocity.

The revised model with the changes discussed above demonstrates no impact to groundwater quality.

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January 13, 2009

Stephen F. Nightingale, P.E.
Permit Section Manager
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794-9276

Re: 0390055036 – DeWitt County
Clinton Landfill No. 3
Log No. 2008-054
Responses to Draft Denial Points

Dear Mr. Nightingale:

Shaw Environmental, Inc. (Shaw) is submitting this response to comments received from the IEPA during the review of the application for the development of the Chemical Waste Unit (CWU) at Clinton Landfill No. 3. The following information responds to each of the groundwater impact assessment (GIA) and groundwater monitoring comments identified by the IEPA in the draft denial letter received on August 13, 2008. This submittal consists of 3 volumes. An original and 3 copies of this submittal are included.

Response to Comments

1. *IEPA Comment: Page 29 through 31 describe the site geology (Upper and Lower Radnor Sand and Organic Soil) based on borings and isopleths contained in another application (Log No. 2005-070), which was previously approved. The minimal requirements for a GIA require documentation of all input as part of the application. Such documentation of the site geology and site hydrogeology for the development of the conceptual model (e.g., borings, isopleths, and cross-sections) must be contained in the application.*

   Applicant Response: Documentation of the site geology and hydrogeology from Log No. 2005-070 (including borings, isopachs, and cross-sections) is provided in Attachment 1 of this submittal. The cross-sections are provided at the end of Attachment 1.

2. *IEPA Comment: Regarding the Upper Radnor Sand, the application states that it has a limited lateral extent, and will be "...removed from the landfill floor perimeter as shown on Drawings Nos. P-EX1 and P-EX2 (submitted previously under Log No. 2005-070). As stated above, a new GIA was not performed on this unit." Along with the cross-sections and isopleths, Drawings P-EX1 and P-EX2, documenting the removal of the Upper Radnor*

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Sand, must be provided as part of this application. Please note, if the Sand is removed from beneath the landfill, but still exists adjacent to the sidewall, it still must be modeled.

Applicant Response: Drawing Nos. P-EX1 and P-EX2 have been provided in Attachment 2. Additionally, Drawing 1 which shows the estimated extent of the Upper Radnor Till Sand compared to the proposed mass excavation grades is provided in Attachment 2. Drawing 1 indicates that the Upper Radnor Till Sand is only present below the far east side of the CWU base grades. As shown on previously submitted Figure 812.314-14 (provided in Attachment 2), the Upper Radnor Till Sand is mainly present in the southeast corner of Clinton Landfill No. 3 and at its highest elevation (653.9 feet (ft.) mean sea level (msl)) it is two feet below the lowest elevation of the CWU mass excavtion grades (located in the sumps at 656 ft. msl on the west side of the CWU). Therefore, the Upper Radnor Till Sand will not exist adjacent to the sidewall of the CWU and will not need to be modeled.

As mentioned in the February 1, 2008 submittal, the proposed design for the facility calls for the installation of a minimum, 20-foot wide cut-off trench to be installed at the toe of the landfill invert sidewalls to restrict lateral migration in the Upper Radnor Till Sand unit. The Upper Radnor Till Sand will be adjacent to the cut-off trench (keyway). The cut-off trench (keyway) was modeled for the MSW unit to determine if lateral migration of contaminants will occur through the keyway. For purposes of the MSW study, it was very conservatively assumed that complete liner failure had occurred and that full-strength leachate is present in the Upper Radnor Till Sand directly beneath the landfill invert. The maximum surrogate concentration at the downgradient edge of the zone of attenuation at the end of the 145-year assessment period predicted by the Upper Radnor Till Sand baseline model for the MSW unit was 2.929×10^{-4}. The maximum surrogate concentration at the downgradient edge of the zone of attenuation at the end of the 135-year assessment period predicted by the Upper Radnor Till Sand baseline model for the MSW unit was 1.585×10^{-4}. Using this same assumption for the CWU would result in the same results as this model essentially neglects the effect of the landfill liner.

3. *IEPA Comment: The Agency does not concur with the wells used for the gradient calculations in the Lower Radnor Sand. EX-4 should be substituted for EX-15, based upon flow direction. Further, the Agency could not duplicate the gradient calculations between EX-7 and EX-15. Agency calculations between EX-4 and EX-7 indicate a mean of .009, as opposed to the mean of .007 provided in Table 812.314-9. However, since the model used a more conservative gradient of .01, no change to the model will be required. The calculations and Table should be updated.*

   Applicant Response: The gradients for the Lower Radnor Till Sand have been revised and are based on monitoring wells EX-4 and EX-7, as per the IEPA's request. The revised gradient table is provided in Attachment 3 which provides model documentation.

4. *IEPA Comment: The Agency does not concur with the gradient calculated for Upper Radnor Sand. Wells EX-22S and EX-23S should be used for the calculations, rather than EX-21S and EX-23S. Except for 1 quarter, EX-22S is not perpendicular to the potentiometric lines, whereas, G22S is always in the direct line of flow. Further, EX-22S to EX23S yields a more*

conservative result, (e.g., 0.011 for the first quarter, as opposed to the calculated .0078). The calculations and Table should be updated.

Applicant Response: The gradients for the Upper Radnor Till Sand have been revised and are based on monitoring wells EX-22S and EX-23S, as per the IEPA's request. The revised gradient table is provided in Attachment 3.

5. *IEPA Comment: The Agency does not concur with the gradient calculated for Organic Soil. Wells EX-14 and EX-20 should be used for the calculations, rather than EX-24 and EX-20. EX-24 to EX-20 is not perpendicular to the potentiometric lines. Further, EX-14 to EX20 yields a more conservative result. The calculations and Table should be updated. Also, this change will affect horizontal Darcy Velocity in the model.*

   Applicant Response: The gradients for the Organic Soil have been revised and are based on monitoring wells EX-14 and EX-20, as per the IEPA's request. The revised gradient table is provided in Attachment 3.

6. *IEPA Comment: The conceptual potentiometric map for the Lower Radnor Sand groundwater flow direction, which determines landfill length in the model was based on 2003-2007 groundwater level averages. This data was not provided. Groundwater flow is shown to be to the west southwest. However, 3 of the 4 current (2007) potentiometric maps show the flow to the southwest. This difference is significant in terms of how landfill length is developed, as the current data would indicate a landfill length along a diagonal from the northeast corner to the southwest corner. This would yield a greater landfill length, than what is currently conceptually represented.*

   Applicant Response: Revised hydrogeologic models for the Lower Radnor Till Sand and the Organic Soil have been provided in Attachment 3. This revised hydrogeologic model for the Lower Radnor Till Sand indicates a greater landfill length along a diagonal from the northeast corner of the CWU to the southwest corner of the CWU. This increased flow length is incorporated into the revised groundwater model for the Lower Radnor Till Sand.

7. *IEPA Comment: The information provided in Attachment 13 is not adequate documentation for layer thicknesses input into the models. Only calculations (division of volumes) were provided in this attachment; there was no information as to how the volumes were derived. If modeling was used to determine the volumes, the following information must be included: all model input and output, as well as discussion and documentation of all model input.*

   Applicant Response: In order to calculate the average thickness of the clay fill and Berry Clay/Radnor Till above the Lower Radnor Till Sand, the surfaces of the compacted clay liner subgrade and top of Lower Radnor Till Sand were modeled in a digital terrain model (DTM). The DTM software (AutoDesk Land Desktop Release 3) was used to create these surfaces. The Civil Design module of the DTM software was then used to calculate the volumes between the surfaces for the compacted clay liner subgrade and top of Lower Radnor Till Sand. In the previous submittal (February 1, 2008), the average thickness was obtained by dividing these volumes (by calculator) by the surface area of the compacted clay liner subgrade. In this submittal, a revised average thickness was calculated using AutoCad and the Composite Method, which is considered a more precise way of calculating the average. The revised average thickness of clay fill and Berry Clay/Radnor Till from the compacted clay liner subgrade to the top of the Lower Radnor Till Sand is 22.77 feet (see Attachment 3 for the AutoCad print out for the revised average thickness). The same method discussed above was used to calculate the revised average thickness of clay fill between the compacted clay liner subgrade and top of the Berry Clay. The revised average thickness of clay fill between the compacted clay liner subgrade and top of the Berry Clay is 2.90 feet (see Attachment 3 for the AutoCad print out for the revised average thickness). In order to find the revised average thickness of the Berry Clay/Radnor Till above the Lower Radnor Till Sand, subtract 2.90 feet (revised average thickness of compacted clay fill) from 22.77 feet (revised average thickness of clay fill and Berry Clay/Radnor Till) to get 19.87 feet.

Isopachs for the clay fill and Berry Clay/Radnor Till combined and the clay fill are provided in Attachment 3. The isopach for the clay fill, by itself, indicates a maximum thickness of 10.0 feet and a minimum thickness of -4.0 feet. Clay fill thickness values of 0.0 feet and less are indicative of areas where the compacted clay liner is founded directly on the Berry Clay/Radnor Till unit. Negative clay fill thickness values, which are located near the lower elevations of the cell (i.e. near the leachate collection sumps), are indicative of areas where the upper portion of the Berry Clay/Radnor Till unit will be excavated to reach the compacted clay liner subgrade elevation. The isopach for the clay fill and Berry Clay/Radnor Till combined, indicates a maximum thickness of 32.0 feet and a minimum thickness of 16.0 feet. Once again, the minimum thickness is located in the sump areas of the CWU. This minimum thickness does not include the clay fill which is not present in the sump areas. A disc containing all of the AutoCad files is provided in Attachment 3.

