David J. De Simone, PhD
957 Babcock Lake Road
Petersburg, NY 12138

hawkeye272david@yahoo.com

518-686-9809 (O)
518-961-5110 (M)

Geological Evaluation of the Proposed Woods Pond Landfill Site, Lee, MA

Introduction: I reviewed documents and evaluated the surficial and bedrock geology for the proposed PCB landfill site north of Willow Hill Road and south of Woods Pond, Town of Lee, MA. My work scope was to address these parameters the nature and stratigraphy of glacial sediments and how this impacts infiltration and lateral movement of ground water beneath the PCB landfill site. Does the landfill site have geological characteristics that weigh against using the site as a PCB landfill? How likely is it that there is natural sediment overlying bedrock beneath the sand and gravel shown on surficial maps that is low in permeability - hydraulic conductivity - and can inhibit infiltration of leachate from inevitable leaks? Double composite liners and leachate collection systems should be expected to fail and I wanted to see what might happen to leachate that infiltrated the site below the liners.

Surficial geology: My analysis of surficial geologic maps of the East Lee 1:24,000 quadrangle by Stone and DiGiacamo-Cohen (2018) and Holmes (1962) indicates the proposed PCB landfill site lies in an area of ice contact stratified drift that is usually not associated with either thick, impermeable till sediment or glaciolacustrine silt-clay of any appreciable thickness or lateral continuity. Ice contact stratified drift is a variable mixture of sand and gravel, sediment that is highly permeable.

The Holmes (1962) map identifies the sediment at the proposed PCB landfill site as “Qcd” - ice contact stratified drift. Holmes described the sediments as kettled, collapsed or eroded glaciofluvial deposits - deposition from melt water and/or meteoric water in contact with melting glacial ice. Such environments may have sediments deposited beneath, within and atop glacial ice. More often than not, the ice itself may have become stagnant and even detached from the active glacial margin. Melting of glacial ice syn-depositionally and post-depositionally causes the sediments to collapse and form a hummocky, kettled landform. If the depositional environment can be associated with a slowed or paused retreat of a glacial margin in a valley, the landform may be identified as a kame moraine, a cross valley accumulation of ice contact sediment associated with a glacial margin. The term kame moraine was defined by Frank B. Taylor during his time as a glacial geologist with the USGS in the early decades of the 20th century. Taylor worked extensively in the western Berkshires and southern Vermont, mostly in the Hoosic River drainage basin. He coined the term “kame moraine” to describe ice contact landforms composed predominantly of glaciofluvial sediments but representing deposition in an environment similar to that of a till moraine. My map review indicates the kame and kettle landforms at the proposed landfill site do not represent a kame moraine. Rather, it appears to be part of a larger area of the valley floor where ice became stagnant and blocks of ice were detached from an active ice front. Woods Pond, thus, represents a large kettle pond. Kame moraines have a greater chance of having some till within the sediment accumulation. Since this is not the case, it is more likely the sediments have little or no till beneath the sand and gravel.

Holmes’ map identifies exposures of sediment in the landfill areas as boulder gravel, cobble gravel, cobble sand and pebble sand. These are all very typical of ice contact stratified drift where the sediment texture can vary highly over a short lateral or vertical distance. In other words, sediments are rarely arranged in neat, horizontal layers but rather form a landform with abrupt and sharp sediment texture changes. This makes prediction of hydraulic properties in these sediments especially difficult to incorporate into ground water flow models, for example. Such models often assume “layer cake” stratigraphy with homogeneous sediment textures within layers. Glaciofluvial ice contact sediments almost never meet this assumption. Thus, modeled ground water flow must be viewed cautiously, at best. Note, these sediments are among the most permeable we find in glacial environments. They are the worst natural sediments to use for a PCB landfill because they allow easy migration of contaminants in the subsurface.

Stone & DiGiacamo-Cohen (2018) identify the same deposit as stratified coarse glaciofluvial sediments:

“Coarse deposits consist of gravel deposits, sand and gravel deposits, and sand deposits, not differentiated in this report. Gravel deposits are composed of at least 50 percent gravel-size clasts; cobbles and boulders predominate; minor amounts of sand occur within gravel beds, and sand comprises a few separate layers. Gravel layers generally are poorly sorted, and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. Sand and gravel deposits occur as mixtures of gravel and sand within individual layers and as layers of sand alternating with layers of gravel. Sand and gravel layers generally range between 25 and 50 percent gravel particles and between 50 and 75 percent sand particles. Layers are well sorted to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. Sand deposits are composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay.”

"Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in the particle-size diagram, figure 12, below), deposited in layers by glacial meltwater. These sediments occur as four basic textural units: gravel deposits, sand and gravel deposits, sand deposits, and fine deposits. On this surficial geologic map, gravel deposits, sand and gravel deposits, and sand deposits are not differentiated and are shown as Coarse Deposits where they occur at the land surface. Fine Deposits also are shown where they occur at the land surface. Textural changes occur both aerially and vertically (fig. 9); however, subsurface textural variations are not shown on this map."

This description is basically the same as Holmes older description of the deposits. What's changed is the nature of the map units used by the USGS. The current map units focus on the sediment types and origins - ice contact glaciofluvial for example - rather than any landforms the sediments may be associated with such as kame and kettle. It's a conservative approach to labelling map units and makes for a more accurate and functional map with fewer interpretations of the landform origins on the part of the mapper. This is a "safer" approach since so many different mappers may contribute to a statewide mapping program as was recently completed in MA.

surficial geology conclusions; The conclusion drawn from the surficial map analysis is that the proposed landfill site contains highly permeable sand and gravel sediments. These sediments vary texturally over both lateral and vertical distances as shown by Holmes descriptors for the sediments just within the landfill areas alone. There is no indication of till present beneath the sand and gravel in significant thickness or continuity to present a barrier to subsurface flow of contaminants. Ice contact stratified drift sediments are very poor locations for landfills due to their high permeability. My primary concern for this site as a landfill is that a leak in the liner and leachate collection system will eventually occur; then, leachate will have no natural sediment barrier to flow in the subsurface. EPA has stated "First, even the best liner and leachate collection systems will ultimately fail due to natural deterioration…"(53 Federal Register 33345, August 30, 1988). The sand and gravel aquifer will become contaminated and leachate will easily infiltrate underlying bedrock. This is a poor site for a landfill.

Bedrock geology: Ratcliffe (1985) mapped the bedrock geology of the East Lee, MA quadrangle. The proposed PCB landfill area is underlain by Stockbridge Formation carbonate rock, chiefly dolomitic marble. This rock contains fractures or joint planes that are migration pathways for ground water and any contaminants based upon my own experience as a mapper where this formation occurs. Further, enlargement of fractures/joints due to dissolution in carbonate bedrock provides pathways for <u>very rapid</u> movement of ground water in the subsurface. Thus, a PCB landfill sited in the proposed location might allow leachate to enter bedrock and flow toward the Housatonic River to the west. Once any leak occurs, the natural gravel and sand substrate - highly permeable sediment - will have pose no impermeable natural barrier to inhibit flow into the underlying marble bedrock. Till is not likely present in a sufficiently thick and continuous layer to inhibit downward flow of the leachate.

bedrock geology conclusion; The Stockbridge marble is a rock that contains fractures/joints that may allow very rapid ground water flow along discrete pathways. Further, dissolution of rock along these fractures/joints makes this an extremely poor choice for bedrock beneath a PCB landfill.

Existing landfills: The 2 closed landfills along Willow Hill Road are identified (MA DEP, 2017) as unlined and capped in 1997 and 1999. A capped landfill minimizes infiltration of meteoric water through the landfill contents into the the water table aquifer and bedrock aquifer(s) below. Unlined landfills have no protection from leachate entering surficial aquifers and/or bedrock aquifers below the landfilled material. Both landfills were situated in the mapped ice contact stratified drift sediments. Both landfills likely took advantage of existing depressions in the land surface that were a result of historic gravel and sand mining. The depth of mining was often limited by the water table in the gravel and sand sediments.

Geological understanding of these glaciofluvial depositional environments is that these sediments are often deposited directly on bedrock with little or no low permeability till sediments to act as an aquiclude to protect the underlying bedrock aquifers. The overburden sediments are often a thick and highly permeable overall package that represent an unconfined aquifer and this sediment is likely directly atop fractured and dissolved marble. Such locales were often chosen for landfills primarily due to expediency and not based upon geology.

The 2 neighboring landfills have been capped, and both were landfills for non-hazardous waste. Yet, recent ground water monitoring results from both landfills reflect that they are leaching hazardous chemicals into the ground water. These results make it even more clear that Willow Hill Road is one of the poorest geological locations for a new PCB landfill.

Summary & suggestions: The surficial and bedrock geology described in the above discussion represents what we professors would tell our students in an environmental geology course as a <u>textbook example of where not to locate a landfill</u>. This location is underlain by highly permeable sediment of sand and gravel texture. Infiltration of PCB leachate through these sediments would not be inhibited by any impermeable sediment prior to reaching marble bedrock. The marble would allow rapid migration of contaminants. Very rapid migration of contaminants along fractures/joints enlarged by dissolution would pose an even greater risk of contamination at further distances from the landfill.

The surficial geology consists of high permeability sand and gravel sediments with unpredictable lateral and vertical stratigraphic continuity. Leachate that infiltrates through the designed barriers into this sediment will flow downward through the sand and gravel into the bedrock aquifer below.

