Hydrogeologic Evaluation of Honey Lake In Hopewell Township, Mercer County, New Jersey

Water: A Natural Renewable Resource

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HYDROGEOLOGIC EVALUATION OF HONEY LAKE IN HOPEWELL TOWNSHIP, MERCER COUNTY, NEW JERSEY

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INTRODUCTION

M^2 Associates was retained by Hopewell Township to conduct an evaluation of the potential influences Honey Lake imposes on groundwater resources of Hopewell Township. Honey Lake was created by the impoundment of Honey Branch, a tributary to Stony Brook, in or about 1964.

Groundwater and surface-water resources within Hopewell Township are closely related and complex. In most areas of New Jersey, streamflows in dry weather are sustained by groundwater discharges. These groundwater discharges form the baseflow of the stream. However, the water resources of Hopewell Township are not this simple. In some parts of the Township, groundwater levels are lower than surface-water levels and streams and lakes lose water to groundwater.

Concerns were raised that if Honey Lake were drained or eliminated, groundwater resources relied upon by residents of the area would be adversely affected by the change in surface-water/groundwater dynamics. While there is no clear empirical data demonstrating the hydraulic relationship between the lake and groundwater resources, geologic and hydrogeologic conditions indicate a strong likelihood that these two water resources are well connected and reliant upon each other. Furthermore, since essentially all of the homes within the area were constructed after the lake and groundwater resources equilibrated, it is likely that the permanent removal of the lake could have severe impacts to the availability of water.

SITE CONDITIONS

HISTORY

Based on information provided to Hopewell Township, Honey Lake was initially planned in the early 1950s along with Baldwin, Curlis, Hunt, Rosedale, and Willow Lakes to limit sedimentation of Carnegie Lake. The six man-made lakes are all located within Hopewell Township along various tributaries to Stony Brook. Honey Lake was reportedly constructed in 1963 and then drained and deepened in 1964. However, historical aerial photographs indicate that construction of the lake was not started till at least late 1963. The dam impounding Honey Lake was designed by the United States Department of Agriculture-National Resource Conservation Service (NRCS) with a life-expectancy of 50 to 100 years.

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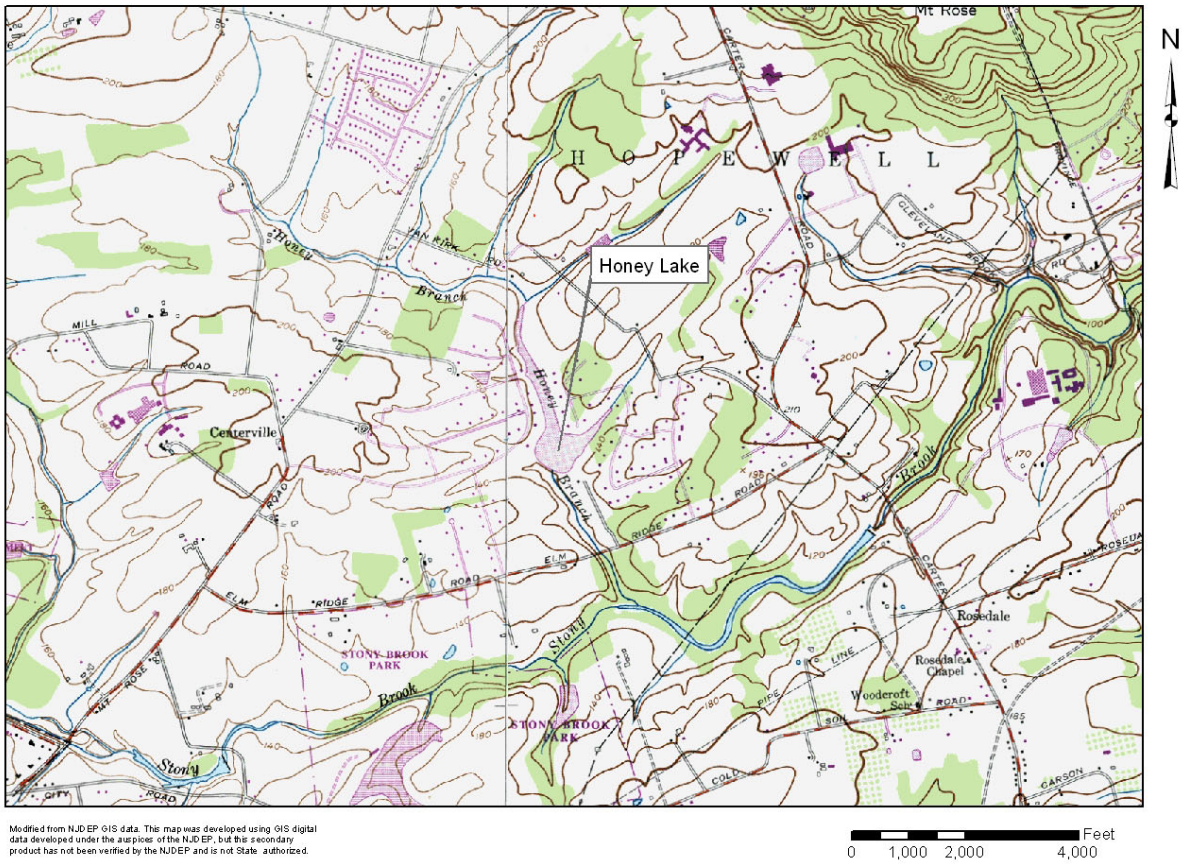
While the U.S. Government indicates that the dam forming Honey Lake is a “significant hazard”, the New Jersey Department of Environmental Protection (NJDEP) designated the dam a “high hazard” apparently because of a home located downstream of the dam. An engineering study has been authorized to evaluate the dam and determine the need for changes to reduce the classification from “high hazard” to “low hazard.”