It should be noted that as part of a response to the IEPA design draft denial points (to be submitted under a separate cover), the liner grades have been slightly modified since development of the GIA responses and the GIA presented in this response. While the liner grades were slightly modified, the sump elevations have not changed but the leachate pipe slope has increased. The modified liner grades did not change the maximum and minimum thickness of the clay fill and the Berry Clay/Radnor Till thicknesses discussed above, but do increase the average thickness of the clay fill and the Berry Clay/Radnor Till discussed above. With the average thickness of the clay fill and the Berry Clay/Radnor Till increasing with the modified liner grades, it was determined that the thicknesses calculated prior to the liner modification would conservatively be used for the GIA responses and GIA presented in this response.

As mentioned above in the response to IEPA Comment No. 6, revised hydrogeologic models for the Lower Radnor Till Sand and the Organic Soil have been provided in Attachment 3. The thickness information has be updated on these hydrogeologic models.

8. *IEPA Comment: The application (pages 32 and 33) states that the average thicknesses of the Lower Radnor Sand and Organic Soil are 2.8 feet and 3.42 feet, respectively, based on boring data submitted in a previous application 2005-070. This information must be provided with the application.*

Applicant Response: Table 812.316-1 from Log No. 2005-070 is provided in Attachment 3. Table 812.316-1 provides the average, maximum, and minimum thickness for the Lower Radnor Till Sand and the Organic Soil.

9. *IEPA Comment: The application states that site-specific total porosities were developed by laboratory testing. These laboratory test results should be provided in this application.*

   Applicant Response: The laboratory test results used for the development of site-specific porosities are provided in Attachment 3.

10. *IEPA Comment: The applicant states that the mean total porosity for the recompacted clay liner is 0.288 and this value is input into the model. Similarly, the measured total porosity for the Barry Clay of 0.286 was input to the model. There is no justification for these input: page 35 states (and the Agency agrees) that effective porosity is less than total porosity. The model requires effective porosity input. Therefore, porosity input should be a fraction of the total porosity.*

    Applicant Response: Table 812.314-2 which is provided in Attachment 3, has been revised to include estimated effective porosities. The estimated effective porosities were based on Sara, M. N. (1994). "Standard Handbook for Solid and Hazardous Waste Facility Assessments", Lewis Publishers, U.S., Page 5-57. The Sara 1994 text describing the different soil types and their respective total and effective porosities is also provided in Attachment 3. Based on the reported total and effective porosities for each soil type, a table was created that presents the percentage difference between the total and effective porosity for each soil type (See Attachment 3). The average percentage sand, silt, and clay values calculated for the Roxanna/Robein Member (used for the Organic Soil due to similar characteristics), Berry Clay, and Radnor Member were used to determine the USDA Soil Classification for each soil so they could be applied to the total and effective porosity table presented in Sara 1994. The respective soil types were Roxanna/Robein Member (Organic Soil)(silt loam), Berry Clay (clay), and Radnor Member (clay loam). The liner and clay fill will be built using a clay loam, therefore the liner and clay fill values were adjusted in the same manner as the Radnor Member. The Lower Radnor Till Sand was adjusted by the percentage difference between the total and effective porosity for the sand listed in the Sara 1994. With the USDA soil classification of each modeled layer determined, Table 812.314-2 was revised to include a column for estimated effective porosity. The liner and clay fill, Roxanna/Robein Member (Organic Soil), Berry Clay, Radnor Member, and Lower Radnor Till Sand had average estimated effective porosities of 0.24 (0.29 - 0.29 x 0.159), 0.40 (0.41 – 0.41 x 0.030), 0.26 (0.33 – 0.33 x 0.189), 0.21 (0.25 – 0.25 x 0.159), and 0.38 (0.40 – 0.40 x 0.046), respectively. The Berry Clay/Radnor Till are combined as a layer in the groundwater models and have a combined effective porosity of 0.24. As one would expect, due to the shape and size of the soil particles, the percentage difference between the total and effective porosities was higher in the clay loam and clay than in the sand and silt loam. Additionally, maximum and minimum estimated effective porosities were also created for the modeled unconsolidated deposits and will be evaluated in the sensitivity analyses discussed in Attachments 4 and 6 of this submittal.

11. *IEPA Comment: It cannot be determined if an effective porosity of 0.05 for the Lower Radnor Sand is representative. There is no section in this application that provides a detailed discussion of the site-specific geology, so it is unknown how much, if any, silt is in this sand unit. As no cross-sections are provided, it cannot be determined from the few boring logs included with the application what units are represented at what depth. Assuming that the Lower Radnor Sand unit is primarily sand, the effective porosity of 0.05 is too low. "Contaminant Transport in Groundwater" a chapter by Mercer and Waddell in Handbook of Hydrology, Maidment (1993), indicates an effective porosity for sand is 0.2. Other sources indicate a range from 0.1 to 0.55.*

    Applicant Response: A revised value (0.38) for the effective porosity of the Lower Radnor Till Sand has been provided in Attachment 3. Maximum (0.52) and minimum (0.24) effective porosities were also estimated for the Lower Radnor Till Sand and were used in sensitivity runs that are discussed in Attachments 4 and 6 of this submittal.

12. *IEPA Comment: The application is not consistent in the description of the witness zone design: in the conceptual model (Attachment 13) it is described as geocomposite, yet in the Attachment 14 calculations and HELP modeling a geonet is represented. In the Drawings (e.g. D8, the notations indicate that either geocomposite or geonet will be used). The scenario modeled is the only design that would be allowed by permitting. The application must specify the materials to be used in liner design and that scenario must be represented in calculations and modeling.*

    Applicant Response: The vertical seepage velocity used in the groundwater models has been revised (see IEPA Comment No. 13 below). The revised vertical seepage rate is based on the very conservative assumption that only the bottom 60-mil HDPE geomembrane exists, and ignores the effect of the overlying geomembrane and geocomposite drainage layer.

    Only a geocomposite will be used for the single layer witness zone under the entire CWU, as shown on Design Drawing D7. The revised HELP model modeled the geocomposite by calculating the equivalent hydraulic conductivity from required transmissivities listed in the CQA plan and associated specifications. All other HELP model parameters were considered to be the same as the HELP model default parameters for a geonet.

13. *IEPA Comment: Calculations for seepage through the liner in Attachment 14 yield a seepage rate, 1.42 x 10-7 m/y, that is approximately 3 orders of magnitude too low. The conceptual model assumes a constant head for the life of the facility + post-closure + 70 years. The most conservative seepage rate from that period of time must be used, and is usually based on seepage from the cumulative maximum leachate head from the 100 year period. The Attachment 14 calculations fail to take this into consideration: The Step 2 ymax (the daily maximum) of 0.0003 in. (0.00001 m.) cannot be used to represent the entire modeling period, as it has been used in Step 3 to develop the seepage rate. In Step 2, it first must be demonstrated that the daily max is static for active life and the 30 year post-closure period while leachate is actively removed. If so, then head for the 70 year period after closure must be calculated (e.g., .00001 m x 365 d + .00001 m x 365 d x 70 y = .26*

m). If the daily max from the active life and post-closure period is not static, any additional accumulation greater than .00001 (for the active life and 30 year post-closure period) must be added to the .26 m. This value of (.26 m or greater) would then be used in Step 3 to develop seepage. (If leachate is to be extracted for the entire modeling period, financial assurance for 100 years after closure must be provided.)

Applicant Response: The previously submitted model accounted for the significantly reduced vertical seepage velocity that would occur through the double composite liner system versus that which would occur through a single composite liner system typical of municipal solid waste landfills. The reduction in vertical seepage velocity results from the decreased hydraulic head acting on the bottom liner of the double composite liner system. The HELP model has been revised in response to IEPA Comment Nos. 23, 24, and 25, and assumes leachate is not extracted following the 30 year post-closure period. The effect of that the double composite liner system has on reducing the hydraulic head on the bottom liner is demonstrated by reviewing the revised HELP model output (refer to Attachment 10). The revised HELP model predicts the maximum hydraulic head (i.e. ymax) on the bottom liner at 0.0051 meters (0.20 inches). Regardless, in order to be very conservative, the vertical seepage velocity value used in the revised groundwater models is based on an assumed constant hydraulic head of 0.3048 meters (12 inches) on the bottom liner. The revised vertical seepage velocity calculation is provided in Attachment 3. The revised vertical seepage velocity is 3.08×10^{-4} m/yr. The revised vertical seepage velocity is approximately three orders of magnitude higher than the previously submitted vertical seepage velocity of 1.42×10^{-7} m/yr, and 40 times higher than that calculated using the maximum head from the revised HELP model.

14. *IEPA Comment: At this time, the Agency cannot agree to the horizontal Darcy velocities calculated for the Lower Radnor Sand and Organic Soils until gradient questions are resolved.*

    Applicant Response: As discussed above, the gradients for the Lower Radnor Till Sand and Organic Soil have been revised, as per the IEPA's request. The revised gradient table is provided in Attachment 3 which provides model documentation. The revised Darcy velocities for the Lower Radnor Till Sand and Organic Soil are discussed in Attachments 4 and 6 of this submittal.

15. *IEPA Comment: The Agency does not concur with the calculated "transverse" dispersivities for the following reasons: Gelhar should be used to determine transverse and vertical dispersivities, not 20% of the horizontal; vertical dispersivity is represented in the model, not transverse; and, vertical Darcy velocity is so low, that vertical dispersivity will be diffusion dominated.*

    Applicant Response: The transverse dispersivities have been revised and are addressed in Attachments 4 and 6 of this submittal.

16. *IEPA Comment: Although the correct equation was used calculating hydrodynamic dispersion, there are questions regarding gradient and effective porosity in the Lower Radnor Sand, and gradient in the Organic Soil. If changes are made to these parameters,*

resulting in different horizontal Darcy velocities, hydrodynamic dispersion will have to be recalculated.

Applicant Response: As mentioned earlier, the gradients for the Lower Radnor Till Sand and Organic Soil have been revised. Additionally, estimated effective porosities for all of the modeled layers have been determined. Therefore, new hydrodynamic dispersion values have been calculated and are discussed in Attachments 4 and 6 of this submittal.

