June 10, 2004

William DiLibero
Robert E. Craven & Associates
50 Park Row West, Suite 100
Providence, RI 02903

RE: Technical Review Comments of
Geohydrological Investigation Report
Victory Woods Housing Project

Dear Mr. DiLibero,

Woodard & Curran (W&C) presents herein our technical review comments of the report entitled "Geohydrological Investigation Report, Victory Woods Housing Project, West Greenwich, Rhode Island, PBA No. 04027" dated April 30, 2004, prepared by the consulting firm Paul B. Aldinger & Associates, Inc. (PBA). The purpose of this review was to determine if the PBA report presented sufficient data to demonstrate that the existing two wells at Blueberry Heights (BH) can provide potable water of sufficient capacity and quality for the existing Blueberry Heights mobile home development and proposed Victory Woods (VW) development. Specifically, W&C has sought to determine if sufficient data has been presented in the PBA report to demonstrate that expansion of withdrawal from the existing BH water supply can support the new proposed demand from the VW development, without impairing the use of drinking water historically enjoyed by BH and to which the BH homes have become accustomed and dependent upon.

Background

Blueberry Heights is an existing residential development consisting of 27 mobile homes. Potable water is provided by a single drilled bedrock well designated as Well #3. Well #3 is regulated as a Community Public Supply Well by the Rhode Island Department of Health (RIDOH). Wastewater disposal is provided by on-site individual sewage disposal systems (ISDS) or "septic systems". A second well, designated as Well #2 is located approximately 80 feet north of Well #3; Well #2 is inactive and is reported to never have been used. The BH development and location of Well #3 are shown on Figure No. 1 (attached).

The developer, SWAP, Inc. (SWAP), proposes to construct 52 new homes east of BH, between BH and Well #3, as part of an affordable housing development called Victory Woods. SWAP has proposed to use and expand the existing BH water supply, including use of both Well #3 and Well #2, as the source of drinking water for the VW development. Wastewater disposal would be provided by a new ISDS system for each home, for a total of 52 new septic systems constructed between BH and Well #3.

PBA performed a continuous pumping test of Well #3 for seven days from April 5-12, 2004. During this pumping test Well #3 pumped its entire flow to waste, and potable water was provide to the BH homes via temporary on-site storage tanks. Drawdown was measured in shallow overburden observation wells, and existing active and inactive bedrock wells. No water quality samples were taken from Well #3 during the pumping test. PBA has concluded that the pumping test data indicates that Well #3 has sufficient capacity to support both the BH and VW developments.

It should be noted that a minimum of two state regulatory agencies would be involved to permit the public water supply and wastewater septic system needs of the VW development. Public water supply permitting is administered by the RIDOH, Office of Drinking Water Quality and septic system permits are administered by the Rhode Island Department of Environmental Management (RIDEM), Office of Water Resources, ISDS Permitting

It should also be noted that water system design should follow some basic best engineering practices for development of a new source or expansion of an existing source, to ensure that the source can meet water system average and maximum day demands under varying climate conditions. For example, for a small system dependent on a bedrock well as a single source, as are the BH homes or the proposed BH/VW water system, the bedrock well should have to be capable of meeting maximum day demand with no drawing from tank storage; tank storage should be sized to maintain system pressures and meet peak hour demands. In addition, testing procedures for a bedrock well should establish that the well has a safe yield greater than the maximum day demand by a defined factor of safety (a minimum of two or greater) to ensure that the uncertainties associated with using short-term test results to gage long-term performance do not result in underestimating the well yield.

In our opinion, the minimum performance standard for expansion of the BH water system to supply the 52 new homes proposed for VW, is that the supply of drinking water to BH is not diminished, compromised, or burdened, simply to meet the new demands proposed for VW. The existing BH development should be able to be provided with the same capacity and quality to which the homes are dependant upon and have enjoyed throughout the history of use of Well #3.

W&C performed a file review of RIDOH records to assess the existing conditions and history of water supply for the BH homes. W&C also reviewed the following state regulations and engineering literature to determine well testing compliance with minimum guidelines recommended for development or expansion of bedrock well community public water supplies, and best engineering design criteria for small water and wastewater systems, including:

- RIDOH, amended June 2001, *Rules and Regulations Pertaining to Public Drinking Water (Rules and Regulations)*.
- RIDOH, July, 1994, *Guide for Small Public Drinking Water System Design (Design Guidelines)*.
- RIDOH, *Application for Approval Package, Public Water System Plans and Specifications (Approval Package)*.
- RIDOH, December, 1989, *Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells (Drilling Regs)*.
- RIDEM, September, 1986, *Wellhead Protection Plan Guidance (WHP Guidance)*.
- RIDEM, January 2002, *Rules and Regulations Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems (ISDS Regs)*.
- Metcalf & Eddy, 1991, *Wastewater Engineering*, 3rd edition (*M&E*).