LOCATION

Honey Lake is located in the eastern portion of Hopewell Township north of Elm Ridge Road, southwest of Bayberry Road, and east of Centerville Road. The location of Honey Lake is shown on Figure 1.

Figure 1: Location of Honey Lake in Hopewell Township, New Jersey.

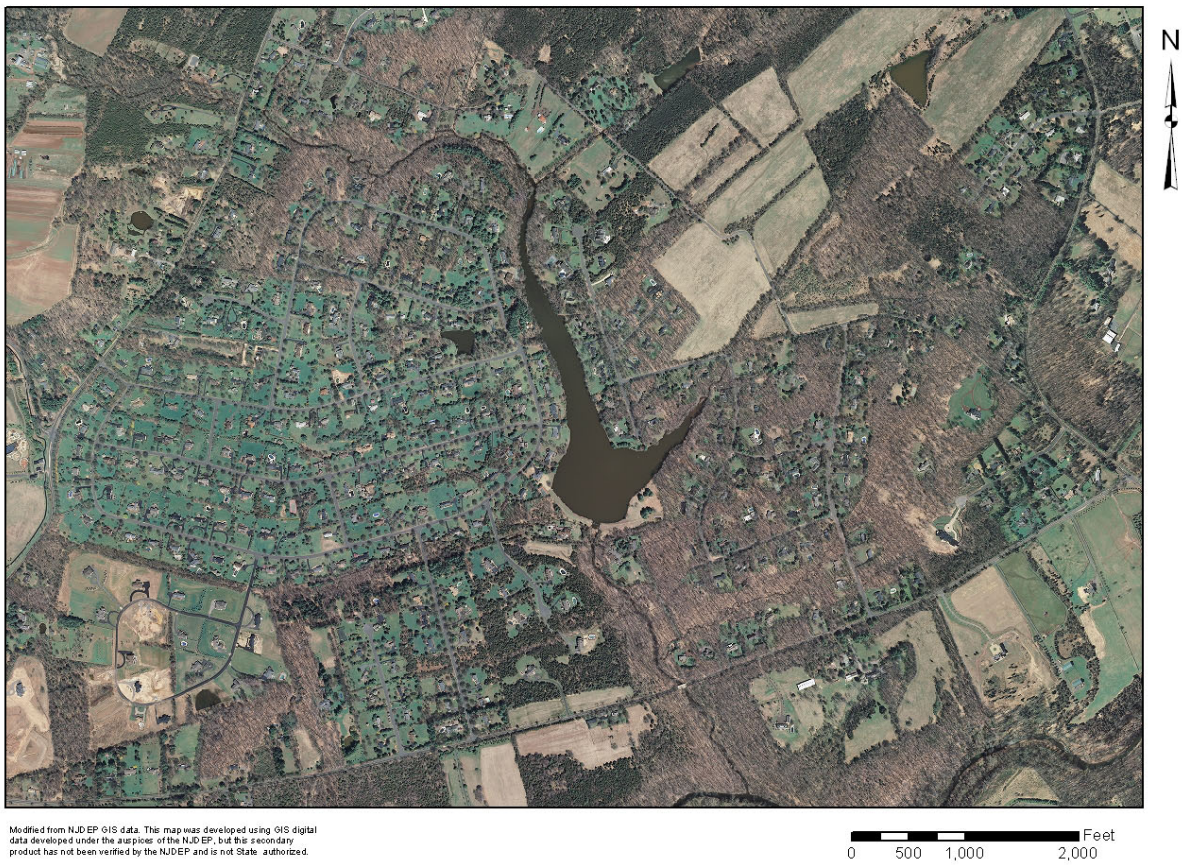


SURFACE WATER

Honey Lake is located immediately downstream of the confluence of five tributaries that form Honey Branch. A sixth tributary to Honey Branch drains to the lake from the east and forms a lobe of the lake near the dam. Ultimately, Honey Branch discharges from the lake and flows downstream approximately 2,800 feet before joining Stony Brook.

Honey Lake encompasses slightly more than 22 acres. Figure 2 is a mosaic of aerial photographs taken on behalf of NJDEP in 2008 that depict Honey Lake and the surrounding residential neighborhoods. While