17. *IEPA Comment: The Agency does not concur with the vertical dispersion. Vertical velocities are so low, vertical dispersion will be diffusion dominated. Further, vertical dispersivity was incorrectly determined. The vertical dispersion coefficient should reflect the diffusion coefficient.*

Applicant Response: The vertical dispersion has been revised and is addressed in Attachments 4 and 6 of this submittal.

18. *IEPA Comment: If the facility will be accepting PCBs at concentrations up to 500 mg/L (500,000 ug/L), 500,000 ug/L should be represented in the model, not 100 ug/L. The normalized leachate concentrations, multiplied by 500,000 ug/L, then compared to the AGQS in the revised models.*

Applicant Response: It appears that the text in the February 1, 2008 submittal may have not been clear on the type of PCB waste that will be accepted at the site. The CWU will accept PCB solid wastes exhibiting a total concentration no greater than 500 milligrams per kilogram (mg/kg) PCBs. The bulk of the PCB wastes anticipated to be disposed at the CWU will consist of PCB-contaminated soils and/or sediments. The facility will not accept liquid PCB wastes. PCBs are virtually insoluble in water and, therefore exhibit very low mobility. As a result, PCB concentrations in leachate will be much lower than their total concentrations in the landfilled wastes. As mentioned in the February 1, 2008 submittal, leachate data from two USEPA-permitted Chemical Waste Landfills that accept PCB waste were acquired via the Freedom of Information Act (FOIA). These two facilities, Wayne Disposal, Inc. (WDI) located in Michigan (USEPA Region 5) and Clean Harbors Grassy Mountain Facility located in Utah (USEPA Region 8) are also permitted as RCRA Subtitle C landfills. The leachate data from the facilities were reviewed and summarized. The WDI facility leachate data (monthly data from 2005 to 2007) indicated that PCBs were detected in only 7 of 231 samples analyzed for PCBs. The highest concentration of PCBs detected was 5.6 parts per billion (ppb). The Grassy Mountain facility leachate data (semi-annual from 2001 to 2007) indicated that PCBs were detected in only 2 of 1,575 samples analyzed for PCBs. The highest concentration of PCBs detected at this facility was 1.48 ppb. CLI notes that both of these facilities are allowed to dispose PCB wastes exhibiting concentrations greater than 500 ppm.

In addition to the leachate data discussed above, the Clinton Landfill No. 2 leachate data from 1995 to present was reviewed for PCB concentrations. Clinton Landfill No. 2 accepts a variety of PCB-wastes, notably auto shredder fluff. There is no limit to the PCB concentrations in the auto shredder fluff which can be accepted. A review of the Clinton Landfill No. 2 leachate data from 3rd quarter 1995 through 2nd quarter 2008 indicates a single reported detection (L302E at 200 ppb during the May 24, 2001 sampling event) from the 66 samples analyzed for PCBs. With the exception of that sample, all other results (including subsequent results from L302E) were reported as not detected with detection limits ranging from 0.5 to 10 ppb. Based on this review, it is apparent that the single reported detection of PCBs in leachate samples from the Clinton Landfill No. 2 is an outlier and not representative of actual PCBs in leachate. Regardless, this value has been used for the PCB leachate concentration in the revised prediction tables in attachment 5. Additionally, the pentachlorophenol value presented in the previously submitted prediction tables seemed very high (1,000 *ug/l*). The 1,000 *ug/l* value was determined off of a high detection limit (100 *ug/l*) and was not based on any detections. Therefore, the Clinton Landfill No. 2 leachate data from 1995 to present was reviewed for detected concentrations of pentachlorophenol. The highest detected value was 0.76 *ug/l*. Based on this data, it appears that using the high detection limit (100 *ug/l*) is more than conservative. Therefore, this value has been used for the pentachlorophenol leachate concentration in the revised prediction tables in attachment 5.

19. *IEPA Comment: The model input for vertical velocity in the Sand units of both models is set to "0". There is no discussion within the text justifying this input. Vertical velocity should be consistent throughout the model layers unless it can be shown that an upward gradient exists.*

    Applicant Response: The groundwater models have been revised and the vertical velocity has been updated as requested by the IEPA. The revised groundwater models are provided in Attachments 4 and 6.

20. *IEPA Comment: Well spacing model input: For the Radnor Sand, dispersivity per Gelhar (1992) was said to be 44 ft and transverse dispersivity of 20 % of this value is 9 ft. These values are extremely high and unsupported by the sited document (Gelhar, 1992). Based on Gelhar text and Figure 3, horizontal dispersivity for 50 feet (15 m) is approximately 1 meter or 3 feet. Transverse dispersivity should be an order of magnitude less, or .3 feet. However, dispersivity should be determined by the entire flow length considered (50 feet + sidewall + distance to MAPC wells = 80 m). Based on 80 m and Gelhar, for the Radnor Till, horizontal and transverse dispersivity should be approximately 10 ft and 1 ft respectively. For the Organic Soil, they should be 7 ft and .7, respectively.*

    Applicant Response: A Monitoring Well Efficiency Model (MEMO) was created for both the Radnor Till Sand and the Organic Soil to evaluate the proposed monitoring well network adjacent to the CWU (refer to Attachment 8). As a result of the incorporation of the IEPA recommended dispersivity values, it was necessary to add an additional monitoring well nest along the western edge of the proposed CWU (G58) and to adjust the location of one of the previously proposed monitoring well nests (G47) in order to achieve an efficiency greater than 99.0%. The resulting calculated monitoring efficiencies were 100.0% and 99.0% for the Radnor Till Sand and Organic Soil, respectively. Additionally, as discussed in the response to IEPA Comment No. 22 below, proposed monitoring well nest G52 will be installed concurrent with the beginning of operations in the CWU.

The Monitoring Well Phasing Plan, which was previously provided within Attachment 20 of the February 1, 2008 submittal, has been updated and is provided within Attachment 9 of this response. Additionally, a revised Groundwater Monitoring Plan (Drawing No. P-GWMP) is also provided within Attachment 9.

21. *IEPA Comment: The application proposes to monitor only the 811 list, stating that the G1 list is representative of liner failure. This is true for only the MSW units, not the CWU. PNAs and PCBs are representative of the CWU waste, but are only proposed for monitoring if they are detected in leachate. This is not appropriate. The application should propose a monitoring schedule for the following parameters of concern in the downgradient CWU unit wells: PCBs, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthrene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Pentachlorophenol, Dibenzo(a,h)anthracene, Fluoranthrene, Ideno (1,2,3-cd)pyrene, Phenanthrene and Pyrene.*

    Applicant Response: Groundwater from monitoring wells adjacent to the CWU and identified on the revised Groundwater Monitoring Plan (Drawing No. P-GWMP) will be analyzed for PCBs, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthrene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Pentachlorophenol, Dibenzo(a,h)anthracene, Fluoranthrene, Ideno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene on a semi-annual basis in addition to the previously proposed G1 and G2 lists. The G2 list for the CWU monitoring wells has been revised to include the additional parameters and is included within Attachment 10 of this response.

22. *IEPA Comment: Review of the potentiometric maps, particularly the Lower Radnor Sand, indicate that the following wells should be included in the CWU phasing plan: G52M, G52D, G52R, G53M, G53D and G53R.*

    Applicant Response: As discussed within the response to IEPA Comment 20, the G52 well nest will be phased in with the CWU and will be monitored per the schedule and parameter list provided within Attachment 10 of this response. The G53 well nest is not proposed to be included within the CWU monitoring network as it is up- and/or side-gradient with respect to groundwater flow from G52. The MEMO models which have been created for both the Upper Radnor Till Sand and the Organic Soil both achieved efficiencies of 99.0% or greater without the inclusion of the G53 well nest.

23. *IEPA Comment: The final water volume from the 8th intermediate cover run was not input as the initial water content in the 30 year closure run for all layers. Specifically, Layers 12 and 14 from the last intermediate cover run correspond to Layers 10 and 12 in the 30 year closure run; however, the final water volume from the 8th intermediate run were not reflected as the initial soil water content in the 30 year closure run. This should be revised and the 30 year closure and 70 year post-closure period models should be re-run.*

    Applicant Response: The HELP model has been revised based on the IEPA design and groundwater comments. The revised HELP model results are provided in Attachment 10.

24. *IEPA Comment: The 70 year post-closure period HELP runs could not be completely reviewed. It appears that it was a 2-sided document that was only copied as 1-sided (e.g., every other page is missing).*

    Applicant Response: The HELP model has been revised and a complete copy is provided in Attachment 10.

25. *IEPA Comment: During the final 70 years, the leachate collection system is not operational; however, in the 70 year post-closure period HELP run, the lateral drainage layer, 14, is still active. (The page showing the input for the other lateral drainage layer, 10, is missing; however, it would appear from the daily values report that it had been converted to a vertical percolation unit.) Drainage layer 14 should be converted to a vertical percolation unit and the model re-run.*

    Applicant Response: The HELP model has been revised based on the IEPA comments. The revised HELP model results are provided in Attachment 10.

We look forward to working with the IEPA to resolve all the of IEPA concerns with this permit application in a timely manner. If you have any questions, please contact me at (630) 762-1400.

Sincerely,

Shaw Environmental, Inc.

Jesse Varsho, P.E., P.G.
Geological Engineer

cc: George Armstrong, PDC Technical Services, Inc.

June 24, 2009

Stephen F. Nightingale, P.E.
Permit Section Manager
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794-9276

Re: 0390055036 – DeWitt County
Clinton Landfill No. 3
Log No. 2008-054
Responses to Draft Denial Points

Dear Mr. Nightingale:

Shaw Environmental, Inc. (Shaw) is submitting this response to comments received from the IEPA during the review of the application for the development of the Chemical Waste Unit (CWU) at Clinton Landfill No. 3. The following information responds to each of the groundwater impact assessment (GIA) and groundwater monitoring comments identified by the IEPA in the draft denial letter received on May 5, 2009. This submittal consists of 1 binder. An original and 3 copies of this submittal are included.