Our review comments are presented below, organized into major topics that we believe are relevant to reviewing the data and conclusions presented in the PBA report. In our opinion, the most significant deficiencies in the data presented for VW so far relate to five major issues:

- Estimated design flows for water supply and wastewater disposal
- Adequacy of pumping test for Well #3
- Absence of testing performed on Well #2
- Assessment of water quality impacts from landuse and new ISDS systems
- Development of Water System Management Plan

Review Comments

1. Estimated Water Demand and Wastewater Flows

a. SWAP/VW has presented design flows for water and wastewater demand based on data presented in a memo prepared by Pare Engineering (Pare) dated November 18, 2003. This memo presented a flow of 32,250 gallons per day (gpd) as a "maximum day demand" for the combined developments of BH and VW, reported to be derived from guidance data included in the RIDOH Guide for *Small Public Drinking Water System Design*, dated July 1994. In our opinion, this estimate of maximum day demand is incorrect.

b. Pare presented an estimate of water supply demand of 8,100 gpd for the existing 27 mobile homes of BH, based on assuming each mobile home has two people at two bedrooms/home or 300 gpd per home, citing water use rates presented in the RIDOH guidance manual. However, W&C has reviewed the guidance and consulted with RIDOH officials and have found that the RIDOH guidance recommends a minimum design flow of 450 gallons per day for mobile homes with minimum dimensions of 8 feet wide by 32 feet long. All BH mobile homes exceed these RIDOH minimum dimensions. Therefore, based on the RIDOH recommended minimum design flows for water supply for mobile homes, W&C calculates the minimum BH water demand to equal 12,150 gpd, which is also equal to 8.84 gallons per minute (gpm) which is approximately 50% higher than the water demand estimated by Pare.

c. The Pare memo also presented a future estimated water demand of 24,150 gpd (16.77 gpm) for the proposed 52 homes of the VW development. The total estimated water demand currently used by VW for planning purposes is equal to 32,250 gpd (22.40 gpm), which SWAP/VW presents as a "maximum daily demand." In our opinion, based on the revised estimated flow for BH presented above, the minimum total daily water demand for the combined BH /VW should be equal to 36,300 gpd (25.21 gpm)

   Furthermore, the flow of 36,300 gpd should be interpreted as the total annual <u>average daily demand</u> for the combined BH/VW developments, not the maximum daily demand. W&C consulted with RIDOH and RIDEM officials (Doris Aschman, RIDOH, and Mike Umbriano, RIDEM) and they confirmed that RIDOH water use rates were simply duplicated from RIDEM minimum wastewater flow rates presented in the RIDEM guidelines for septic system construction (*ISDS Regs*). Therefore, the design flows referenced in the RIDOH guidance for water supply are minimum daily average flows, not maximum day demand flows.

Best engineering practice is that wastewater flows are typically 15% less than water demand due to losses in the water system or unaccounted for water. Therefore, the W&C estimates the annual average daily demand for water supply of a future BH/VW water system is 36,300 gpd/0.85 = 42,706 gpd (30 gpm).

d. In our opinion, best engineering practice for water system planning and design would interpret the water demand of 42,706 gpd as an annual daily average, based on the expected total annual water demand/365 days. The calculation of the average day demand is important because it serves as the basis for determining the design flow parameters for the future expanded water system, and is the basis of determining the capacity of the well needed to be approved by the RIDOH to serve the new expanded water system.

e. RIDOH regulations require that a small community public supply well needs to have a "source capacity" equal to twice the maximum day demand, as defined in Section 3.3 of the RIDOH *Design Guidelines*. W&C consulted with RIDOH to confirm the definition of "source capacity". RIDOH indicated that "source capacity" is defined as a 24 hour per day sustainable yield, analogous to a theoretical "safe yield" for the well. Essentially, RIDOH has defined that for small systems such as BH or VW that would depend on a single on-site well as their single source of drinking water, a factor of safety of 2 for well capacity is required such that the well's safe yield, determined from short-term pumping test results, is twice the maximum day demand for the water system in order to ensure that the well can meet the water system supply requirements under all future long-term seasonal conditions. Therefore, the determination of the required source capacity requires the calculation of the water system maximum day demand.

f. Maximum day demand for small water systems such as BH or BH/VW would typically vary by a factor of 2 – 5 compared to average day demand. Assuming an averaged day demand for BH/VW equal to 42,706 gpd, and using a peaking factor of only 2, we estimate the maximum day demand for the combined developments to be 2 x 42,706 gpd = 85,412 gpd (60 gpm).