a few of the homes east of the lake were constructed in the 1960s, most of the homes, especially those west of the lake were constructed after 1972. Essentially all of the homes around and in close proximity to the lake were constructed after the lake was filled and likely after equilibrating with local groundwater resources.

Figure 2: 2008 Aerial Photograph Mosaic of Honey Lake in Hopewell Township, New Jersey.



GEOLOGY

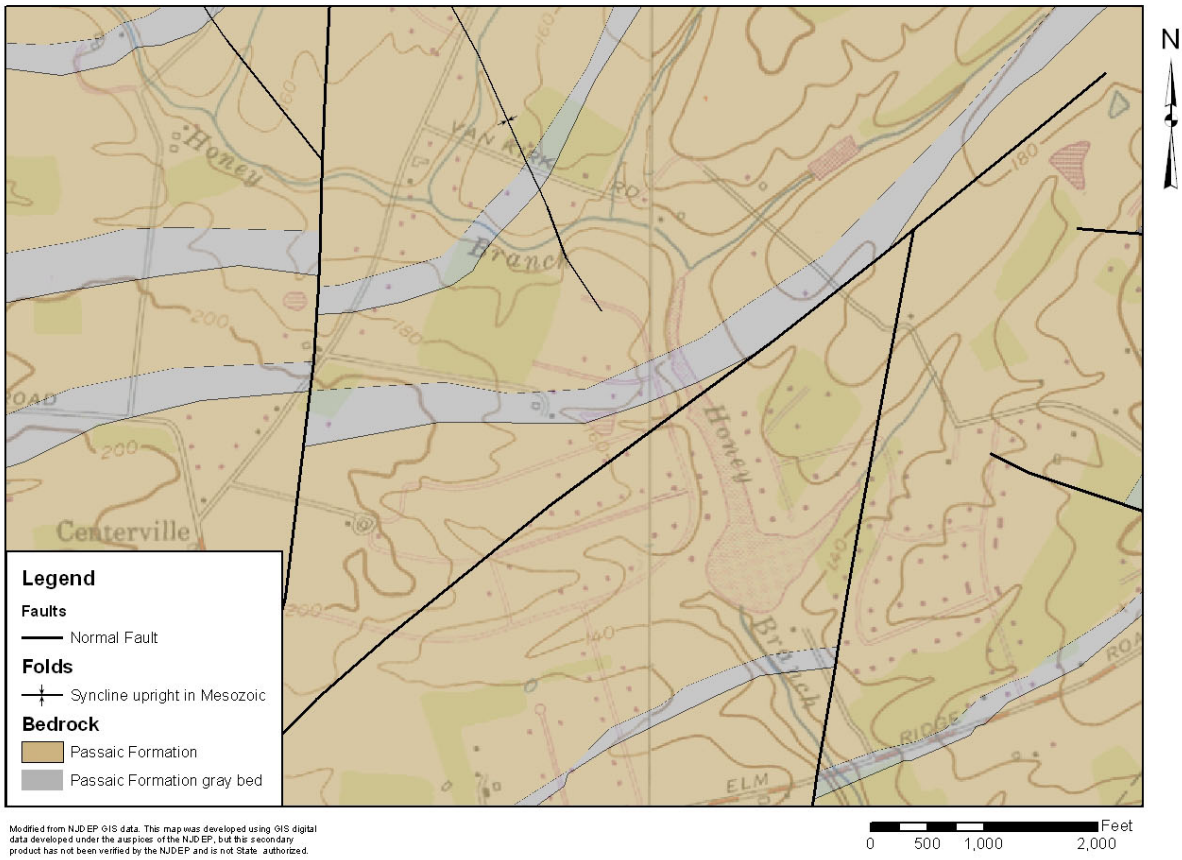
Formations

Honey Lake and the nearby properties are underlain by the Passaic Formation and the gray beds that are a subunit of this formation. The geology of the area as mapped by the United States Geological Survey (USGS) and New Jersey Geological Survey (NJGS) on the 1998 “Bedrock Geologic Map of Central and Southern New Jersey” (Owens et al. USGS MIS Map I-2540-B) is shown on Figure 3.