Response to Comments

1. *IEPA Comment: Reviews of the models indicate some negative values in the results. Default Talbot and Gaussian integration parameters were used and no sensitivities were found for them. These inputs should be altered to attempt elimination of the negative values.*

   Applicant Response: Prior to establishing the baselines for the Lower Radnor Till Sand and Organic Soil models provided in the January 13, 2009 submittal, sensitivity analyses were performed on the integration parameters to try to eliminate the negative results discussed above. The sensitivity runs were not submitted to reduce the bulk of the January 13, 2009 response. As requested, sensitivity analyses for the integration parameters were performed for the Lower Radnor Till Sand and Organic Soil models and are provided in Attachment 1 of this submittal.

   Talbot parameters N and RNU were increased in both models from 11 to 30 and 1 to 3, respectively. As shown on the sensitivity analysis tables and output data provided in Attachment 1, the negatives values remained in both models and the final prediction factor for the Lower Radnor Till Sand did not change and the final prediction factor for the Organic

Soil model did not have a change of significance (1.02×10^{-12} to 1.40×10^{-12}), confirming the previously submitted results.

For the Gaussian integration parameters the number of steps was increased from 12 to 100 in the Lower Radnor Till Sand model and 100 to 200 in the Organic Soil model. The increase in the number of steps was applied to the sensitivity runs with the increased Talbot parameters N and RNU. As indicated in the sensitivity analysis tables and output data provided in Attachment 1, the negative values remained in both models and the final prediction factors for both models did not change, confirming the previously submitted results.

The sensitivity analyses performed for Talbot and Gaussian integration parameters indicate that the results provided in the January 13, 2009 submittal are valid and confirmed.

2. *IEPA Comment: The Illinois EPA disagrees that no further modeling is required for the Upper Radnor Sand. The groundwater flow is to the south-southwest or southwest in the Upper Radnor Sand according to the submitted potentiometric maps. There are no borings due west or southwest of EW-3, or between EX21 and EX-20 to establish the continuity or discontinuity of the Upper Radnor Sand. Given the flow direction, if the sand extends into these area, the cut-off wall, as shown, will not intercept flow in this direction. Either additional investigation for the extent of the Radnor Sand should be made, or the scenario without the cut-off wall should be modeled.*

Applicant Response: Additional exploratory borings have been advanced at the site to determine the presence or absence of the Upper Radnor Till Sand in selected locations between EX-3 and EX-20 and to the west of EX-3. A figure identifying the locations of the Upper Radnor Till Sand exploratory borings and boring logs for the respective boring locations are provided in Attachment 2. This figure also identifies the estimated extent and thickness of the Upper Radnor Till Sand where present. While it appears that the Upper Radnor Till Sand extends only into the northern half of the CWU, some concern remains over the possibility of the Upper Radnor Till Sand extending south between EX-7 and EX-20. Therefore, prior to construction of the CWU, three evenly spaced test pits or borings (approximately 125 feet apart) will be advanced to investigate the presence or absence of the Upper Radnor Till Sand. The test pits or borings will be located along the southern toe of the CWU southern side slope (See Figure 1 in Attachment 2). If the Upper Radnor Till Sand is found to be present in the pits or borings, the cut-off keyway will be extended 20 feet beyond the eastern and western extent of the Upper Radnor Till Sand at that location(s).

As discussed in the January 13, 2009 submittal, the cut-off trench (keyway) was modeled for the MSW unit to determine if lateral migration of contaminants will occur through the keyway. For purposes of the MSW study, it was very conservatively assumed that complete liner failure had occurred and that full-strength leachate is present in the Upper Radnor Till Sand directly beneath the landfill invert. The maximum surrogate concentration at the downgradient edge of the zone of attenuation at the end of the 145-year assessment period predicted by the Upper Radnor Till Sand baseline model for the MSW unit was 2.929×10^{-4}. The maximum surrogate concentration at the downgradient edge of the zone of attenuation at the end of the 135-year assessment period predicted by the Upper Radnor Till Sand baseline model for the MSW unit was 1.585 x 10^{-4}. Using this same assumption for the CWU would result in the same results as this model essentially neglects the effect of the landfill liner.

Table 1 located in Attachment 3, uses a prediction factor of 2.929 x 10^{-4} to assess the CWU parameters at their assumed leachate concentrations. Table one indicates that even with the assumed increased leachate concentrations for the CWU, the site will protect groundwater quality.

The input parameters and sensitivity analyses for the permitted Upper Radnor Till Sand model were reviewed to compare them to the Lower Radnor Till Sand model, which was submitted on January 13, 2009 and is addressed further in this submittal. The most significant input change was the value used for the estimated effective porosity for the sand. The permitted model used a value of 0.05, while the Lower Radnor Till Sand model used a value of 0.38 (as requested by the IEPA). The use of an estimated effective porosity of 0.05 is extremely conservative resulting in elevated prediction factors. Based on the conservative estimated effective porosity for the sand in the permitted model, the sensitivity analyses for the permitted model, and the fact that the permitted model essentially neglects the effect of the landfill liner, the Applicant is confident that the permitted model is effective in evaluating the CWU and that the permitted model (while extremely conservative) shows that the CWU design will protect groundwater quality.

3. *IEPA Comment: The applicant states that the entire landfill base was used along with the Xu and Eckstein equation to determine dispersivity. However, this does not appear to be the case as the horizontal dispersion is too great for the Lower Radnor Sand using that equation. For the contaminant transport modeling, horizontal dispersion in the Lower Radnor Sand is modeled as 19 m2/y. The Xu and Eckstein equation and the entire distance of the landfill base (369m), yields a dispersivity of 8.08m. Multiplying by the advective velocity of 1.63 m/y, the maximum dispersion that could be calculated is 13.17 m2/y. It appears that the GTC dispersion input is based on the Illinois EPA comments on the well spacing model, which were derived from Gelhar as the distance presented was less than 100 m (Xu & Eckstein equation may be used only when distances are greater than 100 m). The more conservative fo the values should be used for both models. Once a new baseline is established, sensitivities need only be performed for those parameters that showed increases in previous sensitivities.*

Applicant Response: Review of notes for the Lower Radnor Till Sand model indicate that the municipal solid waste landfill base length was inadvertently used to calculate the dispersivity value (11.7 m) for the Lower Radnor Till Sand model. The appropriate value for dispersivity of the CWU landfill base length is 8.08 m, as discussed above. The dispersivity values of 11.7 and 8.08 m result in horizontal dispersion coefficients of 19.1 and 13.17 m^2/yr, respectively. The use of an increased dispersivity value and horizontal dispersion coefficient results in a more conservative model. A sensitivity run was performed using a horizontal dispersion coefficient of 13.17 m^2/yr and a vertical dispersion coefficient of 1.317 m^2/yr (assumed to be ten percent of the horizontal dispersion coefficient). The output data, which is provided in Attachment 4, indicates that the prediction factor has decreased insignificantly from 3.07×10^{-6} in the previously submitted Lower Radnor Till Sand model to 2.36×10^{-6} in the sensitivity run provided in this submittal. Based on this sensitivity run, it has been determined that the Lower Radnor Till Sand model provided in the January 13, 2009 submittal is more conservative (as one would expect) and will result in higher predicted values not only for the baseline model but also for all previously submitted sensitivity runs for the Lower Radnor Till Sand. Therefore, the more conservative dispersivity value of 11.7 m and resulting horizontal dispersion coefficient of 19.1 m^2/yr will remain as input parameters in the baseline model.

It should be noted that the sensitivity runs performed to respond to IEPA Comment No. 1 above were based on the more conservative baseline model that was provided in the January 13, 2009 submittal.

4. *IEPA Comment: A new model, MEMO, was used for well spacing. This model requires different input (e.g., diffusion) than the model that was previously used, PLUME. The model input was reviewed. The dispersivity input are in question as has been discussed above. There is no justification for the diffusion coefficient of 0.689 ft2/yr (.064 m2/yr.). (The MIGRATE input is 0.0158 m2/yr.)*

   Applicant Response: The diffusion coefficient of 0.689 ft^2/yr (0.064 m^2/yr) was used as it is the "free solution" diffusion coefficient for chloride at infinite dilution in water at 25° C (See Attachment 5). This value is typically used when evaluating the movement of a contaminant through a porous media.

   However, to address the IEPA concern, the MEMO models have been updated with a revised diffusion coefficient of 0.339 ft^2/yr (0.0315 m^2/yr). Freeze and Cherry 1979 discuss diffusion coefficients for major ions in groundwater and report diffusion coefficients ranging form 0.0315 to 0.0631 m^2/yr at 25° C. Based on this range and the diffusion coefficient for chloride (0.064 m^2/yr) discussed above, one could assume that diffusion coefficient for chloride is likely on the high end of reported range by Freeze and Cherry. With the geologic units being composed of sand and silt, it seems reasonable to use the low end of the range (0.0315 m^2/yr) for diffusion coefficients for major ions in groundwater.

   To further address this comment, the Applicant is proposing revised well nest locations along the southern edge of the CWU. Both models have been updated with the revised well nest locations along the southern edge of the CWU and were re-run. The resulting calculated monitoring efficiencies for both the Lower Radnor Till Sand and Organic Soil models are 100% and 99%, respectively. These efficiencies exceed Federal, State, and Local requirements. The revised MEMO models are included in Attachment 5. A revised Groundwater Monitoring Plan (Drawing No. P-GWMP) is also provided within Attachment 5.

5. *IEPA Comment: The new well locations and installation table, included in Attachment 9, may need revision based on revisions to MEMO.*

   Applicant Response: The Monitoring Well Phasing Plan, which was previously provided within Attachment 9 of the January 13, 2009 submittal, has been updated and is provided within Attachment 5 of this response. As discussed above, a revised Groundwater Monitoring Plan (Drawing No. P-GWMP) is also provided within Attachment 5.