The bedrock consists of Stockbridge carbonate rock that is susceptible to dissolution along vertical fractures and along bedding planes. Dissolution causes very rapid ground water flow along discrete pathways through fractures and along bedding planes. Indeed, ground water flow in conduits - including caverns - is possible if they are present in the subsurface.

The bottom line is the geology of the proposed PCB landfill location is very likely to result in leachate contamination of surficial and bedrock aquifers if leachate penetrates the landfill liners. Based upon site geology, PCB disposal in a landfill in this location is a very poor choice that may result in PCB contamination of the sand and gravel aquifer and the underlying Stockbridge marble aquifer.

Background Information on the Author:

I am a geoscientist/environmental scientist engaged in contract, academic and applied research in geomorphology, geoarchaeology, hydrogeology and environmental geology. Contract work as project geomorphologist for archaeology investigations takes me on projects in the Northeast. My surficial geologic mapping occurs primarily in New York & Vermont for STATEMAP research and for understanding contaminant distribution & migration through glacial and post-glacial sediments.

Throughout my professional academic career as a lecturer and visiting/adjunct professor, I've taught geoscience and environmental science at Williams College, RPI, Bennington College and The College of Saint Rose with a keen eye toward the application of these sciences to practical situations. I have attained a respected status as an expert in the glacial geologic history of upstate NY and adjacent Vermont demonstrated by maps & publications over many decades and by lectures given to colleagues and the public.

Most recently, I mapped the surficial geology of PFOA contaminated regions in Hoosick Falls and Petersburg, NY, and in Bennington and Rutland, VT. The Vermont work was performed for the VT Geological Survey. My research mapping has covered the Hudson-Champlain lowlands, Adirondack and Catskill Mountains, and portions of VT.

I have been a Visiting Scientist for the National Park Service, part of the GSA-NPS Geoscientists-in-the-Parks program. In 2015, I generated both surficial & bedrock geologic maps of 4 quadrangles in the Hudson Valley that encompass the Saratoga National Historical Park, a colonial era battlefield. Past mapping in the Catskills includes the Phoenicia & Thiells quadrangles completed for the NY Geological Survey.

Surficial mapping in VT over decades and the evolution of GIS map layers I developed has become the model for mapping in VT and elsewhere. I've conducted geomorphology research in CO, MT, WY & AK in glaciated, formerly glaciated and periglacial terrain. Cultural Resource Management experience is a growing part of my work along countless rivers, streams and reservoir shores and rights-of-ways.

Recent publications:

*DeSimone, D. J., 2019, **Surficial Geology of the Rutland Airport, VT:** VGS Open File report and maps.
*Rayburn, J. A., DeSimone, D. J., and Frappier, A. B., 2018, **New insights in Glacial Lakes Vermont and Albany:** Guidebook to Field Trips, Trip B-4, joint NYSGA-NEIGC conference, Lake George, NY.
*DeSimone, D. J., 2017, **Surficial Geology of Petersburg, NY and Hydrogeology Implications, A Report to Accompany Surficial Geologic Map:** HFCSD 1:12,000 map with report and map.
*DeSimone, D. J., 2017, **Surficial Geology and Recharge Potential of the North Bennington Area, Vermont:** VGS Open File report VG2017-1, (Plates 1 & 2), scale 1:12,000.
*DeSimone, D. J., 2017, **Surficial Geology of Hoosick Falls, NY with Implications for Hydrogeology of Village Aquifer, A Report to Accompany Surficial Geologic Map and Cross Sections:** HFCSD report and online publication.
*DeSimone, D. J., 2017, **Surficial geology of Hoosick Falls, NY:** 1:12,000 map and cross sections prepared for the HFCSD and online publication.
*Franzi, D.A., et al, 2016, **Post–Valley Heads Deglaciation of the Adirondack Mountains and Adjacent Lowlands,** Adirondack Journal of Environmental Science.
*DeSimone, D.J., 2015, **Surficial Geologic Map of Saratoga National Historical Park and Vicinity, New York:** National Park Service publication, map & text.
*DeSimone, D.J., 2015, **Bedrock Geologic Map of Saratoga National Historical Park and Vicinity, New York:** National Park Service publication, map & text.
*DeSimone, D.J., 2012 in press, **Surficial geologic map of the Thiells quadrangle, NY:** NYS Museum, Map & Chart series in press.
*DeSimone, D.J., 2009, **The surficial geology and hydrogeology of Londonderry, VT:** A technical discussion with executive summary; open file report and maps, Vermont Geological Survey.
*DeSimone, D.J., 2009, **Surficial geologic map of the Phoenicia quadrangle, NY:** USGS map completed under STATEMAP, NY Geological Survey.
*DeSimone, D.J., and Robert G. LaFleur, 2008, **Deglacial history of the upper Hudson region:** NYSGA Guidebook to field trips, 80th annual meeting, Trip 4, p. 35-56.
*DeSimone, D.J., Wall, G.R., Miller, N.G., Rayburn, J.A., Kozlowski, A.L., 2008, **Glacial geology of the northern Hudson through southern Champlain lowlands:** Guidebook to field trip, 71st annual northeastern Friends of the Pleistocene meeting, Queensbury, NY.