Fine-grained sands, silts, and some clays were the sediments deposited in the fluvial, lake, and mudflat environments of the late Triassic-early Jurassic. These deposits were later cemented into the red-brown, brownish-purple, and grayish red shales, siltstones, mudstones, and argillaceous very-fine grained sandstones of the Passaic Formation.

In some areas, gray lake deposits are distinct from other portions of the Passaic Formation and therefore, are mapped as a subunit of the formation. These gray lake deposits are comprised of gray to black silty mudstones, gray and greenish- to purplish-gray argillaceous siltstone, black shale, and gray argillaceous fine-grained sandstone.

Figure 3: Geology of Honey Lake Area in Hopewell Township, New Jersey.



Bedding

Immediately south of the dam, the strike and dip of bedding were measured by USGS/NJGS and recorded as North 83º East and 23º Northwest. Near the northern limits of the lake, bedding was measured as striking North 83º East and dipping 17º Northwest. The USGS/NJGS mapping indicates that north and west of Honey Lake, beds of the Passaic Formation have been gently folded as a result of past deformation of the Newark Basin.

Some beds within the Passaic Formation, such as shales and siltstones which, are brittle, are significantly more fractured then other beds such as sandstones, which tend to be more malleable. Groundwater will be stored and move through the fracture openings in the brittle layers while the poorly fractured sandy layers tend to store little water and limit its movement. Aquifer systems in the Passaic Formation are comprised of multiple layers of highly fractured shales/siltstones containing water, separated by more massive layers of sandstone that store little to no water.

Multi-Layered System

The brittle/highly fractured layers contain water and permit its movement. The water-bearing layers will often range from a few inches to a few feet in thickness. These water-bearing layers are separated by very low permeability to impermeable, massive to thick-bedded layers that often range in thickness from a few feet to several tens of feet. Little to no water is present in the confining/semi-confining layers that separate the thin water-bearing layers.

In most circumstances, the only fractures in the confining sandstone layers are vertical to near vertical openings sometimes referred to as joints that formed as the basin opened or was pulled apart. These vertical/sub-vertical fractures serve as groundwater conduits connecting water-bearing layers along the stratigraphic column. Water removed from one water-bearing layer can be replaced by water from an underlying or overlying water-bearing layer by leaking through these vertical/sub-vertical conduits. Groundwater moves from one highly fractured bed to the next one, either up or down the stratigraphic column depending on gravity and pressure, through these vertical to near vertical joints.

Bedding Strike

The orientation of bedding is important to understanding groundwater flow dynamics and resource availability. Groundwater in the Passaic Formation rocks tends to migrate through the water-bearing layers in directions that parallel bedding strike. Based on the strike of bedding near Honey Lake, groundwater is very likely migrating in a nearly east to west direction. Pre-1964 or before the lake was constructed, to the west of Honey Branch, groundwater was in most probability, migrating in a direction approximately oriented North 83º East. Also pre-construction but to the east of Honey Branch, groundwater was most likely migrating approximately 7º south of the east-west axis. Groundwater was moving on both sides of the stream through the water-bearing layers along strike toward Honey Branch. The stream was the local groundwater discharge point and today, the lake serves as the potential discharge sink.

Construction of the 22-acre lake would not change the fundamental controls to or orientation of groundwater movement but if water levels in the lake are higher than in the water-bearing layers on either side, gradients exist to sustain movement of water from the lake to the aquifer in the direction of bedding strike. Under these conditions,

the lake would lose or “leak” water to bedrock. This condition exists approximately 7700 feet along the direction of bedding strike to the west of Honey Lake at the Bristol-Myers Squibb campus. It has been estimated that the 9-acre pond on the campus leaks an estimated 100,000 gallons of water each day to the underlying bedrock aquifer system. At a comparable rate, Honey Lake could leak 250,000 gallons per day, which is more than sufficient to sustain the daily water demands imposed by the residences on the 450 or more property parcels located within 1-mile of the dam.