Therefore, any single well serving the BH/VW developments would have to show a theoretical safe yield equal to 2 times the maximum day demand, which is equal to 2 x 60 gpm = 120 gpm to meet the regulatory performance standards established by RIDOH. It should be noted that the regulatory standard defined by RIDOH is established to provide an adequate factor of safety to ensure that the well can safely provide a reliable capacity of the well for long-term use based on short-term pumping test results. Future severe droughts can typically last for six months or greater. Since bedrock wells often exhibit changes in drawdown due to seasonal fluctuations in precipitation ranging from a few tens to hundreds of feet, a sufficient buffer or safety mechanism has to be built into the well capacity to withstand the reasonable extreme droughts that can be expected, and still allow the well to meet daily average and maximum day demands. Maximum day demand for small systems can be further increased by the fact that these demands occurring in the summer when outdoor water use creates additional demand on a water system. Since short-term pumping test results of any well will not be able to simulate the inevitable regional droughts that occur in a given region, the imposition of factors of safety that require a source capacity greater than the exact calculated maximum day demand is a routine practice in water supply engineering.

In our opinion, in order to show that Well #3 or Well #2 can produce 120 gpm, the best engineering practice is to estimate safe yield based on actual well pumping performance at the desired performance flow rate, not based on extrapolation from lower pumping rates. Furthermore, due to the uncertainties of estimating long term well capacity based on short term pumping results, the well should be overpumped by 33% or pumped at a rate of 160 gpm during a pumping test run to stabilization; the source capacity (or safe yield) would then be calculated as being 75% of the pumping rate at which stabilization occurred. Such "overpumping" performance standards for bedrock wells is the dominant expected engineering standard for pumping tests performed on small system bedrock public supply wells, since typically there will be no long-term back-up source of water on which the developments can depend if the capacity of the bedrock well source is underestimated.

2. Adequacy of Pumping Test

Based on the data presented by Paul Aldinger at the April 2004 Zoning Board meeting and the pumping test report, our opinion is that the data has not demonstrated that Well #3 can provide a reliable source of drinking water for both the BH and VW developments, nor does the data demonstrate that the well has a capacity that meets the regulatory source capacity criteria required by RIDOH. The key factors, in our opinion, that make the results of the seven day pumping test performed on Well #3 incomplete and unreliable to conclude that Well #3 has sufficient capacity or quality are:

a. Well #3 was pumped at too low a capacity (20-25 gpm) to show that the well can produce the safe yield expected by RIDOH for approval of expanded withdrawal from the well, which is 120 gpm. In effect, the well was pumped at a rate of only 16% of the rate recommended for best engineering practice to establish that the well has a safe yield of 120 gpm. Therefore, we cannot agree with PBA that the seven day pumping test proved that there is adequate capacity in Well #3 for the proposed combined water system of BH/VW.

b. Since the average day withdrawal rate of Well #3 is proposed to be increased by at least a factor of 3, the area of contribution to the well will expand and induce recharge from areas of the bedrock aquifer and overburden which likely have not previously recharged Well #3. The water quality from these new sources of recharge could be different from the quality to which Well #3 has been accustomed and could require treatment for aesthetic constituents (pH, iron, manganese), or for hazardous constituents contributed from a pollution source (i.e.: sand & gravel operation downgradient of Well #3). No water quality samples were taken during the seven day pumping test, therefore; the impacts to water quality from the expanded area of contribution cannot be evaluated even in a preliminary sense. We think this is a significant deficiency in the performance of this pumping test that alone justifies a need to repeat the pumping test at an appropriately higher pumping rate. RIDOH has indicated that any pumping test used to establish source capacity for expanded withdrawal from an existing public supply well should include water quality testing prior to obtaining system approval from RIDOH.

c. The pumping test report acknowledges that the significant rainfall events before and after the pumping test cannot be totally factored out of the pumping test data. In addition, the contribution to bedrock aquifer recharge from the unnamed stream located approximately 200 feet north/northwest of Well #3 and Well #2 was acknowledged to be a potential source of induced surface water recharge to the bedrock aquifer (Section 9.25.5). These observations raise several concerns with respect to water quality impacts to Well #3 or Well #2 if the stream is a significant regular source of recharge:

   1) The water quality at the wellhead would have to demonstrate absence of pathogens as demonstrated in two rounds of Microscopic Particulate Analysis (MPA) tests performed on both wells. United States Environmental Protection Agency (USEPA) guidelines and best engineering guidance for wells located within 200 feet of streams, or wells suspected of obtaining significant recharge from surface water sources such as streams via induced infiltration, are that such wells should be evaluated for the potential for pathogen contamination from the stream water due to the presence of microorganisms such as cryptosporidium and giardia; these organisms are common to surface water from mammal sources and cause acute intestinal ailments that can have serious health effects for vulnerable populations. The flow of water from a stream through soil overburden and then into bedrock fractures may not provide sufficient filtration and treatment to remove or inactivate these forms of pathogens. Positive detection of these pathogens in MPA water quality tests would require provision of disinfection treatment for the wells.

   2) W&C would recommend that both Well #3 and Well #2 would have to be retrofitted (or new wells drilled) to include a cement grout sanitary seal around the well casing to prevent short-circuiting of contaminated surface water runoff down into the well that bypasses any filtration from the till overburden. A grouted annular seal is indicated in RIDOH's guidance for construction of artesian wells in geologic conditions were the sealing of the annular space between the outside of the casing and borehole well may not be adequate (Section 7.06.A, Section 7.10.B- *Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells*, dated December, 1989). Due to the proximity of the wells to the unnamed stream and relatively level ground surface elevation between the wells and the stream bank that may allow for seasonal inundation by stream flooding of the ground around the well casing, and the prevalence of naturally high bacteria and other pathogens in surface water, and retrofit of both wells to have a grouted annular seal would be highly recommended.

d. Conflicting records for Well #2 and Well #3 have led, in our opinion, to confusing interpretations of the original potential capacities of both wells. Based on our review of the RIDOH files, and discussions with RIDOH officials, we have concluded the following:

   1) Well #2 is a 6-inch well 300 ft deep, drilled in 1993 and at best produced only 25 gpm with no report of drawdown when originally installed. Therefore, this well lacks even a preliminary estimate of specific capacity.

   2) Well #3 is a 6-inch well 300 ft deep, drilled in 1993, and at best produced 60 gpm with 60 feet of drawdown after pumping for 48 hours. No drawdown data or climate/precipitation data was found to be available for this pumping test, and this pumping rate is only 38% of the rate we recommend for establishing the safe yield required by RIDOH for a well to serve the proposed BH/VW water system. Therefore, in

our opinion this test is insufficient to be used to estimate long-term pumping capacity for the future BH/VW water system.

e. We disagree with the methods presented in the report to estimate the safe yield of Well #3. In our opinion, estimates of long-term well yield for a bedrock well should be based on actual performance at that pumping rate, instead of extrapolation of results based on lower pumping rates. Since long-term (i.e.: years) of pumping of test wells is accepted as uneconomical for testing proposed wells, use of pumping rates slightly above the desired well safe yield during short-term pumping tests is the accepted engineering practice to ensure reliability of safe yield estimates from short-term pumping test data.

   The method of estimating the well pumping capacity presented in the report has been based on extrapolation using calculated specific capacity and available water in Well #3, to estimate higher well yields based on pumping tests performed at lower pumping rates. In our opinion, this method of extrapolating to calculate safe yield using specific capacity is not suited for bedrock wells (although it is an accepted method of yield estimation for sand & gravel aquifer wells). The estimated average day demand for the proposed BH/VW water system is 42,706 gpd (30 gpm), and the estimated maximum day demand is 85,412 gpd (60 gpm). The RIDOH required source capacity is for the well to have a 24 hour per day safe yield of 120 gpm. Best engineering practice would dictate overpumping a bedrock well by 33% to prove a particular well capacity. Therefore, since a safe yield of 120 gpm would be required for Well #3, the well should have been pumped at a rate of 160 gpm to stabilization to prove a capacity of 120 gpm.

   Well #3 is reported to have only been pumped at an average rate of 23 gpm during the seven day pumping test. Based on the drawdown exhibited by Well #3 while pumping for seven days at 23 gpm, and the remaining water in the well (available drawdown) at the end of the pumping test, the report concludes by extrapolation that Well #3 can produce “at least 22 gpm and … in excess of 60 gpm for at least several hours.” In our opinion, the well was pumped at too low a pumping rate to support these conclusions. Furthermore, the conclusion of well capacity to pump “60 gpm for at least several hours” would still be deficient to meet the projected maximum day demand of 60 gpm for 24 hours, and factor of safety required by RIDOH to provide a well with a safe yield equal to twice the maximum day demand or 120 gpm in the case of the proposed BH/VW water system.