6. *IEPA Comment: The application should propose the installation of the G53 nest, should the G52 nest experience organic detections that result in assessment.*

   Applicant Response: As previously indicated, the G53 well nest has not been proposed to be included within the CWU monitoring network as it is up- and/or side-gradient with respect to groundwater flow and the CWU. Additionally, the groundwater monitoring well spacing model passed without this location. Clinton Landfill, Inc. will propose appropriate assessment activities, possibly including installing and sampling wells at the G53 well nest location (and/or other appropriate locations) in the unlikely event that organic detections at the G52 well nest result in assessment.

We look forward to working with the IEPA to resolve all the of IEPA concerns with this permit application in a timely manner. If you have any questions, please contact me at (630) 762-1400.

Sincerely,

Shaw Environmental, Inc.

Dan Drommerhausen, P.G.
Senior Hydrogeologist

cc: George Armstrong, PDC Technical Services, Inc.

August 18, 2009

Stephen F. Nightingale, P.E.
Permit Section Manager
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1021 North Grand Avenue East
Springfield, Illinois 62794-9276

Re: 0390055036 – DeWitt County
Clinton Landfill No. 3
Log No. 2008-054
Responses to Draft Denial Points

Dear Mr. Nightingale:

Shaw Environmental, Inc. (Shaw) is submitting this response to comments received from the IEPA during the review of the application for the development of the Chemical Waste Unit (CWU) at Clinton Landfill No. 3. The following information responds to each of the comments identified by the IEPA in the draft denial letter received on July 21, 2009. This submittal consists of 2 binders. An original and 3 copies of this submittal are included.

Response to Comments

1. *IEPA Comment: The number of Gauss integration steps are still relatively low for both models. The number of steps should be increased at least to 300. If the change results in new concentrations in the baseline, sensitivities should be run again for those constituents that showed increases in the previous submittals.*

   Applicant Response: As discussed in the June 2009 submittal, Talbot parameters N and RNU were increased in both models from 11 to 30 and 1 to 3, respectively. The results indicated that the final prediction factor for the Lower Radnor Till Sand model did not change and the final prediction factor for the Organic Soil model did not have a change of significance (1.02×10^{-12} to 1.40×10^{-12}). While the Organic Soil model did not have a change of significance, it was determined that the Organic Soil baseline model would be re-run at 300 steps with Talbot parameters N and RNU at 30 and 3, respectively. The Organic Soil baseline model output and respective concentration versus time and distance plots are provided in Attachment 1. Additionally, sensitivity analyses for parameters that showed an increase in the previous submittals were re-run. A summary of the sensitivity analyses and respective output are also provided in Attachment 1.

The new prediction factor for the Organic Soil baseline model for the entire 134 year simulation period at the edge of the zone of attenuation is 1.85×10^{-12}. A revised prediction table for the Organic Soil is provided in Attachment 2. The prediction table indicates that the model predicted groundwater concentrations in the Organic Soil at the Zone of Attenuation (ZOA) do not exceed the Applicable Groundwater Quality Standard (AGQS) for each respective constituent at the CWU.

Thus, the proposed CWU design and site hydrogeologic characteristics are such that there will be no adverse impact on groundwater quality in the Organic Soil. Expected concentrations in the groundwater will actually be lower than those predicted in the Groundwater Impact Assessment (GIA) because of the overly conservative nature of the model.

The sensitivity analyses mentioned above for the Organic Soil resulted in satisfactory results for all of the sensitivity runs.

As discussed above, Talbot parameters N and RNU were increased in the Lower Radnor Till Sand model from 11 to 30 and 1 to 3, respectively. The results for the Lower Radnor Till Sand model indicated that the final prediction factor did not change. Therefore, the Lower Radnor Till Sand baseline model was re-run at 300 steps with Talbot parameters N and RNU at 11 and 1, respectively. Additionally, the Lower Radnor Till Sand baseline model was re-run using a horizontal dispersion coefficient of 13.17 m^2/yr and a vertical dispersion coefficient of 1.317 m^2/yr (assumed to be ten percent of the horizontal dispersion coefficient). The Lower Radnor Till Sand baseline model output and respective concentration versus time and distance plots are provided in Attachment 3. Sensitivity analyses for parameters that showed an increase in the previous submittals were also re-run. A summary of the sensitivity analyses and respective output are provided in Attachment 3.

The new prediction factor for the Lower Radnor Till Sand baseline model for the entire 134 year simulation period at the edge of the zone of attenuation is 2.36×10^{-6}. A revised prediction table for the Lower Radnor Till Sand is provided in Attachment 2. The prediction table indicates that the model predicted groundwater concentrations in the Lower Radnor Till Sand at the ZOA do not exceed the AGQS for each respective constituent at the CWU.

Thus, the proposed CWU design and site hydrogeologic characteristics are such that there will be no adverse impact on groundwater quality in the Lower Radnor Till Sand. Expected concentrations in the groundwater will actually be lower than those predicted in the GIA because of the overly conservative nature of the model.

The sensitivity analyses mentioned above for the Lower Radnor Till Sand resulted in satisfactory results for all of the sensitivity runs.

2. *IEPA Comment: A new baseline for the Lower Radnor Sand should be submitted to incorporate a decreased longitudinal and transverse dispersion (based on corrected dispersivity), Talbot N and RNU, and Gauss integration. New sensitivities need only be conducted for constituents that showed increases in the previous submittals.*

   Applicant Response: A new baseline model for the Lower Radnor Till Sand was discussed above in IEPA Comment No. 1. The new baseline model included a decreased longitudinal and transverse dispersion (based on a corrected dispersivity) and an increase in the number of steps to 300. As indicated in the response to IEPA Comment No. 1, the change in the Talbot N and RNU parameters have no affect on the Lower Radnor Till Sand model results. Therefore, no baseline model changes were made to these parameters. Sensitivity analyses for parameters that showed an increase in the previous submittals were also re-run.

3. *IEPA Comment: The application proposes to install a keyway extension if the Upper Radnor Sand is found during future investigation with test pits/borings along the southern boundary of the CWU unit. The applicant must either conduct the investigation prior to permit approval of the alternate design, or model the Upper Radnor Sand for the GIA, using the assumption that it exists in that area and a keyway will be installed.*

   Applicant Response: The Upper Radnor Till Sand has been modeled at the CWU, using the assumption that the Upper Radnor Till Sand exists at the southern end of the CWU and a keyway will be installed. As stated in the June 2009 submittal, at least three additional test pits or borings will be advanced along the southern edge of the CWU floor. The designed keyway will be installed if the Upper Radnor Till Sand is encountered, as described in the June 2009 submittal.

   The input values and documentation for the model are provide in Attachment 4. The following paragraphs discuss the input values for the Upper Radnor Till Sand baseline model and subsequent results and sensitivity analyses.

   Model Input

   Model Length

   Two (2) layers were modeled at the site: a 20-foot (6.096 m) wide keyway (cut-off wall) (1.0 x 10^{-7} cm/sec) and approximately 80 feet (24.38 m) of the Upper Radnor Till Sand (extending from the outer edge of the keyway to the ZOA and excluding the sidewall length). The permitted GIA for the Upper Radnor Till Sand included a sidewall length of 100 feet, conservatively the sidewall length has been excluded for this model.

   Because the model predicts contaminant transport through the keyway and out to the ZOA, the model length is the sum of the keyway thickness and the distance to the ZOA. The total model length is 100 feet (30.48 m). Although the model has been set up assuming an infinite bottom boundary, the model was evaluated at the ZOA.

Initial Leachate Concentration

The initial leachate concentration input used was one (1). This value is unitless because it represents unit leachate concentration of any given constituent. Therefore, the model results represent a fraction of the initial leachate concentration for any particular constituent.

Number of Layers

As discussed above, two layers were modeled at the site: a 20-foot (6.096 m) keyway and 80 feet (24.38 m) of the Upper Radnor Till Sand. POLLUTE also allows a layer to be subdivided so that the predicted concentration distribution within a layer can be evaluated.

The keyway and the Upper Radnor Till Sand were divided into 4 and 16 sublayers, respectively.

Modeling Period

The modeling period is the expected life of the landfill plus 100 years after closure. The expected life of the landfill has been conservatively estimated to be approximately 34 years, resulting in a modeling period of 134 years.

Talbot Parameters

POLLUTE uses a Laplace transform to find the solution to the advection-dispersion equation. The numerical inversion of the Laplace transform depends on the Talbot parameters. The model provides default values for the Talbot parameters or they can be selected by the user. The default Talbot parameters were used in this groundwater model.

Boundary Conditions

POLLUTE requires the specification of an upper and lower boundary condition. The top boundary condition typically represents the landfill as a potential source. When modeling the landfill as a surface boundary, the concentration of each constituent in leachate can be assumed to be constant or a specific mass can be assumed to be present. Assuming a specific mass results in a decreasing source concentration over time, which would most accurately represent the fact that leachate concentrations in landfills with leachate collection and removal systems will gradually decrease over time. However, a constant concentration was assumed as it results in conservative model results.

The lower boundary condition was specified as an infinite bottom layer. This boundary condition assumes that horizontal flow can continue to any distance, which allows for realistic analysis of conditions at the ZOA.

Advective (Darcy) Velocity

POLLUTE requires the input of a Darcy velocity, which is calculated across the complete length of the groundwater model. The Darcy velocity (3.811×10^{-3} m/yr) for the model was based on the previously permitted Upper Radnor Till Sand model. The calculations for the determination of the Darcy velocity are provided in the model documentation provided in Attachment 4.