Not only is the strike of bedding important to understanding passive groundwater flow conditions, it is also needed to understand pumping dynamics in the Passaic Formation. When groundwater is pumped from a well, water levels and pressure within the aquifer decline. When that well is completed in the Passaic Formation, the shape of the zone of depression is an ellipsoid or similar to the bottom part of a football that has been cut in half from end to end. Within the ellipsoid, water levels and pressure within the aquifer are lowered creating a gradient that induces water movement toward the pumping well. The long axis of the ellipse will in nearly every circumstance, parallel the direction of bedding strike because groundwater in the water-bearing layers of the Passaic Formation is more easily transmitted in this direction.

The residential wells on either side of Honey Lake will create elliptical zones of influence that when combined, likely extend to and beneath the lake. These pumping influences can and very likely do induce the movement of water from the lake into the aquifer. For several decades and still continuing today, hydrogeologists would purposely locate major wells in the Passaic Formation near a stream or body of water. The well would be located at a point where the stream was in the direction of bedding strike. The purpose was to maximize groundwater withdrawals by inducing leakage from the stream to replace the withdrawn water. With a multiple layer system such as the Passaic Formation, water can drain from the stream into the aquifer over long stretches, thereby significantly increasing the yield of the well.

Bedding Dip

The dip of the bedding is also critical to understanding groundwater resources within the Passaic Formation rocks, especially with respect to the availability of these resources. While the beds initially started in a horizontal or near horizontal orientation, as the Newark Basin expanded 140 to 210 million years ago, the beds became inclined with a general slope to the northwest. Near Honey Lake, those beds are sloping approximately 23º Northwest. Therefore, a bed exposed at ground surface near the dam in the southern part of the lake, would be encountered at an approximate depth of 850 feet below ground surface, 2000 feet to the north at the start of the lake.

The water-bearing layers and confining/semi-confining units are all dipping beneath the lake. Where a water-bearing layer is exposed beneath the lake, there is a direct hydraulic connection between the lake and groundwater resources.

In comparison to groundwater flow in the direction of strike, the component of groundwater movement in the direction of dip is typically much less significant. Near recharge areas, there is likely to be downward movement of water and near discharge points such as streams, there is likely to be an upward flow component. Some of the upward and downward movement of water will be through vertical/sub-vertical fractures in confining/semi-confining layers and some of it will be through bedding plane fractures in the direction of dip. Under non-pumping conditions, the component of groundwater movement up and down dip is small, if not negligible in many cases.

However, when water is removed from a water-bearing layer, it must be replaced by water either moving downdip or through vertical/sub-vertical fractures from an overlying/underlying layer. Most wells completed in Passaic Formation rocks intersect multiple water-bearing layers. When these wells are pumped, the water removed from the well is replaced by water either migrating downdip or leaking from an overlying layer. In either case, where there is a hydraulic connection between the lake and groundwater resources, water will be induced to infiltrate from the lake into the underlying water-bearing layers.

Some time shortly after a lake is constructed, water in the lake will equilibrate with the local groundwater system. The lake becomes an outcrop or exposure of groundwater. When water levels in the lake are higher than in the surrounding aquifer system, water can leak from the lake into underlying bedrock fractures. When wells surrounding the lake are pumped, the resulting lowering of water levels in the aquifer system will induce leakage from the lake. When groundwater is removed from a water-bearing layer, it will be replaced with water infiltrating from overlying layers and/or water in storage in the same layer. The orientation of bedding is essential to understanding the dynamics and reservoir capacity of groundwater systems in the Passaic Formation.

Hydraulic Connection

Based on the orientation of bedding as mapped by USGS/NJGS near Honey Lake, it is very probable that the aquifer system beneath and surrounding the lake is hydraulically well connected to the lake. The hydraulic connection would be limited if a liner were installed at the time of construction or if sufficient organic material and sediment in-filled the bottom and sidewalls to separate the lake from bedrock beneath. However, given the multi-layered system of the Passaic Formation and orientation of bedding, it is highly unlikely if not improbable to assume that no hydraulic connection exists.