   In our opinion, the report additionally relies too much on supporting evidence of well safe yield on the 48 hour pumping test performed on Well #3 at a rate of 60 gpm when it was originally installed in 1993. The report presents the 1993 pumping test of Well #3 as a demonstration of sufficient pumping capacity to meet peak demands or of ultimate 24 hour per day well safe yield. In our opinion, the 1993 test was performed in a fashion that was not documented to meet the minimal best engineering practices attempted during the recent 2004 pumping test. For example, no report of precipitation conditions or climatic influences was made for the 1993 pumping test. In fact, the report concludes that the 1993 pumping test demonstrates that Well #3 can produce at a pumping rate "in excess of 60 gpm for at least several hours." In our opinion, this old pumping test is insufficient and of unreliable quality to be used in the calculation of well capacity for the proposed expanded water system that will consist of 79 homes. In our opinion, the report depends on estimates of long-term future performance of Well #3 by using data based too much on extrapolating short-term performance based on lower pumping rates, instead of actual short-term performance based on the required RIDOH source capacity (which is 120 gpm in our opinion).

Therefore, we disagree with the report's conclusions that the original well construction pumping tests, and the recent seven day pumping test, are sufficient to demonstrate that there is adequate capacity from Well #3 to provide 100% of the source capacity required for the combined water demand of BH and VW.

f. In our opinion, the source of recharging fractures to Well #3 has not been sufficiently explored and defined. The report presents opinions of depth of recharging zones in Well #3 based too much on conjecture and speculation, without actual confirmatory exploration evidence to determine the depth and capacity of the primary fractures recharging the well. The identification of the depth and location of primary recharging fractures is necessary to substantiate drawdown and capacity results obtained from pumping tests to understand that well fractures are sufficiently deep and of enough capacity to withstand future regional drought conditions.

For example, in Section 10.20 the report presents speculation that Well #3 could produce in excess of 100 gpm for at least several hours, but acknowledges that no data has been reported or obtained to identify the depth of major yield zones in this well or Well #2. In addition, the report further acknowledges that if only one major fracture exists at the bottom of the well, the well yield for short-term pumping would be limited to no greater than 60 gpm. Therefore, we see no basis for the report to conclude that Well #3 can reliably pump 60 gpm or 100 gpm. In our opinion, the method of long-term high yield estimation used in this study is based too much on extrapolation from unreliable data, instead of results based on pumping at the actual required pumping rates.

The impact of lack of understanding of the depth of primary fractures can be to overstate the reliability of the well capacity. In our opinion, bedrock wells with shallow depth primary recharging fractures (i.e.: less than 100 feet) are vulnerable to severe reduction of well yield or even drying up completely during typical drought conditions if these wells are overpumped. The well completion reports for Well #3 and Well #2 make reference to "soft" zones of rock between the depths of 35 – 70 feet; the PBA report also acknowledges this depth interval as the highly fractured zone of the wells (Section 8.00). Therefore, based on available information related to the depth of fractures for each well, it is our opinion that additional testing is required to identify in more detail the depth and recharging capacity of the primary fractures in Well #3 and Well #2.

The minimal effort required to identify the depths of high yielding fractures would involve performing a step-drawdown test with pumping rates ranging from 25% to 200% of the desired safe yield for the well. Our understanding is that no such test is proposed on either Well #3 or Well #2, but we would recommend that these tests be performed on both wells.

g. Based on our review of the pumping test report for Well #3, we recommend the following:

1) In our opinion, Well #3 should have a new seven day pumping test performed at a pumping rate of 160 gpm, repeating the same logistics as performed during the previous pumping test with the following minimum modifications: 1) increase pumping rate to 160 gpm for seven days, 2) collect water samples for secondary contaminants, total colliform,

VOCs, radionuclides at the midpoint and end of the pumping test, and collect an MPA sample during the final 24 hours of the pumping test.

2) A step-drawdown pumping test should be performed on Well #3 to identify the depth and capacity of the primary recharging fractures.