Hydrodynamic Dispersion Coefficient

POLLUTE requires the input of a hydrodynamic dispersion coefficient for each layer. The hydrodynamic dispersion coefficient is calculated by the following equation:

$$D = D^* + av \qquad \text{(Equation 1)}$$

where,

D	=	the hydrodynamic dispersion coefficient (m^2/yr),
a	=	the dispersivity (m),
v	=	the groundwater seepage velocity (m/yr),
D*	=	the effective diffusion coefficient (m^2/yr).

The input table provided in Attachment 4 lists the model dispersion coefficient values. The dominant transport mechanism in the keyway will be diffusion. An input of 0.0158 m^2/yr was used to represent the effective diffusion coefficient in the keyway. In the Upper Radnor Till Sand diffusion and dispersion were considered for the hydrodynamic dispersion coefficient. The scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming high reliability data (provided in Attachment 4) was used to determine the horizontal dispersivity ($0.20(\text{Flow Length})^{0.44} = 0.20(24.38)^{0.44} = 0.8$ m). The dispersion coefficient was then obtained by taking the Darcy velocity 3.811×10^{-3} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 3.811×10^{-2} m/yr) and multiplying by the dispersivity (0.8 m). A dispersion value of 0.0305 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0463 m^2/yr.

Porosity Input

The estimated effective porosity value for the keyway (0.24) was based on laboratory data for the recompacted clay liner for Clinton Landfill No. 2, which is provided in Attachment 4. This estimated effective porosity was documented in the response to IEPA Draft Denial Comment No. 10 in the January 2009 submittal to the IEPA.

The estimated effective porosity value for the Upper Radnor Till Sand (0.10) was based on discussions with the IEPA and recommended estimated effective porosities ranging from 0.10 to 0.55 for sand and 0.001 to 0.10 for silt. With the Upper Radnor Till Sand logged as a silty sand, it was conservatively assumed that the estimated effective porosity for the Upper Radnor Till Sand was at the low end of the range for a sand and high end of the range for a silt.

Model Evaluation Distance

The model evaluation distance is not a model input parameter. However, this distance is needed in order to evaluate the results of the model since the model only provides results for specified distances. The model was evaluated at the ZOA, a distance of 100 feet (30.48 m). As mentioned earlier, the permitted GIA for the Upper Radnor Till Sand included a sidewall length of 100 feet, conservatively the sidewall length has been excluded for this model.

Results

The model output for the Upper Radnor Till Sand is included in Attachment 4. The model prediction factor for the entire 134 year simulation period at the edge of the zone of attenuation is 1.06×10^{-11}.

A revised prediction table for the Upper Radnor Till Sand is provided in Attachment 2. The prediction table indicates that the model predicted groundwater concentrations in the Upper Radnor Till Sand at the ZOA do not exceed the AGQS for each respective constituent at the CWU.

Thus, the proposed CWU design and site hydrogeologic characteristics are such that there will be no adverse impact on groundwater quality in the Upper Radnor Till Sand. Expected concentrations in the groundwater will actually be lower than those predicted in the GIA because of the overly conservative nature of the model.

Concentration versus time and depth plots for the baseline model are presented in Attachment 4.

Sensitivity Analyses

The sensitivity analysis focused on the effect of changes in baseline model input parameters on the model prediction factor at the ZOA. The sensitivity analyses are provided in Attachment 4. Justification for the variation used in the sensitivity analyses is discussed as follows. A table at the front of the sensitivity analyses summarizes the sensitivity analyses performed on the Upper Radnor Till Sand baseline model.

Darcy Velocity

The Darcy velocity used in the baseline model (3.811×10^{-3} m/yr) was based on the HELP model for the permitted solid waste landfill. The HELP model for the permitted landfill calculated a seepage rate out of the landfill assuming approximately 130 inches of leachate head and leachate recirculation. This seepage rate was the major component of the Darcy velocity for the baseline model. The CWU will have not use leachate recirculation and is expected to have a leachate head less than 1 foot. Additionally, the HELP model for the permitted solid waste landfill incorporated a composite liner, where as, the CWU will be built with a dual composite liner. Therefore, the Darcy velocity used in the Upper Radnor Till Sand baseline model is already extremely conservative and it was determined that doubling the Darcy velocity to 7.622×10^{-3} m/yr and cutting the Darcy velocity in half to 1.906×10^{-3} m/yr would result in a satisfactory sensitivity evaluation of this parameter.

Coefficient of Hydrodynamic Dispersion

In the keyway and the Upper Radnor Till Sand, the baseline values used for the coefficient of hydrodynamic dispersion were 0.0158 and 0.0463 m^2/yr, respectively.

In the keyway, the coefficient of hydrodynamic dispersion is based on laboratory studies and it was determined that an increase and decrease of the coefficient of hydrodynamic dispersion by an order of magnitude would result in a satisfactory sensitivity evaluation of this parameter.

As mentioned above, in the Upper Radnor Till Sand diffusion and dispersion were considered for the hydrodynamic dispersion coefficient. The scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming high reliability data (provided in Attachment 4) was used to determine the horizontal dispersivity ($0.20(\text{Flow Length})^{0.44} = 0.20(24.38)^{0.44} = 0.8$ m). The dispersion coefficient was then obtained by taking the Darcy velocity 3.811×10^{-3} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 3.811×10^{-2} m/yr) and multiplying by the dispersivity (0.8 m). A dispersion value of 0.0305 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0463 m^2/yr.

By taking the scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming data for all reliabilities (provided in Attachment 4), a horizontal dispersivity of 1.3 m was calculated ($0.063(\text{Flow Length})^{0.94} = 0.063(24.38)^{0.94} = 1.3$ m). The dispersion coefficient was then obtained by taking the Darcy velocity 3.811×10^{-3} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 3.811×10^{-2} m/yr) and multiplying by the dispersivity (1.3 m). A dispersion value of 0.0495 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0653 m^2/yr. A hydrodynamic dispersion coefficient of 0.0653 m^2/yr will be used as a sensitivity analysis for the higher range of this parameter.

The baseline dispersivity was then reduced by 0.5 m (the amount of increase detailed above 1.3 m - 0.8 m = 0.5 m) to 0.3 m (0.8 m - 0.5 m = 0.3 m) and the dispersion coefficient was then obtained by taking the Darcy velocity 3.811 x 10^{-3} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 3.811 x 10^{-2} m/yr) and multiplying by the dispersivity (0.3 m). A dispersion value of 0.0114 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0272 m^2/yr. A hydrodynamic dispersion coefficient of 0.0272 m^2/yr will be used as a sensitivity analysis for the lower range of this parameter.

Porosity

The estimated effective porosity of the keyway, that was used for the baseline model (0.24), was based on the site specific laboratory data for the compacted liner at the Clinton Landfill No. 2. Due to the availability of estimated effective porosities based on the site specific data, it was possible to obtain a range of values (0.20 to 0.28) from the samples tested. As such, sensitivity analyses were run using both the maximum and minimum estimated effective porosity expressed in the laboratory results for the compacted liner at the Clinton Landfill No. 2.

The estimated effective porosity of the Upper Radnor Till Sand, that was used for the model (0.10), was based on discussions with the IEPA and recommended estimated effective porosities ranging from 0.10 to 0.55 for sand and 0.001 to 0.10 for silt. With the Upper Radnor Till Sand logged as a silty sand, it was conservatively assumed that the estimated effective porosity for the Upper Radnor Till Sand was at the low end of the range for a sand and high end of the range for a silt. As such, sensitivity analyses were run using the average estimated effective porosity for the sand and silt, 0.33 and 0.05, respectively.

The model prediction factor for the Upper Radnor Till Sand corresponds to the time period of 134 years. All the sensitivity analysis runs were carried out corresponding to a time period of 134 years.

A summary of results table for the Upper Radnor Till Sand is provided in Attachment 4 and includes all of the sensitivity analyses.

Sensitivity analysis of the above mentioned parameters resulted in satisfactory results for all of the sensitivity runs.

4. *IEPA Comment: Monitoring of the Upper Radnor Sand will be required if it is encountered on the southern boundary. A MEMO model must be provided and well locations proposed unless/until it is demonstrated that the sand does not extend along the southern boundary.*

Applicant Response: Clinton Landfill, Inc. proposes to provide a well spacing model to the IEPA for the Upper Radnor Till Sand, if it is found to exist (during construction of the CWU), on the southern boundary of the CWU. Clinton Landfill, Inc. believes that this is appropriate since the extent of this unit (if present) and, thus, the area requiring monitoring will be defined following the additional investigation activities previously described.

5. *IEPA Comment: The Agency's deficiency 4 indicated that the MEMO model used incorrect dispersivities in the Lower Radnor Till and that the diffusion coefficients in both models (0.064 m2/y) were too high and should be consistent with the contaminant transport model. The applicant did not adequately address this deficiency.*

The applicant did not address the dispersivity issue in the Lower Radnor Sand at all. Different longitudinal dispersivities were input for the each monitored zone: 10 ft in the Lower Radnor and 7 ft in the Organic Soil. Dispersivity is scale dependent, which means different distances were used in each model. This could be due to flow direction (using a fixed location) or due to use of different distances. The latter is not acceptable. The applicant must justify the dispersivity inputs.

The applicant provided documentation that 0.0315 to 0.064 m2/y is the maximum dilution factor in water (not specific to geologic materials). They alter the model to use the lower fo the range. The applicant did not address the Agency's deficiency. Specifically, a diffusion coefficient of 0.0158 m2/y (specific to geologic materials) was chosen for the same materials for the MIGRATE model. The diffusion coefficient must be consistent between the two models. Either all MEMO models must be revised or all MIGRATE models must be revised. Adequate and appropriate justification must be provided. If MIGRATE is revised, all sensitivities must be re-run.

Applicant Response: To address IEPA concerns, the MEMO models for both the Lower Radnor Till Sand and Organic Soil have been updated with a revised diffusion coefficient of 0.170 ft^2/yr (0.0158 m^2/yr).