Furthermore, given the number of homes nearby (probably more than 400 within 1 mile of the dam), it is highly likely that the pumping of wells creates significant potential to induce leakage from the lake into the underlying and/or surrounding bedrock fractures. As discussed above, the much smaller pond at Bristol-Myers Squibb very likely loses 100,000 gallons per day to the underlying bedrock fractures. A comparable loss rate of 250,000 gallons per day from Honey Lake would represent less than a ½ -inch change in water levels in this 22-acre lake. Given that the water is replaced by discharges from

the six tributaries of Honey Branch, this volume of leakage from the lake would be imperceptible unless consistent and continuous inflow and outflow measurements were made and compared.

Faulting

In addition to the bedding plane fractures, the opening of the Newark Basin resulted in extensive faulting of the brittle Passaic Formation rocks near Honey Lake. One fault crosses through the western branch of the lake and a second related splay crosses through the eastern lobe. A third fault closely parallels the main body of the lake to the north and a fourth fault, which is apparent by the separation of gray beds across the trace, has been mapped approximately 3600 feet east of Honey Lake (see Figure 3). Three other faults have also been mapped nearby.

The presence of faults is significant with respect to groundwater resources because in the subsurface, water is transmitted and stored in bedrock fractures. Faults represent zones of intense fracturing and increased fracture density. Movement along the faults not only increased the density of fractures in bedding planes, but increases the density of vertical to near vertical fractures within the beds that separate water-bearing layers. It is through these vertical to near vertical fractures that groundwater moves from one water-bearing bed to the next.

It is very probable given the number of major faults mapped near Honey Lake, that water can readily move vertically between water-bearing layers. The presence of the faults, especially those that intersect the lake, indicate a high degree of interconnection between water in the lake and groundwater. It is highly likely that when water levels are lowered in the underlying water-bearing layers, leakage from the lake is increased.

THREE AQUIFER SYSTEMS

The Passaic Formation does not have primary porosity or openings between grains or particles through which, groundwater migrates. Groundwater movement through these rocks is controlled by secondary porosity including the fractures or openings formed by faulting and along bedding planes.

In the early 1990s, hydrogeologists from the USGS started noting that streams in portions of the Newark Basin oriented perpendicular to strike of bedding, such as Honey Brook at Honey Lake, tended to be better hydraulically connected to groundwater resources than streams oriented parallel to bedding strike. Streams flowing perpendicular to strike intersected more beds and therefore, intersected more groundwater flowing along strike of those beds. These streams receive more groundwater than streams oriented parallel to strike.

The initial streamflow observations suggested that bedding or fractures nearly parallel to the strike of bedding served as the major conduits for groundwater movement under

both pumping and non-pumping conditions. The data indicated that fractures or features perpendicular to bedding such as dip, had much less influence on groundwater movement.

Herman (2001) separates the Passaic Formation into three aquifer systems. The shallow system is comprised of weathered bedrock materials and overburden sediments and has a general thickness of less than 20 feet. A perched or seasonal water-bearing zone is typically associated with the shallow system. If this shallow system existed, it would have been partially or entirely removed with the soils and highly weathered bedrock when Honey Lake was excavated.

From approximately 20 to 70 feet below ground surface, Herman (2001) defines the intermediate zone or water-table aquifer, which has formed as a result of long-term weathering. Groundwater is typically encountered at depths less than 50 feet below ground surface in this zone. He found that the vertical movement of water “abruptly” stopped at the bottom of this aquifer. Less weathered, and fractured beds limited further passive downward movement of water into deeper zones.

Herman’s (2001) deep zone is primarily encountered at depths greater than 70 feet below ground surface and is comprised of confined or semi-confined aquifers separated from the shallow and intermediate zones except at locations where the deep zone is recharged or hydraulically connected to these overlying systems. An example of this situation is the previously discussed bed that intersects ground surface near the dam. This same bed is very likely encountered at a depth of 850 feet near the northern end of the lake.

In an attempt to illustrate how this bed that intersects ground surface near the dam fits the three aquifer systems indicated by Herman (2001), assume that it is a thin layer of highly fractured shale:

- Within a horizontal distance 50 feet north of the dam, the layer is likely very weathered and encountered within 20 feet of ground surface. Water in this layer would be considered the shallow aquifer and given local elevations, directly connected to the lake. Given local soils and topography, it is likely that this shallow seasonal aquifer is not extensive and only encountered in very close proximity to the lake. It would have been partially or entirely removed from beneath the lake when the lake was excavated.