3. Absence of Testing Performed on Well #2

RIDOH recommends that community public water supplies have more than one source with the capability of meeting peak demands with the largest producing well out of service (Section 3.3, *Design Guidance*). Common for most small systems like BH that are dependent on drinking water from an on-site well, a second source is not technically available on land controlled by BH or VW. In our opinion, Well #2 is not a separate source at it is drilled into the same bedrock aquifer fracture system as Well #3. In other words, a separate source would be located in a different watershed and be independently recharged and not affected by a catastrophic contamination event; if the aquifer of Well #3 becomes contaminated due to a man-made release of pollution, we would expect that Well #2 would be similarly contaminated. Therefore, we conceptualize that Well #2 provides at best a level of "mechanical backup" that withdraws water from the same source aquifer but could provide benefits in terms of well rotation and recovery if used in a lead/lag operation with Well #3.

SWAP/VW has proposed that Well #2 would be used in a rotating pumping/backup capacity with Well #3, implying that Well #2 has the same capacity as Well #3. Use of Well #2 is subject to approval by RIDOH as the well has never received full approval. Based on our review of RIDOH files and discussions with RIDOH officials, no final plans and specifications were ever submitted to RIDOH or otherwise approved by RIDOH for the use of Well #2. RIDOH records of the well completion report indicate that at best, Well #2 has only been shown to pump at a rate of 25 gpm for 48 hours when installed in 1993, but no pumping test drawdown data was available for review in the RIDOH files. Therefore, existing RIDOH data indicates that Well #2 has less than half the potential capacity of Well #3 and may not be a reliable backup well as proposed by SWAP.

Furthermore, RIDOH regulations indicated that approval of plans and specifications granted by RIDOH expire in two years if construction of the approved source has not begun within that period (Section 3.0- *Rules and Regulations*). Therefore, use of Well #2 will require submission to RIDOH of well testing and water quality data to demonstrate desired well yield, safe water quality, and plans and specifications for connection into the proposed BH/VW water system.

In our opinion, Well #2 needs to be subjected to identical well testing procedures as Well #3 if Well #2 is to be assumed to have 100% of the pumping capacity of Well #3. Currently, it appears that VW/SWAP does not intend to perform a pumping test on Well #2. Therefore, a separate controlled seven day pumping test at a rate of 160 gpm should be run on Well #2 with similar water quality tests performed as recommended to be performed on a re-test of Well #3. A step-drawdown pumping test should also be performed on Well #2 in a fashion recommended above for Well #3, to identify the depth and capacity of recharging fractures.

4. Assessment of Water Quality Impact from Landuse, Stormwater and New ISDS Systems

The report indicated that approximately 89 percent of the ISDS wastewater will be returned to the minimal area of contribution (drainage area) for Well #3. Section 7.10 of the report implied that that the recharge (or "diversion") area to Well #3 would minimally include the surface drainage area upgradient of Well #3 plus some drainage area downgradient of the well. Fractures that recharge a bedrock well can cut under and across drainage divides delineated based on surface drainage. In the absence of evidence to the contrary, the RIDOH delineates Wellhead Protection Areas (WPA), or areas of contribution for wells based on a circle with a radius proportional to the well pumping rates. Based on the current BH water system, the WPA is a circle with a radius equal to 2,800 feet. Based on the WPA for BH alone, the entire BH and VW developments are located within the area recognized to provide recharge to Well #3. Therefore, landuse within the WPA to Well #3 (or Well #2) is understood to determine the water quality pumped from these wells; water consumed from Well #3 or Well #2 will reflect the quality of recharge which falls into the WPA from natural and manmade sources.

a. Impacts from ISDS

The SWAP/VW development will add 52 new septic systems into the recharge area to the wells, all located upgradient of the wells. The average day wastewater flow for ISDS's from the BH/VW developments is 36,300 gpd, loaded within an area of 84.1 acres, for an average loading rate of 432 gpd per acre of sewage that only receive primary treatment. Best engineering practice is to limit the loading from septic systems within a WPA to less than 400 gpd per acre to limit the loading of nitrate-nitrogen to drinking water. Once in the groundwater, nitrate-nitrogen does not react or otherwise decompose. Concentrations of nitrate-nitrogen that exceed 10 milligrams per liter (mg/L) are recognized by EPA to potentially affect the ability of blood to transport oxygen, particularly in children. Furthermore, the proposed 52 ISDS systems are all located upgradient of Well #3, which is the most vulnerable location for new development within a well's WPA. In our opinion, the presence and overall density of the proposed VW development could negatively impact the water quality of Well #3 and Well #2.

Water quality impacts from new ISDS systems are also derived from uncontrolled disposal of non-sanitary waste by ISDS owners. Unfortunately, ISDS systems are not designed to treat for hazardous, non-sanitary waste disposed in residential wastewater. Therefore, the proposed VW development will create 52 new potential entry points of contamination into the bedrock aquifer that recharges Well #3. This density of new ISDS construction within the WPA is interpreted to be excessive and a threat to drinking water quality.