The flow directions in the Lower Radnor Till Sand and Organic Soil are slightly different, which result in different distances. The horizontal and transverse dispersivities used in the MEMO models were obtained from IEPA Comment No. 20 of the draft denial letter received on August 13, 2008.

> *"IEPA Comment: Well spacing model input: For the Radnor Sand, dispersivity per Gelhar (1992) was said to be 44 ft and transverse dispersivity of 20 % of this value is 9 ft. These values are extremely high and unsupported by the sited document*

(Gelhar, 1992). Based on Gelhar text and Figure 3, horizontal dispersivity for 50 feet (15 m) is approximately 1 meter or 3 feet. Transverse dispersivity should be an order of magnitude less, or .3 feet. However, dispersivity should be determined by the entire flow length considered (50 feet + sidewall + distance to MAPC wells = 80 m). Based on 80 m and Gelhar, for the Radnor Till, horizontal and transverse dispersivity should be approximately 10 ft and 1 ft respectively. For the Organic Soil, they should be 7 ft and .7, respectively."

Both MEMO models provided in this submittal used horizontal and transverse dispersivities of 7 and 0.7, respectively.

As discussed in previous submittals, a Monitoring Well Efficiency Model (MEMO) has been created for both the Radnor Till Sand and the Organic Soil to evaluate the proposed monitoring well network adjacent to the CWU. These MEMO models have been updated with the revised diffusion coefficient of 0.170 ft^2/yr (0.0158 m^2/yr) and horizontal and transverse dispersivities of 7 and 0.7, respectively. As a result of the incorporation of the IEPA recommended values, it was necessary to add an additional monitoring well location (G59) along the southern edge of the proposed CWU and to adjust the locations of the previously proposed monitoring well nests in order to achieve an efficiency greater than 99.0%. The resulting calculated monitoring efficiencies were 99.2% and 99.4% for the Radnor Till Sand and Organic Soil, respectively.

The revised MEMO models are included in Attachment 5. A revised Groundwater Monitoring Plan (Drawing No. P-GWMP) is also provided within Attachment 5.

6. *IEPA Comment: The new well location and installation table, updated within Attachment 5 of the June addendum, may need to revision based on revisions to MEMO.*

   Applicant Response: The Monitoring Well Phasing Plan, which was previously provided within Attachment 5 of the June, 2009 submittal, has been updated and is provided within Attachment 5 of this response. As discussed above, a revised Groundwater Monitoring Plan (Drawing No. P-GWMP) is also provided within Attachment 5.

7. *IEPA Comment: In response to the final deficiency, the applicant states that the G53 well nest will not be installed as it is upgradient to sidegradient. The Agency does not agree that the G53 location is upgradient to the landfill.*

   Applicant Response: Clinton Landfill, Inc. concurs with the IEPA that the G53 well nest is not upgradient of the CWU.

8. *IEPA Comment: The applicant state that if assessment is necessary due to organic impacts, the applicant will propose assessment activities; they propose to "possibly address" adjacent well locations G53. This is unacceptable.*

Applicant Response: Clinton Landfill, Inc. will propose appropriate assessment activities at the G53 well nest location (and/or other appropriate locations) in the unlikely event that organic detections at the G52 well nest result in assessment. All assessment activities would be approved by the IEPA prior to the initiation of any assessment activities.

9. *IEPA Comment: The following issues were noted in the revised stability analysis is provided in Attachment 7 of the addendum dated June 11, 2009.*

   a. *Liner Block Failure - Short Term/Static Analysis; Liner Block Failure - Long Term/Static Analysis; and Foundation Circular Failure - Short Term/Static Analysis scenarios provided in Attachment 7 used peak value for the interface between geosynthetics on the bottom liner (0 psf and 24^0). As per Table 1 provided in Attachment 7 for static conditions residual values will be used.*

   b. *Foundation Circular Failure - Short Term Static and seismic analyses stability runs used cohesion of 8310 psf and a friction angel of zero for Radnor Till. As per Table 1 provided in Attachment 7 of June 11, 2009 addendum the shear strength of Berry Clay and Radnor Till under long term conditions is 6000 psf and 0^0.*

   c. *Foundation Circular Failure - Long Term/Static and seismic analyses stability runs used cohesion of 7200 psf and a friction angle of 17.70 for Radnor Till. As per Table 1 provided in Attachment 7 of June 11, 2009 addendum the shear strength of Berry Clay and Radnor Till under long term conditions is 1100 psf and 18^0.*

Applicant Response: Clinton Landfill, Inc.'s response to these comments was submitted to the IEPA on July 28, 2009.

10. *IEPA Comment: As per the cover letter for the June 11, 2009 addendum unit costs were updated for inflation for the years 2007 and 2008. However, the Gas Collection System costs have only been inflated for 2008. The 2.8% inflation factor for 2007 has not been applied to these costs.*

Applicant Response: Clinton Landfill, Inc.'s response to these comments was submitted to the IEPA on July 28, 2009. However, the post-closure care cost estimates require revision to include the additional groundwater monitoring wells located at (G59) that is currently proposed in the response to IEPA Comment No. 5. Revised closure and post-closure care cost estimates, including the additional wells, are provided in Attachment 6. The revised cost estimates in Attachment 6 replace those submitted on July 28, 2009.

We look forward to working with the IEPA to resolve all the of IEPA concerns with this permit application in a timely manner. If you have any questions, please contact me at (630) 762-1400.

Sincerely,

Shaw Environmental, Inc.

Dan Drommerhausen, P.G.
Senior Hydrogeologist

cc: George Armstrong, PDC Technical Services, Inc.

September 4, 2009

Stephen F. Nightingale, P.E.
Permit Section Manager
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794-9276

Re: 0390055036 – DeWitt County
Clinton Landfill No. 3
Log No. 2008-054
Responses to Draft Denial Points

Dear Mr. Nightingale:

Shaw Environmental, Inc. (Shaw) is submitting this response to comments received from the IEPA during the review of the application for the development of the Chemical Waste Unit (CWU) at Clinton Landfill No. 3. The following information responds to each of the comments identified by the IEPA in the draft denial letter received on September 3, 2009. This submittal consists of 1 binder. An original and 3 copies of this submittal are included.

Response to Comments

1. *IEPA Comment: Darcy velocity is calculated as the sum of landfill flux from HELP, and horizontal seepage across the keyway, utilizing the Upper Radnor Sand gradient from 2007. Darcy velocity should be revised. The current application has revised HELP and gradient results within this application. HELP results and the Upper Radnor Sand gradient from the January 2009 addendum to this application should be used to calculate Darcy velocity.*

   Applicant Response: The Darcy velocity has been revised for the Upper Radnor Till Sand baseline model. The revised Darcy velocity is based on the HELP model results and the revised Upper Radnor Till Sand gradient from the January 2009 addendum. The revised Darcy velocity and all other input values are discussed below.

   The hydrogeological and conceptual models, a summary of input values, and documentation for the model are provided in Attachment 1. The following paragraphs discuss the input values for the Upper Radnor Till Sand baseline model and subsequent results and sensitivity analyses.

Model Input

Model Length

Two (2) layers were modeled at the site: a 20-foot (6.096 m) wide keyway (cut-off wall) (1.0 x 10^{-7} cm/sec) and approximately 80 feet (24.38 m) of the Upper Radnor Till Sand (extending from the outer edge of the keyway to the ZOA and excluding the sidewall length). The permitted GIA for the Upper Radnor Till Sand included a sidewall length of 100 feet, conservatively the sidewall length has been excluded for this model.

Because the model predicts contaminant transport through the keyway and out to the ZOA, the model length is the sum of the keyway thickness and the distance to the ZOA. The total model length is 100 feet (30.48 m). Although the model has been set up assuming an infinite bottom boundary, the model was evaluated at the ZOA.

Initial Leachate Concentration

The initial leachate concentration input used was one (1). This value is unitless because it represents unit leachate concentration of any given constituent. Therefore, the model results represent a fraction of the initial leachate concentration for any particular constituent.

Number of Layers

As discussed above, two layers were modeled at the site: a 20-foot (6.096 m) keyway and 80 feet (24.38 m) of the Upper Radnor Till Sand. POLLUTE also allows a layer to be subdivided so that the predicted concentration distribution within a layer can be evaluated.

The keyway and the Upper Radnor Till Sand were divided into 4 and 16 sublayers, respectively.

Modeling Period

The modeling period is the expected life of the landfill plus 100 years after closure. The expected life of the landfill has been conservatively estimated to be approximately 34 years, resulting in a modeling period of 134 years.

Talbot Parameters

POLLUTE uses a Laplace transform to find the solution to the advection-dispersion equation. The numerical inversion of the Laplace transform depends on the Talbot parameters. The model provides default values for the Talbot parameters or they can be selected by the user. The default Talbot parameters were used in this groundwater model.

Boundary Conditions

POLLUTE requires the specification of an upper and lower boundary condition. The top boundary condition typically represents the landfill as a potential source. When modeling the landfill as a surface boundary, the concentration of each constituent in leachate can be assumed to be constant or a specific mass can be assumed to be present. Assuming a specific mass results in a decreasing source concentration over time, which would most accurately represent the fact that leachate concentrations in landfills with leachate collection and removal systems will gradually decrease over time. However, a constant concentration was assumed as it results in conservative model results.

The lower boundary condition was specified as an infinite bottom layer. This boundary condition assumes that horizontal flow can continue to any distance, which allows for realistic analysis of conditions at the ZOA.

Advective (Darcy) Velocity

POLLUTE requires the input of a Darcy velocity, which is calculated across the complete length of the groundwater model. The Darcy velocity (6.86×10^{-4} m/yr) for the model was created by adding the seepage rate out of the CWU (3.08×10^{-4} m/yr) to the Darcy velocity (3.78×10^{-4} m/yr) created by multiplying the permeability of the keyway (1.0×10^{-7} cm/sec) by the gradient of the Upper Radnor Till Sand (0.012).