- From approximately 50 feet to a point approximately 165 feet north of the dam, bedrock would be less weathered and continue to exhibit residual characteristics of the original bed but with enlarged fracture openings as a result of weathering. Water in the bed, which is encountered from 20 to 70 feet below ground surface, would be considered part of the intermediate or water-table aquifer. It is also likely given local topography, that the intermediate aquifer would have a direct connection to the lake. It is highly probable that the water level in the water-table

aquifer would be very similar and directly related to the water level in the lake. As water levels in the lake increase or decrease, water levels in the aquifer would increase or decrease. This water-table aquifer will extend well beyond the lake and beneath the surrounding neighborhoods.

- And from the point 165 feet north of the dam, the layer would be encountered at depths greater than 70 feet below ground surface. The layer would continue to exhibit many of its original bedding characteristics with little weathering. Water in the fracture openings is considered part of the deep aquifer. This deep bedrock aquifer also extends well beyond the lake. Water levels in this aquifer are elevated by pressure exerted by the overlying rock, forcing the water upward toward Stony Brook and Honey Branch and possibly to elevations higher than the lake. If there is a strong hydraulic connection between the deep bedrock and intermediate aquifer, it is likely that water levels in the deep aquifer will closely correlate with lake levels. If not, it is possible depending on the ease at which water can move through the aquifer, that water levels will be higher or significantly lower in the deep bedrock aquifer than in the water-table system.

Water removed from the deep bedrock aquifer through residential wells must be replaced by water migrating down dip along the bedding plane from the intermediate aquifer and/or from leakage through vertical/sub-vertical fractures that connect this water-bearing layer to an overlying or underlying water-bearing layer. Water removed from the intermediate shallower zone must also be replaced either by precipitation and/or leakage from the lake.

Although the illustration refers to a single layer, the aquifer systems are actually comprised of multiple water-bearing layers separated by low permeability confining/semi-confining layers. Within the intermediate/water-table aquifer, fracture openings have been enlarged by weathering and the separation between water-bearing layers by competent/poorly fractured units is diminished if not entirely eliminated. Within the deep bedrock aquifer, the separation continues.

As discussed above, Honey Lake is an outcrop of groundwater in the intermediate aquifer. When water levels in the lake are higher than in the surrounding/underlying water-table aquifer, water will leak from the lake into the aquifer. Also, when water is removed from the water-table aquifer or replaces water removed from the deeper aquifer, the potential will exist for leakage from the lake to the intermediate aquifer.

The pumping of wells at Bristol-Myers Squibb very likely increases the rate of leakage from the small pond on this campus into the underlying water-table and ultimately, deep bedrock aquifer beneath this site. The same conditions very likely exist given the orientation of bedding near the much larger Honey Lake. The pumping of residential wells that intersect both the water-table and deeper bedrock aquifer, induce leakage from the lake. This leakage sustains withdrawals within the aquifer and maintains equilibrium between the deep bedrock system, the water-table aquifer, and the lake.

LOCAL WELL DATA

In Hopewell Township, the three aquifer systems of the Passaic Formation are often encountered and typically, wells are completed in the intermediate and deep zones. The Hopewell Township Health Department data for wells located along both the east and west banks of Honey Lake were reviewed. Data from 17 well records indicate well depths ranging from 100 to 380 feet below ground surface with yields ranging from 3 to 50 gallons per minute. Static water levels at the time of installation, which ranges from 1967 to 1994, are reported between 1 and 40 feet below ground surface.

The data from the wells located on the shores of the lake at first inspection, do not appear strikingly different from other areas of Hopewell Township. The well with the deepest reported static water level (40 feet below ground surface) is also the oldest well in the group and was installed in April 1967, approximately 3 years after the lake was constructed. The static water level for this well may suggest that before the lake and groundwater systems had equilibrated, groundwater was encountered at greater depths and that water levels have risen in the aquifer system as indicated by the data from the other 16 wells. However, this one water level should be viewed cautiously given that 1967 was at the end of the “Drought of Record” when water levels were naturally much lower than during subsequent years.

The highest yielding well (50 gallons per minute) also has the shallowest reported static water level (1 foot below ground surface) and is located near the southwestern corner of the lake. The second highest yielding well (30 gallons per minute) also has a shallow static water level (8 feet below ground surface) and is located on the parcel immediately adjacent to the highest yielding well but slightly further from the lake. It is very likely that these two high yielding wells coincidently intersected a zone of intense bedrock fracturing that extends beneath the lake and parallels the major fault that intersects the lake. It is possible given the proximity of these two wells and orientation of the nearby major fault, that the increased yield of the one well is because of its closer proximity to the lake.