In our opinion, the impact to groundwater quality from the total wastewater load contributed by the proposed VW development plus the existing BH development needs to be evaluated under the expanded pumping regime proposed for Well #3/Well #2, with the performance of a Pollution Impact Analysis. At a minimum, this would involve an evaluation of the fate and transport of the nitrate contributed by sanitary wastewater, and travel time due to groundwater advection from the closest ISDS system to Well #3 and Well #2. The need for centralized wastewater treatment due to impacts from the ISDS systems needs to be determined in the course of this Pollution Impact Analysis.

In addition, minimal subsurface testing results has been performed that satisfactorily demonstrates that 52 new septic systems with primary and reserve areas can be constructed on the property at the proposed locations. The construction of a septic system is solely dependent on the subsurface geology conditions of seasonal high water table elevation and soil texture and infiltration rate. Sufficient soil evaluation testing, including deep test pits and percolation tests, are the necessary standard to demonstrate that a site can support construction of an ISDS system. US Geological Survey geology maps indicate that the surface geology deposits are characterized as till, which is a glacial deposit of highly variable composition both laterally and vertically. RIDEM has indicated to W&C that soil evaluations for new subdivisions constructed within the WPA of a public supply well, where the native soil is characterized as till, would be required to perform a soil evaluation at each house lot, in order to ensure that soil conditions indeed can support the proposed wastewater disposal rate. We recommend that at least 25% of the proposed lots undergo soil evaluation tests consisting of test pits and percolation test to verify the expected soil conditions at the site and determine the feasibility of SWAP/VW applying to RIDEM for construction of 52 new ISDS systems.

b. <u>Impacts from Landuse</u>

In addition, routine RIDOH approval of public water supply wells requires development of a landuse site plan prepared according to *Section 3.0- Rules and Regulations*. This plan is required to show landuses located within at least 1,750 feet of the well; if the well has a larger recognized WPA, then landuses must be delineated within the larger area. The site plan should include, but not be limited to, the location of existing and proposed ISDS systems and any other existing or proposed potential sources of pollution including but not limited to those listed in Appendix 4 of the *Rules and Regulations*. This plan should be included in the Pollution Impact Analysis.

Best engineering practice further recommends that should any existing or potential sources of contamination be identified within the recharge area to a public supply well, a network of strategically located monitoring wells be installed to serve as an "early warning detection system" to detect groundwater contamination before it gets to the supply well. A monitoring well plan using existing or new wells should be included in the Pollution Impact Analysis.

c. <u>Impacts from Stormwater</u>

In our opinion, the well testing efforts at this time should include a presentation of the proposed stormwater management plan (SWMP) for the proposed subdivision. Best management practices require that post-construction stormwater runoff quantity and quality, and on-site runoff quantity and quality = pre-construction conditions. The construction of 52 new homes with associated driveways and paved road infrastructure will create new impermeable surfaces that will alter the ability of the pre-construction recharge area of the wells to infiltrate precipitation that recharges these wells. The presumption that much of the water pumped from the wells will be recharged on-site via the new ISDS systems under post-construction conditions presumes that sufficient precipitation recharge, which is the original source of the well water, is allowed to infiltrate the soil and recharge the aquifer.

Additionally, due to the proximity of the wells to a stream and bordering vegetated wetland areas that currently affect local hydrology and water balance of recharge area to the wells, the delineation of wetland resource areas should be presented and mitigation measures should be identified to ensure that the project does not negatively affect the local stream and wetland hydrology habitat that are necessary to maintain capacity of the well.

The need for more detailed preliminary soil evaluations is relevant for any component of the new subdivision that will depend on infiltration of water into the ground; this includes ISDS systems and the two proposed stormwater infiltration basins. Test pit data available for W&C to review did not include percolation (perc) test data, but soil profile data including soil texture and depth of oxidation features (mottles) suggests the presence of a high seasonal water table and soil of low permeability. The test pit data reviewed by W&C indicated the presence of a dense basal till layer (Cd) which is commonly a soil layer of low permeability, and highly variable in permeability across a large site. Therefore, the ability of the ISDS or stormwater infiltration basins to even function requires a more definitive preliminary investigation that demonstrates the height of the seasonal high water table based on a combination of soil characteristics (i.e.: mottles) and observed water table elevations, and perc tests. In addition, we recommend that mounding calculations be presented for the infiltration basins to demonstrate that under the design storm events, the basins will hydraulically function to store runoff until runoff infiltrates into the ground and prevents overflow of runoff off site and out of the well recharge areas.