It should be noted that the revised HELP model for the CWU (provided in the January 2009 addendum) predicts the maximum hydraulic head (i.e. ymax) on the bottom liner at 0.0051 meters (0.20 inches). Conservatively, the seepage velocity (3.08×10^{-4} m/yr) discussed above and used in the revised groundwater models for the Lower Radnor Till Sand and the Organic Soil is based on an assumed constant hydraulic head of 0.3048 meters (12 inches) on the bottom liner. Additionally, the gradient for the Upper Radnor Till Sand (0.012) was documented in the January 2009 addendum.

Hydrodynamic Dispersion Coefficient

POLLUTE requires the input of a hydrodynamic dispersion coefficient for each layer. The hydrodynamic dispersion coefficient is calculated by the following equation:

$$D = D^* + av \qquad \text{(Equation 1)}$$

where,

D	=	the hydrodynamic dispersion coefficient (m^2/yr),
a	=	the dispersivity (m),
v	=	the groundwater seepage velocity (m/yr),
D*	=	the effective diffusion coefficient (m^2/yr).

The input table provided in Attachment 1 lists the model dispersion coefficient values. The dominant transport mechanism in the keyway will be diffusion. An input of 0.0158 m^2/yr was used to represent the effective diffusion coefficient in the keyway. In the Upper Radnor Till Sand diffusion and dispersion were considered for the hydrodynamic dispersion coefficient. The scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming high reliability data (provided in Attachment 1) was used to determine the horizontal dispersivity ($0.20(\text{Flow Length})^{0.44} = 0.20(24.38)^{0.44} = 0.8$ m). The dispersion coefficient was then obtained by taking the Darcy velocity 6.86×10^{-4} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 6.86×10^{-3} m/yr) and multiplying by the dispersivity (0.8 m). A dispersion value of 0.0055 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0213 m^2/yr.

Porosity Input

The estimated effective porosity value for the keyway (0.24) was based on laboratory data for the recompacted clay liner for Clinton Landfill No. 2, which is provided in Attachment 1. This estimated effective porosity was documented in the response to IEPA Draft Denial Comment No. 10 in the January 2009 submittal to the IEPA.

The estimated effective porosity value for the Upper Radnor Till Sand (0.10) was based on discussions with the IEPA and recommended estimated effective porosities ranging from 0.10 to 0.55 for sand and 0.001 to 0.10 for silt. With the Upper Radnor Till Sand logged as a silty sand, it was conservatively assumed that the estimated effective porosity for the Upper Radnor Till Sand was at the low end of the range for a sand and high end of the range for a silt.

Model Evaluation Distance

The model evaluation distance is not a model input parameter. However, this distance is needed in order to evaluate the results of the model since the model only provides results for specified distances. The model was evaluated at the ZOA, a distance of 100 feet (30.48 m). As mentioned earlier, the permitted GIA for the Upper Radnor Till Sand included a sidewall length of 100 feet, conservatively the sidewall length has been excluded for this model.

Results

The model output for the Upper Radnor Till Sand is included in Attachment 2. The model prediction factor for the entire 134 year simulation period at the edge of the zone of attenuation is 4.21×10^{-18}.

A revised prediction table for the Upper Radnor Till Sand is provided in Attachment 3. The prediction table indicates that the model predicted groundwater concentrations in the Upper

Radnor Till Sand at the ZOA do not exceed the AGQS for each respective constituent at the CWU.

Thus, the proposed CWU design and site hydrogeologic characteristics are such that there will be no adverse impact on groundwater quality in the Upper Radnor Till Sand. Expected concentrations in the groundwater will actually be lower than those predicted in the GIA because of the overly conservative nature of the model.

Concentration versus time and depth plots for the baseline model are presented in Attachment 2.

Sensitivity Analyses

The sensitivity analysis focused on the effect of changes in baseline model input parameters on the model prediction factor at the ZOA. The sensitivity analyses are provided in Attachment 4. Justification for the variation used in the sensitivity analyses is discussed as follows. A table at the front of the sensitivity analyses summarizes the sensitivity analyses performed on the Upper Radnor Till Sand baseline model.

Darcy Velocity

The Darcy velocity used in the baseline model was 6.86×10^{-4} m/yr. It was determined that an increase and decrease of the Darcy velocity by an order of magnitude would result in a satisfactory sensitivity evaluation of this parameter.

Coefficient of Hydrodynamic Dispersion

In the keyway and the Upper Radnor Till Sand, the baseline values used for the coefficient of hydrodynamic dispersion were 0.0158 and 0.0213 m^2/yr, respectively.

In the keyway, the coefficient of hydrodynamic dispersion is based on laboratory studies and it was determined that an increase and decrease of the coefficient of hydrodynamic dispersion by an order of magnitude would result in a satisfactory sensitivity evaluation of this parameter.

As mentioned above, in the Upper Radnor Till Sand diffusion and dispersion were considered for the hydrodynamic dispersion coefficient. The scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming high reliability data (provided in Attachment 1) was used to determine the horizontal dispersivity ($0.20(\text{Flow Length})^{0.44} = 0.20(24.38)^{0.44} = 0.8$ m). The dispersion coefficient was then obtained by taking the Darcy velocity 6.86×10^{-4} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 6.86×10^{-3} m/yr) and multiplying by the dispersivity (0.8 m). A dispersion value of 0.0055 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0213 m^2/yr.

By taking the scaling relationship method described by Schulze-Makuch (2005) for unconsolidated sediments and assuming data for all reliabilities (provided in Attachment 1), a horizontal dispersivity of 1.3 m was calculated ($0.063(\text{Flow Length})^{0.94} = 0.063(24.38)^{0.94}$ = 1.3 m). The dispersion coefficient was then obtained by taking the Darcy velocity 6.86×10^{-4} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 6.86×10^{-3} m/yr) and multiplying by the dispersivity (1.3 m). A dispersion value of 0.0089 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0247 m^2/yr. A hydrodynamic dispersion coefficient of 0.0247 m^2/yr will be used as a sensitivity analysis for the higher range of this parameter.

The baseline dispersivity was then reduced by 0.5 m (the amount of increase detailed above 1.3 m - 0.8 m = 0.5 m) to 0.3 m (0.8 m - 0.5 m = 0.3 m) and the dispersion coefficient was then obtained by taking the Darcy velocity 6.86×10^{-4} m/yr dividing by the estimated effective porosity (0.10)(creating the groundwater seepage velocity 6.86×10^{-3} m/yr) and multiplying by the dispersivity (0.3 m). A dispersion value of 0.0021 m^2/yr was obtained and added to the diffusion coefficient 0.0158 m^2/yr to produce a hydrodynamic dispersion coefficient of 0.0179 m^2/yr. A hydrodynamic dispersion coefficient of 0.0179 m^2/yr will be used as a sensitivity analysis for the lower range of this parameter.

It should also be noted that the hydrodynamic dispersion coefficients in the Upper Radnor Till Sand ranged from 0.0164 m^2/yr to 0.0707 m^2/yr and 0.0202 m^2/yr to 0.0295 m^2/yr in the Darcy velocity and effective porosity sensitivity analyses, respectively.

Porosity

The estimated effective porosity of the keyway, that was used for the baseline model (0.24), was based on the site specific laboratory data for the compacted liner at the Clinton Landfill No. 2. Due to the availability of estimated effective porosities based on the site specific data, it was possible to obtain a range of values (0.20 to 0.28) from the samples tested. As such, sensitivity analyses were run using both the maximum and minimum estimated effective porosity expressed in the laboratory results for the compacted liner at the Clinton Landfill No. 2.

The estimated effective porosity of the Upper Radnor Till Sand, that was used for the model (0.10), was based on discussions with the IEPA and recommended estimated effective porosities ranging from 0.10 to 0.55 for sand and 0.001 to 0.10 for silt. With the Upper Radnor Till Sand logged as a silty sand, it was conservatively assumed that the estimated effective porosity for the Upper Radnor Till Sand was at the low end of the range for a sand and high end of the range for a silt. As such, sensitivity analyses were run using the average estimated effective porosity for the sand and silt, 0.33 and 0.05, respectively.

The model prediction factor for the Upper Radnor Till Sand corresponds to the time period of 134 years. All the sensitivity analysis runs were carried out corresponding to a time period of 134 years.

A summary of results table for the Upper Radnor Till Sand is provided in Attachment 4 and includes all of the sensitivity analyses.

Sensitivity analysis of the above mentioned parameters resulted in satisfactory results for all of the sensitivity runs.

2. *IEPA Comment: Hydrodynamic dispersion for the Upper Radnor Till Sand must be revised based on the revised seepage calculations.*

   Applicant Response: The hydrodynamic dispersion coefficients for the Upper Radnor Till Sand model have been revised based on the revised seepage calculations and were discussed in the response to IEPA Comment No. 1.

3. *IEPA Comment: The new baseline results must be presented in Concentration versus Time and Distance plots in 5 year increments. New tables comparing the results to the AGQS must also be included.*

   Applicant Response: New baseline results that are presented in concentration versus time and distance plots in five year increments are provided in Attachment 2. It should be noted that the model time period is 134 years, so the last increment was presented as 4 years.

   A revised prediction table that compares the results to the respective AGQS for each constituent is provided in Attachment 3.

4. *IEPA Comment: New sensitivities, along with discussion and Concentration versus Time and Distance plots must be included.*

   Applicant Response: New sensitivities were discussed in the response to IEPA Comment No. 1. Additionally, a sensitivity analyses summary table, sensitivity analyses output, and concentration versus time and distance plots are provided in Attachment 4.

We look forward to working with the IEPA to resolve all the of IEPA concerns with this permit application in a timely manner. If you have any questions, please contact me at (630) 762-1400.

Sincerely,

Shaw Environmental, Inc.

Dan Drommerhausen, P.G.
Senior Hydrogeologist

cc: George Armstrong, PDC Technical Services, Inc.