Further evaluation of the well data indicate that the median yield (20 gallons per minute) of the 17 wells is higher by 5 to 10 gallons per minute or 50 to 100 percent greater, than the median yield for wells completed in the Passaic Formation rocks throughout Hopewell Township. And the median well depth (165 feet below ground surface) indicates that the wells are typically installed to shallower depths near the lake.

Data for two wells obtained from Widmer (1965), which were completed before the lake was constructed do not further clarify the relationship between yield and static water level, and the presence of the lake. The one well completed along Honey Brook Drive in 1961 had a reported yield of 30 gallons per minute and static water level of 30 feet below ground surface. The second well completed to the west of Honey Branch along Elm Ridge Road in 1942 had a reported yield of 58 gallons per minute and static water level of 19 feet below ground surface.

Data from Jacobsen et al. (1993) indicates that at least along the western side of the lake, groundwater levels are higher than surface-water levels suggesting that Honey Lake is receiving groundwater and not losing water to the underlying aquifer. However, the one well near the lake indicated a very shallow static water level of 4.41 feet below ground surface in October 1987. As this measurement is from one date and one well, it cannot be used to say that at all times and at all locations, groundwater is at higher elevations than surface-water in the lake.

In summary, the local well data from the Health Department, Widmer (1965), or Jacobsen et al. (1993) indicate that yields and static water levels may be higher in proximity to Honey Lake but do not clearly show that the these parameters are higher simply because of the lake. The higher yields and static water levels may be higher near Honey Lake than elsewhere in Hopewell Township simply because of the much greater fracture density near the faults. Absent aquifer testing, long-term groundwater-level monitoring data, and stream inflow and outflow measurements, the local well data are not sufficient to clearly demonstrate the relationship between groundwater resources and water in the lake.

STREAMFLOW

No continuous or consistent stream inflow and outflow data for Honey Lake are available on public databases or from USGS. Twenty-four streamflow measurements were recorded by USGS from March 1968 to April 1988 in Honey Branch downstream at the dam where the stream flows beneath Elm Ridge Road. These measurements indicate flows ranging from 1.5 to 490 cubic feet per second (cfs). Data from this station and one upstream of the lake where Honey Branch flows beneath Wargo Road are not sufficient to show changes in stream rates into and out of Honey Lake.

USGS has periodic water level measurements for an observation well located near Wargo Road. The well is not located in sufficient proximity to Honey Lake to assess water level influences and the periodic measurements are not sufficient to determine if such an influence existed.

There are no empirical data to clearly demonstrate the hydraulic relationship between Honey Lake and groundwater resources within the Passaic Formation rocks beneath and surrounding the lake. Long-term monitoring of stream inflow and outflow for the lake, water level measurements within the aquifer systems beneath the shores of the lake, and aquifer characteristics determined from pumping tests would be necessary to fully define the hydraulic relationship. These data were not available for this evaluation and would require several months if not years of monitoring to reasonably quantify the relationship.

CONCLUSIONS

Based on the geologic, hydrogeologic, well and streamflow data reviewed, the findings of the hydrogeologic evaluation are as follows:

1. There are no empirical data to clearly define the hydraulic relationship between Honey Lake and groundwater resources in the Passaic Formation aquifer systems beneath and surrounding the lake. Compilation of the data needed to quantify the relationship was beyond the scope of this evaluation and would require several months if not a few years of water-level monitoring, continuous streamflow measurements, and aquifer testing.

2. Circumstantially, the geologic and hydrogeologic data for the Passaic Formation strongly indicate that Honey Lake and the groundwater resources are highly connected. Given the number of homes (possibly 400 or more) within close proximity to the lake and groundwater resources of the Passaic Formation systems, it should be expected that the lake is essential to sustaining groundwater withdrawals. Leakage from the lake into the underlying water-bearing layers of the Passaic Formation, very likely replaces water withdrawn from the aquifer systems through residential wells, especially in periods of prolonged dry weather.

3. Honey Lake is an outcrop of the water-table aquifer system that extends from at least Elm Ridge Road to Bayberry Road and Pennington-Rocky Hill/Centerville Road. As such, over the last 45 years, the lake has equilibrated with groundwater resources. When water levels in the lake are higher than in the surrounding/underlying water-table aquifer, water will leak from the lake into the aquifer. Also, when water is removed from the water-table aquifer or replaces water removed from the deeper aquifer, the potential will exist for leakage from the lake to the intermediate aquifer.

4. Since essentially all of the homes within the area were constructed after the lake and groundwater resources equilibrated, it is likely that the permanent removal of the lake would have severe impacts to the availability of groundwater for these homes.

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