Therefore, we recommend that SWAP prepare and submit to the Zoning Board a preliminary Stormwater Management and Wetlands Impact Plan that identifies wetland resource areas, function of resource areas in sustaining capacity and quality of water supply well, and stormwater best management practices (BMPs) that will be employed to ensure that pre-construction recharge quality and quantity = post-construction recharge quality and quantity with respect to stormwater. BMPs that may be employed and that are recommended by DEM include, but should not be limited to, vegetated drainage swales and infiltration basins, deep sump catch basins, and oil & water separators.

5. Development of Water System Management Plan

RIDOH drinking water regulations (*Section 3.9- Rules and Regulations*) require that a Water System Management Plan (aka "Capacity Assurance Plan" or CAP) would be required to be developed by the proposed water system manager entity for the water system that would supply water to both BH and VW. The CAP would include information pertaining to the demonstration of the system's financial, managerial, and technical capacity to comply with all drinking water regulations and address all system performance and water quality monitoring requirements for this water system. RIDOH has indicated to W&C that prior to submission of the CAP, RIDOH would desire that BH and VW have separately executed a mutually-agreed plan to determine the form and mechanism of the entity that will manage and be responsible for the expanded water system. The CAP must also address any future treatment needs for the wells should the water quality change due to natural or man-made conditions.

In our opinion, SWAP/VW should prepare a draft of a CAP and inter-party agreement between BH and VW, for review by the Zoning Board to show a mechanism of water system management that will provide a reliable source of potable water to the BH development and preserve supply of drinking water to BH to which BH has been accustomed and enjoyed from Well #3, and which meets RIDOH expectations.

Recommendations:

Based on the review comments presented above, we recommend that the Zoning Board require the following from SWAP to demonstrate that a safe and reliable source of drinking water can be provided to the proposed expanded BH and VW developments:

a. Revise water supply and wastewater flows under average day and peak day conditions according to technical review comments presented above.

b. Perform step drawdown pumping tests on Well #2 and Well #3 to identify depth and recharging capacity of primary fractures.

c. Repeat the seven day pumping test of Well #3 under conditions of average precipitation conditions, including water quality sampling per comments above, and at a pumping rate that is 33% above the proposed RIDOH "source capacity" for the well.

    1. Prior to performing the pumping test, SWAP should prepare and submit to the Zoning Board and RIDOH a "Pumping Test Design" which outlines proposed procedures to use for well testing, including, but not limited to: pumping test flow rate, wells to monitor for drawdown, drawdown and recovery monitoring and water sampling schedule.

d. Perform seven day pumping tests of Well #2 according to the same protocols used for testing Well #3 if Well #2 is to be used as a source of drinking water.

e. Prepare new updated site land use plan for both wells in accordance with *Section 3.0- Rules and Regulations*, according to comments included herein. At a minimum, this site plan should include landuses described in Appendix 4 of the *Rules and Regulations*, within the existing 2,806 foot radius Wellhead Protection Area of Well #3, including that portion of the WPA that extends off of the BH/VW property.

f. Perform a water quality Pollution Impact Analysis that accounts for addition of 52 new ISDS systems associated with the VW development plus the existing BH development, nitrogen loading analysis, contaminant transport travel time to Well #2 and Well #3 for all sources of pollution identified in updated landuse site plan, and proposed monitoring well network within the Wellhead Protection Area.

g. Based on results of pumping tests and water quality impact analysis, present report to Zoning Board that updates estimates of well capacity, water quality, surrounding landuses and potential contamination sources within the WPA, and conceptual water system design including schematic layout of pumping, treatment, distribution, and storage equipment.

h. Prepare and present to Zoning Board a draft CAP that presents all information required by RIDOH. Include a final agreement executed between BH and VW that establishes the entity who is financially and operationally responsible for system maintenance and compliance in accordance with RIDOH regulations.

i. Based on results of and test pits and perc tests performed at a minimum of 12 proposed ISDS locations, present wastewater facility plan that presents assessment of feasibility to construct 52 new ISDS systems on site.

j. Prepare and present to the Zoning Board, a preliminary SWMP that identifies proposed mechanisms and locations for stormwater collection, treatment and infiltration devices. Also present delineation of wetlands resources and mitigation measures to prevent impacts from development that may impact water supply.

If there are any questions, please do not hesitate to contact this office.

Sincerely,

WOODARD & CURRAN, INC.

Christopher J. Kilbridge, P.G.
Project Geologist

CJK/ls
Project # 210077

Enclosures