Recent abstracts:

*DeSimone, D. J., 2018, **PFOA Surficial Mapping in Bennington, VT:** NE-GSA Abstracts with Programs, Burlington, VT, March 2018.
*DeSimone, D. J., 2018, **PFOA Surficial Mapping in Hoosick Falls, NY:** NE-GSA Abstracts with Programs, Burlington, VT, March 2018.
*DeSimone, D. J., 2018, **PFOA & Surficial Mapping - Contrasts Between VT & NY Cases:** NE-GSA Abstracts with Programs, Burlington, VT, March 2018.
*Rayburn, J.A., and DeSimone, D.J.,2017, **A Revised Correlation of Glacial Lacustrine Strandlines Between The Champlain and Hudson Valleys Helps Pinpoint A Missing Threshold:** NE-GSA Abstracts with Programs, Pittsburgh, PA, March 2017.
*DeSimone, D.J., 2016, **Surficial & Bedrock Maps of the Saratoga National Historical Park Generated for Archaeological & Educational Purposes:** NE-GSA Abstracts with Programs, Mt. Washington, NH.
*Rayburn, J.A., and DeSimone, D.J., 2016, **Ice Flow Indicators and the Behavior of the Hudson-Champlain Lobe During A Drawdown Of Glacial Lake Albany:** NE-GSA Abstracts with Programs, Mt. Washington, NH.
*DeSimone, D.J., and Miller, T.S., 2015, **Geomorphic History Determined from Coring at an Archaeologically Sensitive Site along the Wynants Kill, Troy, NY:**
NE-GSA Abstracts with Programs, Mt. Washington, NH.
*DeSimone, D.J., et al, 2015, **Hudson River Terraces Delineated from Archaeological Investigations, Van Schaick Island, Cohoes, NY:** NE-GSA Abstracts with Programs, Mt. Washington, NH.

*Rayburn, J.A., et al, 2015, **Age of ice advance lake on the lee side of the Catskill Mountains, New York, and rough estimates for the rate of ice advance to the LGM:** NE-GSA Abstracts with Programs, Mt. Washington, NH.
*DeSimone, D. J., Rayburn, J. A., et al, 2013, **Emerging views of Esopus basin glacial history:** NE-GSA Abstracts with Programs, Mt. Washington, NH.
*Staley, A. E., Rayburn, J. A., DeSimone, D. J., 2013, **3D Modeling of surficial sediments in the Stony Clove basin, Catskill Mountain region of New York:** NE-GSA Abstracts with Programs, Mt. Washington, NH.
*DeSimone, D. J., and Rayburn, J. A., 2012, **Phoenicia mapping suggests alternative glacial history**: NE-GSA Abstracts with Programs, Hartford, CT.
*Sandstrom, R. M., et al, 2012, **Reconnaissance mapping of surficial geology in the Catskill Mountains of New York:** NE-GSA Abstracts with Programs, Hartford, CT.
*DeSimone, D. J., and Kilkenny, C., 2011, **Archaeology and geomorphology – Hudson River terraces, Troy North quadrangle, NY:** GSA Abstracts with Programs, annual meeting, Minneapolis, MN.
*Kiser, K., et al, 2011, **Modeling the glacial history of the Ashokan watershed in the Catskill Mountains of New York using GIS:** GSA Abstracts with Programs, annual meeting, Minneapolis, MN.
*Carey, C. J.B., et al, 2011, **Surficial geology of a critical reach in Warner Creek, Phoenicia, NY, and its potential impact on New York City's drinking water supply:** NE-GSA Abstracts with Programs, Pittsburgh, PA.
*Becker, L. R., et al, 2009, **The Vermont geo-hazard experience and the NESEC State Geologists:** NE-GSA Abstracts with Programs, Portland, ME.
*DeSimone, D.J., 2008, **Field evidence for readvances – the Luzerne example**:
NE-GSA Abstracts with Programs, Buffalo, NY.
*Becker, L.R., et al, 2008, **Groundwater resources in the town of Williston, northwestern VT:** NE-GSA Abstracts with Programs, Buffalo, NY.

Recent honors and awards:

Co-recipient, 2020 EPA Region 1 Environmental Merit Award for scientific research into the PFOA contamination in North Bennington and Bennington, VT. Award presented in a virtual ceremony, September, 2020.